VALUE OF ELECTRIC PROPULSION FOR SAILBOATS

Properly designed and installed electric auxiliary propulsion is a far superior propulsion system for sailing vessels than traditional internal combustion engines. It also replaces the entire power storage and management systems on board with a much more capable, higher capacity and completely integrated whole vessel power system.

The higher initial cost does not tell the whole story if the electric motor is only viewed as a propulsion source. To understand the cost of the electric propulsion system, it has to be compared to the equivalent internal combustion engine, as well as the battery storage replacement and upgrade, the power management automation and interface, charging, inverting and environmental power capture and storage devices it replaces. The cost is a function of all the added capabilities to the vessel in both propulsion and the vessel's livability. Once comprehensively compared to all the systems being replaced, the cost variable is much less than it first appears.

Weight difference Diesel vs Electric in Salona S35

Weights in kg	Diesel	Electric
Motor	144	43
Batteries (house/propulsion)	95	68
Fuel	200	0
Charger	4	9
Start battery/house battery	27	27
TOTAL	**470**	**147**

Weight difference Diesel vs Electric in Arcona 435

Weights in kg	Diesel	Electric
Motor	264	47
Batteries (house/propulsion)	192	131
Fuel	200	0
Charger	20	21
Start battery/house battery	27	27
TOTAL	**703**	**226**

Weight difference Diesel vs. Hybrid in Voyage 480

Weights in kg	Diesel	Hybrid
Motors (incl. generator)	640	359
Batteries (house/propulsion)	264	186
Fuel	400	400
Charger	20	21
Start battery/house battery	27	66
TOTAL	**1351**	**1032**

Enhanced user experience

From a design standpoint electric propulsion is more in-line with a sailboat's form functions, enhancing both the sailing and motoring experience. Quicker access to power, concise control and comfort all lead to higher user enjoyment, more frequent use of the vessels and ultimately market growth for sailing as a whole.

The helm's ability to start and stop the vessel is much smoother and easier with electric motors' constant torque. Switching direction without a gearbox or its associated lag, the constant high torque and fine-tuned control lever all contribute to making vessel navigation in tight places and docking far easier. Also, because the system doesn't need to idle or be 'started' propulsion is much easier to access when needed and can be used strategically to make day-sailing and cruising much easier and more enjoyable.

If all that is achieved by switching to an electric propulsion system is greatly improved handling performance, the switch is justified as a value proposition. If a vessel is easier to handle, stress goes down and enjoyment goes up. Something as simple as docking anxiety can ruin an experience and turn-off users towards sailing. A vessel that is smooth, powerful and reliable will be more attractive to be used and enjoyed, ultimately more than justifying the initial cost.

Comparing apples to apples

Understanding the needs and numbers is very important, and there are many misconceptions around power comparisons. The old way was **HorsePower (HP)** and now we are talking about **kilowatts (kW)**. HP is a marketing number that is based on the engine's maximum power over time. This HP number is not completely worthless as it allows engines to be compared to engines, but does not really provide meaningful information for real life use in a Marine application. For that we need to look at a power dynamometer test to see what functional work is done in the real world versus the theoretical HP number assigned to the engine.

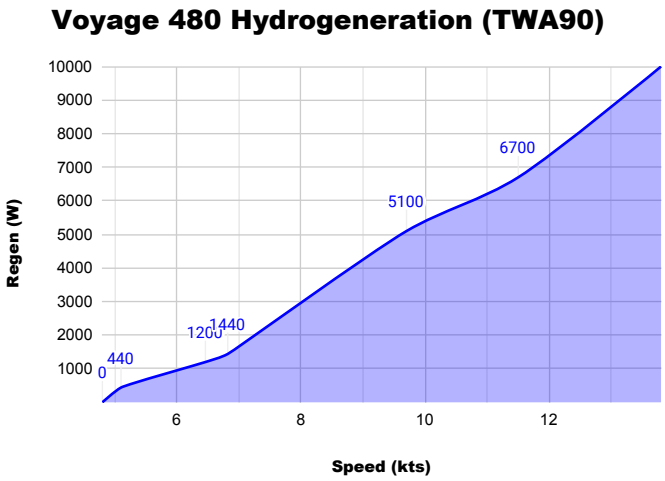
When underway, within the range of the electric propulsion system's battery **Reserve Capacity (RC)**, there is no exhaust and operating noise and vibrations are a small fraction of an internal combustion engine's collateral outputs.

This again is a full value justification for switching to electric propulsion. By making the vessel not only more pleasant but also much less impactful the enjoyment factor rises again. There is also now a whole new reason to sail. Because the hydrogeneration is a direct product of boat speed, now trimming sails and sailing well is rewarded by creating more power.

Self-sustainable vessels with infinite range

The best value can be realized when designing vessels, and identifying existing vessels, where sailing and hull performance will optimize electric propulsion and the ability to regenerate while under sail. The complete system will combine with solar and/or wind inputs to allow for completely self-sustaining vessels while underway or moored.

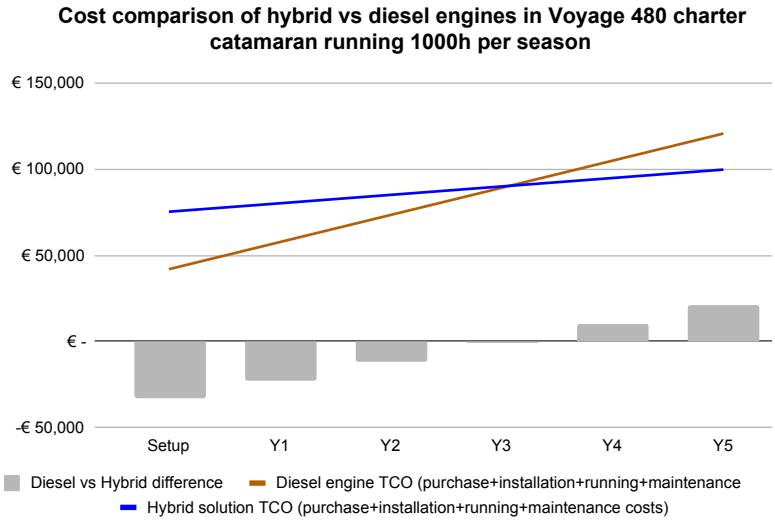
The hydrogeneration allowed by Oceanvolt systems has the potential to be the largest supplier of power to a self-sustaining vessel. With a maximum regenerative capacity of 5kW per drive, a fast sailing vessel can rely on this power the same way regenerative braking in electric and hybrid cars extend the range far beyond the batteries. Additionally, a sailboat is the perfect machine for this technology because the wind powered sailing can extend the range to infinity and also supply house and service power needs while underway through hydrogeneration.



This creates a new paradigm in sailing where at a designed ratio of sailing to motoring a vessel can effectively have infinite range. This of course has always been the case, but now a sailing vessel can have infinite range for the auxiliary propulsion as well as unlimited house and service loads when charging conditions are met.

Cheaper and easier to own and maintain

There are orders of magnitude less complexity in an **electric motor (motor)** than in a traditional fossil fueled **internal combustion engine (engine)**. Because of the highly reduced complexity of motors, breakdowns are far less frequent. Maintenance is a tiny fraction, therefore delivering much lower cost of ownership than a traditional engine driven system. Especially for fleet vessels and charter vessels, electric propulsion makes them more profitable to operate and out-of-service less often for maintenance and repairs.



In a commercial application the value is realizing return on investment, or for the private user who values reliability and robustness, the value is also clear. Here is yet another point where the switch to electric propulsion can completely justify the cost.

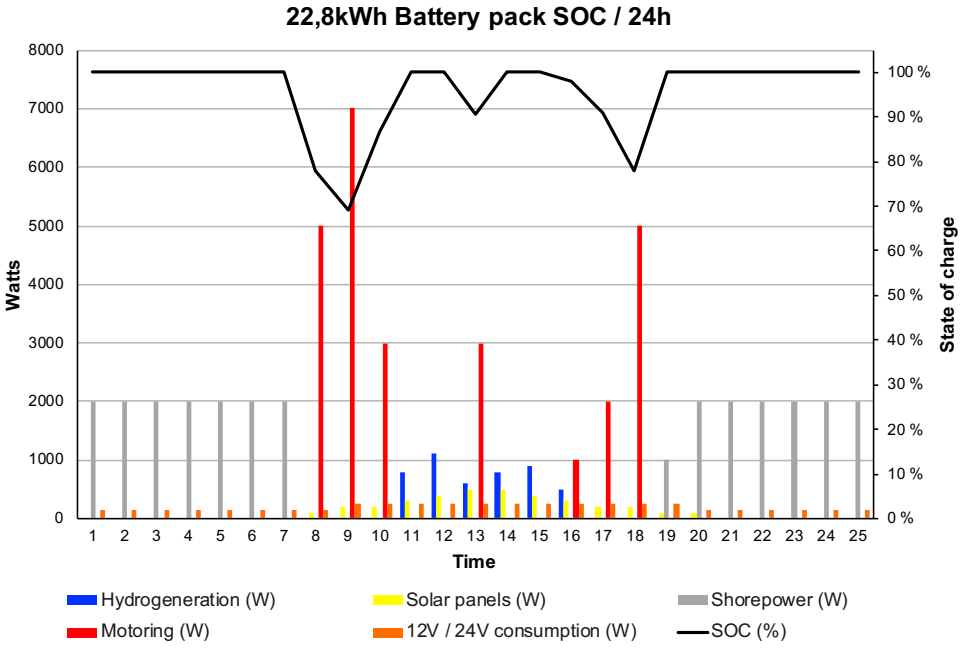
Complete power management

A properly designed and installed high **Reserve Capacity (RC)** battery bank, when combined with a complete power management system and an electric auxiliary propulsion system, gives many new functions and increases the usability of all vessel systems. The user can have a complete picture of the vessel's power use, generation and remaining RC especially when all input and outputs are integrated into the vessel's power management system. This information and control creates a far superior user experience because comfort and livability of any sized vessel is dramatically increased. A sailboat can be operated in a self-sustaining manner on many levels of comfort and performance depending on design.

Ultimately, the electric propulsion system's advantages can be realized with all these new possibilities in mind. Rethinking the budget traditionally allocated towards auxiliary propulsion is the only barrier to having a fully self-sustaining sailboat.

Hybrid systems with electric propulsion and a **VDC Generator (48vdc output)** meet the needs of every cruiser for both auxiliary propulsion, house and service loads. This hybrid configuration has many advantages over the traditional propulsion engine and **VAC generator (110 - 220vac output)**. The large battery bank covers the gaps between time of generation/charging and when the needs for propulsion and house loads arise. This allows the generator to be operated at the best time for comfort as opposed to real-time to meet needs. The end user experience is greatly increased with more control and being able to use whatever power draws, whenever they wish. This hybrid system allows for the traditional ability of adding fuel to extend range and meet house and service loads not met by solar or other sources.

Additionally, the generator's engine can run in its most efficient power band, unlike a typical marine propulsion engine. As a DC generator its only concern is to run based on the battery **State Of Charge (SOC).** There it can always run at an ideal constant speed until the batteries are full. This allows for more efficient fuel consumption and less modulation as power consumption changes.



Remote service and system updates

Another huge advantage of electric propulsion, specifically Oceanvolt, is in how service and support can be much quicker and more comprehensive. Because everything is talking together and integrated through the **Remote Service Interface (RSI)**, almost every possible issue can be seen through diagnostic software and services. Anywhere in the world where the vessel can get online, Oceanvolt's service technicians can log into the system and diagnose and repair issues remotely. Upgrades and refinements will simply be remotely installed because many of the design and performance improvements will be through software improvements.

Oceanvolt's RSI is very effective because of the fore-thought and engineering that Oceanvolt has applied. The simplicity and robust mechanics of the system, along with complete system integration, means that nearly all diagnostics, upgrades, updates and most repairs can be made remotely. This reduces any downtime in waiting for an on-site technician and means the vessel can be serviced anywhere in the world internet is available.

Freedom of design

Electric propulsion allows for much greater freedom in boat design. If the design's form function is weight reduction, an electric propulsion system can be much lighter and fulfil all the propulsion needs. Electric propulsion allows for many more systems to be supported by less weight and tech space. It also enables the required components to exist in much smaller spaces, allowing for more liveable space and greater capability on smaller vessels.

The new design and use paradigms when considering electric offer the largest value by designing whole boats around the new paradigms. The same hull and displacement can carry more systems by standardizing power sources. This allows a vessel to have a large enough power reserve and the ability to regenerate through a variety of ways: hybrid, solar, wind, hydrogeneration, or a combination of any of these sources.

This allows very capable vessels to be either smaller or faster. In both cases the cost of ownership is highly reduced. Smaller vessels with owner-operators can be overall more capable, much easier to use docking, sailing and while at anchor. Faster vessels can weigh less while prioritizing speed over range and other luxuries but still have much more capacity to the users. Vessels that go largely unused by operators now will be more appealing as electric due to ease of use, reduced stress through breakdown and ultimately the reward of being able to sail well enough to be energy self-sufficient.

Now sailing and using the propulsion systems are not only more pleasant, but the act of sailing is in fact rewarded. Sailing to save RC, motor-sailing, and regeneration are all direct results of the owner's sailing prowess. By sailing better and sailing more, a vessel can go from range-anxious to fully self-sufficient with the generator standing by if needed on hybrids.

Sailing is one of the great leisure activities and electric auxiliary propulsion will be a new era. Vessels can now be emission free after production with incredibly long product half-lives and highly reduced cost of ownership.

If you enjoyed this whitepaper please look forward to these topics, where we hope to get much more in depth on some of the subjects we've just touched on here.

Lithium Chemistry Batteries: Value and Advantages
System Design
Optimizing Range
Cruising with Pure Electric
Cruising with a Hybrid Electric
Power Management
Docking and Handling