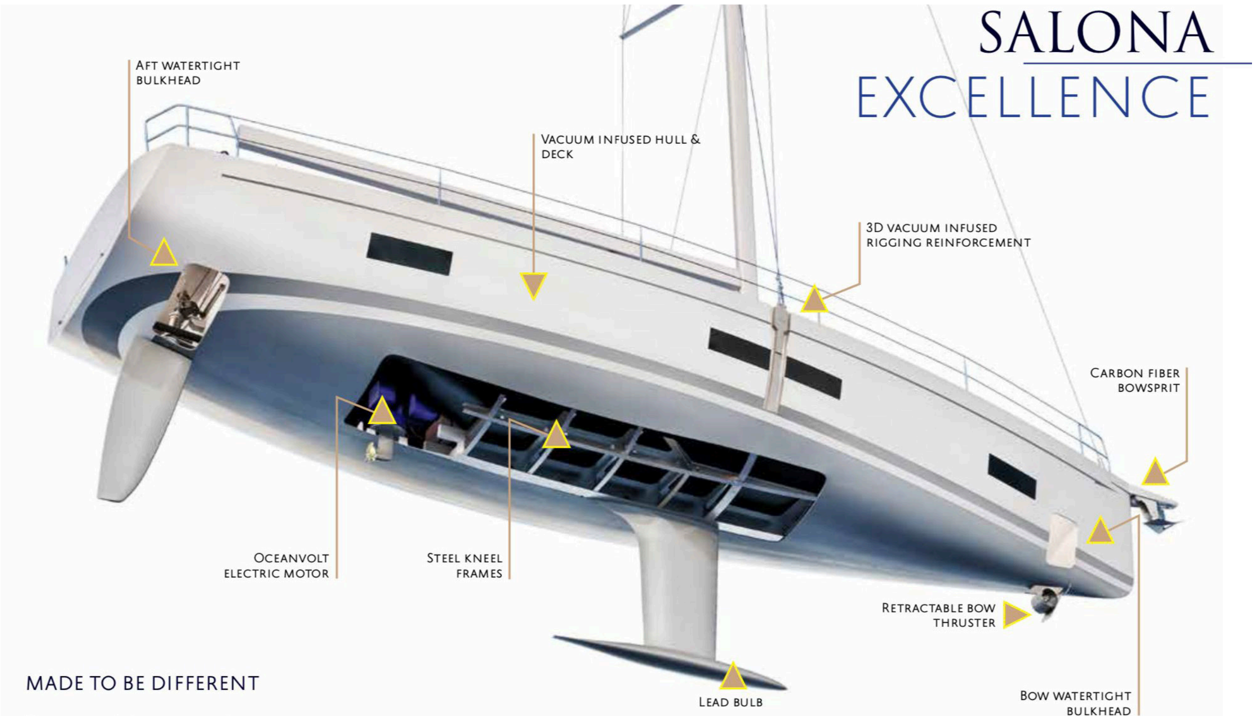
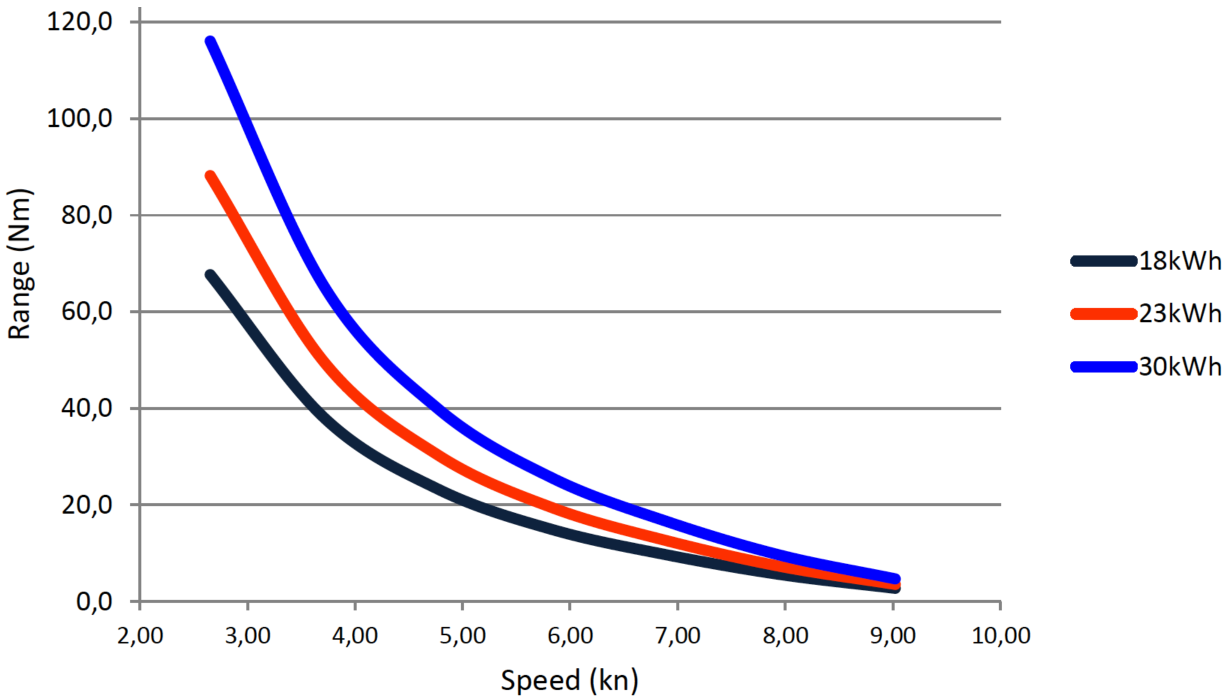
VALUE OF ELECTRIC PROPULSION FOR SAILBOATS PART 2: DESIGNED TO BE ELECTRIC



Design is always moving forward and new paradigms allowed by electric propulsion are allowing for many new ideas and innovative solutions. Understanding the needs and numbers is very important, and we will start with power. The old way was **Horse Power (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 doesn't really provide meaningful information for real life use in a Marine application. For that we need to look at a power dynamotor test to see what functional work is done in the real world, versus the theoretical HP number assigned to the engine.

Once the propulsion needs of the vessel are determined and matched with a solution to meet the vessel's design and intended use. Range calculations can be based on a comprehensive hull resistance calculation.



House and service loads should be calculated, then added to propulsion needs to create **Total Vessel Potential (TVP)**. Based on the vessel's intended use and characteristics it should be determined if the system will be a hybrid or pure electric vessel.

Battery banks have to be sized on the minimal 'C' coefficient. For **Lithium Iron (Ferro) Phosphate (LFP)** Batteries the C=1 so for 10kW of TVP the battery bank size needs to be at least 10kWh of battery bank **reserve capacity (RC)**. For **Nickel Manganese Cobalt (NMC)** batteries the C=1.4 so 10kW of TVP would need at least 14kWh of RC.

TWO TYPES OF RANGE

There are two types of Range to consider. **Continuous Range (CR)** being the maximum distance the vessel can travel over water, which is **STW (Speed Through Water) x Time** in a benign sea state, without taking on any charge. The CR is a variable that is very dependent on speed. In typical use of pure electric STW will be adjusted down as range is needed, and up as the situation allows or demands. If the trip is just into the dock where shore power waits, the speed can be the vessel's displacement hull speed. In cruising situations where RC (Reserve Capacity) is large enough to allow the typical ideal STW is where both range and speed are maximized. This can be adjusted by a few factors but is usually around 65-75% of displacement hull speed, depending on vessel's characteristics. This is a **vessel's cruising speed (VCS)**. VCS is a speed where performance can be typified at a point allowing for efficient consumption, at an acceptable STW.

The next range is **Total Trip Range (TTR)**, which has many variables. The vessel's performance and the skill of the crew as well as wind speed and direction will all factor into how much power can be generated by the hydro-generation of the Oceanvolt System. For boats that can sail fast enough we are able to achieve infinite range with a sailing:motoring ratio of 4:1, where the average sailing speed can generate enough power in 4 hours to attain an hour's worth of motoring at the VCS.

For a hybrid system the Total Trip Range is based on fuel capacity, but there is also no reason the regeneration could be a large contributor to power needs. A hybrid vessel is a much easier transition from an engine for propulsion because range can be extended as long as fuel is available. Hybrid vessels will be used when more motoring is required. So every vessel is different, but the main advantage of either pure electric or a hybrid is that the effective Total Trip Range (TTR) can be much higher than a traditionally engine powered vessel that is always limited by its fuel capacity.

Another design note for pure electric vessels to consider is that there is no longer an alternator to contribute to battery charging to meet service and house draws. Either planning for capacity needed in the whole vessel RC, or adding enough solar and/or wind generation to meet the house and service needs is important to consider in the whole vessel design.

SYSTEM DESIGN CONSIDERATIONS FOR PURE ELECTRIC

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, have a large enough power reserve and the ability to regenerate as a hybrid and/or with solar/wind or hydro-generation-ultimately through sailing performance.

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 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.

Also now sailing and using the propulsion systems are not only more pleasant but sailing is 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.

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.