



Electric Boating Seminar

43rd Port Townsend Wooden Boat Festival

- Background
- Tradeoffs - Salish 100
- Next steps

This version has speaking points added.



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Founder, CEO of PropEle Electric Boat Motors Inc. since 2009. Concept development and innovation management; marine propulsion, consumer products with Philips & L'Oréal. Research experience in photovoltaics, flying countermeasures and medical diagnostics. B.S. Physics, coursework in Yacht Design, Manufacturing, Industrial Design. 31 patents issued + 51 published.



Electric Propulsion: growing by 11% annually.

And it shows. Finally, a Google search displays options.

The image displays a grid of 30 different electric outboard motor models and components. Each motor is accompanied by a small text caption and a source URL. The motors vary in size, color (mostly black and grey), and design. Some are shown in use on a boat, while others are studio shots. A sidebar on the right contains 'Related searches' such as 'homemade electric outboard motor', '150 hp electric outboard motor', and '10 hp electric outboard motor'. At the bottom right, the text 'Google search: electric outboard' is visible.

Related searches:

- homemade electric outboard motor >
- 150 hp electric outboard motor >
- 10 hp electric outboard motor >

Google search: electric outboard

With more options come better options...

...in terms of Capability, Experience, and Cost. But are they good enough?

This is Swe'Pea, our wooden dinghy circa 2011 when there were few electric outboard options and none that met our needs.

So I built one. It was perfect for the way we used the boat.

Though there are many good options today, electric powering still has tradeoffs. It's a vastly superior choice for some families, but not for others.

Are you better served by electric propulsion?



Tradeoffs

Remember the switch to smart phones? Not a good phone compared to the old ones with full ear coverage, no finger over the microphone, no lost signal, and easier to hold. I asked the seminar attendees, “Who has no landline?” and most hands raised. So the smartphone wins even though, as a phone, it’s inferior.

It’s more, and it’s less. Electric boating is like that, too.



By Jonathan Mauer - Own work, CC BY-SA 4.0,
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By Rafael Fernandez - Own work, CC BY-SA 4.0,
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Experience: Electric wins.

“Experience” has many dimensions, and in almost all of them, Electric is a better choice.



Respect
Control
Sound
Safe
Smell
Clean
Simple
Maintain
Charge
Pride



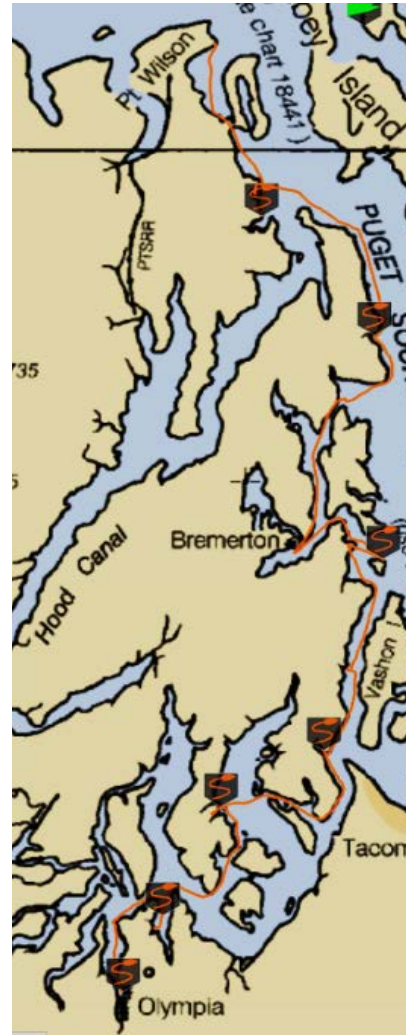
Range is the biggest question for boaters

Intent: to help unravel some range tradeoffs.

We'll look at two small boats on week-long cruise.

We'll compare their performance and how they used the EP Carry differently.

These examples relate to small boats but the principle and data is perfectly scalable to larger craft.



Salish 100:

A late June inland cruise: Olympia to Port Townsend.

100 miles/ 6 days.

Each day was between 10 and 16 miles.

Kerfuffle



Swe Pea



Moderating speed makes a big difference in range.

An 11 ft ballasted sailing pram



Kerfuffle's online performance prediction from epcarry.com

Full throttle speed (knots) 3.5	Half-throttle speed (knots) 2.6
Full throttle range (nautical miles) 3.5	Half-throttle range (nautical miles) 5.3

EP Carry:



Designed for ship-to-shore, fishing and sailing dinghy auxiliary use.

14 lb. motor, 6.4 lb. battery.

Runs 1 hr. at full power—typically 3.5 – 4.5 knots.

Kerfuffle found options to suit the day's conditions.

- 1) Range to 3.5 nm: One battery, full throttle (3.5 knots x 1 hr. Refer to range chart above center).
- 2) Range to 5.3 nm: One battery, ½ throttle (2.6 knots x 2 hrs.).
- 3) Range to 8 miles: One battery, ¼ throttle (2 knots x 4 hours) (1/4 power not shown on chart).
- 4) Range to 10.6 nm: Two batteries, ½ power (5.3nm/battery x 2 batteries).
- 5) Range to 16 nm: Two batteries, ¼ throttle (2 knots x 4 hrs/battery x 2 batteries).

Conclusions from Scamp case:

- Max reasonable auxiliary cruising range up to 16 nm with an extra battery/charger and planning ahead.
- Comfortable auxiliary cruising range is 10 nm.
- Requires recharging each night on shore (< 5 hrs.) or alternating with second battery on solar charge.
- It is especially important to leverage tides with a heavy, short-waterline boat.
- Appropriate for club cruising in company with similar boats and with rowing boats.
- Propulsion system (EP Carry) costs \$2,120 including second battery and second charger (solar panel not included).

Note that the Scamp has water ballast. Some scamp builders substitute lead acid batteries for this ballast. Two 27 group batteries provide a range of 36nm.

Adding the Sun – Swe'Pea's Solar Sailing Salish Adventure

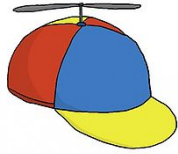
Just like sailing

- Uses energy provided by nature in real-time.
- 'Auxiliary' is the floating 6-lb battery.
- You still mind the tides.
- You still watch the weather. But instead of wind, you use the sun.

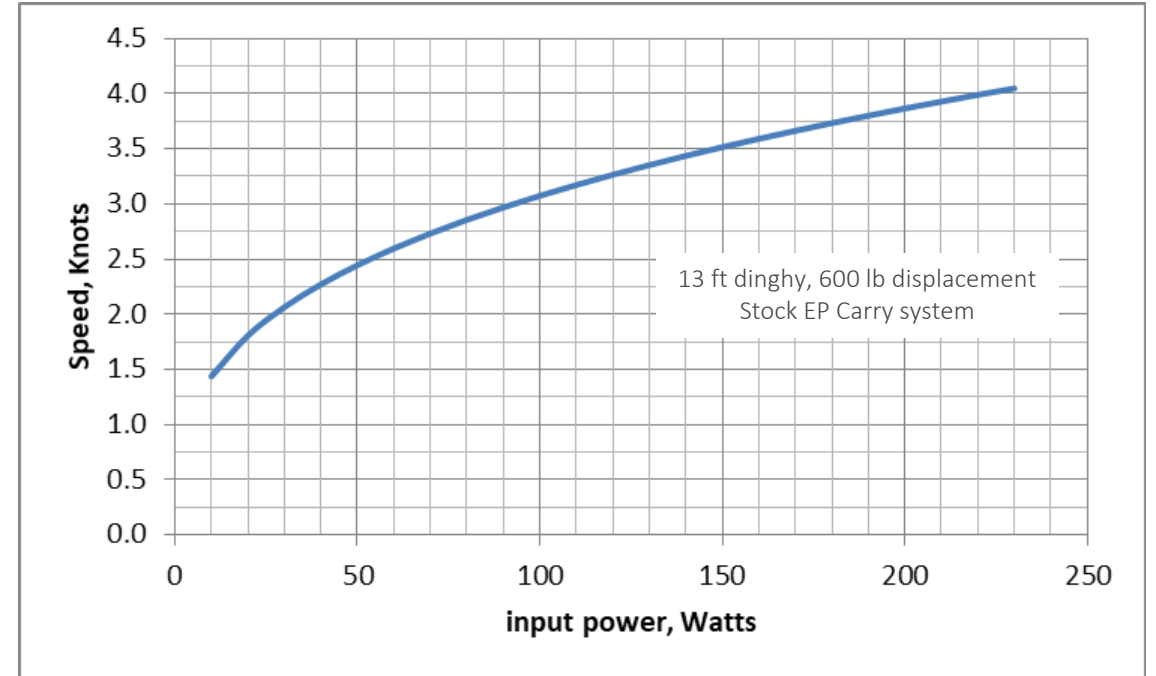
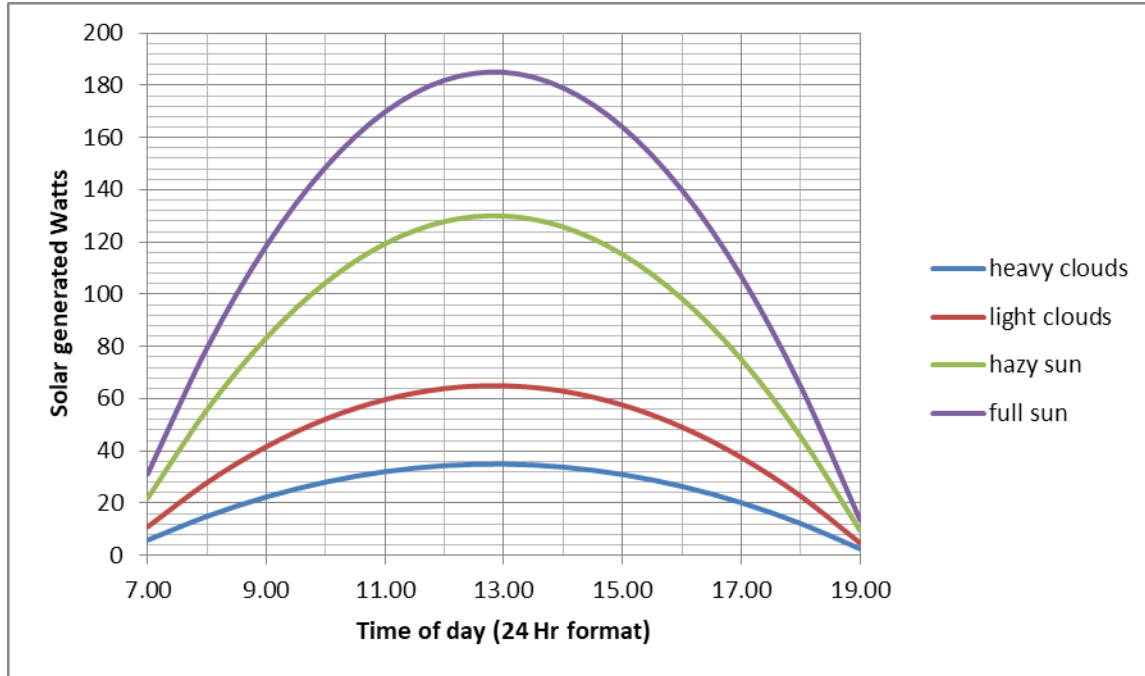


“Propeller Head” slide

Horizontal array
Mid June, 48 N



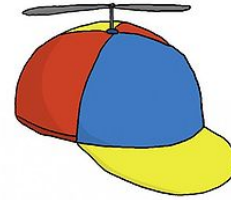
In the seminar, we spend time on this slide. Key question: What speed can Swe’Pea go at 9:00 AM on a day with light clouds?
Use the Chart on the left - find 9:00AM and the red line. 40 Watts is generated at 9:00 AM. Look on the right chart to see what speed relates to 40 watts. *Answer is on next slide - no peeking!*



I generated these charts from measurements of my solar array and measurements of my boat’s drag. The solar chart can be scaled. This array was rated at 200 watts.

Note the approx. 5:1 wattage difference between sun and heavy clouds.
Next slide shows that the speed difference is actually much less.

“Propeller Head” slide 2



Answer: Speed of travel if using solar alone at 9:00 AM on a lightly cloudy day: about 2-1/4 knots.

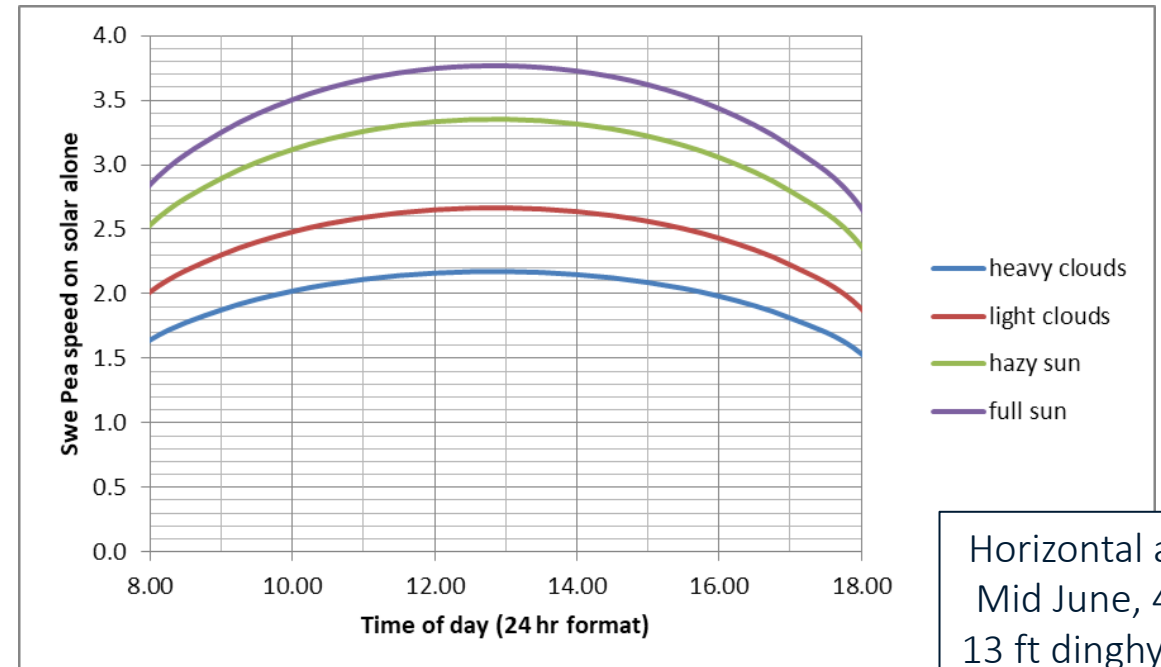
This chart eliminates the Wattage axes on the previous charts so it directly shows “solar-sailing” speeds throughout the day. It’s easier for trip planning.

Interesting note: If you add each hour’s speed, you can estimate the daily solar sailing range possible.

Heavy clouds	23.7nm	*
Light clouds	29.1nm	
Hazy sun	36.5nm	
Full sun	41.1nm	

Practical example:

On the Salish ride Swe’ Pea went 26 miles in one day - mostly patchy sun and last 8 miles in a thunderstorm, mostly with the tides but against the tide through the storm. Battery was used for the stormy portion. In reality, conditions change so the chart can be used all day as they change. Also, it’s sometimes good to use your auxiliary battery power in the morning and recharge while running during mid day.



* You might be surprised to see that full-sun range is less than 2x the range in heavy clouds. The reason for such a small difference is that boats are more efficient at lower power levels.

Horizontal array
Mid June, 48 N
13 ft dinghy, 600 lb displacement
Stock EP Carry system and no battery.

Swe'Pea's Solar Salish Adventure Wrap-up:

600 lb. 13 ft. boat

Standard EP Carry with 6.4 lb./9.6Ah battery

4 sq. ft. array (two 100-Watt panels) & solar controller

- Late June, 30% sun, mostly cloudy.
- 120 nautical miles traveled.
- Average speed 3.1 knots.
- Max speed 5.5 knots (with 1.5 knot flow).
- Minimum full-power speed 1.7 knots over ground, against chop, tide and 20+ knot winds.
- Total travel time was almost 40 hours.



Swe'Pea's trip averaged over 1000 nautical mpg

Distance traveled: 120 nm.

Time of travel: Almost 40 hours.

Power: Average speed: 3.1 knots. Looking at the speed chart, that corresponds to roughly 100 watts of power.

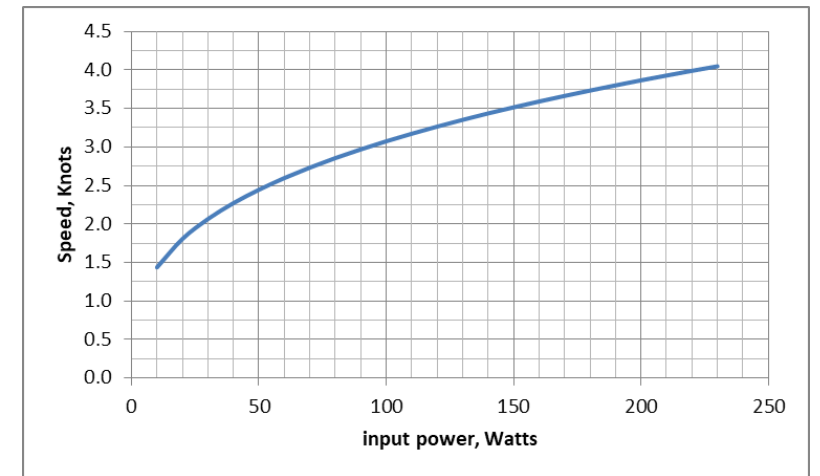
Energy: Multiplying 100 watts by 40 hours produces 4 kWh of energy used. (Note: actually the energy used was lower because the tide lift contributed to speed through the water.)

Gallon equivalent calculation: According to the EPA's formula, there are 33.7 kilowatt-hours of electricity in one (US) gallon of gasoline. Therefore, 4 kw / 33.7 kWh/gal produced an equivalent 0.119 gallons of gasoline.

Final nautical mpg calculation:
 $120 \text{ nm} / 0.119 \text{ gal} = 1008 \text{ nautical mpg}$
Equivalent

	start	end	Planned distance, nm	Actual distance, nm
22-Jun	olympia	Henderson inlet	12	12.65
23-Jun	Henderson inlet	Penrose pt stpk	16	14.3
24-Jun	Penrose pt stpk	Gig Harbor	15	13.58
25-Jun	Gig Harbor	Blake Island	16	19.58
26-Jun	Blake Island	Kingston	14	25.54
27-Jun	Kingston	Matt's Bay	16	17.44
28-Jun	Matt's Bay	PT	13	17

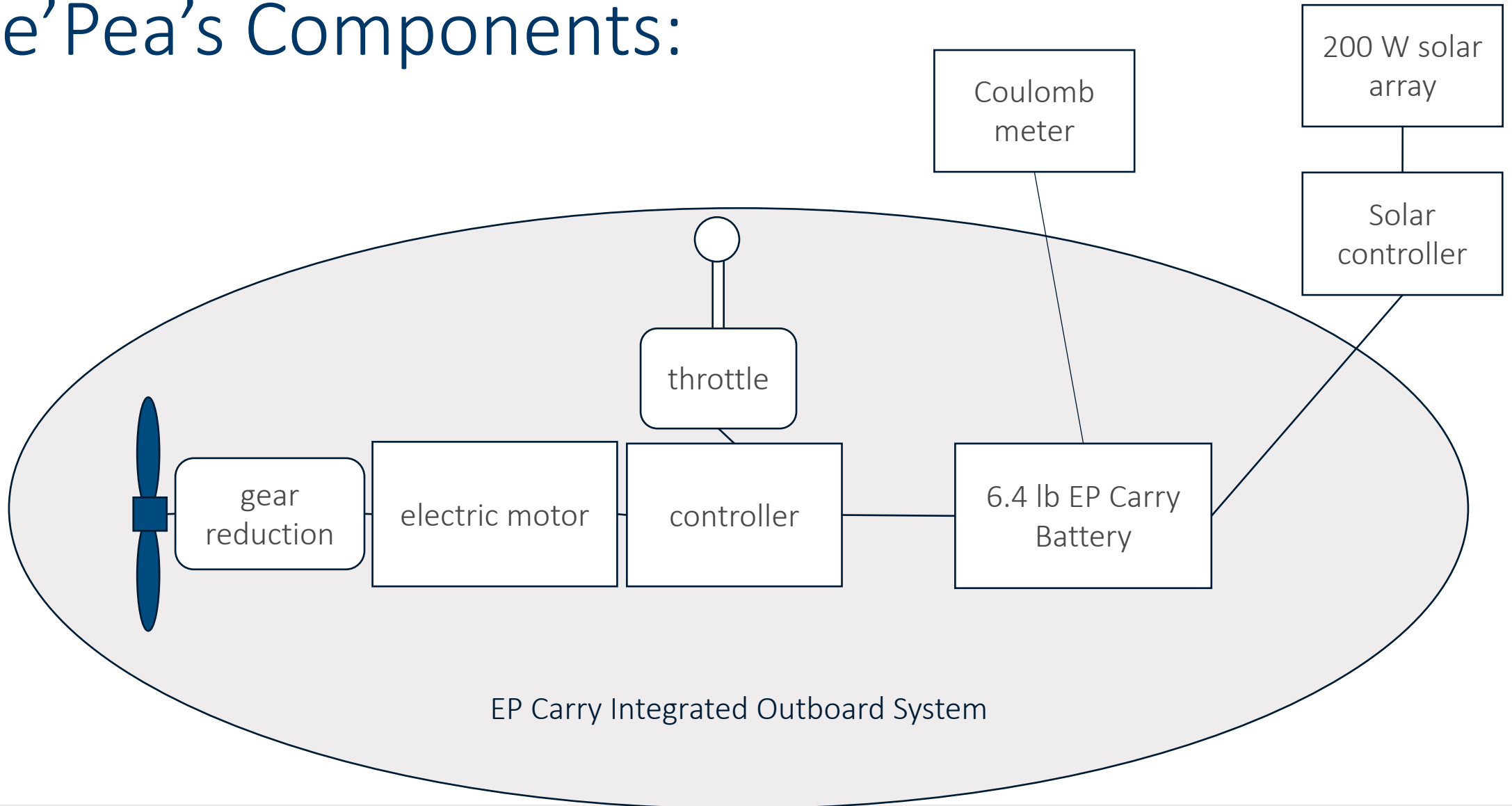
120 nm total



Conclusions Solar Swe'Pea:

- No shore recharging required. Confirmed.
- Over 1000 mpg equivalent
- Batteries often topped up in the hours following or preceding the travel times.
- Max reasonable solar cruising range between 23 and 41 nm over the water, depending on the cloud cover. Cruise was in June so ranges will be lower seasonally and geographically.
- There is less than a 2:1 speed and range difference between heavy clouds (raining) and clear sun. That makes solar sailing even more predictable and practical. Even so, heavy clouded days seem very slow outside of 10:00 through 14:00 hrs.
- This trip is possible without a battery but a battery provides an 'auxiliary' to solar sailing when needed and batteries are a safety requirement. At most times, I maintained 2-3 nm full-speed range in reserve which was appropriate for coastal cruising in the Salish. The battery weighs 6.4 lbs and sits in the motor well.
- It is especially important to leverage tides with a short waterline boat.
- Appropriate for club cruising in company with similar boats and with rowing boats.
- Propulsion system (EP Carry with one battery, 200 watts solar panels, and controller) costs \$2,120.
- A meter is a useful addition. A coulomb meter that reads energy into and out of the battery, and states the battery's state of charge is appropriate.

Swe'Pea's Components:



Swe'Pea's Components:

- Boat: Total dry weight approx. 300 lb. A 1950s hot-molded mahogany jet-14 hull shortened by 1 ft to remove rotted sections, 1-1/2" fir transom and motor well. Shear was raised by 8 inches and a new deck and windshield added in 2001. Forward and aft bench seating.
- Motor and battery: Total weight 20.4 lb. From the standard EP Carry system package, I used the motor and battery. I also brought 3 spare batteries and two chargers. I dispensed two batteries and chargers to other EP Carry users on the trip, and kept the third for emergency but never needed it. The motor was modified for remote steering and throttle control but otherwise it was standard issue.
- Solar panels: 2 ALLPOWERS Solar Panel 100W 18V wired in series. There are many brands of semi-flex panels using Sunpower cells. This is just the one I happened to purchase. These panels are recommended. Panels were fashioned into a pop-top to act as a rigid bimini up and away from shadows. It could also be lowered for windage reduction, heavy seas and when trailering. Total weight 16 lb.
- Solar controller: The EP Carry battery will self-regulate its charge with a direct connection to solar panels under 100 watts but I was using 200 watts of panels so I needed a charge controller: a GreeSonic MPPT Solar Charge Controller 15A 12V/ 24V Waterproof (MPPT1575). However, for this trip, I would recommend instead the Genasun GV-Boost solar charge controller with MPPT for 24V Lithium Batteries.
- Meters: I used a \$45 LCD screen coulomb counter meter (Battery Coulometer TK15) arranged to show the battery's state of charge and charge/discharge rate. It is not robust physically but worked flawlessly on this trip. This product is recommended if it can be adequately protected from the weather and handling. Other options are to use an ammeter that can show positive and reverse current flow, and a good state of charge meter. Note that voltage meters are not effective or accurate on lithium batteries unless readings are taken in fixed conditions. A true coulomb meter is the best.

Contact PropEle Electric Boat Motors

- Partner with boat manufacturers for customized propulsion solutions.
- Electric boating seminars, best suited to small craft, specializing in long range solar powering.



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