Not Your Father's Outboard

The four-horsepower Solid Nav Traveler pushed our Cape Dory Typhoon test boat (2,000 pounds displacement) from a smooth slow-ahead idle to hull speed during testing in calm Chesapeake Bay conditions.

Solid Nav's 4-horsepower electric kicker lives up to its performance claims.

Exploring the benefits of electric propulsion is an ongoing effort at *Practical Sailor*. As we test products currently on the market, we also keep an eye on new gear that's in the works.

We've evaluated gas-less trolling motors like Minn Kota's 24-volt RT80/S-3X (May 15, 2005) and 12-volt RT-55S (May 1, 2004), the Torqeedo Travel 801L portable electric outboard (November 2007), and electric alternatives for diesel inboards (September 2008).

Among the newer products on the market is the four-horsepower Traveler electric outboard motor marketed by Solid Nav and manufactured by Suzhou Parsun Power Machine Co., China's largest outboard exporter. Using a brushless 48-volt DC motor made by Mars Electrical Co. of Milwaukee, Wis., the Traveler combines a familiar drive train and an innovative solid magnet electric motor. At first glance, it looks like a small conventional outboard—the kind that even two-stroke visionary Ole Evinrude would recognize. But its stealthy nature is hidden under the cowl, where engineers have extracted the internal combustion motor and replaced it with a brushless DC motor and water-cooled electronic controller.

As we did with the Torqeedo and Minn Kota, *Practical Sailor* put the Solid Nav Traveler to work in sea trials to determine whether the kicker was a viable replacement for a small boat's gas-powered outboard.

ARE YOU ELECTRIC?

Small-boat skippers considering electric propulsion should first answer a few important questions. The first: How much time do you actually spend under power and in what type of conditions? If the answer is lots (20 percent or more), and you often find yourself powering to windward in choppy seas, the electric engine needed to deliver the goods is both complex and costly. It involves a good-sized diesel engine driving a hefty, high-voltage DC generator that directly powers a large DC motor, coupled to a conventional drive train. In this case, it's more efficient to just connect the diesel directly to the drive train and forget about an electric alternative.

However, there is legitimate opportunity for electric innovation on boats where powering is less prevalent and the demand for thrust is modest to moderate. This includes auxiliary use aboard daysailers and pocket cruisers that may need more than an oar to exit a tight slip and harbor confine. It also encompasses marina-based weekend or point-to-point cruisers who have ample access to shore-power to feed the outboard.

All electric propulsion systems come with ampere or watt ratings that help define the current or total power they will consume. In the go-slow mode, it's a lot less than at full speed. To get a feel of whether electric is a good fit for a boat and its owner's motoring needs, add up the anticipated energy needed in amp-hours (time run in hours x amperes) and add a safety margin. The result will give you a good idea of just how feasible it is to power between pit stops with a specific size battery bank.

For example, the Traveler has an 80-amp, full-power continuous rating, but it pushed the 19-foot Cape Dory Typhoon test boat (2,000 pounds displacement) along at almost 4 knots in a flat calm, using only 20 to 24 amps. (See "How We Tested," page 19.) Note, however, that the outboard's 20-amp appetite is based upon a 48-volt-DC, not 12-volt-DC, system. This translates in terms of actual power consumed (measured in watts) to four times the energy consumed by a 20-amp, 12-volt piece of equipment.

HIGH VOLTAGE

One reason electric propulsion engineers prefer higher voltage is that more wattage or power can be conducted through smaller-gauge wire. At lower voltage, the amperage must increase to derive the same amount of power (in watts).

The 100-amp-rated, 48-volt DC Trav-

Photos by Ralph Naranjo

Field Testing e-Power

In order to get an accurate feel for the relationship between the amperes consumed and the thrust developed, testers installed a new 48-volt DC North Star Energy 1 battery bank on a Cape Dory Typhoon daysailer (14 feet LWL, 2,000 pounds displacement). The system was equipped with amp- and volt-meters, and a portable GPS was used to measure the boat's speed over ground (SOG). (For more on the battery bank setup, see "The Battery Tank," page 21.)

Test runs were made in calm conditions during times of slack water. Each measured run was made over 0.25 nautical miles, and the test boat entered the run at a specific speed and maintained that velocity for the quarter mile. The ampere consumption was noted, and a speed-versus-current draw relationship determined.

Engine tilt and vessel trim were experimented with and held constant in their optimized position during final testing. Prior to each set of evaluations, batteries were charged overnight and the "no load" voltage at the start of each test was stabilized at 50.5 volts DC (+ or – .2 volts).

PS VALUE GUIDE — SOLID NAV TRAVELER

AMPERES	10	20	30	40	50	60
BOAT SPEED (KNOTS)	1.4	3.6	4.2	4.6	4.8	4.9
RUN TIME (HOURS)	7.1	3.3	2	1.2	1	0.8
FINAL VOLTAGE (VOLTS)	43	43	43	43	43	43

eler has a max power demand of 4.8 kilowatts. To create the same power in a 12-volt system, it would require 400 amps of current, and the wire size of the motor windings and delivery cable would increase accordingly. Regulatory bodies see 50 volts as the upper limit of "low voltage" applications; above that, the hazard of electrocution becomes an issue, so they mandate much more elaborate testing and safety protocols for "high-voltage" systems (over 50 volts).

FINDINGS

The long-shaft Traveler we tested pushed the short-waterline sloop (almost 14 feet) to hull speed, or about 5 knots, in calm conditions. Though it possessed additional thrust, a basic premise of naval architecture held sway: A displacement hull becomes quite inefficient as it nears and attempts to exceed hull speed. (In this case, the 5-knot calculation comes from the formula HS =1.34 x √LWL, where LWL equals 14 feet.) We were able to efficiently achieve 4 knots of boat speed using an average of 22 amps of current, but the prospect of driving the boat to 5 knots doubled the current draw and shortened battery life by a factor of three.

Another key observation was that the Solid Nav Traveler was a bit too large for the Typhoon daysailer. But as with a diesel engine that has more horsepower than needed, the solution lies in just throttling back a bit to an efficient speed and putting up with the extra weight. (We would have loved to test out a two-horsepower option on the Typhoon, if it were available.) The four-horsepower Traveler could push along a Cal 25 (20 feet LWL, 25 feet LOA, and 4,000 pounds displacement) or similar-sized pocket cruiser, in our opinion.

The weight (67.5 pounds) and bulk of the Solid Nav Traveler put it outside the range of outboards to be left in the locker awaiting the moment when the breeze disappears and the sea goes glassy. It is definitely a motor to have on a transom bracket.

Testers favored the sensible design approach that keeps the Traveler's electric motor out of the water. Other units such as the Torqeedo or Minn Kota trolling motors that use a submersible motor rely upon seals that will eventually deteriorate allowing sea water to enter with disastrous consequence. The Traveler's electrical motor is nestled in the dry confine of the engine cowl, well away from the immersed propeller. Unfortunately, because of the motor's placement, operation falls short of a savor-the-silence experience thanks to the rotary noise, drive shaft clatter, and sound of metal rotating parts. But for those who are looking for long-term reliability from an electric outboard that's used in saltwater, we feel the noise associated with the motor in the power head is worth putting up with.

PROS AND CONS OF ELECTRIC

Electric propulsion has many important attributes. One is the simplicity of a permanent magnet, solid state-controlled electric motor, a source of reliable torque converted to thrust.

The optimist in our test crew reveled in the non-combustion technology and extolled the simplicity of pushing a single lever in one direction to go forward and pulling it back for reverse—no need for neutral. Electric outboards also offer the benefit of no or low maintenance as there's no oil to change (except the gear oil in the lower unit), and there are no fuel issues to be concerned about like damage from ethanol. The tester also noted the welcome absence of a recoil starter, cantankerous idle, and the foul fumes associated with gasoline-powered outboards.

But the reality of an electric engine is that it requires battery power to keep it going. An electric outboard's battery bank can be considered a tank of amp-hours that runs empty much faster than a conventional liquid-fuel tank. Skeptics may point out that battery-based propulsion is like having only a two-gallon

The Mars 48-volt permanent magnet electric motor directly delivers torque to the outboard's drive shaft; no conversion of reciprocating energy is necessary.

At three-quarters throttle, the Traveler had the Typhoon at hull speed and the dinghy was planing.

diesel tank. But if all you use between convenient pit stops is about one gallon of fuel, it's by no means a showstopper. In fact, it's a lot easier to plug in a power cord than stand diesel-spill watch at the end of a fuel hose—granted the latter needs to be done far less often.

This "just enough juice" is a valid approach for small electric inboards and outboards, but if no provision for onboard regeneration is present—vis-à-vis a small DC genset—it would be prudent to keep a good book on hand to read while you're waiting for the wind.

Energy management can be handled via Ohm's law (Voltage applied = Current in amps x Resistance in ohms) or by monitoring the power meter built into the cowl of the Traveler.

The more cynical *PS* tester, concerned with an outboard's thrust-per-pound ratio, called the Traveler a "sheep in wolf's clothing." Admittedly longing for the old days, when his 15-horsepower OMC two-stroke outboard weighed 81 pounds and planed a RIB with the whole family aboard, the tester was skeptical of the 60-pound Traveler and its two-thirds less horsepower. (This same tester happened to be the one who had to drag down the dock and heft aboard a battery bank that weighed over three times the outboard's weight. He mentioned once or twice that his antique OMC ran twice as long on a tank of gas, which weighed about 10 percent of the battery bank, and cost about $1,200 in 1984 dollars)

In addition to performance and maintenance factors, there's the environmental issue to consider when weighing the pros and cons of electric propulsion. Fossil fuels are undeniably a less clean source of power than electricity, at least in respect to the end user. With electric outboards, there's no exhaust, no possible discharge of unburned fuel or oil, and there's far less "sound pollution." However, to make an electric engine truly a "green" alternative to petroleum-fueled propulsion, its batteries should be charged using renewable resources like solar and wind. The energy used to charge batteries via a dockside hookup or at home likely was produced by nonrenewable, dirty coal. Using solar panels or a wind generator to charge an engine's battery would make the most of its environmental friendliness and offer an alternative to dockside charging, but an "off-the-grid" electric outboard raises some practical obstacles, particularly if the engine is run frequently (not to mention the cost of installing an adequate charging system).

In practical applications, those who use the boat on weekends and allow the batteries to solar charge all week in at least a partially sunny climate can make up the amps used on the weekend. Based on the test results tabulated on page 19, four 50-watt solar panels ($299 each, rated peak output 2.9 amps) should be enough to replenish our Cape Dory's batteries during the week. That's assuming we don't do much more than two hours of motoring at 4.2 knots (requiring 30 amps) each weekend.

CONCLUSIONS

Available in both long-shaft (20 inches) and short-shaft (15 inches) models, the Traveler is a robustly built, powerful electric outboard best suited for a pocket cruiser or similarly sized weekend cruiser. However, its required battery entourage limits its portability, and charging needs limit its practical use on smaller boats. At 36.4 and 34.5 pounds, the Torqeedo and Minn Kota are both much lighter than the Traveler.

Torqeedo offers smaller outboards that have internal lithium-manganese batteries, and of the electric engines we've tested, these were the only option for a truly portable one that can easily be used on the mother ship and tender. However, the Torqeedo lacks the heavy-duty construction of the Traveler, and the Torqeedo we tested had some issues operating in saltwater. Its immersed motor is more vulnerable to water damage than the Traveler's head-mounted engine.

The Minn Kota RT80 is the least expensive of the electric OBs we've reviewed, but it is also fragile compared to the Solid Nav. Although our test engine is still going strong after four seasons, we do not expect long-term service from its submerged motor. However, the lower up-front cost and the fact that Minn Kota is a proven player in this market lead us to recommend it for sailers with trailered boats looking for an electric outboard to meet modest motoring demands.

Unlike the Minn Kota, Solid Nav's Traveler and Torqeedo's engines are fairly new to the market, but Torqeedo is a growing company that we predict will continue to make innovative products in this arena. Solid Nav, however, has yet to establish a secure dealer network in the U.S.

As with most electric engines, cost may be the final tipping point.

Advertised at $2,500 with a two-year limited warranty, the Solid Nav Traveler must be fed by a reliable battery bank, and the four AGM batteries we installed retail for $373 each, tallying up to about $1,500. Add in some electrical cable, terminals, a battery switch, and a fuse, and you have slipped over the $4,000 threshold.

The cost is more than triple the Minn Kota ST80 (with batteries), but it's comparable to Torqeedo's closest model, the $2,700 six-horsepower Cruise 2, which we have not yet tested. The Cruise 2 also requires an amp-hour-rich, 24-volt DC battery bank that will bring the all-up cost into the realm of the Traveler.

Bottom line: At this stage, we are reluctant endorse a $3,000 to $4,000 electric outboard system with limited a track record as a practical replacement for a gasoline outboard, particularly on larger pocket cruisers with greater demands in range and power. When all is said and done, a four-horsepower, long-shaft, four-stroke Mercury outboard retails for about $1,350, is miserly with fuel consumption, and weighs 57 pounds. For each of these reasons, it remains the most practical choice for auxiliary outboard propulsion for most large trailerable boats and pocket cruisers.

For those who own inboard auxiliary sailboats in the 5,000- to 15,000-pounds displacement range and are looking to convert to electric propulsion, the range of alternatives is growing. Solid Nav offers the Explore and Voyager units. Since our September 2008 article, some new products have gained a foothold, including Electric Yachts (*www.electricyacht.com*), and we hope to pin down some performance numbers from it and similar products this year.

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THE BATTERY TANK

North Star's AGM Batteries Get Five-Star Rating

Our battery test bank was a big winner for an easy-to-measure reason: It out-performed the less expensive option and provided a 200-plus-percent advantage in total charge cycles. So despite the hefty price tag, we evoke the "you get what you pay for" rule and give a thumbs up to North Star's Energy 1 AGM batteries.

An efficient battery is like an ampere hotel accepting and housing an electrical charge. And just as there are five-star ratings for vacation resorts, the same exists for battery technology. The five-star nickel-metal-hydride option remains too high in price, and for the moment, lead retains a dominant role in the marine realm.

With three mainstream technologies vying for market share (wet cell, gel, and AGM), we chose the latter for our Traveler testing. The battery bank we set up to test the Solid Nav outboard was comprised of four North Star Energy 1 Group 24 AGM batteries. Each of these compact energy reservoirs weighed 59 pounds and delivered a whopping 920 cold-cranking energy rating.

But for our interest, a more meaningful number was the "reserve capacity" rating of 140 (minutes). It meant that the battery could deliver 25 amps of current for two hours and 20 minutes before the charge reached its endpoint marked by a 10.5 voltage reading. Naturally, all this is at 12 volts DC, but by wiring four batteries in series, we raised the voltage to 48 volts and kept the ampere-hour and reserve capacity stats the same.

Prior to deploying the battery bank, we compared the North Star AGMs with an inexpensive Sea Volt lead-acid Group 24 battery. Each battery was cycled from full charge to 10.5 volts using a resistive load comprised of two 48-watt, 12-volt incandescent bulbs. The AGM batteries delivered current nearly 35 percent longer before reaching the 10.5 critical voltage.

Terminal design and inter-connectability make these batteries a good choice when it comes to linking four in series to create a 48-volt bank. Dealer-provided, short link, highly conductive lug connectors helped to eliminate unwanted resistance—a problem often introduced via inefficient cabling. The higher the current draw, the more impact inefficient connections become. Heat is generated at the point where resistance increases, and such wastes of energy drain the battery bank without producing any additional thrust.

The more efficient the battery bank, the less disparity there is between energy input and output. However, there are several caveats regarding battery technology that need to be noted. When it comes to delivering amperes for consumption, the total wattage, or power available, varies according to the current consumption at any given moment. So, the higher the demand for amps, the less efficient the battery becomes. For example, if you discharge a battery at 3 amps, and at 20 hours, it reaches 10.5 volts, you can say that it provided 60 amp-hours of energy. However, fully recharge the same battery and change the discharge rate to 30 amps, and you may assume that you'll have two full hours of usable energy, but that would prove to be incorrect. The non-linear relationship between discharge rate and amp-hour availability results in the witching hour of 10.5 volts being reached in just 1.5 hours—leaving you with only 45 usable amp-hours, instead of 60.

So instead of using a low-voltage amp-hour rating to determine approximate charge life, we looked at the reserve capacity rating (140 minutes), which is based on a 25-amp discharge rate. It hinted that the North Star AGMs would give us over two hours of runtime at 4 knots. They delivered all of that and a tad bit more.

Testers used four North Star Energy 1 Group 24 AGM batteries (right) to power the Traveler during testing.