Glow Conversions Made Easy

by Greg Covey

Introduction:

In the past few years, I have heard two main concerns from many R/Cers wishing to try electric-powered flight; cost and complexity. The market has responded with lower prices through competition and reduced complexity through outrunners and “combo” packages of matched components that work together. This has attracted more enthusiasts than ever before to try their first glow to electric conversion. The biggest confusion I see now from people wanting to use electric power is in selecting a motor. A general rule of thumb for electric powered flight was originated by Dr. Keith Shaw several decades ago based upon the older Astro Flight Cobalt brushed motors. It is this same general rule that allows us to make a motor selection and glow conversion easy. Read on!

Glow Conversions Made Easy:

The two main concerns heard from many R/Cers over and over are cost and complexity. They were concerned with the cost of the motor and then the added speed controller. The cost of paying for fuel up front, like batteries and especially Lithium cells, was a foreign concept to most glow-powered enthusiasts wishing to try an electric conversion.

The complexity comes from gearboxes, gear ratios, mounting patterns, selecting prop sizes, selecting motor sizes, cell count, and series or paralleled cells. The wide dynamic range of brushless motor operation mystifies most of the glow-oriented R/Cers. Each vendor proclaims that their product is the best.

Did these areas change? YES! Outrunners have eliminated the need for a gearbox. Outrunners reduce the prop size range to select from and also reduced the range of cells that could be used for a particular motor. ESCs like the Jeti Advance PLUS line greatly simplify programming the setup by using a tiny card that can reside in your field box. New Lithium cells have eliminated the need to parallel cells and increased safety through being non-combustible at high charging voltages. Lithium safety and pack longevity were further enhanced by adding taps to multiple cell packs. New chargers and devices allow for balancing on charge and discharge while in the plane. Automatic peak chargers for all cell types are now available.

What does this leave us with? The selection of the electric power system is now the biggest unknown. The question I get asked a dozen times per week now is, “What motor should I use?”

Bob Aberle addressed this issue in the March and April 2005 issues of Model Aviation magazine. Additionally, Steve Neu’s March 2005 column in Quiet Flyer dissolves the myth that big outrunners are inefficient. Both the AXI 5330 and Actro 60 motors displayed 87% efficiency at 50amps on a 10s Lithium voltage (35v under load) which is almost 2KW (or 2.7h.p.) of power!

Today, you can fly a 20lb plane on a $250 electric motor and even less for the controller. Castle Creations new line of HV ESCs allows for 12s Lithium packs to provide up to 7 h.p.! One of the biggest confusions for most people selecting an electric motor is, “What is a watt?” The glow guys are used to horsepower and electric power systems are measured in watts. (1 h.p. = 746 watts or about 750 watts)

Power Level in Watts equals Voltage x Current where the voltage is affected by cell count and the current

is affected by prop size and throttle setting. Instead of tuning a carburetor on a fueled engine by listening to the sound by ear, the wattmeter now becomes the primary tool for measuring the power of an electric motor system. Watt meters measure power input (not watts to the prop). Since brushless motors are around 80% - 90% efficient, most of the power gets to the prop

Rule Of Thumb:

What's so easy about selecting an electric motor?

A general rule of thumb for electric powered flight was originated by Dr. Keith Shaw several decades ago based upon the older Astro Flight Cobalt brushed motors that were only 60%-65% efficient. The rule read something like this:

50-75w/lb for Cub-like planes or Trainers

100w/lb for Sport/Aerobatic/Pattern planes

125-150w/lb for 3D or high performance planes

Since brushless motors are now 80%-90% efficient, only 65w/lb is all that is needed for ROG from grass, to climb well, and, to perform mild aerobatics on a .40-size trainer plane. Swap your NiMH or NiCd battery packs for Lithium technology and you're flying duration doubles or quadruples, respectively.

The sequence for choosing the right electric motor is made simple by a combination of Keith Shaw's findings and today's abundance of information both on-line and in catalogs. Here is the sequence that I use to help people select the right motor class.

Choosing An Electric Power System

1) Determine the flying weight of the plane and multiply flying weight by 50, 100, or 150 depending upon plane type and expected performance (50 for Cub-like or Trainer, 100 for Sport Aerobatics, or 150 for 3D and high performance) The result is power in watts needed from the motor at full throttle. This result determines the power class of the motor needed for your application which is a value typically displayed in the manufacturer's motor specifications.

2) Use Vendor Web site recommendations (most vendor sites now post motor power levels as well as recommended setups for a particular power level)

3) Copy a review setup. There exist many descriptive reviews that you can benefit from reading for your own application

4) Copy a similar size plane with similar design and wingarea. If a review uses a certain power system on a .40-size high wing trainer, it will likely work fine on your similar application.

5) Use a computer program to assist you in the motor selection process (Sid Kaufman's ElectriCalc or Stefan VorKoetter's MotoCalc). Both of these power system selection programs can give you a reasonable start or verify the merit of your existing component choices.

6) Lipo Calc II from FMA Direct is an online tool that quickly helps you choose a LiPo pack configuration that best suits your aircraft and propulsion system.

Glow Conversion Example:

Let's try an example using the Graupner Taxi Cup II from Hobby Lobby. Although this plane is a high wing aileron trainer, the clean design (low drag) makes it unusually fast so a pilot needs intermediate skills to fly it successfully. The manufacturer says that the plane weighs 96oz (or 6lbs) when equipped with a .40-size glow engine. Using the middle of our rule of thumb power level for trainer-type planes, we multiply 65watts times 6lbs to get 390 watts which is about ½ h.p. The result of about 400 watts is the motor class that we need to select from for our conversion project.

The AXI line of outrunner motors has several selections in this 400 watt class, the heavier 4120 motor for 12-16 cells, and, the lighter 2826 for 10-16 cells. The AXI motors are direct drive brushless designs that are virtually maintenance-free. Since there are no brushes to wear out and no gears to lubricate or strip, the motors need no maintenance other than perhaps a yearly lubrication of the ball bearings supporting the drive shaft. I selected the AXI 2826/12 motor because it can be powered by readily available 10-cell NiCd/NiMH packs or 3-cell Lithium (LiPo) packs. This also means that I can use an ESC with a built-in Battery Eliminator Circuit (BEC) to eliminate the complexity of using a receiver battery pack.

Simply take the Lithium cell voltage under load of 3.6v times the # of cells used times the maximum burst current to get power class in watts.

- For the AXI 4120/14, it is 3.6v x 4 cells x 40amps = 576w.
- For the AXI 2826/14, it is 3.6v x 3 cells x 40amps = 432w.

The Jeti 40-3P ESC comes with a Battery Eliminator Circuit (BEC) which eliminates the need for a receiver battery. The BEC provides voltage to the receiver and the servos through the ESC control cable which eliminates the need for a second battery for the receiver. This convenience means that you'll never need to worry about the charge on the receiver battery again! When using a folded 10-cell CP2400mAh NiCd pack or a 10-cell GP3300mAh NiMH pack, the model will balance perfectly without adding and lead weight to the nose. These 10-cell packs weight about 22oz.

When you combine the AXI 2826/12 motor with either a 10-cell NiMH pack or 3-cell Lithium pack, a 40-amp ESC, and, an APC 13x10 e-prop, the resulting power system will provide about 385 watts at 37amps. Note that this power level can be easily measured with a wattmeter by plugging it in-line between the battery pack and ESC. This gives our 6lb application 385w/6lb or about 64w/lb which fits in our rule of thumb range.

My Taxi Cup II was ready to fly at 100 ounces (6-1/4 pounds) with a power system that will provide about 385 watts or about ½ h.p. The plane can perform most aerobatic maneuvers while remaining incredibly stabile in flight. The design is quite rugged and can handle those less than perfect landings without sustaining any damage. The Graupner Taxi Cup II is an excellent next step after mastering a trainer and

will also offer seasoned pilots great aerobatic performance with increased speed. Not only was my conversion to electric power made easy by Dr. Keith Shaw's general rule of thumb but I no longer needed to wipe down the plane after flying.

When using the LipoCalc II tool, it shows that a 3-cell Kokam 3.2AH pack weighs only about 248g (9oz) which means that I needed a 3s2p configuration (two 3-cell packs in parallel) to get near my 10-cell 3300 NiMH pack weight of 22oz. This would provide a 6.4AH total capacity and double the fight duration over my NiMH pack.

Summary:

When using the general rule of thumb, choosing an electric motor is as simple as knowing the all-up weight of your model. There is no mystery in selecting an electric power system; only confusion by the overload of choices we currently see on the market. While the abundance of motor manufacturers helps keep the cost down through competition, we can empower ourselves by first determining the power class of the motor we need to make it an easier selection.

Good luck on your next glow to electric conversion project! Your plane will last much longer by staying clean (no more wipe downs) and flying noise-free without all the nasty vibrations.

References:

Jeti ESCs, Kokam packs, and Taxi Cup II at Hobby Lobby Int: www.hobby-lobby.com/
Kokam packs FMA Direct at: www.fmadirect.com
Lipo Calc II from FMA Direct: www.fmadirect.com/site/fma.htm?calc=true
MotoCalc at www.motocalc.com/
Ecalc at Hobby Lobby Int: www.hobby-lobby.com/ecalc.htm

Questions and Answers:

Q) I am wondering if there is a publication or thread somewhere that explains brushless motors. What I am trying to figure out is how they are rated and what the numbers regarding their size and power mean, and how that relates to the size of plane they should be in.

A) For the motor numbers, it is best to use a software package like MotoCalc or E-Calc. To answer your question, the numbers break down like this.

Example: AXI 4130/16 (Note: Do not use these numbers for determining the actual size of the motor for mounting purposes.)

41 = 41mm diameter of the inner stator (bigger diameter means more power and more weight) most people find it easier to think of this dimension as the rotating outer case diameter

30 = 30mm Motor length without shaft (or rotor) length (longer length means more power)

16 = # of winds inside (less winds equals higher Kv or higher RPMs per volt)
(higher Kv is generally used to spin smaller props faster or use a gearbox)

Sometimes, the last numbers after a dash - represent the Kv in Killo-RPMs/v.

Since there are so many choices of motor brands, and, you often have several solutions for a particular application, it is usually best to pick a motor that fits in your plane the best. For example, does it use the existing GWS stick mount or is an expensive motor mount needed...etc.

Q) What is an Outrunner or Inrunner motor?

An inrunner motor is the more traditional electric motor that we commonly saw in the older brushed Speed 400 and Speed 600 motors from Mabuchi. The armature (stator) rotates inside the motor while the outer case stays fixed. This allows you to use a "clam shell" clamp to easily mount it onto a glow engine footprint or a dual set of posts. Inrunner motors are capable of very high RPM but often require a gearbox to swing a bigger prop for more torque.

In an outrunner motor, the inner stator is stationary while the outer case rotates. An outrunner can turn a lower Kv (RPM/Volt) and develop tremendous torque. This allows a larger prop to be used on outrunners without the need for a gearbox. The so-called "maintenance-free" operation of an outrunner is attractive from its simplicity of use and lower cost due to not needing a gearbox.

Q) How do you tell which motor is equal to what glow engine?

A) One of the biggest confusions for most people selecting an electric motor is, "What is a watt?" The glow guys are used to horsepower and electric power systems are measured in watts.

(1 h.p. = 746 watts or about 750 watts)

Don't go by the max rating for HP that engine manufacturers publish. That is a MAX figure and very seldom is an engine for sport use operated at that figure. The h.p. drops off quite a bit when the RPM is not at the rated figure which is usually around 16,000 RPMs or greater.

- *.20-size glow engine / 300w electric motor*
- *(OS Max 0.20 engine develops 0.4 hp = 300 watts electric motor (AXI 2820))*
- *.35-size glow engine / 500w electric motor*
- *(Fox 0.35 stunt engine develops 0.7 hp = 522 watts electric motor) (AXI 2826)*
- *.40-size glow engine develops 1.0 hp = 750 watts electric motor (AXI 2826 or 4120)*
- *.60-size glow engine develops 1.3h.p = 975w electric motor (AXI 4120 or 4130)*
- *.90-size glow engine develops 1.6h.p = 1200w electric motor (AXI 5320 or 4130)*
- *1.20-size glow engine develops 3.0h.p = 2250w electric motor (AXI 5330)*
- *DA-50 develops 5 hp = 3750w electric motor (AXI 5330)*
- *DA-100 develops 9.8 hp = 7311w electric motor (Double AXI 5330)*

See E-flite Park 400 and Power 60 series that mimic replacement sizes for old brushed motors and glow engines.