Watts the Difference?

Gas/Glow to Electric conversions

A Primer By

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So you want to switch from Gas/Glow to electric planes and want to know where to begin? I asked that same question when converting my Hobbico Avistar ARF from an O.S. 40 Max 2 stroke glow to an electric motor. I have broken the process down to 7 steps.

1.) Determine Power to weight ratio target.
2.) Choose motor size based on P/W from #1.
3.) Find the size of ESC needed.
4.) Choose battery size and type.
5.) Choose a Propeller
6.) Modify model to fit new components
7.) Balance model pre test flight.

Step 1.) Just like in a Gas/Glow configuration Flight characteristics are all based on the power to weight ratio. There is a simple rule of thumb for the power to weight ratio of electronic motor driven airplanes. This chart comes from Eflite's website.

Watts / Lbs	Flying style
50-70	Min level of power for decent performance of lightly loaded slow flyer an park flyer models
70-90	Trainer and slow flying scale models
90-110	Sport aerobatic and fast flying scale models

110-130	Advanced aerobatic and high-speed models
130-150	Lightly loaded 3D models and ducted fans
150+	Unlimited performance 3D and aerobatic models

Step 2: Motor Selection

Electric motors have four properties we care about: Weight, Size, KV (RPM per volt), Watts. We know about how much our plane is supposed to weigh at the end, so we can use some rules of thumb to determine the right motor:

A) Watts per pound:

> If we are building a 5 pound plane, and we want sport acrobatic performance we can use the table above to determine that we need at least 500 watts = (5lbs x 100 watts)

B) Propeller efficiency:

> Front propeller motors are most efficient at around 9000 RPM. We can play with the pitch and diameter of a propeller to give different properties.
>
> * Big diameter x small pitch == lots of thrust with low top speed (3d)
> * Small diameter x big pitch == low thrust with high top speed.

In general, the bigger the plane, the lower the KV.

Model weight	general KV rating
3lbs	1000kv
5lbs	700kv
8lbs	500kv

C) KV to voltage ratio:

The reason that as plane sizes go up KV goes down, is that the bigger the plane, the higher the voltage of the battery.

RPM = KV * Voltage.

Going back to the 9000 rpm rule of thumb we see that as plane size goes up, battery voltage should too:

RPM	KV * volts (lipo battery size.)
9000	1000kv * 9v (3s 11.1 volt lipo under load sags to about 9v.
9000	700kv * 12.8v (4s 14.8 volt lipo sags to about 12.x volt)
9000	500kv * 18v (5s lipo will sag to about 18 volts

D) Watts per gram:

General rule of thumb is an electric brushless motor can take about 3 watts per gram of weight.

Linking these three rules of thumb together we now know that our hypothetical 5 lb plane needs a motor that weighs about 170 grams and 700kv that can take 500+ watts on a 4s lipo.

A couple of examples that fit this bill:

O.S. Motor OMA-3825-750 -- Meaning a 38mm rotor diameter, 25 mm magnet length and a 750 KV, 590 Watt rating, and weighs 190 grams.

Hobby King NTM 4238-750 -- Meaning a 42mm can diameter, 38 mm can length and a 750 KV , 770 Watt rating and weighs 169 grams.

You'll notice the names of both these motors have a bunch of numbers that they reference different dimensions of the motors. OS motors measure rotor (can) diameter and magnet length, whereas hobby king measure can diameter and can length. There is no one offical naming convention for electric motors. that's why the rules of thumb are so useful. They are independent of the names.

Step 3: Electronic Speed Controller (ESC)

Watts = Volts * Amps. We know the volts that we are working with from step 2. Now we need to calculate the needed amps.

We've decided our fictional plane will use a 500 watts at about 14 volts nominal (4s)

So: 500 = X * 14 solve for X = 34 Amps.

Now you ALWAYS want to have an ESC that can take more than the max estimated. in this case I would use a 50amp esc minimum. However 55-60 amp are easier to find.

NOTE:

ESC's can also have a BEC or Battery Eliminator Circuit. These remove the need for a separate flight battery. They are rated by the volts and max amps. This is the voltage and amperage available to the servos and receiver in the plane.

Rule of thumb: Most servos use about 0.5-0.75 amps when in use and not binding. If you have 4 servos in your plane that's .75 * 4 = 3amps. Bigger servos use more power. And always leave headroom of at least 2 amps on the ESC. If your ESC has a BEC and you don't want to use it. just pull the red wire out of the ESC's receiver side plug, tape it back, and use a receiver battery.

Step 4: Battery

Batteries are measured in three ways: Voltage, milliamp hours (mah), and Constant (C) rating.

Voltage is determined by the number of individual Cells in series. 3.7 * number of cells.

mah is the capacity of each cell measured in milliamp hours. This determines flight time.

Constant (C) rating is more complicated. The C rating is the rate at which the battery can be discharged as multiples of the mah / 1000. For example:

Max Amps constant	C rating	Milliamp hours
1	1	1000
20	20	1000
40	10	4000

I always calculate batteries to give me a 5 minute flight time. It's long enough to have fun, but short enough to let others fly and take a break.

Flight time = ((mah / 1000) * 60) / Amps

Given our fictional plane uses about 40 amps:

5min = ((X / 1000) * 60 / 40 Solve for X = 3,333 mah battery.

Using the 80% rule of (only use 80% of a batteries stated capacity we actually want a 4000mah battery.

Step 5: Propeller

We now know that we have a 700 kvt motor, a 60 amp ESC, and a 4000mah 4s battery. NOW we can choose a propeller. In electric airplanes, the propeller determines the flying style: Big diameter for 3d, small diameter for fast planes. Selecting a propeller is best done using a calculator. I like eCalc: http://www.ecalc.ch/motorcalc.htm?ecalc&lang=en

Using E-calc we input our Battery, Motor and ESC

And the rule of thumb for starting prop size:

prop diameter == ⅙ - ¼ wing span. to find a prop that puts out at least 500 watts with an airspeed I want that does not overheat the motor, or stall the propeller. This takes some playing around to find the right one.

Our fictional plane using the NTM motor eCalc says a 12x6

APC-E propeller would work nicely.

Step 6 / 7) Both of these steps will be up to the individual on how to modify the plane to fit the electronics and balance the plane. But some quick tips though.

- Make the battery easily removable, cutting a hatch with a hinge and/or latch makes battery changing easier at the field.
- Cooling of electronic components is essential. Make sure to properly vent the intake where the esc, motor and battery are mounted. All three can get very hot.
    - Air flow rule of thumb Exhaust area should be 2 times the area of the inlet. This creates negative pressure inside the plane and sucks heat out.
- Make sure the motor mount can adjust the motor or the mount is set for proper down thrust and or side thrust angles. Refer to airplane instructions for required thrust angles.
- Make sure battery is securely fastened. As stated before, most esc's come with a BEC and LVC for low battery conditions but if the battery falls out, you lose all control.