RC Electric Flight Orientation

Step one, getting an idea of the size of components needed in the aircraft:

A good starting point is to work out how much power you wish to use in your model. To do this the rule of thumb guideline is:

- 50-70 watts per pound; Minimum level of power for decent performance.
- 70-90 watts per pound; Trainer and slow flying scale models
- 90-110 watts per pound; Sport aerobatic and fast flying scale
- 110-130 watts per pound; Advanced aerobatic and high-speed models
- 130-150 watts per pound; Lightly loaded 3D models and ducted fans
- 150-200+ watts per pound; Unlimited performance 3D and aerobatic

If we use the Reactor biplane as an example, the flying weight of this model is 7.5lb so if we assume that we want unlimited performance from this we are looking at

150 x 7.5 = 1,125 watts

Step two, finding motors and batteries to fit the bill:

This power needs to be supplied by our choice of LiPo battery which means we need a battery that can supply this power for a reasonable length of time. The most important electrical formula in our world is:

P = V * I (watts = Volts x Amps)

This states that Power (measured in watts) dissipated in an item is equal to the Voltage across that item multiplied by the current passing through it. Typically the item in question will be the motor that we use however the formula is generic for all electrical items which has relevance when considering things like BEC technology.

Since power is a product of volts multiplied by amps then different battery cell counts will result in different current requirements. Another consideration in the LiPo specification is the C rating since this identifies the maximum current that battery can safely produce at a continuous rate. We can calculate the current requirements for different LiPo cell counts and also get some idea of what size of battery (the amp/hour rating, often printed as milliamp/hour on the battery) is required for different C ratings. For example if we have a 3000 mA/h battery rated at 20C this means that the maximum current it can safely provide is 3000mA * 20 = 60,000mA or 60 Amps (1 mA is 1/1000 amp).

A chart showing the current requirements to be able to supply 1125 watts of power using different LiPo cell counts would look like:

Cells	Voltage	Current	A/h for 20C	A/h for 30C
1	3.7	304.1	15.2	10.1
2	7.4	152.0	7.6	5.1
3	11.1	101.4	5.1	3.4
4	14.8	76.0	3.8	2.5
5	18.5	60.8	3.0	2.0
6	22.2	50.7	2.5	1.7
7	25.9	43.4	2.2	1.4
8	29.6	38.0	1.9	1.3
9	33.3	33.8	1.7	1.1
10	37.0	30.4	1.5	1.0
11	40.7	27.6	1.4	0.9
12	44.4	25.3	1.3	0.8

Easy to get (and cost friendly) LiPos range from very low currents up to a maximum of 5 A/h and the lower the C rating the lower the cost of the battery. So from the chart it would seem logical to consider a cell count of 3 or more since lower counts require higher current batteries and higher C ratings.

A little detective work is now needed to identify a motor that will be suitable for this application. We know we need one that can handle 1125 watts or more and it should do this for 3 or more LiPo cells (11.1 volts or more).

	RimFire .80 50-55-500	EFlite Power 90	Scorpion 40mm 4020/12 542Kv 85A
Watts	1154	1560	1850
Continuous Volts	22.2	31.2	22
Continuous Current	52A	50	85
Kv	500	325	542
Prop rpm at 22v (6cell)	11,000 rpm	7,150 rpm	11,924 rpm
Weight	10.5 oz	15.8 oz	10.72 oz

Step 3, selecting the setup to use:

I have listed 3 motors here, the rimfire is the recommended motor for this aircraft, the others are common motors with comparable specs. Since all of these motors would work the important details (for me) become available batteries, weight and performance. An important consideration at this point is the Kv of the motor since this will determine the propeller speed. I am not an expert on propeller choice but I believe a good upper rpm range for a propeller is around 9,000 – 13,000 rpm. Many motor manufacturers will produce multiple motors in a particular size with varying Kv values for this purpose since it then gives the customer more flexibility about what battery size to use to attain the required rpm.

Reasons for my choice were:

1) I want to use 6 cell LiPo so the peak power needs to be attainable with this voltage (22v) this would rule out the EFlite since I would need to overrate the maximum current spec of 50A at 22V to achieve the quoted 1560 watts that this is capable of since it needs 70A at this voltage to achieve the required power.

2) In my case I have 6 cell LiPos with 5Ah rating so for the RimFire I would need a minimum of 52A/5Ah which is just over 10C, for the Scorpion I need 85A/5Ah which is 17C. Neither is a limiting factor in my case since my batteries are at least 25C.

3) I would like to be able to call on the most power with my 6 cell battery if necessary so the Scorpion motor wins out in this respect since it offers the higher power at a very similar weight to the RimFire product. It is possible that I will not use the maximum power by selecting a propeller that does not load the motor enough however this would be by choice.

Since the Scorpion motor can take 85A continually and more at peak I chose to use a 100Amp ESC with built in BEC for receiver and servo power. ESCs of this form are available either US built (CastleCreations ICE range) or Asian (**TURNIGY K-Force 100A Brushless ESC)**.

Step 4, other considerations:

Flight time:

To get an idea of the flight time possible with a particular setup we need to take into account the current drain of the brushless motor and the size of the selected battery. In my case the current drawn at full speed is about 90A however it is unlikely that I will be running this fast for the whole flight so for now I will assume that this will happen for under 50% of the overall flying time. I will assume the average current drawn will be 45A.

The battery being used here is a 5Ah 6 cell LiPo. This means that it can supply 5A for 1 hour or 10 A for 0.5 hour or 20 A for 0.25 hour etc. So it can supply 45 A for about $1/9^{th}$ of an hour or 6 minutes.

Note that this is only a rough guide and is used mainly to see if the numbers are reasonable. The early flights will be checked with a meter to see how much energy is actually used and a more accurate time established from that. In this case 6 minutes is not bad and makes a good, early, hard cutoff time for testing.

CG:

When selecting the battery my choice was made mainly by the fact that I had the batteries in question in my kit (I currently use them for my helicopter). This made it easy to put the plane together with the battery early on so that I could ensure achieving the required CG. If you are just experimenting to find what batteries will work you will need to mock up a block of the right size and weight to test that you can both fit the battery into the model as well as get the model to balance correctly once the battery is inside it.

Glow Conversion:

Converting a glow plane to electric is an interesting process since the planes are usually built more rigidly for glow operation. This makes them much tougher but requires a stronger electric setup to make them fly well. To work out what size motor to use you will need to know the recommended glow engine and do a little detective work.

For example by searching the web (using google) I found that the OS61FX claims to deliver 1.9hp at 16,000 rpm according to its spec sheet. This is a good starting point since it should be the maximum power achievable for that engine in ideal circumstances.

A key formula here is:

1 HorsePower = 745 watts

So the OS61FX can deliver 1,415 watts. From this you can now start working out the kit needed to convert the aircraft to electric power.

The following is a chart showing engine horsepower for a range of OS engines.

Description	Practical RPM	Output (hp (watts) @rpm)	Break-in Prop
25AX	2,500-17,000	0.8hp (596watts) @ 15,000	—
25FX	2,500 - 19,000	0.8 hp (596watts) @ 18,000	9x6
35AX	2,500-17,000	1.3hp (968watts) @ 16,000	10x6
46AX	2,000 - 17,000	1.63hp (1,214watts) @ 16,000	10x6
55AX	2,000 - 17,000	1.72hp (1,281watts) @ 16,000	—
61FX	2,000 - 17,000	1.9hp (1,415watts) @ 16,000	11x7
75AX	2,000-16,000	2.4hp (1,788watts) @ 15,000	—
91FX	2,000 - 16,000	2.8hp (2,086watts) @ 15,000	16x14
120AX	1,800 - 9,500	3.1 hp (2,309watts) @ 9,000	15x10
160FX	1,800 - 10,000	3.7 hp (2,756watts) @ 9,000	17x10
140RX-P	1,800 - 10,000	3.5hp (2,607watts) @ 9,000	15x14

Speed

A rough estimate of theoretical aircraft speed is (**engine rpm * pitch in inches)/1000 = speed in mph**
So at 9000rpm a 12x6 prop could give a maximum speed of about 54mph. The diameter of the prop will determine how fast the terminal speed will be reached.