# Electro Fundamentals

SKYCADEMY

The Electric flying Fundamentals briefing outlines the key points of difference of this exciting new air propulsion method.

**Requirements**
This mandatory lesson is a briefing only (no air exercise) and can be completed in conjunction with the Introductory Lesson, or before Mission 1, Effects of Controls

**Duration**
The Electro Fundamentals lesson takes around 75 minutes to complete in full.


## Getting Started

This briefing and information package will give you the tools and information required to effectively develop your pilot skills on the ground, in the air, and on the controls of the Electro aircraft.

**Booking Platform**
The modernisation of Pilot training and aircraft access begins with our digital booking system. To get moving on your next lesson or to book a plane for personal use when you are certified, use the booking portal at https://flyone.com.au/book-a-flight/

**Personal equipment**
As a new pilot, you'll need to start building up your personal kit of information resources to keep with you for pre-flight planning and for reference in flight. Our recommended personal resources are as follows..

VTC map
VFR Guide
Kneeboard
Airport ground maps
Alpha emergency procedures
Mission plan worksheets

Many of these resources are available for free at https://flyone.com.au/skycademy/free-training-resources/ or for purchase in our Pilot shop

## Breezylog

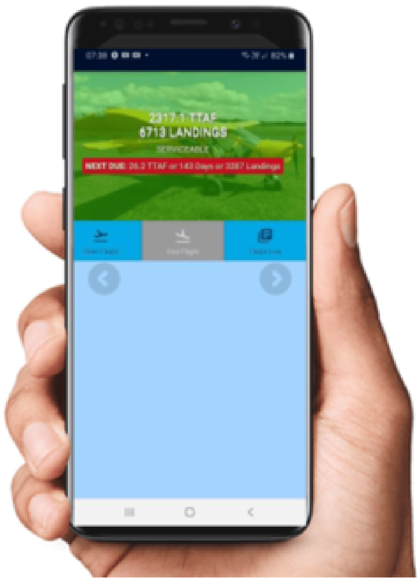
A modern aircraft deserves a modern flight and maintenance management system.
The Pipistrel Elelctro aircraft are ‘paperless’, as all flight logs and maintenance schedules and inspections are logged digitally.
To train and operate in the Pipistrel Electro you will need to be a (free) Breezylog member, which allows you to log flights in the aircraft and doubles as your Free CASA approved digital log book that you can use for your entire pilot career.
To complete your signup, you’ll need a copy of your RA-AUS membership and number (temp or permanent) and a clear digital image of your signature.
Begin your sign-up at https://flyone.com.au/breezylog/

The Breezylog platform manages these typical aviation documents that are required daily, or for each flight.

- **Daily Maintenance release.** This mandatory (digital) document is the daily inspection declaration that is required before the commencement of flying each day. The individual who completes the daily inspection is taking full responsibility for the declaration of airworthiness of the aircraft at this time, this responsibility is not to be taken lightly.
  It can only be completed by a Pilot Certificate Holder or Level 1 or higher approved maintainer.

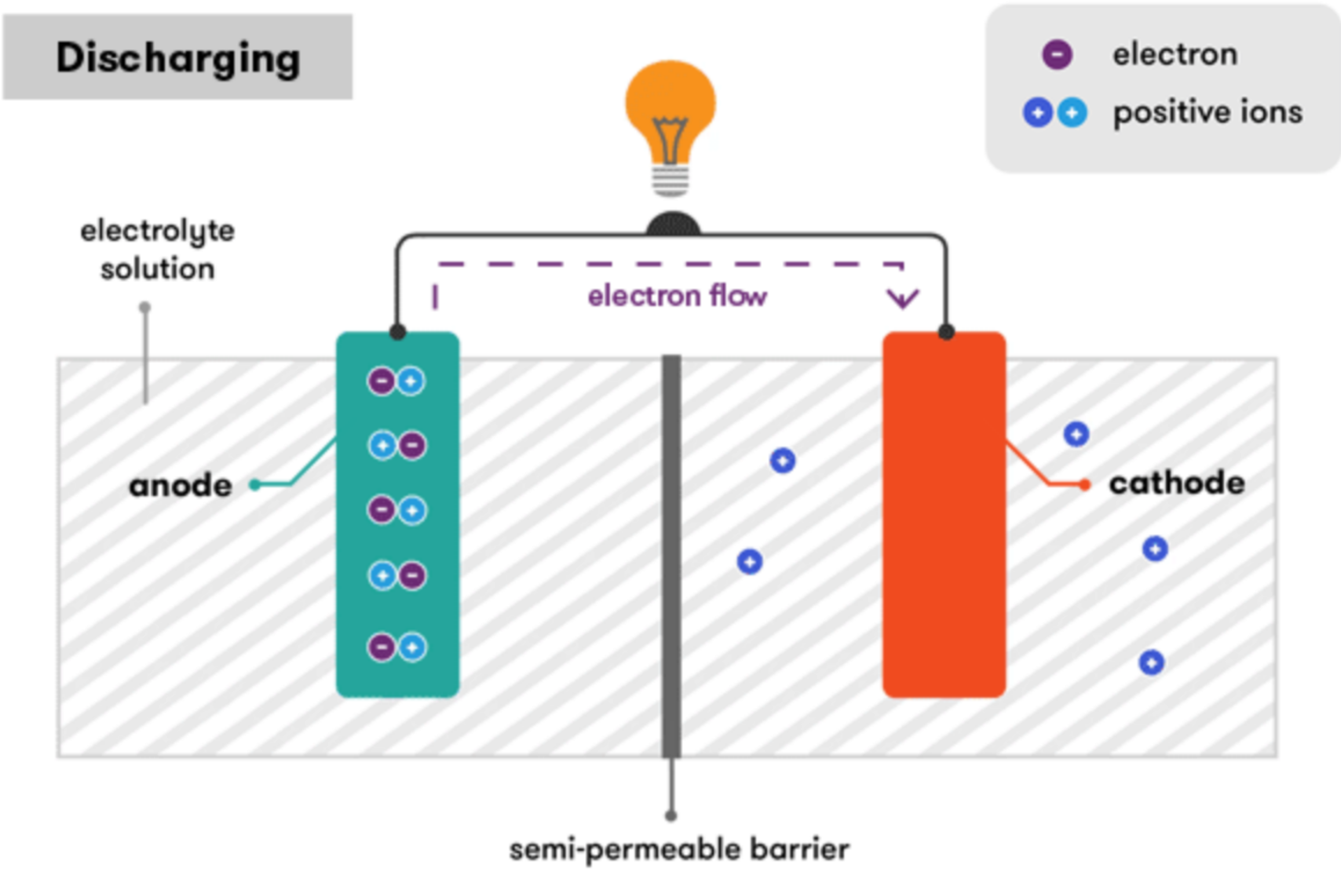
- **Weight and Balance check.** This mandatory check is conducted before each flight and is a tool used to identify the payload and center of gravity for the aircraft before each flight to ensure that intended payloads are within operational parameters. This must be completed by the Pilot in Command.

- **Flight log and notes.** The Flight log is begun PRIOR to departure as a part of the Preflight sequence.
  This serves to log the Pilot in command and other passenger/s on board, to confirm the flight switch hour reading (Hobbs meter) and to log the relevant notes for billing (eg. CD TRAIN, RACWA, MEM)



## Understanding our source of energy

When flying in a battery-electric aircraft, our energy source comes directly from the batteries on board the aircraft.
A battery is a device that stores chemical energy, and converts it to electricity. This is known as electrochemistry and the system that underpins a battery is called an electrochemical cell.
Electricity is a type of energy produced by the flow of electrons. In an electrochemical cell, electrons are produced by a chemical reaction that happens at one electrode and then they flow over to the other electrode where they are used up. When the power control lever is engaged, we have a situation where there is a continuous flow of electrons (through the motor circuit) and positively charged ions (through the electrolyte). If this continuous flow is halted – if the power lever is dis-engaged – the flow of electrons is halted.




As the battery is ‘opened’ by the application of the power lever, and the reactions at both electrodes engage, Electrons move through our motor circuit and create forward thrust.
As the capacity for the reactions to occur is used up by the positive Ions moving through the electrolyte to the opposite side of the semi-permeable barrier, the EPSI display will indicate you have a reducing **State of Charge.**
This reaction creates a kind of resistance over time that can prevent the reaction from continuing with the same efficiency. When this resistance becomes too great, the reaction slows down. The electron exchange between the cathode and anode loses its strength and the electrons stop flowing. At this point, the EPSI system will indicate that the battery has a low state of helath (SOH).

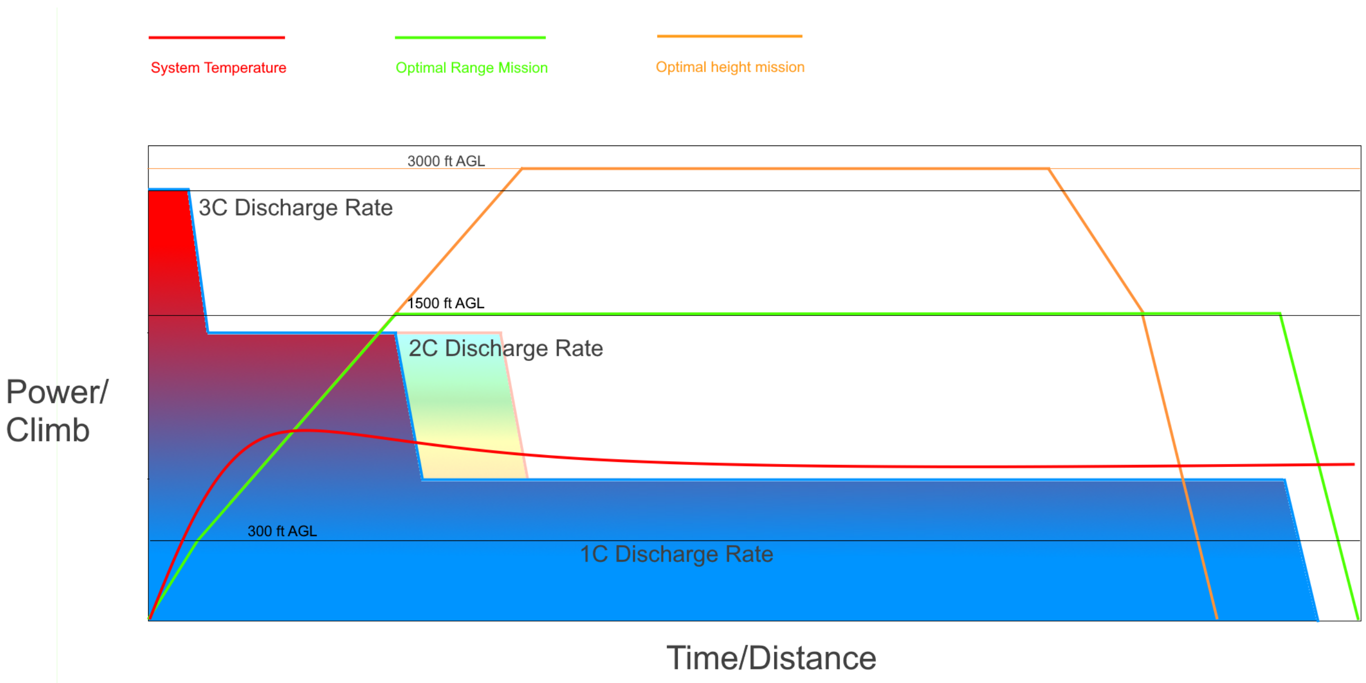
## Battery discharge during flight (heat and C rating)

It’s important to understand how the above battery chemistry and reactions translate to available energy during flight.
It’s also important to understand the secondary effects (byproduct) of charging and discharging, which is the accumulation of heat in the electrochemical cell.
By planning our flight missions accordingly, we can easily manage the heat accumulation to acceptable levels, as well as extend both the range of our flight mission and the lifetime longevity of the battery cells.

In this section we will highlight

- Battery discharge rates and how they affect **mission time**
- Battery discharge rates and how they **accumulate/dissipate heat**
- Battery discharge rates and how they affect **battery longevity**
- Battery charge practices and how they affect **battery state of health**

## Flight discharge visualisation




The above diagram is a visualisation of how a typical flight mission will incur different discharge rates over time.

A battery discharge rate is often referred to in a ‘C’ capacity or C rating. The capacity of a battery is generally rated and labeled at the 1C Rate (1C current), this means a fully charged battery with a capacity of 20kWh should be able to provide 20kW for one hour.

The Pipistrel Alpha Electro has a battery capacity of 21kWh, with the last 1kW indicated to be unusable by the Pilot Operating Handbook (POH). So we have 20kWh of energy with which to plan our mission and suitable reserve, and a 1C rating of 21kW.

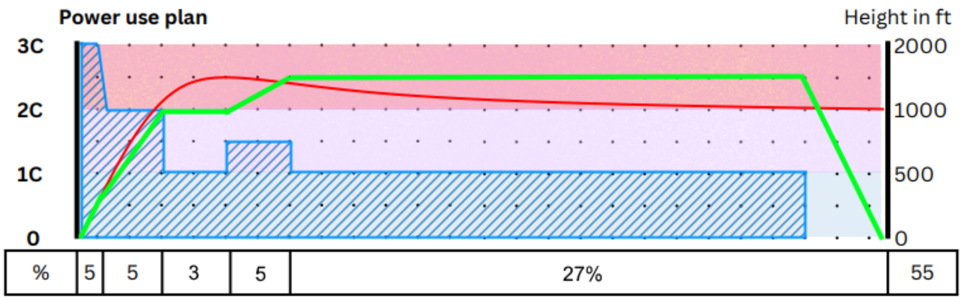
Where the C rating becomes important beyond mission planning, is when we are discharging (or charging) at a higher-than-1-C rate. Eg. In the climb.

Discharging at a 2C or 3C rate is detrimental to the longevity of the battery and has a secondary effect of fast heat accumulation (as a by-product).
A fast discharge rate degrades the battery chemistry and, over time, will reduce the capacity and reliability of the battery cells, where as a 1C discharge rate can be completed up to 1000 times for a typical electric aircraft battery without degradation.
.
Thus, it is critical that we minimise the time in which we are at a 3C or 2C discharge rate during our mission profile. This will, in-turn, also increase our range in the mission profile.

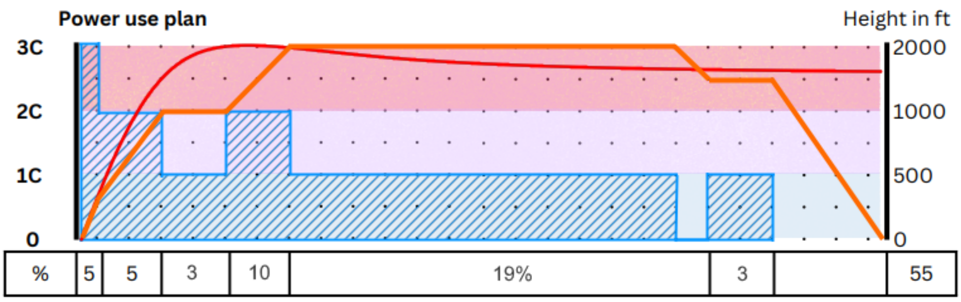
For instance, a typical mission profile would consist of..

**0-300ft of climb - Apply 54kW - 3C discharge rate**
**300-1500ft of climb - Apply 44kW - 2C discharge rate**
**Straight and level cruise for the remainder of the mission duration - 16-21kW - ≤1C discharge rate**

This mission profile (Indicated in Green) executes a climb to a safe height and speed, in accordance with the POH with a minimal application of a discharge rate that will degrade the battery chemistry.




If we were to choose a higher climb mission profile, as indicated in Orange below, we can see that the 2C discharge rate is held for longer during the climb configuration.
This both shortens the lifetime of the battery, but also shortens the mission duration, as we are using twice as much energy in the same amount of time for that period of climb.




Similarly, in cruise the FASTER we fly, the higher the power setting will need to be.

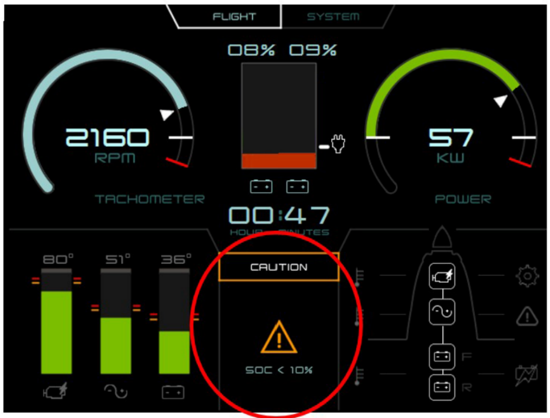
A typical cruise power setting at maximum weight with a high cruise speed of 90 knots will require a 1.2C power setting of 25kW.
However, you could configure the aircraft for a slower cruise speed of 70 knots or lower, and if you were carrying a payload of only 70-150kg, would only need approx. 15kW of applied power to maintain straight and level flight.
Not only is this greatly extending the lifetime duty cycle capability of the batteries, but you are also reducing your energy consumption and extending your cruise endurance by 40%

In short, the aircraft will fly a fixed distance based on the energy available on board (in the case of the Pipistrel Electro, approx. 140km including reserve)
If you configure the aircraft to fly that distance at a **LOW SPEED**,
you will experience a **LONGER FLIGHT TIME**
However,
If you configure the aircraft to fly that distance at a **HIGH SPEED**,
you will experience a **SHORTER FLIGHT TIME**

Climbing higher will gain you height and available glide time, but at the cost of reducing the lifespan of the batteries. Additionally, the glide (descent) ratio of the aircraft is 15:1, very efficient, but the Climb ratio of the aircraft at best climb speed is only 12:1. So you will only be able to recover about 80% of the energy used in the climb as usable glide time.

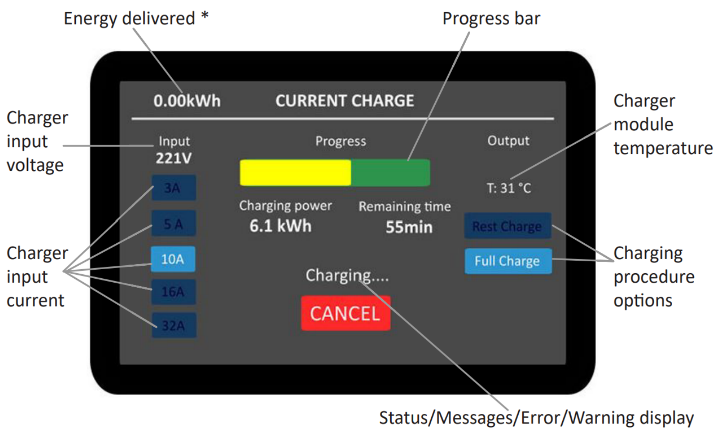
## Battery balancing

A part of regular operations when flying electric is to analyse the Battery state of health, manually, by checking the weakest cell in the series (represented as the lowest power in mV) and identifying the differential between the lowest and highest level of cells.
Our ideal voltage differential between cells is ≤30mV, with the maximum allowable difference being 150 mV. At this point and beyond, the cell balance is compromised and may result in additional heat build-up or 'hot spots' in the battery during flight.
Battery balancing is a standard part of maintenance and will usually be completed for you, but balancing is part of electric flight and is the responsibility of every user of the electric aircraft.




EPSI570 screen area displaying warning and caution messages


**The best rule of thumb to maintain battery balance is to 'Run it low and charge it slow'.**
Meaning, that we discharge the batteries as low as allowable during the mission while still landing with the required reserve, and charge them as slow (and as long) as possible.
This is the best method of care for the battery chemistry and allows the cells to balance during the extended (overnight) charge cycle. The charger will continue to read a power level output even if it indicates 'Charge Complete' if it is still balancing the lower voltage cells.
Merely fast charging the plane without any regular overnight charge cycles is not acceptable.



## Dip the tanks

When flying a conventional piston engine aircraft, one of the required Pre Flight checks is to 'Dip the tanks'.
In this check, a dip sick is inserted into the fuel tank to assess the level of the available energy, in this case, in the form of a combustible liquid. This is done to verify the level as fuel gauges are often not accurate enough to identify the exact amount of fuel on board.

We can do something similar in the Pipistrel Electro. Before each flight, as a part of assessing the battery balance, we are essentially 'Dipping the tanks' by checking manually, the amount of available energy we have on board, irrespective of the main energy percentage gauge. Which can sometimes misread.
To assist with this, we have a manual reference chart to compare the minimum battery cell voltage with, that will let us assess the true state of charge of the batteries.

**TABLE 1. BATTERY SOC ESTIMATION BY VOLTAGE**

| MIN CELL V | 4.2V | 4.0V | 3.90V | 3.85V | 3.75V | 3.64V | 3.54V | 3.40V |
|---|---|---|---|---|---|---|---|---|
| APPROX. SOC% | 100% | 90% | 80% | 65% | 50% | 38% | 30% | 20% |

## Mission plan

The modest endurance of an electric aircraft means that critical mission planning is more important than ever before.
We plan for factors such as heat, climb, payload, wind direction (at various heights), alternate runway availability and more. All of these are typical of aviation planning, but usually only on longer cross country flights.
We also prepare the aircraft on the ground for our mission by heat managing the batteries with a pre-cool cycle when required.
The Mission planning document overleaf is designed to help new Electro Pilots plan for all flight area conditions to safely manage the range and performance of the aircraft before, during and after flight.

# Electro Mission Plan

SKYCADEMY
PILOT TRAINING - ELECTRIFIED

| | | Time (UTC) |
|---|---|---|
| MO | | |

## ATIS - Departure Aerodrome

| | | | | | |
|---|---|---|---|---|---|
| **Airport** | | **Info.** | | **RWY** | |
| **Wind** | | **Min/Max** | | **X wind** | kn |
| **Visi.** | | **Cloud** | | **Temp.** | |
| **QNH** | | **GND Freq.** | | **TWR freq.** | |

N
W E
S

## Destination Aerodrome

| | |
|---|---|
| Radio Freq. | |
| Wind (Ground) | kn |

Wind sock

## Mission Area

| | |
|---|---|
| Radio Freq. | |
| Wind (2000ft) | kn |

Wind sock

Active RWY

0

270

90

180

25NM Area

**Power use plan**

| | | | Difference | Total % |
|---|---|---|---|---|
| Min/Max cell mV | | | | |

| | Height in ft |
|---|---|
| 3C | 2000 |
| 2C | 1000 |
| 1C | 500 |
| 0 | 0 |

| | | | | | | |
|---|---|---|---|---|---|---|
| % | 5 | 5 | | | | 55 |