# Design of a Lightweight and Durable Kite for Pumping Kite Power Generation

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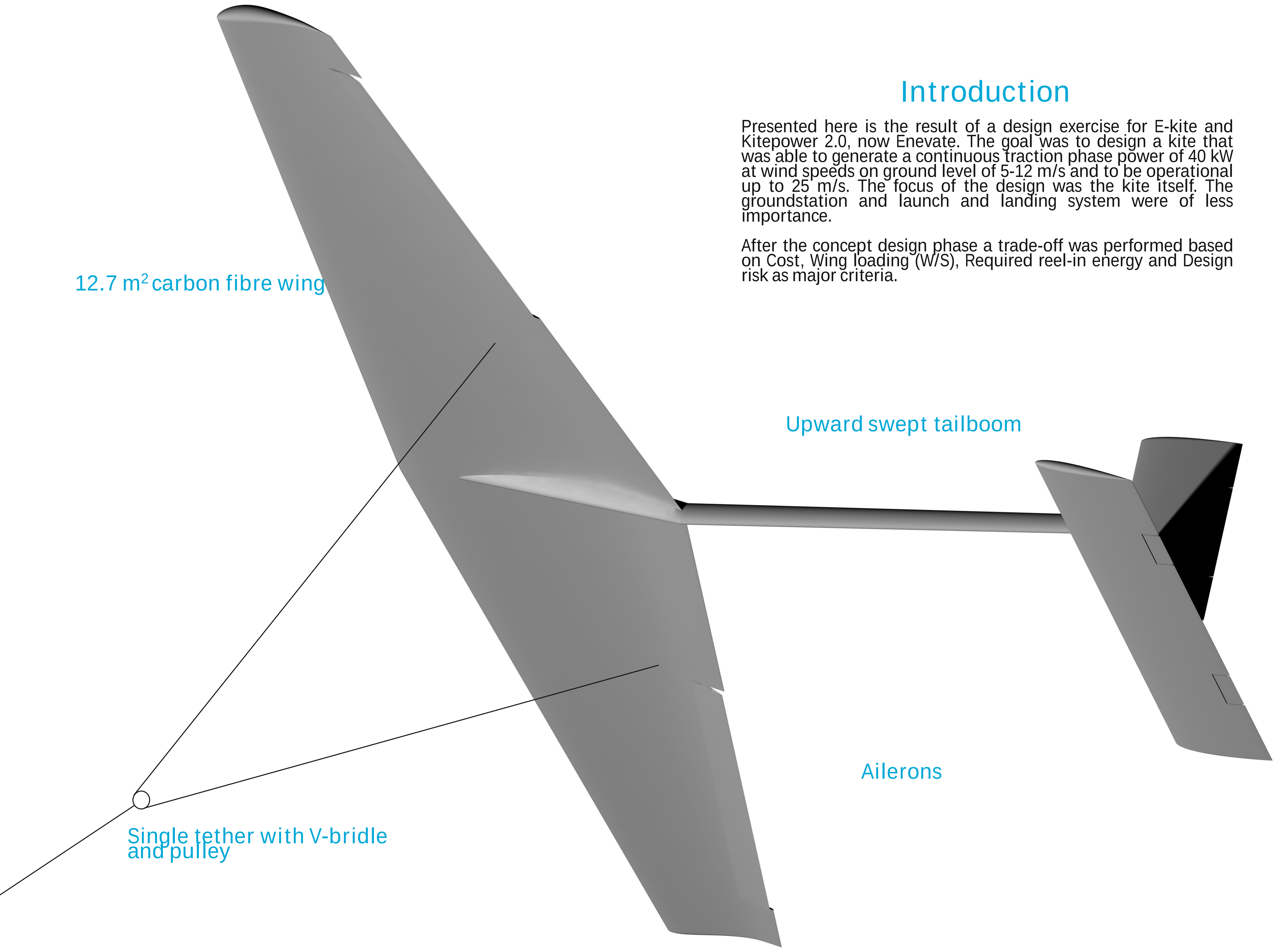



## Introduction

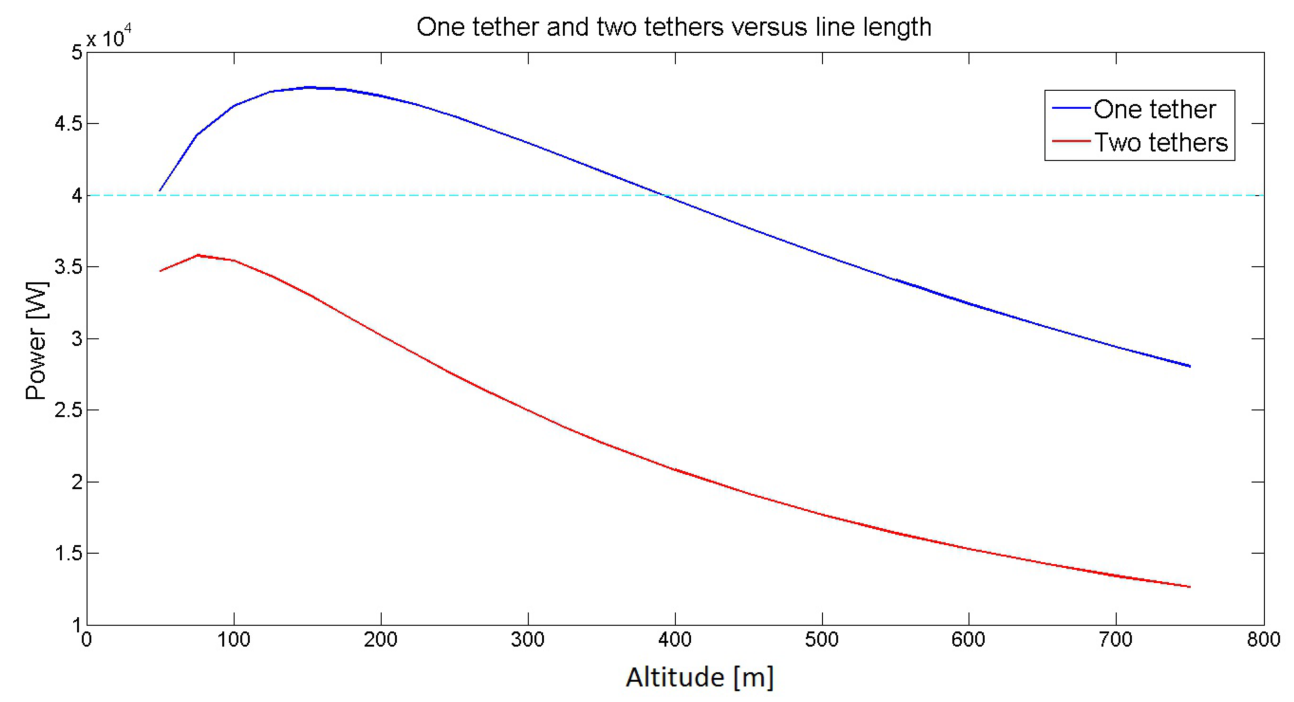
Presented here is the result of a design exercise for E-kite and Kitepower 2.0, now Enevate. The goal was to design a kite that was able to generate a continuous traction phase power of 40 kW at wind speeds on ground level of 5-12 m/s and to be operational up to 25 m/s. The focus of the design was the kite itself. The groundstation and launch and landing system were of less importance.

After the concept design phase a trade-off was performed based on Cost, Wing loading (W/S), Required reel-in energy and Design risk as major criteria.

## Requirements

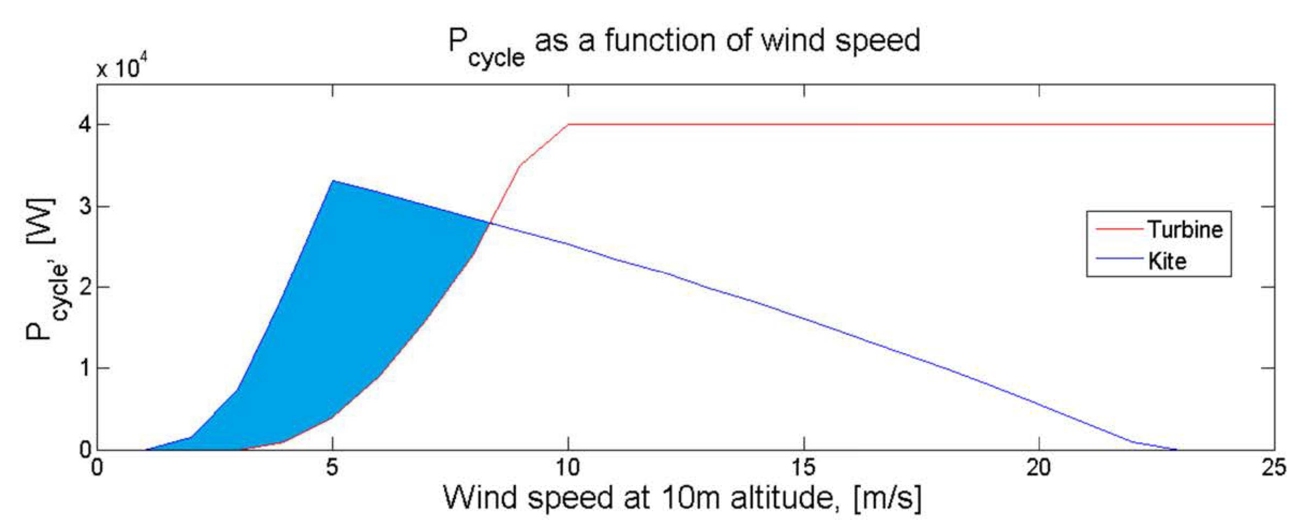
- Continuous traction power of 40 kW
- At 5-12 m/s ground wind speed
- Operable up to 25 m/s
- W/S < 8 kg/m²

## Number of tethers



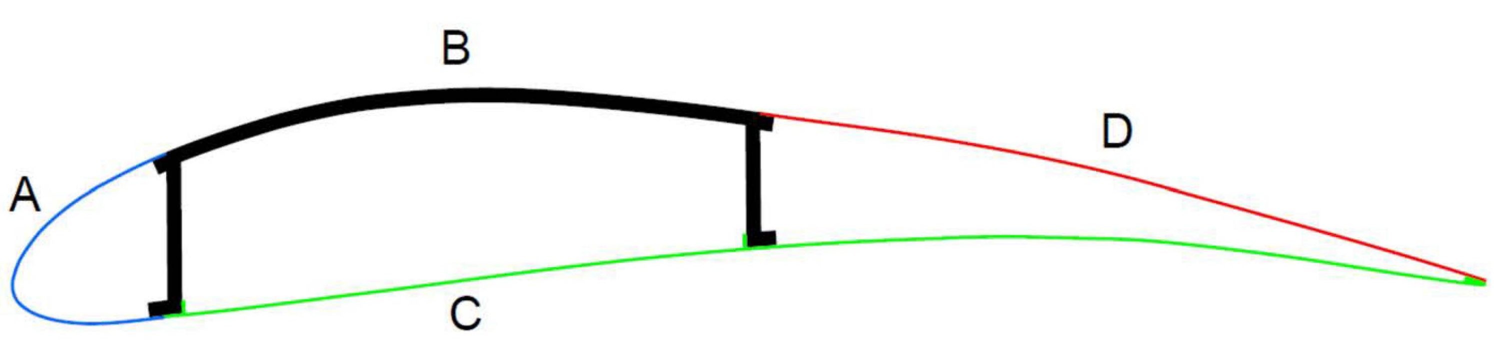

An analysis on the number of tethers was performed. A clear choice for a single tether became apparent when peak power for the same kite was almost 25% lower. Also, the choice was influenced by other disadvantages of a double tether such as control input lag and lack of controlability in case of a tether disconnection. A double tether does however have a structural advantage so a v-bridle wa employed with a pully at the split to remain fully controllable.

## Cycle Power



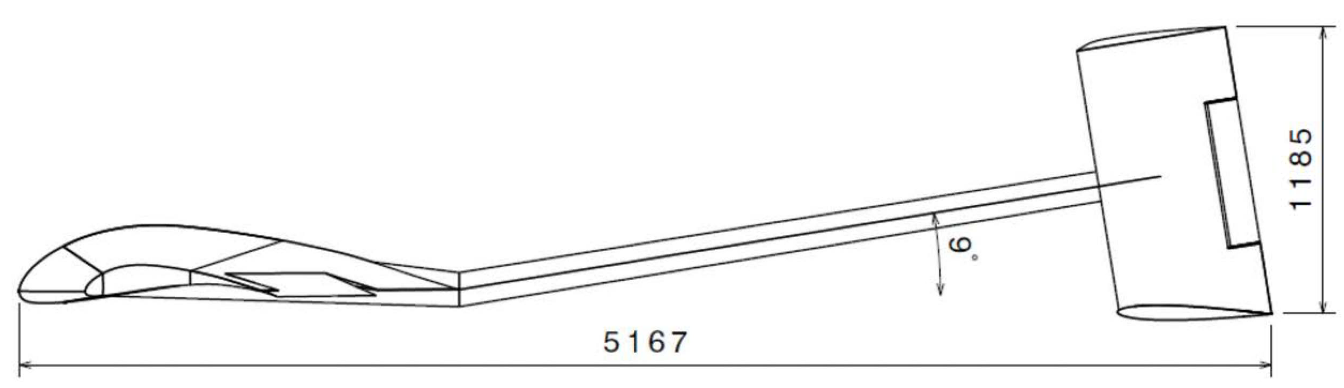

The kites average cycle power declined after its design point at 5 m/s. This was found to be due to an increase in reel-in power. This power was determined by using the minimum tether force to keep the lin a catenary shape. The optimum reel-in veloctiy was found to be around 45 m/s, independant of wind speed. The average cycle power at high wind speeds could be optimized by inreasing the duration of the traction phase by decreasing reel out velocity. The average anual yield was found to be 22.8 kW, compared to 21.3 kW of a conventional 40 kW turbine

## Wing structure




The kite is fully made from Carbon Fibre Reinforced Polymer. The main wing consists of 4 parts that are adhesively bonded together. The main load carrying part is part B. This is made from sandwich panels to counteract buckling. Because the choice was made for a bridle with two attachments the bottom skin did not have the need for a sandwich structure. The result was a kite that can handlle twice the maximum lift load of 20 kN and weighs only approximately 40 kg.

## Aerodynamics




The fuselage was swept upward to reduce drag in high angle of attack flight. These condtions are critical to be able to produce the required 40 kW at maximum tether length. Also it was found that, as can also be seen in the figure on tether number, that at ar certain point nt the $C_L^{\,3}/C_D^{\,2}$ of the kite is dominating but rather the contribution of the tether. It turns out that $C_{L,max}$ of the wing is the driving coefficient to design for.