Airborne Wind Energy systems evaluation matrix

AWES Decision Factors		Standard Tower based Wind Turbine	Makani and windlift flygen drag energy kite	Sky windpower quadcopter autogyro	Kitegen & x-wind (NTS) track & Carousel	Ampyx & Twingtec rigid yo-yo kite planes	Altearos BAT	Kitemill and kitegen stem soft kite yo-yo	Superturbine	Windswept and Interesting Daisy stack
Criteria	Wt.									
Build and installation Cost	2.0	10	5	-2	6	-4	-2	-6	-5	-7
Design and development cost	1.5	0	6	4	2	1	-7	1	-6	-6
Safety	2.0	0	5	3	-2	2	0	0	1	-2
Power scaling	2.0	5	5	5	0	5	5	-2	5	-5
Reliability	1.0	0	4	4	2	4	2	0	4	-1
Control Cost	1.0	0	3	3	2	3	-4	2	-3	-3
Time to market	1.0	0	5	5	5	3	0	2	2	1
IP maintenance	0.5	0	6	3	2	2	4	2	0	-7
Windspeed range	1.0	0	-2	2	2	-2	2	2	-4	1
Generation surface efficiency	2.0	-5	-4	-3	-1	-4	-4	2	-3	-2
Land use efficiency	1.0	0	5	5	0	2	5	2	-4	-4
Stack arrayable in the air	1.0	10	8	0	4	8	0	0	-2	-3
Drone field management	1.0	0	-6	-2	-2	-2	-2	-3	-6	-2
O&M cost	1.0	0	2	1	1	-2	2	-2	0	2
Generator height demand	1.0	0	0	2	-5	-4	3	-5	-5	-5
Weighted Scores		30.0	**53.0**	33.5	19.0	10.5	-2.5	-11.5	-31.0	-58.5

What's the most likely AWE architecture

Investing in Airborne Wind Energy is complicated. This decision matrix highlights some of the stark differences in design.

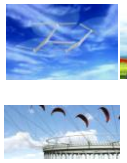
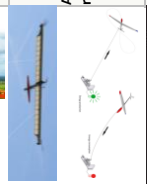
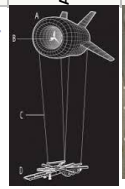
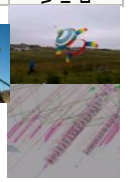
LOWEST SCORE = BEST OPTION scores are as compared to Tower based wind turbine.

Criteria	Definition
Build and installation Cost	As a product how expensive will this option likely be per investment? (ROI)
Design and development cost	How expensive will this product be to develop to TRL9?
Safety	Once installed, How many different dangerous failure modes will still exist?
Power scaling	Does this architecture have mass scale limitations?
Reliability	Is there a likelihood of catastrophic failure?
Control Cost	Will the system fly itself or does it need complex control and optimisation?
Time to market	How many years until public and product are ready for each other?
IP maintenance	Is FAA certification standard easily atainable and open to public optimisation?
Windspeed range	What is the cut in speed and can it keep generating in a hurricane?
Generation surface efficiency	Can the system develop to hard fast efficient blade surfaces or does it have to be flappy cloth?
Land use efficiency	How much land do you need per kwh?
Stack arrayable in the air	Can you stack and pack the turbines high into multiple working altitudes?
Drone field management	Can field operations be handled automatically or will it need expensive human workforce?
O&M cost	How intense are the operation and maintenance costs likely to be?
Generator height demand	Does the architecture use energy to lift the generator?

Note on calculation

The formula for weighted scores uses a Sumproduct formula and has conditional formatting applied. Please check that the formula and conditional formatting includes the correct cell ranges if you add or remove any rows or columns.

Instructions: Select and insert a score of **-10 to +10** for each criteria. The score will be multiplied by the weight to arrive at the total weighted score.
Keep the first column for **status quo** (i.e. no change) and score the options against the status quo.

	Standard Tower Based Wind Turbine	Makani and windlift flygen drag energy kite	Sky windpower quadcopter autogyro flygen	Kitegen & x-wind (NTS) track and ground Carousel	Ampyx & Twingtec rigid yo-yo kite planes	Altaeros BAT	Kitemill and kitegen stem soft kite yo-yo	Superturbine	Windswept and Interesting Daisy stack
system image									
System Description	A tower based on a concrete pad holds up rigid spinning turbine blades, a gear box and generator	A rigid kite flys circles to increase aparent wind over 8 turbines. Electrical power is sent to ground	A set of rotors connected by a rigidised frame is tilted into wind for lift and generation. Electrical power is sent to ground	Multiple soft kites to pull generators around a large radius track on the ground	rigid glider kites fly yo-yo patterns to pull a tether from a ground based drum generator	A lightweight turbine is lifted into higher wind inside a helium baloon shroud	Larger soft kite designs used to pull cable from a ground based drum generator	A rigid but flexible shaft with multiple short blades spins rapidly. Lifted at top, generator on the ground	Kite ring turbines are flown over a guiding lift line axis.
Website	www.awea.org/	http://www.google.com/makani/technology/	http://www.skywindpower.com/index.htm?_p=Y	https://www.x-wind.de/en/	http://twingtec.ch/_www.ampyxpower.com	http://www.altaerosenergies.com/bat.html	http://www.kitegen.com	http://www.selsam.com/	http://windswept-and-interesting.co.uk/