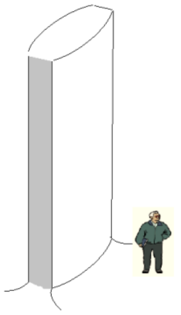
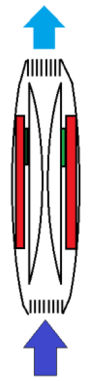
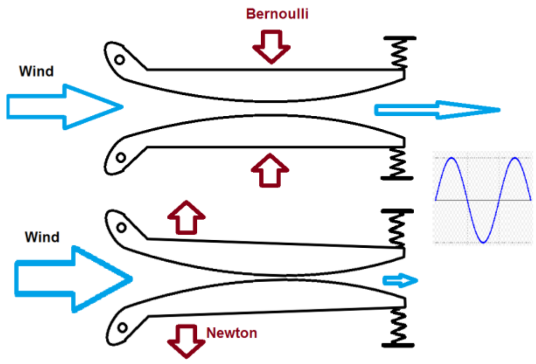
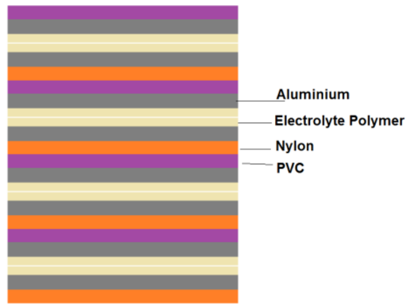
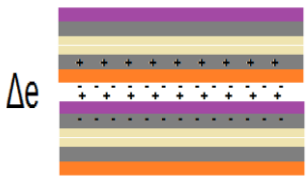


This is an ambitious project with many questions to answer; the reader may worry that our technology may simply not be feasible. Thus even though we aim to prove the likely feasibility, we felt it very important to show we understand and aim to mitigate all risks. We here explain the principle of how we convert wind energy to kinetic energy and the conversion to electrical energy. Unlike classical wind turbines ours is a pseudo static structure; see left. Wind enters the forward port passes over aerofoils and exits the rear port; see right. The aerofoils are hinged and sprung and wind passing over the curved surfaces results in lift (Bernoulli) forcing the aerofoils to close in on themselves. At a certain point the air speed drops and wind momentum change forces the aerofoils apart (drag, Newton). This creates an oscillating motion of a few centimetres whose energy can be used for power generation. To convert this we use a combination of tribo-electric charge generation and variable capacitance electrical voltage generation.

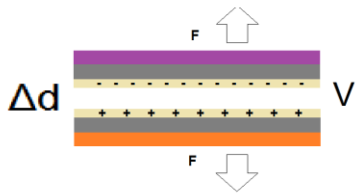


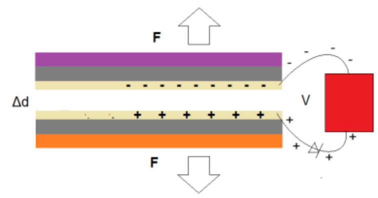


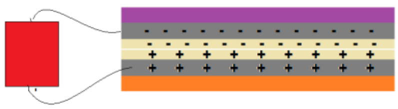




The red panels either side of the aerofoils (top right) comprise large areas of "mille-feuille" stacked plates; aluminium, electrolyte, aluminium, nylon, polyvinylchloride, aluminium *repeat*. Under aerofoil forces, the separation of the plates occurs in a sequence; first the nylon and PVC plates separate by 100 microns Δe. The tribo-electric effect charges the aluminium plates by electrostatic induction. Across the electrolyte, the aluminium plates form a capacitor with voltage V_1. As the aerofoil forces separate the aluminium plates by Δd (1 or 2 mm), the voltage rises rapidly since the capacitance drops for constant charge. The electronics monitors V and at the right time switches it to charge a storage cell shown in red box. When the aerofoils compress the stack not only does the tribo-electric effect recharge the plates but we also use a proportion of the standing voltage of the storage cell to complement the capacitive voltage V_1 and create V_2 which is greater than V_1. As this cycle repeats the voltage stored on the cell grows as a function of the work done. The storage cell energy is then used to charge a battery system, which later feeds the grid. Please reference our patent application GB1620410.9 for full details.

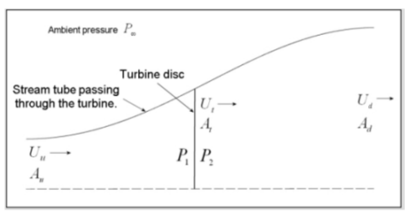


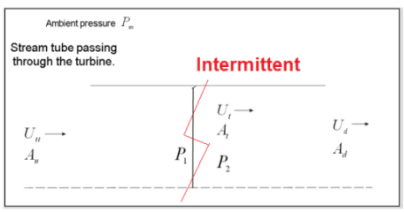




Risk 1: **<u>The lift drag process will not work</u>**. In fact we have built a small prototype and tested it at different wind speeds. The rig oscillates well and we have measured the generated forces over the full oscillation cycle at different wind speeds. As explained in Appendix Q3, we estimate a large static tower approximately 16m high by 1m wide can generate 1 to 3Kw at full efficiency.

Risk 2: **<u>It will be inefficient compared to (Betz Limit) conventional turbine.</u>** We argue that classical turbines are already limited to well below Betz's limit because they have only 3 blades (Betz assumes infinite), they have a central hub and atmospheric flow of air is not constrained. In our design we aim to use the intermittent drag flow oscillation to extract as much kinetic energy as possible for a given airflow; we have no blocking hub, our effective area is the

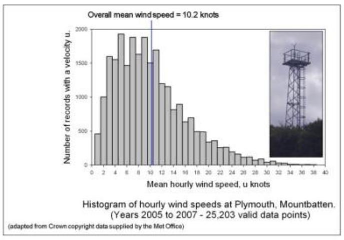




full input port area and we have infinite blades in the sense that we make use of all airflow kinetics.

Risk 3: **<u>The area of the input port area is small compared large turbines</u>** This risk is dealt with in three ways, first practically we try to make the input area large by making a tall structure, second we can place structures side by side, increasing the total area and applying a gap and stagger. We will also prove that, a comparison of swept area to our input port area is not meaningful, since classical turbines have only 3 (and not infinite) blades to avoid tower shadowing/vibrations and since atmospheric flow of air is not constrained it expands before the turbine swept area.

Risk3: **<u>Urban wind speeds are too low for this to work</u>** Classical large turbines cannot begin to work below 6m/s wind speeds. In contrast we can intelligently scale energy production down by controlling the capacitor voltages and therefore the required forces; so we can operate down to 2m/s and still be harvesting since the plates we are moving will be extremely light weight plastic film laminates. Moreover because we can work at low wind speed we take advantage of the much higher frequency of occurrence of low speed wind <u>in any context</u> since, for example 5m/s wind speeds are the most common occurring (see right); thus our technology may produce less energy at low speeds but would do so for much longer times. Finally the approach works in highly changeable gusty conditions, very common in urban areas. Classical turbines cannot react to short term gusts.



Histogram of hourly wind speeds at Plymouth, Mountbatten. (Years 2005 to 2007 - 25,203 valid data points)
(adapted from Crown copyright data supplied by the Met Office)

Risk 5: **<u>Vibration and Noise</u>** We know that classical wind turbines create noise and architects warn that the few that have been integrated into buildings cause unacceptable vibrations. We will avoid this since the unit operates below audible frequency and all moving masses are of very low mass, whereas classical turbines have high mass and a wide range of vibration energies.

Risk 6: **<u>The public will not accept such structures.</u>** This is a big risk and we aim to fully mitigate it during the project by using focus groups in public and architect consultation so as to arrive at designs that the majority of people will readily accept. This will be guided by Professor Lehman, renowned for his work on Sustainable Urban Future Cities.

Risk 7: **<u>The kinetic to electrical energy conversion will not work or will be inefficient</u>** In fact we are optimising a well-known conversion principle and making it more efficient by adding tribo-electric pre-charging of plates. Classical methods use an external power source to do this making it inherently less efficient. The large area Tribo-elecrtic plates we are going to use will generate substantial charge, removing most of the basic inefficiency. Moreover by automatically adjusting the amount of feedback charge the system will tune the impedance of the system to load match the plate forces with the wind kinetics; thus always adapting and operating at maximum efficiency.

Risk 8: **<u>The amount of energy that can be generated per structure is limited</u>** we can reduce this risk greatly by optimising all aspects of the process and rely on multiple structures to be combined to achieve a specific target power; we strongly believe that we will be able to compete with solar and with **<u>equal input port area to swept area</u>** we can generate more than a classical turbine.

Risk 9: **<u>High cost of a structure and installation</u>** Our system comprises low cost light weight laminates. The resulting light weight low cost structure should be able to be manufactured at a cost that will significantly reduce amortisation periods. Additionally the simple structures will be installable at low cost.

Risk 10: **<u>No wind to test with</u>** We will run trials in two places know to have high likelihood of winds. We also will run extensive in house wind trials using very large pseudo laminar flow fans.

Risk 11: **<u>No mathematical model of the physics</u>** This will be an important aspect of the project and a specific work task has been dedicated to it. An extremely competent Maths Physicist will be in charge with support from Dr Ajaj at the Aeronautics Department of Southampton University.