**Rhythm of the Wind**

**Technology**

Project uses tree look alike vertical wind mills to emulate a forest park for power generation. Conventional wind mills generate torque with tangential force created on turbine blades by wind speed (Bernoulli effect). Most industry wind turbines are tall and located offshore for high speed wind; they are effective at wind speeds of 30 Km/h or above. Conventional wind mills are less effective with slow speed wind inland or nearby ground surface.

Although slow speed wind is less effective for power generation, it still has normal pressure and carries respective kinetic energy. The presented project illustrates a new cost-effective method designed to collect wind energy from slow speed wind.

Proposed vertical wind mill implements swingable rigid sail paddles to collect normal pressure of the wind. Each mill is composed of multiple levels of rotors and each rotor has four rigid sail paddles. Each paddle is about 1.2 sq. meters in area and mounted on a pivot at the corner of a rotor frame. The pivot divides the paddle into two unequal area segments. When wind blows onto the paddle, it swings around the pivot by uneven forces applied to uneven areas of the paddle. The paddle uses the swing to jibe itself in response to wind direction (Fig. 1). Any time wind blows to the rotor, three paddles are stopped by the rotor frame to form an approximately 45-degree angle to the wind direction; these paddles receive the wind pressure and generate forces to push the rotor to rotate, similar to sails that push a sail boat. The fourth paddle forms a free swinging 90-degree angle to the wind direction and it yields the wind pressure. The rotor therefore generates a torque with uneven forces created by paddles on the rotor (Fig. 2).

Different from conventional turbine, proposed wind mill is more effective to slow speed wind. However, unbalanced forces created by each rotor may cause vibration to the center post. To correct the unbalanced forces applied to the center post, a matching opposite rotating rotor at the next level with mirrored paddles arrangement is used to generate an equivalent counter balancing force to correct the center post from vibration (Fig. 3). A 1 to -1 ratio gear is used to link and synchronize these two paired rotors.

A mill may have multiple rotor pairs and the torque sum of all paired rotors is linked and delivered down to the bottom gear to drive the electric generator. Mills would be installed on 2.5 meters tall base trunks. For a group of mills (a forest), there would be a recreational space underneath the mills with 2.5 meters tall ceiling for gardening or public activities.

Each mill top would be tied up to others to form a reinforcement net to increase the structure strength to withstand strong winds. Proposed design is scalable and expected to sustain category II storm.

**Art presentation**

Day time wave rhythm show:

Each paddle is painted with one side dark green and opposite side yellowish light green. When wind front passing by wind mills, the wave front leads the acceleration of mills rotation. Audiences can see the color flipping following the wave front passing by the forest as a rhythm of the wind.

Optional Night time light rhythm show:

Mirror refractors could be installed onto rotors to refract LED (white, red, green and blue) light beams to the peripheral areas. The intensity of light beams would be proportional to the rotational speed of the mills and a moving bright light band would follow the wave front of the wind.

Light temperature of the moving light band could follow the rhythm of the music. Audiences may be encouraged to download smart phone applications and upload their composition of music with color emotion presentation to the control center via WiFi for visitor’s entertainment.

**Dimension**

Each mill has a diameter around 4 meters. Mills are built in three heights (Fig. 4); short mills would be 6 meters in height with 2 paired rotors, median mills would be 8 meters in height with 4 rotors and tall mills would be 10 meters in height with 6 rotors. The park would be artfully laid out with combination of three sizes of mills to emulate a natural forest.

**Material used**

Mills are built with:

1. Anti-rust coated center steel post, 2. Anti-rust and self-lubricated glass or ceramic ball bearings, 3. Steel and polymer rotor frames, 4. Anti-rust and self-lubricated nylon or ceramic gear boxes, 5. Polymer wind paddles, 6. LED lights and wires, 7. Rubber bands and damper pads, 8. Electric generators, 9. Electronics controller (microchips, PCB, etc.), 10. Polymer and anti-rust coated steel tube trunks, 11. Anti-rust coated steel cables, 12. Batteries and grid tie inverter, 13. Cement mill foundation. Estimated 95% building materials are recyclable and 100% of the mill is repairable and low maintenance.

**Annual estimated generation KWh**

Each mill is 4 meters in diameter or 6 meters diameter including peripheral areas; a mill would take 3.14 X 3**2** = 28.3 sq. meters in area. For a park size of 300m X 90m = 27,000 sq. meters, assuming 80% utilization, effective area for mills would be 21,600 sq. meters. Estimate 21,600 / 28.3 = 763 mills could be installed.

Each rotor is estimated to generate 150-Watt effective power at surveyed area with 15 Km/h (9.3 mile/h) average wind speed; a park with 400 tall mills, 200 median mills and 163 short mills would generate (400X6 + 200X4 + 163X2) X150 = 528,900 Watt of power. Assuming generator and energy storage / grid tie inverter efficiencies are both 80%, effective power contributed to the grid would be 528,900 X 0.8 X 0.8 = 338,496 Watt. Estimate annual generation would be 338496 X 24 X 365 = 2,965,224 KWh.

**Cost**

Estimated cost for each mill would be $3000 (combination of three heights), generator would be $500 each. Construction and wiring for each mill would be $1000. Energy storage, grid tie invertor and control room construction would cost $200,000. Lightening, gardening and land cover would cost another $200,000. The complete structure cost would be 763 X 4500 + 400,000 = $3,833,500 for 338,496 Watt. Per Watt cost for the system is $11.33, well under $30 per Watt allowance.

**Environmental impact:**

Proposed project has low environmental impact based on following analysis: 1. Low to median noises, 2. Minimum hazardous material used, 3. Most material would be recyclable, minimum land fill expected, 4. No smoke or emission generated, 5. Sustainable to category II storm, 6. components are repairable or replaceable, 7. Minimum maintenance.