J-19

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS

Department of Physics and Astronomy
Rutgers, The State University of New Jersey
136 Frelinghuysen Road • Piscataway • New Jersey 08854-8019
FAX: 732/445-4343

This document has been prepared by Terry Matilsky, Professor of Physics at Rutgers University. He has several decades of experience in applying the laws of physics to various envirornmental and commercial isuues, and has served and testified as an expert witness in several venues, including United States Federal Courts.

CALCULATION OF ICE THROW DISTANCES FOR WACHUSETT WIND POWER SITE

WHAT WE KNOW: blade radius is about 130'

hub height is about 230'

rotational speed at rated capacity is 1 rev/ 3 seconds or 20 rev/min

RESULTS:

1) Rotor tip speed: In one revolution, the blade sweeps out a circle whose circumference is $2\pi r$ (Here r=134 feet) or about 800 feet. Since it does this in 3 seconds, the speed is feet/sec or about 190 mph! 280/2≈$tr\pi$

2) Range: The range of any projectile at a given initial velocity is maximized when launched at a angle from the vertical. At this point, with the above turbine parameters, the projectile will be a horizontal distance feet from the hub. This will later be subtracted from the total distance traveled to yield the distance traveled from the base of the tower. Also, at this point, it will be 95 feet higher (vertically) from the hub, or at a total vertical distance from (level) ground of 230+95=325 feet. °459545cos134=°=x

$R=v^2/g$, where v=initial velocity of the projectile, and g=gravitational acceleration or 32 ft/sec/sec. This is the horizontal distance to come back down to the *original* vertical height. I.e. after this distance, it is *back* to being 325 feet from the ground. Thus, $R=280^2/32=2450$ feet.

At this position (neglecting air resistance), its vertical velocity is the same as when it was launched (except now it's going down, instead of up). Thus, $v_v = v \cos 45^o = 280 \times .707 \approx 200$ ft/sec. The extra time it takes to fall to the ground from this height can be found from solving for t in the equation: $s = v \cdot t + 1/2gt^2$. With s=325 ft g=32 ft/sec/sec and v=200 ft/sec, we get t≈1.5 sec. Since the

95 PU-08-34 Filed: 6/8/2009 Pages: 3
Exhibit J-19 from June 5, 2009 Hearing

Office of Administrative Hearings

horizontal velocity is constant in the absence of air resistance, the increase in the range over the 1.5 extra seconds that it takes to fall to the ground is: $d=v_h \cdot t$, where v_h is the initial horizontal velocity, which for a launch angle of 45^o is also 200 ft/sec. Thus, d=200•1.5=300 feet. Therefore, the total range of the projectile is 2450 feet + 300 feet = 2750 feet. Now, we subtract the 95 feet that the projectile was behind the hub when it was launched, and we get the maximum range of the projectile being 2655 feet, or slightly OVER ONE HALF A MILE.

3) Speed of the projectile at impact: v_h=200 ft/sec and $v_{vi}=v_{vo}+g\cdot t$, where v_{vi} is the vertical velocity at impact, having v_{vo}=200 ft/sec originally, and being subject to the gravitational acceleration of 32 ft/sec/sec for an additional 1.5 seconds (t). Thus, $v_{vi}=200 + 32\cdot 1.5 \approx 250$ ft/sec. The final velocity upon impact is therefore: $v=\sqrt{(v_h^2+v_{vi}^2)} = \sqrt{(200^2 + 250^2)} \approx 320$ ft/sec or OVER 200 MPH.

4) To account for the change in elevation at the proposed sites, we can use the site maps, According to which, at a distance of one half a mile from the tower (which is the theoretical maximum range on level ground), the falloff from the north tower is from approximately 445 m. to 345 m. From the south tower, the elevation change is from about 430 m. to 345 m. Thus, there is approximately an extra 100 meters of drop, or about 300 feet. So, if the blades of the turbines were oriented in a plane along the average gradient of the mountain (which would make the ice throw occur in that direction as well), you would get an extra 300 vertical feet that the projectile would fall before it impacted the ground. At v_v=250 ft/sec, this would add about 1 sec to the impact time, which translates into an additional 200 feet of horizontal range. Note that this is a slight underestimate, since in that 200 additional feet, the ground would drop off further, yielding a further (small) vertical falloff over which the projectile would move. But for all practical purposes, the theoretical maximum ice throw, in the absence of air resistance, would be about 2855 feet.

EXHIBIT 2.9.5
Rutgers university - Professor terry matilsky
Theoretical Calculations of ice throw distances
for wachusett wind power site

Note that the presence of air resistance, and wind, can modify these values somewhat. For example, an aerodynamically blunt chunk of ice could reduce the range in the absence of wind, but if there were substantial crosswinds, the maximum range could be increased. These considerations are of necessity beyond the scope of this document. But it seems like it would be quite reasonable to take about ONE HALF MILE as the canonical number for the maximum range of a projectile launched with the above wind turbine parameters.

Respectfully submitted,

Professor Terry Matilsky
Department of Physics and Astronomy
Rutgers University
Piscataway, N. J. 08854