

Wind Energ. Sci. Discuss., author comment AC1
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Reply on RC1

Ivan Kennedy et al.

Author comment on "A New Way to Estimate Maximum Power from Wind Turbines: Linking Newtonian with Action Mechanics" by Ivan Kennedy et al., Wind Energ. Sci. Discuss., <https://doi.org/10.5194/wes-2022-22-AC1>, 2022

We thank Reviewer 1 for critical discussion given in response to our article. From these comments, we can make certain improvements.

However, it seems unfair to review our article using an approach based purely on continuum calculus rather than the "new way" we propose based on wind momentum and blade pressures. The reviewer inflexibly prefers the "old way" even though it has many uncertainties that this article seeks to solve. Partial differential equations typify continuum hypothesis, even though air in wind is not infinitely divisible but consists of particles exerting pressure with momentum and direction. We request that the review be conducted fairly, by considering instead the Newtonian experimental mechanics conserving momentum that we base our method on. The new action mechanics explains the close to cubic response of maximum power to wind speed but raises issues with respect to angle of attack and blade length that need more investigation. The review should not be about mathematical purism, particularly when the extensive results found with this new method are more accurate than current approaches based more loosely on the wind's kinetic energy.

- Our title indicates we only intended to estimate **maximum** theoretical power from wind turbines, a function of wind speed and the angle of the blade with respect to the wind. We consider this a very useful result. Our equations were never intended to deal with inefficiencies in the drive train and electrical equipment. We claim therefore that equation (6) is true in terms of the title of the article.
- We were careful to explain that only the relatively small directional wind vector existing over the random microscopic velocities was relevant. We never discussed generation of power from molecular or microscopic behaviour as claimed, except in terms of the rate of radial action of particles moving in wind, that we define as torques.
- We consider that section 1.1 *Radial action theory* and Figure 1 adequately explain the derivation of equations (4) and (5), in terms of moments generated by wind pressure and the blades on air, controlled by tip-speed ratio. However, we will improve this text for logical clarity.
- We make clear that drag as normally understood for aerofoils does not apply for estimating the leeward or back torque of equation (5). Given the much greater velocity of most of the turbine blade impacting air up to the tip compared to wind speed, while lift is important drag is irrelevant.

- Regarding experimental testing of our hypothesis, Figure 3 illustrates one obvious test in its prediction of an optimum angle for flat blades near 55-60 degrees or wind incidence. Another critical test in the spirit of Karl Popper's definition of rich hypotheses relates to the existence of an optimum blade length. Ultimately the tip-speed ratio of longer blades defeats the windward torque depending on wind speed. Responding to the criticism regarding possible falsification, we will now include differential equations for variations in power with respect to angle of wind incidence $\partial P/\partial\theta$, blade length $\partial P/\partial L$ varying with wind speed and optimum length with wind speed, all predictions testable in field practice.

Unfortunately, Reviewer 1 only considered the first few pages of our article, neglecting completely the equally novel hypothesis regarding heat generation, based firmly on our three recent publications in the *Entropy* journal. This prediction is also eminently testable and is confirmed in some respects in recent papers in other journals. Given the utility of our simple equations for estimating maximum wind power and their correspondence to the demonstrated power of real-world turbines, we reject the reviewer's final sentence as unscientific and as unhelpful as the comment on predicting Putin's future.