VALLEY OF THE WINDS WIND FARM (SSD-10461)
APPLICANT MEETING RICHARD PEARSON (CHAIR)
Written Submission to the Applicant Meeting: NSW Independent Planning Commission
Coolah April 10, 2025

To Mr Richard Pearson, Chair at Coolah

My submission is driven by sincere concerns for the 'Valley of Winds' wind farm, and on my professional knowledge and sense of care for the social and environmental well-being of the Central-West Orana region. I grew up in similar farming country in Western Australia in the 1940s and I have the greatest respect for the productivity of our risk-taking farmers with a deep love for the bush all across Australia. Sinc then I have grown to know it well, and 70 years later I have been professionally trained at taxpayer expense, including taxes paid by farmers here today. My professional expertise has been in various areas of environmental risk management.

Since retiring from teaching, with my research team I now focus on climate science research, with several recent publications estimating maximum power from wind turbines – even power in tropical cyclones, drawing attention to meteorological effects up to 50 km downstream of wind farms, known as wake effects. Downwind, the velocity of winds is reduced to half at turbine hub height, increasing wake air pressure because of retarded air flow and causing significant convective turbulence. Not visible in air, these convective results may even initiate thunderstorms many km away.

We also predicted from our analysis of wake evapotranspiration that this must dry out the landscape, caused by swirling heat release when strong straight winds are made turbulent. This potentially reduces regional farming productivity and increases bushfire risk many km distant. Remember, farmers pay large levies on their produce to fund research for agriculture. Research is needed by government to mitigate these wind fam effects, to avoid charges of negligence.

The likelihood of ignition from spotting embers and intensity of heat generation was shown in USYD Bushfire CRC research to be increased several times, if moisture is reduced to half in foliage from eucalypts. I strongly recommend that wind farms should only be located at sites far distant from wake risk. Farmers have enough risk with climate and finances already.

My submissions to two Senate Inquiries on windfarms and energy regulation have both been accepted and granted parliamentary privilege, protecting my right to speak out. My submission to the NSW Minister for Energy Penny Sharpe received a polite reply just this week from Mr. Chric Ritchie, an Executive Director for Energy, Resources and Industry acknowledging my concerns. Although his department declines to do the relatively inexpensive research on wakes needed to estimate the magnitude of risk he states "It is highly likely that any localised impacts would be offset by the need to mitigate climate change and transition to renewable energy". As a professional climate scientist seeking truth I find this statement extremely odd logic. This is a weak hypothesis about the future that lacks certainty, except in politics. I conclude scientifically that wind farms will make no beneficial difference to climate, other than negative in the lifetime of everyone here today. What about the risks posed to farming communities now?

I draw attention to intense wildfires on Maui, Hawaii and the Attica fires where at Mati, a suburb of Athens, hundreds of people died in 2018, also with windfarm wakes. Particularly in Maui, the direction of the wake air flow is towards the town where everyone died had no escape route. In Athens, district fire department members were recently sentenced to prison, in my opinion, falsely. The prevailing wind roses in both cases showed wind farm wakes pointing directly towards these towns.

Strikingly, in my home state of Western Australia severe bushfires north-west of Perth are more frequent each summer, after the establishment of 100 MW wind farms about 100 km north of Perth. The prevailing wake direction there in mid-winter and early spring is also pointed SW into this direction, following normal winter rains beginning in May. The relatively new Gin Gin Fire and Rescue is a result now with 3,000 members, perhaps the largest such organisation in WA, fighting frequent fires in a lightly forested area that I describe as 'horse country'. Jai Thomas of the Department of Energy in WA responded in writing to my concerns, but denying that risk research by them was needed, suggesting I should organise it and then report back to him with results.

As a professional still publishing climate scientist asking questions, I judge there is no prospect of effective global mitigation by wind farms in our life-time. Even if there is a reduction in CO_2 in the atmosphere, by no means certain, any beneficial climate effect will be delayed at least to 50 to 75 years into the future, with only a global hope lacking certainty. This is a scientific viewpoint, not politics. By contrast, farmers in this Orana region of rural Australia could be suffering the negative consequences I predict just 10 years from now.

My written submission to this meeting next week will include much of the evidence I have presented at previous Senate Inquiries, focussing on this region. Never before has such a major transformation of the Australian landscape been promoted by government so rapidly, with no sign at all of responsible social diligence that would follow from relatively inexpensive prior research. I am confident that such damaging unintended consequences are highly probable, worse than any uncertain benefits from impacts of climate change.

I am particularly concerned at the reckless lack of diligence in that almost no research has been done on such effects under hot and dry Australian climatic conditions. To me this shows a lack of diligence and power companies may later face legal class actions because of this neglect.

Yours sincerely,

[redacted]

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Submission to the New South Wales Independent Planning Commission
A similar submission was made to the Select Committee on Energy Planning and Regulation in Australia and to the Hon. Penny Sharpe, NSW Minister for Energy in November 2024

Understanding Wake Effects from Offshore and Onshore Windfarms: A Need for Research on Downwind Meteorology and Rainfall, Rates of Evapotranspiration and Drying on Land and the Risk of More Intensive Wildfires

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Abstract
Despite almost complete ignorance of their meteorological effects, engineered wind turbine plants have been enthusiastically adopted worldwide as a source of renewable energy. But is this source of electrical power renewable if it slows the laminar wind flow, inducing turbulence and chaotically affecting wake meteorology? Published evidence of aerial or satellite measurements shows that while extracting wind energy, turbines create turbulent wakes, slowing airflow at hub height and releasing heat, two effects potentially raising wake pressure and inducing convection. Warmer, turbulent air increases rates of evapotranspiration and therefore increases landscape dryness, depending on predominant wind direction. Field and laboratory studies show that such dryness of soil and vegetation will increase the risk of more intense local wildfires. Three cases of windfarms in the proposed Illawarra Offshore Windfarm, the windfarms near Dandaragan, north of Perth, Western Australia and a major windfarm on Maui, Hawaii, are studied about their possible wake effects. Research is recommended to measure the predicted heat release, the extent of turbulent convection and localised drying effects from wind farms, established both onshore and offshore. This may throw light on the potential risks and costs of placing wind farms in particular locations, providing information on where they might be better placed to minimise such future costs.

Introduction

Windbreaks have been long known to provide shelter from impacts of winds. A well sheltered zone behind a break with low permeability to air flow is typically warmer and more humid, with the ascending turbulent wake zone cooler and dryer than an unaffected control flow (Cleugh, 1998). Figure 1 illustrates such wakes caused by an offshore windfarm, the meteorological conditions favouring precipitation releasing latent heat proportional to the rate of condensation of water in a saturated atmosphere. While onshore windfarms do not significantly affect global wind speeds or patterns (Li et al. 2023), there is published evidence that windfarms do affect local wind speeds tens of kilometres downwind, requiring them to be well separated. Moreover, they generate their own characteristic turbulence independent of any turbulence existing in their wind inflow, as shown in wind tunnel experiments (Neunaber et al. 2021).

Figure 1. Turbulent moisture-laden wakes in an offshore windfarm near Denmark.

Evidence for turbulent properties of windfarm wakes

Roy and Traiteur (2010) recommended that wind farms be located on land with rough surfaces, using wind already turbulent. Onshore windfarms in arid northern China have been shown to cause variation on land surface temperature as sensed by satellites, with localised heating of the order of 0.2-0.3 ^{o}C near windfarms compared to landscape without turbines ((Liu et al., 2022). No difference between daytime or night warming was detected, disputing the conclusion that nighttime warming was caused by overturning warmer air during a temperature inversion (Roy and Traiteur, 2010).

Vees et al. (2019) identified interference by wind turbine wakes as a major limitation to wind power electricity. For this reason, Barthelmie et al. (2019) characterised wind turbine wakes in complex surface terrain. Aerial measurements and satellite imagery reveal windfarm wakes to be several tens of kilometres, with maximum wind speed deficits of 40% at turbine hub height. During more unstable meteorological conditions in daytime, differing from more stable laminar flow at night, windfarm wakes are shorter (Platis et al. 2018); this indicates a greater rate of dissipation of wind energy in daytime.

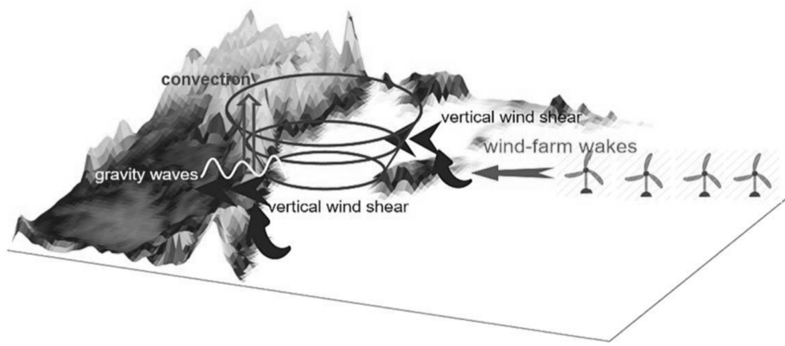

Figure 2. Schematic diagram of the mechanism of influence of offshore wind farms on the tropical depression downstream of wind farms (Fig. 10, Deng et al. 2023).

The wake of an offshore windfarm in China has been shown to amplify low-level vertical wind shear and cooling convection offshore, caused by the turbines diminishing the airflow's downstream axial momentum (Deng et al. 2023); this makes vertical momentum (Fig. 2) the main contributing term arising from the diminution of horizontal momentum, as a Bernoulli effect with gravity waves. Strong laminar airflows in anticyclones charged isothermally by greenhouse gases as internal work release heat by turbulence from friction (Kennedy and Hodzic, 2023), as a chaotic process. We propose this potentially causes rain in humid air at sea, diminishing subsequent rainfall on land in the hinterland, a result of premature cooling convection. Offshore windfarms strongly affect the distribution of accumulated precipitation, with an apparent decrease at onshore regions downstream and an increase in offshore areas (Pan et al. 2018).

Environmental effects from turbulence, regarding warming and evapotranspiration

Miller and Keith (2018) showed for stable night conditions a significant warming effect at 28 operational US wind farms using MODIS satellite detection. They also concluded that this warming could exceed warming avoided by reduced carbon emissions. Thess and Lengsfeld (2022) reviewed evidence for impacts of farms on air velocity, temperature, moisture and precipitation in their vicinity, with ecological effects. Wang et al. (2023) showed in China that windfarms dried surface soil significantly, both temporarily and spatially. Bodini et al. (2023) using measurements of airflows made on aircraft that turbulence from wind turbine plants reduced axial air speed as much as 30% downwind at hub height to at least 30 km. The turbulent eddies in air flow, delaying axial wind speed, naturally increase the probability of evaporation by greater exposure of soil and vegetation.

Several studies (Zhou et al. 2010; Gao et al. 2017; 2021) have shown that turbulent air is more highly evaporative than air in laminar flow, caused by disturbance of the more humid boundary layer that would otherwise restrict evaporation.

Accelerated downwind environmental drying from turbulent heat release

Novel research on wind turbines (Kennedy et al. 2023) using least action modelling,; Kennedy and Hodzic (2023) have proposed that air in laminar flow in anticyclones releases vortical latent energy as heat when made turbulent by surface friction. This explains our interest in the effect of turbulence of drying the landscape. Using this novel least action method to successfully estimate maximum power from wind turbines, we predicted (Kennedy et al. 2023, Table 5) that a 70 turbine 105 MW windfarm might cause turbulent heating of wake air up to 3 ^{o}C, if all heat released was contained in a stream about 100 m high and a kilometre wide. Using the Penman-Monteith equation we estimated the enhancement in evapotranspiration to be 5% at 25 ^{o}C ambient temperature. With slower turbulent winds, a 10% increase in drying could occur, sustained if wind direction and laminar flow strength is maintained. While this prediction is hypothetical, it can be tested under field conditions. While wind droughts with speeds insufficient to generate power from wind farms occur (Miskelly, 2012), depending on direction, the wake drying effect of such turbulence is cumulative, with the water evaporated transported elsewhere.

Wake drying effects on landscape productivity and fire riskhighly significant

Elevated global temperature can increase the vapour pressure deficit (VPD), which is difference in the amount of moisture in the air and the amount of moisture the air can contain when saturated. The consequence of increased VPD is both an increase in the potential for plants to lose water to the surrounding air - resulting in increased water stress - and increased rates of water loss from soils. Both these factors can lead to an increase in plant drought stress (Grossiord et al. 2020) and the drying of both live and dead fuels (Rothermel 1983, Novick et al. 2024).

A general effect of global warming is an increasing VPD for water in the atmosphere (Novick et al. 2024). This has a strong ecological effect for plant growth productivity in agriculture and natural ecosystems, including the dryness and fire risk in the landscape. While CO_2 can have a radiative forcing effect on temperature, water is by far the predominant greenhouse gas with meteorological effects on weather, or in powering tropical cyclones (Kennedy and Hodzic, 2023).

Given the high latent heat of vaporisation for water of 2.26 MJ per kg, a major part of its total entropic heat content from absolute zero of 3.12 MJ per kg at 298.15 K (Kennedy et al. 2019) plus heat of 1.40 MJ per kg to heat steam to 1000 K, the peak temperature of a wild fire, the influence of fuel moisture content on the ignition and combustion of *Eucalyptus* foliage is must be defining. The heat energy released when dry woody fuel is burnt is near 20 MJ per kg dry weight of foliage (Possell and Bell, 2013). However, elevated fuel moisture will absorb much of this energy during combustion resulting in a less intense fire. In tests of three different species of eucalypt foliage, the likelihood of ignition was increased by a factor of three (0.3 to 0.9) and the peak heat release doubled (from 70 to 140 kW m^{-2}) when the fuel moisture content was decreased from 100% to 50% dry weight (Possell and Bell, 2013).

Curing of grass is a function of the proportion of dead material in the grass, contributing significantly to fire spread (Cheney and Sullivan, 2008). In summer, grass curing may be close to 100 percent elevating flammability. Grasses, commonly found adjacent to wind turbines, are most susceptible to constant dry wind where dead fuels can dry out quickly. Once the dead fuel moisture drops below about 20% of the oven dry weight there is both a greater probability of ignition and fires can also spread very rapidly, even under light winds (Cheney and Sullivan 2008). To the extent that windfarm wakes increase VPD and increase the drying of vegetation for many kilometres, they will intensify general effects of high temperatures and drought in warm areas.

Case studies predicting turbulent wake drying and risks to plant production or fire

The now approved establishment of a much larger offshore Illawarra Windfarm, 100 km south of Sydney could threaten rainfall in the Warragamba catchment, by causing premature precipitation at sea because of the turbulent convective effect identified by Deng et al. (2023). Little or no research data exists to test this hypothesis though it could be conducted at relatively little cost, given the potential future risk if it operates ten years from now.

A second case is in Western Australia, north of Perth in Gingin and surroundings near Wooroloo and Bindoon. Here fires have destroyed hundreds of homesteads with loss of human lives and livestock. This recent history has required a major response in the establishment of the Gingin Volunteer Fire and Rescue which mobilises 1600 personnel each summer fire season. The prevailing winds in the winter rainfall season are consistent with some enhanced drying of the landscape, even at more than 50 kilometres distance.

Frequently in regions with installed turbine wind plants, intense wildfires have been observed. Here we examine first the case of the devastating Maui wildfire of August 2023 that destroyed the town of Lahaina, where one hundred deaths resulted. To maximise power generation, the Kaheawa Windfarm is located to take advantage of the prevailing winds to this island, blowing across the island from the south-east towards Lahaina. At question is whether the intensity of the fires in early August were enhanced by evapotranspiration in the previous months, elevated by wind farm turbulence. Since the windfarm is still operating, this hypothesis can be tested.

Case 1: Gingin, Wooroloo, Bindoon Fires North-east of Perth

Since wind power was used for electricity, a pattern of frequent bushfires north-east of Perth has emerged. In January 2021, 71 dwellings were destroyed in a pastoral area near Wooroloo, but every year, 1600 volunteer members of Gingin Volunteer Fire & Rescue are challenged by bushfires. Before, summer bushfires were less typical of this area, lightly forested with sandy soils of low water-holding capacity. More usually, they were more located in forested areas, south of Perth. Since rainfall in southwestern Australia is predominantly in winter months from May, turbulent winds blowing in that season could predispose the area affected to summer bushfires, when additional drying occurs as temperature rises. In winter, the Gingin Wind Rose indicates winds are mainly from the north in June and July, from the region south of several operating windfarms near 31 ^{o}S latitude. A large 214 MW capacity windfarm was completed in October 2020 near Dandaragan. Half a degree of latitude further north, another 209 MW of windfarms operates between the coastal port of Jurien Bay and wheat and sheep farming town, Coorow, further away from the Gingin area at 31.3 ^{o}S. For suitable wind speeds delayed to 10 metres a second, even turbulent air will move 72 kilometres in one hour drying the terrain.

Heat production from wake turbulence can have significant environmental effects, as reduced ecological productivity and increased bushfire risk (Kennedy et al. 2023). We recommend that the turbulent heating and increased wake drying be assessed regarding effects of evapotranspiration on plants and soil.

Figure 5. Dandaragan Windfarm shown yields 100 MW of dispatchable electricity, when strong winds blow, is about 85 km north of Gingin where previously rare bushfires now occur intensely more frequently. The July Wind Rose shows turbulent drying can occur in June and July after winter rainfall.

Any deficit in soil and vegetation moisture caused in winter may provide conditions in early summer where fire, once ignited from whatever cause, burns more intensely, less heat being absorbed as latent heat of vaporisation. A research program recording effects on wind speeds, turbulence and evaporimeters to measure drying rates with respect to distance from windfarms is recommended, to test this hypothesis. Comparisons with control areas are required.

Case 2: The Tragic 2023 Maui, Hawai Wildfire

About 20 percent of Maui's electrical power is derived from windpower and more is planned. A devastating wildfire occurred in August 2023. The August 8th-9th wildfires in Hawaii resulted in the United States' deadliest wildfire recorded. The coastal and upcountry fires caused widespread destruction and loss of life, predominantly in the coastal town of Lahaina. The Lahaina fire was speculated to have been from downed power lines, which sparked and ignited dried vegetation in areas experiencing moderate (D1) to severe (D2) drought conditions, according to NOAA.

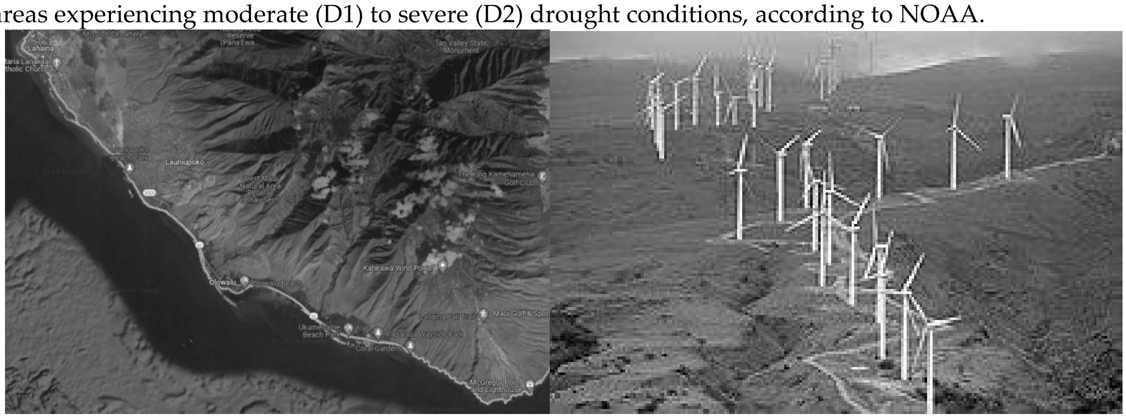

Figure 3. Coastal Maui map showing the windfarm bottom right dispatching 51 MW of electricity at around 1000 m elevation near the Lahaina Pali Trail. Lahaina is located 13 kilometres in the windfarm's wake in the north-western corner.

Enhanced drying of the downwind landscape

Obviously, Lahaina and the upwind terrain will frequently experience windfarm turbulence, almost normal to the line of the wind turbines. The distance involved for drying of vegetation and human structures to Lahaina is 13 kilometres. Our hypothesis of warming and enhanced evapotranspiration from turbulent airflow well prior to the fires could increase the flammability of the landscape by a significant factor. Fire intensity is highly responsive to dryness, given that the major cooling effect of evaporation is limited, allowing unimpeded combustion.

Although local wind roses are sometimes dominated by local topology, the predominant turbulent airflow clearly disposes the landscape leading up from the windfarm directly to Laihana. No other townsite in Maui is at so much risk from a tinder-dry situation. The theory that the fire was initiated by sparks from strong winds bringing down a power line recorded as a flash is consistent with this hypothesis.

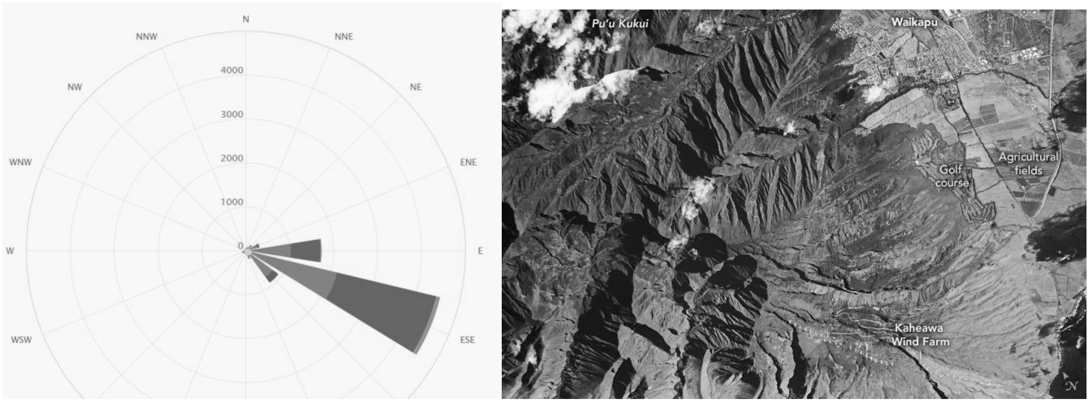

Figure 4. The general wind rose for central Maui shows how many hours per year the wind blows from the indicated direction**.** Strongest and most consistent wind power from the northern trade winds blow towards west-northwest, explaining the strategic location of the windfarm.
https://earthobservatory.nasa.gov/images/147527/capturing-wind-on-maui

Conclusion

The chaotic meteorological effects of windfarms from wake turbulence is significant. More intense wildfires in North America reported in recent years, are often in regions with installed wind turbine plants. Greece had a total of 2.9 GW capacity by 2018 on an area almost as small as the size of Tasmania, increasing rapidly by installing turbines on mountain ridges near Athens or on islands like Agios Georgios 20 kilometres offshore of Athens ports. Fires out of control in summer are now typical, having required human evacuations from islands such as Rhodes, or 100 deaths at Matis east of Athens in 2018. The potential contribution 0f wind turbines to these fire-prone conditions requires careful study.

Relatively little research on the effects of windfarms has been done, in comparison with the scale of windfarm introductions, a process driven by fear of climate change. Whether these impacts include major effects on local weather, such as generating thunderstorms, is undecided. However, the initiation of storms and the ability of turbulence to generate such convective conditions (Platis et al. 2018) is a necessary precondition. Management of these risks demands a response as diligent research, by investors in windfarms or regulators, to ensure the safer environmental placement of wind farms.

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