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Parsimonius regulations for wind turbine noise

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Summary

Overviews show that many countries have some form of regulation for wind turbine noise. These vary a lot on all essential ingredients like indicators, calculation and/or measurement methods, incentives, control mechanisms and more.
As over the past years more insight is gathered on the effects of wind turbine noise it may be possible to use the experiences with the existing regulations to build up an ideal regulation. Such a regulation is efficient, and regulates the problem with the least number of elements to avoid administrative burdens for operators as well as for the authorities. At the same it should be a fair and transparent system that protects the population from getting more than their share of the burdens that even sustainable energy sources may have. The paper details such a regulatory framework

1. Introduction

Although wind turbines are in use for many centuries to produce useful power, the development in size and number made a complete new phenomenon in society. It is no wonder that governments struggle to keep up with their regulations - not only for noise but also for safety and visual aspects. The pattern is that first general rules for industries are applied or old specific rules for wind turbines. When after a while complaints start to come from citizens that they are not sufficiently protected or from wind farmers that they are frustrated in building or operating their machines the administration adapt the rules. Apparently the easiest way is to repair perceived shortcomings, thereby often increasing the complexity.

As this happens everywhere a number of times, a bewildering number of different regulations for noise control has arisen. The overview by Fowler e.a (Fowler, Koppen, Matthis, 2013) describes 34 regulations, with very few overlap between them. In the next sections the differences and similarities are analyzed. Subsequently the question is which is the best way to regulate wind turbine noise. And to start with: how to rank regulations?

2. Elements of noise control in existing wind turbine noise regulations

The overview by Fowler e.a. quoted above is a good starting point for the discussion as it provides basic information for the different regulations. The purpose of this analysis is not (as in Fowler e.a.) to compare the different regulations but to get an impression of the elements used therein.

Indicators

LAeq is used in the majority of the regulations (28 out of 34), 3 use LA90, 2 use Lden, 1 Ldn, 1 Lnight, 1 Lp,LF and 1 uses LA50 (more than the number of regulations because some use more than 1 indicator).

Calculation basis

Most specify that the indicator is calculated over all wind speeds, 1 at 6 and 8 m/s, 1 at 8 m/s. The time base is often not specified. Only where Lden, Lnight and Ldn are used the averaging time is standardized on 1 year. In 2 cases an averaging time of 10 minutes is used (LA90, 10

minutes). In 7 cases day and night are treated separately, the others do not specify or integrate day and night (like in Lden and Ldn).
Background noise
In 10 cases the background noise plays a role in the regulation
Low frequency noise
In 2 cases a specific regulation for low frequency noise is in use
Tonal and impulse corrections are in force in 7 regulations, but it is not clear how often these are actually applied.
Limit values. Absolute limit values are the most used control mechanism. In 4 cases only the background noise is used to control the impact.

The present author can only share the conclusions from Fowler e.a that .... there is a wide range on how stringent a jurisdiction is when regulating noise from wind turbines..... And they did not explicitly take the differences in measuring and calculation methods into consideration, in which case the estimate of differences up to 20 dB in protection level would have been still higher.
However, there is virtually no - published - information on the effectiveness of these regulations

3. Quality criteria for wind turbine noise regulations

There are several guides for regulators, and doubtless about every nation has its own internal rules for designing good regulations. A nice example are the OECD(2005) "Principles for good regulation". This starts with a list of recommendations, which could be seen as quality criteria.

	OECD principles of good regulation
i	Serve clearly identified policy goals, and be effective in achieving those goals
ii	Have a sound legal and empirical basis
iii	Produce benefits that justify costs, considering the distribution of effects across society and taking economic, environmental and social effects into account
iv	Minimise costs and market distortions
v	Promote innovation through market incentives and goal-based approaches
vi	Be clear, simple and practical for users
vii	Be consistent with other regulations and policies
viii	Be compatible as far as possible with competition, trade and investment-facilitating principles at domestic and international levels

Much of these principles have to do with the process: identify policy goals, sound legal basis, cost/benefit analysis, and compatibility which will not be discussed here.
Important for the purpose of this paper are:
ii: sound empirical basis
iii: produce benefits that justify costs
vi: be clear, simple and practical for users
Translating this to wind turbine noise regulations it appears that they should be:
- based on evidence
- lead to a fair balance between costs and benefits
- the regulation must be easy to implement and transparent for the all the stakeholders.

4. Elements for a lean regulation

The elements that were found in section 2. are now evaluated on the basis of the criteria in section 3.

Indicator for noise.

The search for the best indicator lingers on for many years. The studies carried out so far have not resulted in a single candidate, but showed that the bulk of the indicators correlate very well between them. As the correlations between noise exposure and biological effects are modest at

best (for the best correlating effect - annoyance - correlation coefficients rarely exceed 0.4) it is not possible to prove the superiority of one indicator over another. The choice for an indicator can therefore be based on other considerations, like the availability of dose-effect relations, ease of calculation, and familiarity. As LAeq - measures are (based on) an ISO-standard and are used in many regulations already, this is an obvious starting point. There is evidence that different periods of the natural day may have different consequences. The most obvious is the night period which is mostly responsible for sleep disturbances. But also the evening period can be hold responsible for a more than an equal share in provoking annoyance reactions. Hence the weighted LAeq measures like Lden and Lnight. There is still much debate if Lnight is a good measure for sleep disturbance, but an alternative has not been proposed yet. As at present it is not sure if wind turbine noise cause sleep disturbance at all, there is much discussion if it necessary to introduce additional protection. Because of the finding that in wind turbines the levels for the different periods are highly correlated, night protection can also be achieved by a 365 day, 24 hr level.
Percentile measures are not a good choice: difficult to assess, no standardisation and no dose-effect relations.

Calculation basis.

ISO 1996-1 states merely that a reference time interval should be defined. For Leq measures it is suggested that long periods like 3 months, 6 months or a year may be used. In that case all contributions at any wind speed are to be taken into account. Very short or unspecified time bases lead to large uncertainties so should be avoided.
There is no good reason to use any particular wind speed to base the assessment on. It also complicates life for controllers and citizens.

Background noise

The use of background noise in regulations is to be avoided. It is usually low level and fluctuating depending on meteorological conditions, and there is no good definition for background noise. This makes it also hard to replicate, and a pain for those who have to control compliance. Probably because of this, any good studies on dose-response relations in interaction with background noise are missing. All good reasons to resist the temptation to base regulations on background noise. One should also realise that field studies take any normal background already into account so there is no reason to do it over again.

Low frequency noise

That sufficient low frequency noise is annoying is no surprise. But is it more annoying than can be expected on the basis of the A-weighted level? Many people think so, but actual proof is not very convincing. The few laboratory experiments do not show this (Vos(2010), Moorhouse(2005),von Hünerbein(2011)). Instead, these experiments show an increase due to amplitude modulated sounds, and wind turbine noise is one of the few examples in everyday life. As virtually all wind turbines now in use show this phenomenon, it is part of the dose-effect relations which at least for annoyance show a distinct excess reaction.

Tonal & impulse corrections

Modern wind turbines are well enough engineered to not producing tonal or impulse noises, so most of the time this would ineffective. Also in this case the evidence for tonal and impulse corrections is rather thin.

Limit values

Absolute limit values allow regulators to strike a balance between protection level and the amount of power generated. A low limit will permit less wind turbines to be build. With relative limit values (like the ones relating to background levels) the situation is less predictable.
There is little evidence for refinements in limit values with regard to residential situation or specific groups. The only group that stands out in the studies are the people with economic interest in the turbine (usually the owner). They report much less annoyance. Of course this may or may not extend to other effects (sleep disturbance, blood pressure) but the numbers are too small to study this. And it is unlikely that there will ever be sufficient numbers of highly exposed, given the low level of noise production from wind turbines.

Practical

One very important aspect in regulations is the control section. Many noise regulations rely on measurements as the sole method of verification of the limit values. That is complicated enough for most noise sources (good calculation is difficult, but good measurements even more), but for wind turbines with their low incident levels and wind speed dependence this is a long and labour intensive process.

5. Discussion

Designing regulations is a long and tedious process. As many parties are involved, it is inevitable that the regulations increase in complexity. It takes a lot of effort to check this tendency. Complexity is not named as a separate criterion by OECD, but "simple" hints clearly at complexity reduction. The less elements a regulation contains, the easier it becomes to implement. This may lead to conflicts in the design process, when more fairness can only be achieved by adding more factors to control for.
An interesting example is the discussing around protection of sleep from wind turbines in the 2012 Wind Turbine Noise Regulation in the Netherlands. In the original version only limits in Lden were proposed. There was insufficient evidence to warrant the introduction of separate indicator (and limit) for night time noise, so this was left out (after due deliberation). The Parliamentary Commission where this proposal was discussed however demanded on political grounds a separate night protection. As a result, the Lnight was taken up in the regulation, with a level which corresponded to the Lden limit value (5.5 dB lower) as no evidence was available for a different value. Of course afterwards the reactions were of a disappointed nature: the Lnight limit offered no improved protection. It seemed difficult to accept that this better protection could have been obtained by lowering the Lden limit value. Either way, this would have reduced the potential for wind turbines - which was politically unacceptable.
My impression is that the same process played a role in the Danish Low Frequency protection for wind turbines. It seems to offer no real additional protection, but may have served to address protests that this aspect was underestimated. But it definitely added a complication.

6. Conclusions

To paraphrase Einstein: wind turbine noise regulations should be as simple as possible - but not simpler than that. Overlooking the evidence and other requirements that means:
- 1 single noise indicator for all effects. Preferably LAeq based, and with a sufficient long time base (at least 3 months; year is fine).There is actually no evidence that in this particular case evening and night corrections improve the relation so a 24 hr level might work just as well. Using Lden has the advantage that a dose-response relationship is available.
- 1 single limit value for all uses, with perhaps an exemption for people with economic interest.
- Corrections for background noise, low frequency, tonal or impuls have no added value and complicate use in every day practice
- Compliance should be tested near the wind turbine where reliable measurements of the sound power are possible. A state of the art calculation model completes the chain between sound power and exposure. To avoid discussions, the wind speed on hub height should be the starting point of the calculation.

The only thing that is left for (to?) politicians is to make a sensible choice for the limit value. Too low gives great protection, but is bad for climate (and industry). Too high, and it will feed the feelings of abuse that already exists. Who said that politics is simple?

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