IEA Task 41: D1.2 for DK(EUDP) justification for changes to standards regarding distributed wind

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IEA Task 41: Denmark D1.2 for EUDP
justification for changes to standards

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Preface

This report fulfils Deliverable 1.2 (from work package 1) for the EUDP-funded Danish component of IEA Wind Task 41. It was originally scoped to address “technical justification of proposed changes to the standards” around distributed wind. As mentioned in the report, this scope has fortunately narrowed due to international collaboration across the IEA task groups, and parallel reported works driven in part by the Danish contributions.

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Content

1. Introduction

A previous report by Kelly *et al*. (2021), driven and supported by the IEA Wind Task 41, identified issues in the (IEC) standards and gave recommendations on potential standards changes for distributed wind. These were mostly related to turbine classification, testing, and operational conditions, without much consideration of grid-related or electrical aspects; the latter were considered separately.

The first and most extensive recommendation was to update the turbine classification scheme, in order to accommodate different sizes and types in a fair manner; the second and other recommendations also relate to this and/or follow from it. A table of the recommendations from Kelly *et al*. (2021) follows. Note that some recommendations did not directly involve the standards, but rather outlined required research and developments towards improvement of standards; these are denoted in *gray italic* text.

1. Update the turbine classifications to fairly address different sizes and types.
2. Change certification and testing requirements, per appropriate turbine classes and types.
3. Re-specify a conformity assessment framework, since IEC 61400-22 was dissolved.
4. Adapt/revise aeroelastic models for DW, validate them, provide methodology.
5. Add annex to 61400-13 for loads testing and characterization.
6. Turbulence prescription, characterization, and classes
7. Informative amendment to 61400-2 on performance and conditions (reporting power curves).
8. Informative supplement/annex to 61400-2 on tower dynamics/interaction.
9. Update the Simplified Loads Model (SLM), adapt for VAWTs and microturbines.
10. Simplification of 61400-11 (§F.5) on acoustic/noise testing.

Table 1: list of recommendations identified in IEA Wind Task 41.

2. Status of standards at end of 2022

Much of the change recommended in the earlier IEA Task 41 report (Kelly *et al*., 2021) have been implemented within the new American Clean Power (ACP) standard SWT-1, an IECRE operational document (OD-554-1), and some are also within the revision drafts for the upcoming 61400-2 update. A report by Summerville *et al*. (2021) has already given justification for the updates to the SWT-1 (also known as the ACP 101-1). Therefore, much of the technical justification needed to achieve the recommended updates has been essentially superseded by the latter report and/or through most recommended updates having been implemented. However, for the implemented (or in-process) updates, ongoing justification can be accomplished through continued research, as outlined e.g. in Kelly *et al*. (2021) on research needed towards improvement of the standards covering small wind turbines. Further justification for unimplemented recommendations follows in the next subsection.

2.1 Technical justifications for updates that are yet to be implemented

As done in the NREL report on the ACP's SWT-1 (ANSI standard) by Summerville *et al*. (2021), it is useful to separate conformity assessment from technical requirements. Conformity assessment for small turbines, previously covered by the IEC 61400-22 (which was rescinded) has been updated via the IECRE operational document OD-554-1 (starting 2021); this also provides some type certification.

As for technical justifications, the recommendations remaining to be implemented—for which technical justification should be provided—include aeroelastic model usage, loads testing and characterization, turbulence characterization & classification, performance testing, tower-turbine dynamics & interaction, simplified loads model (SLM) updating.

2.1.1 Aeroelastic modelling and loads testing/characterization

The ACP 101-1 (2021) standard gave turbine subcategories (below 1 kW, 1–30 kW, 30–65 kW, and 65–150 kW), with no aeroelastic modelling needed for micro turbines (<1 kW) and increasing modelling requirements for the progressively larger subcategories. Similarly, smaller turbines were exempted from loads testing by the ACP 101-1. However, for non-HAWT topologies there is still a lack of specification or justification, as well as lack of validated modelling software — requiring more research.

2.1.2 Turbulence characterization & classification

In addition to the technical findings of IEA Wind Task 27, Summerville *et al*. (2021) note turbine test measurement environments having higher turbulence intensities than prescribed by the IEC 61400-2. Further, the work of Kelly (2020) gives some technical details of what is needed to estimate atmospheric turbulence over complex terrain; however, this needs to be harmonized with works such as Nagel *et al*. (2023) for urban obstacle-induced turbulence to give more detailed justification. I.e., the effects of atmospheric stability and interaction of background turbulence with the local surfaces needs to be considered, in a way that allows better estimation of the turbulent environment considered for a small turbine—guiding where and what measurements should be taken.

Generally, universal characterization of the local turbine environment (with obstacles) is still lacking, but this is the subject continuing proposed study through the next IEA Wind Task 41 cycle. Further, classification of turbines including size-dependence (due to e.g. turbulence length scale) is an ongoing subject of research, with yet more measurements needing to be made and analyzed across different turbine sites.

2.1.3 Performance testing

As noted in Summerville *et al*. (2021), regarding performance the key metric for classification of distributed wind turbines was recognized by the ACP 101-1 (2021) standard to be peak power; this contrasts with the old metric of rotor size (swept area). Justification for this was given that peak power is an indicator for mechanical and electrical design, and because some newer technologies include lower specific power per swept area. In regards to performance, Summerville *et al*. (2021) recommended removal and reduction of various IEC 61400-2 requirements, based on consideration of 31 commercial turbine tests collected and re-analyzed. Based on the observed failure rates for the aforementioned tests, reduced hours of power production (2500 to 1000) were recommended; producing power for at least 250 hours in winds 20% higher than average was deduced to not be a driver for wind turbine test failure, and thus should be dropped as a requirement; power production at 1.8 times average speed was recommended to be reduced from 25 to 10 hours[1], due to the length of time needed to capture such strong winds, and similarly the requirement for normal operation at $2.2V_{ave}$ was recommended to be dropped.

2.1.4 Tower-turbine dynamics & interaction

As guidance the IECRE OD-554-1 suggests analysis/checking for critical blade deflection and dynamic analysis of the tower, with a type certificate covering one turbine type and tower design. Justification for this has followed that used for establishment of the 61400-1.

2.1.5 Simplified loads model (SLM) updates

The ACP 101-1 dropped the requirement for loads analysis on microturbines (<1 kW peak power), discouraged its use for turbines with P_{peak}<10 kW, and disallows SLM for turbines rated at more than 30 kW peak power. Technical justification is at least two-fold: the SLM does not appropriately characterize fatigue loads for larger models, and is at the same time conservative to the extent that it requires heavier components; further, it is not adapted for VAWT and other turbine topologies.

[1] With an additional 3 years of surveillance to track operation, for post-certification follow-up.

3. From 2023 and beyond

Driven by the earlier IEA Wind Task 41 work and ACP 101-1 standard (ANSI update), the formalization of the IECRE operational document OD-554-1 along with the fourth edition update of the IEC 61400-2 will address a number challenges identified. More work is needed through continuation of this IEA Wind task in order to continue collecting and developing technical justification for standards updates and finding the optimal updates. The Task 41 extension proposal includes in particular work from Denmark towards technical justification and recommendations for turbulence and its characterization.

In the 2023 Danish shareholders workshop it was further identified that more work is needed connecting small turbine manufacturers and technical students (e.g. master's-level), including exploration of turbine performance, testing, loads, and tower-turbine dynamics. This will be fostered, hopefully, by continued EUDP funding of the Danish part of Task 41 (proposal under way).

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