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WtG Guideline for the Assessment of Wind Comfort in urban Areas

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SUMMARY:
The wind-technological society for Germany, Austria, and Switzerland, WtG (Windtechnologische Gesellschaft) maintains three standing committees on building aerodynamics, wind comfort, and numerical methods. Each committee is currently preparing or updating individual guidelines on these fields. This paper presents the results from committee II on the guideline for the assessment of wind comfort in urban areas for which basic outlines and considerations were presented on the ICWE in 2019. Main focus has been throughout the entire process the target group of German-language practitioners, to whom the state of the art in this field shall be conveyed. Internationally seen, the presented guideline is not the first to describe background and evaluation criteria for the investigation of human wind comfort in cities. With the first concepts emerging in the 1970's, criteria have changed over time and vary in format. Where it was before important to give the investigating expert a scientifically sound approach for wind comfort assessment, it is today maybe even more important to help the practitioners navigating through the spectrum of existing recommendations. On this background, the purpose of the WtG guideline is besides providing the actual criterion, the context of its applicability and comparability to other internally renowned guidelines.

Keywords: Wind comfort, assessment guideline, context and comparison

1. INTRODUCTION

It is a fair assumption that local climatic conditions have always played a role in city planning and in the perception of urban environments throughout human history. Maybe not ranging as a top priority, but the urban microclimate is frequently used as a quality measure for settlements and inner city open space between buildings. For the city of Kahun hot winds from the desert and pleasant winds from the north were mentioned as background factors for residential preferences about 2000 BCE (Aynsley, Melbourne and Vickery, 1977). Aristotle related the healthiness of a city to its topographic orientation (Aristotle, 350 BCE). Such considerations are inseparably connected to city planning and living quality. With the advent of large cities and the need of heating with fire places, oven or stoves air pollution became a significant problem. In search for solutions, Edme Mariotte (1686) made some first documented attempts to study and understand the smoke dispersion from domestic fire heating in the urban environment. The industrial revolution in the 19th century aggravated air pollution even further driving the development of better concepts for future cities such as the "Garden City" by Ebenezer Howard (1902), the controversial design of the "Radiant City" by Le Corbusier (1930), or "Broadacre City" by Frank Lloyd Wright (1934).

The notion that a well-designed urban microclimate is not only a luxury commodity of comfort experience but also is essential to societal health and productivity, lead to Olgay's publication on "Design with Climate bioclimatic approach to architectural regionalism" in 1963. In aftermath of the 2019 COVID pandemic, the UN Sustainability Development Goal, SDG11, on sustainable cities and communities included the importance of open urban spaces as a key factor for societal health and economic resilience. Understanding the importance of a good urban environment and the demand for sustainable and resilient design poses a difficult task to the city planner since those requirements do not include the approach on how to deal with them. Today, a variety of advanced simulation tools are available to determine many parameters of the urban microclimate as a sub-aspect of the urban environment such as the airflow characteristic between buildings, gas dispersion processes, sun radiation, air temperature and humidity for given boundary conditions. With each parameter, the simulation complexity increases and even if manageable with the most advanced modelling technology, the results need to be translated for practical application by comprehensive yet clear and reliable evaluation criteria. Amongst all parameters, the wind is considered as the main driver for climatic impact on humans in urban areas. Readily available data on occurrence probabilities of wind speeds and directions allow for seasonal or all-year assessment of the local wind conditions and evaluation against comfort criteria. First assessment methods appeared in the early 70ies (e.g. *Canada*: Davenport 1972; *UK*: Penwarden 1973, Hunt et al. 1976; *France*: Gandemer 1975; *Australia*: Melbourne 1978), which in the following decades were copied, varied and adapted for practical application. Due to the growing number of derivations and local adaptions, comparison studies are frequently conducted to provide some structured overview (Ratcliff and Peterka, 1990; Koss, 2006) or to summarize and recommend specific approaches (Blocken and Carmeliet, 2004), just to name some few examples. Wind action on humans in urban areas can produce dangerous situations but in general, the aspect of urban climate and city planning is considered as a question of comfort rather than of safety. Hence, attempts to harmonise approaches are not associated to the same urgency as safety-related aspects such as wind load for construction design and regulation is left to consensus in the academic and commercial Wind Engineering community. This imposes following challenges for practical application:

1. The evolution in wind comfort assessment has led to a large diversity of evaluation criteria. Most of them, if not all, have been calibrated to real life experience and are hence valid – at least for cases similar to the reference cases used for calibration.
2. There is no clear evidence for which criterion is better or superior to others. There is no transparency with respect to comparability.
3. Limited distribution of information surrounding the assessment criteria to practitioners.

The communication between academia, industry and practice in general is a core concern of the WtG and their guidelines shall serve this purpose. Apart from recommending a uniform set of criteria, the guideline shall also provide clarity about the analysis procedure, key aspects of simulation method (aided by the WtG guidelines on wind tunnel and numerical simulation), and the comparability to other internationally established guidelines.

2. STRUCTURE AND CONTENT OF GUIDELINE

2.1. Structure

The guideline intends to provide necessary and useful information for both expert and non-expert in the field of wind studies in the urban environment. With that, it combines general considerations and explanatory sections on topics such as the wind flow in urban areas and the link to the local wind climate with its statistical description and more detailed recommendations for the investigating expert such as the height of measurement points over ground and the transfer of climate data from a meteorological observation station to the location of interest. As mentioned above, it is a key interest to present the entire material accessible for non-experts. Illustrations, graphs and examples shall make the process of a wind comfort study, its capabilities and limits transparent and understandable. The general structure of the guideline is:

1. **Introduction** (area of application; relation to other regulations; prerequisites; terms and abbreviations)
2. **Necessity of Investigation** (wind around buildings; necessity; levels of investigation; requirements to simulations; description of gustiness)
3. **Comfort Assessment** (general concept; required information; annoyance due to wind; wind danger; comfort criteria; comparison to other criteria)
4. **Wind Climate** (atmospheric wind; climate data; transfer of climate data to location of interest)
5. **Investigation** (preparation; wind tunnel testing; numerical simulation (CFD); probability; documentation of results)
6. **References**
7. **Glossary**

2.2. Comfort Criteria

The WtG guideline offers two sets of assessment criteria to the user: the mean wind speed based criterion of the NEN 8100 and a gust wind speed based criterion after Gandemer (1975, 1978), each addressing four situations: three comfort related pedestrian activities and one regarding wind danger. For application guidance it is stated that both methods will produce similar but not identical results and that the selection of criterion may depend on the choice of simulation method. Table 1 lists the key information regarding the limit wind speed, U_{lim}, used in these criteria to evaluate the probability of comfort level and danger. The detailed description will be in the full-length paper.

Table 1. Limit wind speeds used in the comfort criteria to evaluate the probability of exceedance as basis for comfort level assessment.

Importance	Comfort			Danger
Pedestrian activity	sitting	walking, strolling	brisk walking	
Mean wind speed criterion (NEN 8100)				
U_{lim}	5 m/s	5 m/s	5 m/s	15 m/s
Gust wind speed criterion (Gandemer, 1975, 1978)				
U_{lim}	6 m/s	6 m/s	6 m/s	23 m/s
g	1.0	1.0	1.0	3.5

2.3. Comparison of criteria

Since the wind comfort assessment is based on the combination of probabilities regarding overall wind direction and speed and their relation to the local turbulent airflow at pedestrian height, the similarity and difference of the criteria will be discussed using data of real local wind speeds obtained in field measurements in the inner city of Copenhagen. Figure 1 shows an example of the illustrations and graphs used in the guideline. The time histories of the local wind speeds $U_{L,1}$ and $U_{L,2}$ are real, the depicted case is fictional. This comparison will be part of the full-length paper.

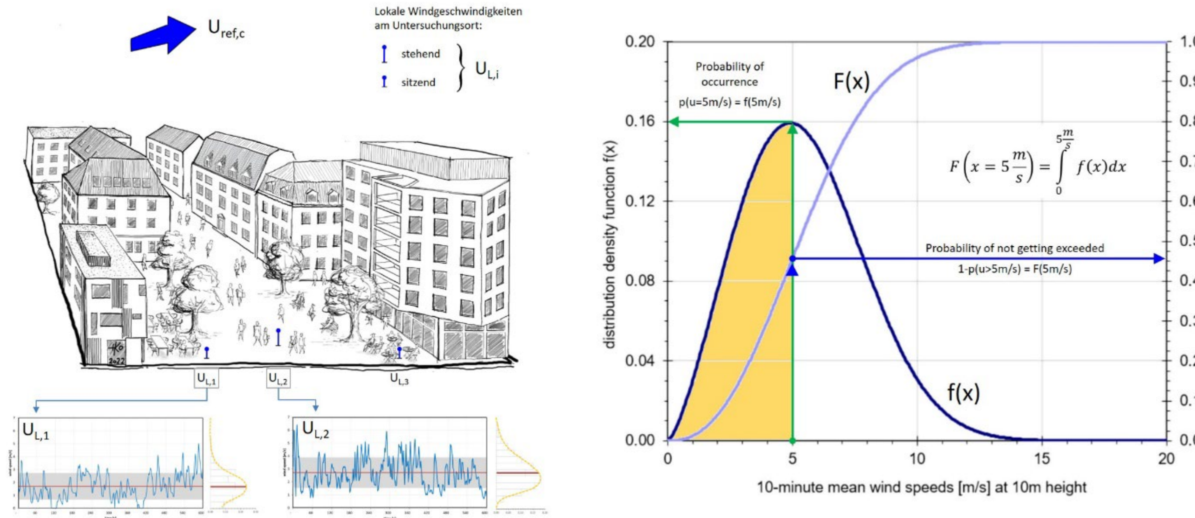

Figure 1. Examples of illustration and graphs in the WtG guideline to explain and clarify the definition of wind parameters, measurement locations, flow characteristics, and statistical description.

3. OUTLOOK

The main contribution of this guideline is the attempt to clarify key aspects and necessary assumptions to conduct a wind comfort study to both, the practitioner and the expert. Especially the relation of the recommended criteria to other criteria plays a central role for practical application. These and other aspects will be discussed in detail in the full-length paper.

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