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Adaptation to climate change - Guidelines on using climate data in infrastructure standards

Anpassung an die Folgen des Klimawandels - Leitlinien zur Verwendung von Klimadaten in Infrastrukturstandards

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Adaptation to climate change - Guidelines on using climate data in infrastructure standards

Anpassung an die Folgen des Klimawandels - Leitlinien zur Verwendung von Klimadaten in Infrastrukturstandards

This draft Technical Report is submitted to CEN members for Vote. It has been drawn up by the Technical Committee CEN/TC 467.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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European foreword

This document (FprCEN/TR 18365:2026) has been prepared by Technical Committee CEN/TC 467 Climate Change, the secretariat of which is held by UNI.

This document is currently submitted to the Vote on TR.

Introduction

The increase in damage caused by climate change as well as the geopolitical and security landscape, is forcing Europeans to ask not only how climate change will affect future generations but also what we must prepare for today. This involves possible disruptions to the economy, the supply chain, and society, underscoring the significance of coordinated and common EU efforts to tackle these issues. As stated by Special Adviser Niinistö in the report "Safer together: a path towards a fully prepared Union", the EU's preparedness is urgent, and we need to awaken to a new, unstable reality [1].

The World Economic Forum estimates that climate change impacts are likely to cause 14,5 million more deaths and $12,5 trillion in economic losses worldwide by 2050, as projections indicate higher morbidity and mortality from climate-intensified natural disasters [2]. Exposure to global warming of 3°C above preindustrial levels would result in an annual wellfare loss in the EU of 175 billion EUR, 1,38% of the EU Gross domestic product (GDP) [3]. The Copernicus Climate Change Service reported that 2024 is the first year to exceed 1,5°C above pre-industrial level, with a high increase in extreme temperatures [4]. Climate change mitigation-related legislation and regulation initiatives addressing climate change have therefore steadily increased over the past few years, as noted in the assessment by the Intergovernmental Panel on Climate Change [5].

There is scientific consensus that climate change is happening and humans are the cause. The extent of climate change that we can expect will be a result of how effective we are at climate change mitigation through reducing our emissions and removing carbon (or equivalent) from our atmosphere. Not knowing how effective we will be at doing so creates considerable uncertainty about what we can expect. In addition, given the time lag between emissions and impacts, there is a need to adapt to the inevitable future climate change that is already locked in or "committed" resulting from past emissions. This uncertainty is a product of the complexities in predicting how the climate and earth's eco-systems will react, as well as predicting the extent to which human behaviours will be able to respond (both in reducing carbon in the atmosphere, and in developing adaptation measures).

In terms of infrastructure and the built environment, rapid changes in climate as evidenced in recent years and long infrastructure life-cycles means that infrastructure operators, owners and designers will need to consider projected climate data in standards. It can seem difficult for users of standards to find and use practical and reliable data about future climate conditions. Additionally, climate data that can be sourced are not necessarily aligned to the needs of the standardization sector or the intended end users. However, those working on standards are already very familiar with ensuring weather risks have been considered appropriately. Climate change brings a different dimension to this.

Users of this Technical Report can gain a level of understanding about what is available in terms of climate data, and how to use these data to design, operate and maintain infrastructure in a safe, climate-resilient way. The Technical Report permits informed choices to be made by infrastructure owners, designers, operators and maintainers as to whether they need to engage specialist expertise at any stage of the infrastructure life-cycle, such as:

— Climate adaptation infrastructure experts;

— Climate data providers;

— Meteorological service providers;

— Climate service providers.

In any case, those that commission such expert services ought to assure themselves that service providers are competent in the expert area chosen.

This Technical Report has ten principal areas set out in the main body. They are as follows:

— Policy and standardization frameworks;

— Other standardization deliverables;

- How climate data are used in standards;
- Hazard data;
- Data sources;
- Flexibility concerning data;
- Addressing impacts and risks.

1 Scope

This document specifies what climate data from climate projections are and where to find relevant climate data suited for infrastructure climate adaptation and resilience-building needs. This document gives support to both standards users and standards writers (with the emphasis on the former) whether detailed climate data and information is specified in a standard, such as in a National Annex, or the standard requires the user to determine relevant climate data and information as a separate exercise. This document is relevant to all climate system data. Users of this Technical Report can also find this document helpful in dealing with derived climate system data, e.g. atmospheric pollution, flooding, ground water levels, wave heights. In addition, guidance is provided for designers of cross-border infrastructure systems, for example on the harmonisation of climate data used.

This document is intended for infrastructure owners, designers, operators and maintainers and staff of central/ regional authorities who are responsible for infrastructure within countries that are associated with CEN/CENELEC. Users includes the national standards' bodies and authorities who will be responsible for the use of climate data in national annexes to standards.

The document does not define or prescribe the broader climate service delivery process, co-production methodologies, or stakeholder engagement practices.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

— ISO Online browsing platform: available at http://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
climate
statistical description of weather in terms of the mean and variability of relevant quantities over a period of time ranging from months to thousands or millions of years

Note 1 to entry: The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization.

Note 2 to entry: The relevant quantities are most often near-surface variables such as temperature, precipitation and wind.

[SOURCE: EN ISO 14090:2019 [6], Definition 3.4]

3.2
climatic action map
representation of an area providing the characteristic values of climatic actions to be used for structural design

Note 1 to entry: According to the definition in EN 1990-1:2023+A1:2026 [7] , characteristic values of climatic actions are based upon a 2% probability that its time-varying part is exceeded during a one-year reference period.

3.3
weather
state of the atmosphere at a particular time, as defined by the various meteorological elements, including temperature, precipitation, atmospheric pressure, wind and humidity

3.4
climate change
change in *climate* (3.1) that persists for an extended period, typically decades or longer

Note 1 to entry: Climate change can be identified by such means as statistical tests (e.g. on changes in the mean, variability).

Note 2 to entry: Climate change might be due to natural processes, internal to the climate system, or external forcing such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use.

[SOURCE: EN ISO 14090:2019 [6], Definition 3.5]

3.5
climate model
qualitative or quantitative representation of the *climate system* (3.6) based on the physical, chemical and biological properties of its components, their interactions and feedback processes and accounting for some of its known properties

[SOURCE: IPCC, 2021: Annex VII: Glossary [8]]

3.6
climate system
global system consisting of five major components: the atmosphere, the hydrosphere, the cryosphere, the lithosphere and the biosphere and the interactions between them

[SOURCE: IPCC, 2021: Annex VII: Glossary [8]]

3.7
climate projection
simulated response of the *climate system* (3.6) to a scenario of future emissions or concentrations of greenhouse gases (GHGs) and aerosols and changes in land use, generally derived using *climate models* (3.5)

[SOURCE: IPCC, 2021: Annex VII: Glossary [8]]

3.8
climate change mitigation
human intervention to reduce emissions or enhance the sinks of greenhouse gases

Note 1 to entry: Regardless of the efforts to mitigate climate change, Europe's future will see a notably altered and potentially very different climate. The effects of climate change are already occurring, advancing faster than projected, and are expected to increase in both frequency and magnitude.

[SOURCE: IPCC, 2021: Annex VII: Glossary [8]]

3.9
climate change adaptation
process of adjustment to actual or expected climate and its effects

[SOURCE: EN ISO 14090:2019 [6], Definition 3.1]

3.10
risk
effect of uncertainty

Note 1 to entry: An effect is a deviation from the expected. It can be positive, negative or both. An effect can arise as a result of a response, or failure to respond, to an opportunity or to a threat related to objectives.

Note 2 to entry: Uncertainty is the state, even partial, of deficiency of information related to, understanding or knowledge of, an event, its consequence, or likelihood.

[SOURCE: EN ISO 14091:2021 [9], Definition 3.13]

3.11
impact
effect on natural and human systems

Note 1 to entry: In the context of *climate change* (3.4), the term "impact" is used primarily to refer to the effects on natural and human systems of extreme weather and climate events and of climate change. Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services and infrastructure due to the interaction of climate change or hazardous climate events occurring within a specific time period and the *vulnerability* (3.12) of an exposed society or system. Impacts are also referred to as consequences and outcomes. The impacts of climate change on geophysical systems, including floods, droughts and sea level rise, are a subset of impacts called "physical impacts".

[SOURCE: EN ISO 14090:2019 [6], Definition 3.8]

3.12
vulnerability
propensity or predisposition to be adversely affected

Note 1 to entry: Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

[SOURCE: EN ISO 14090:2019 [6], Definition 3.15]

3.13
hazard
potential source of harm

Note 1 to entry: The potential for harm can be in terms of loss of life, injury or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems and environmental resources.

Note 2 to entry: In this document, the term usually refers to climate-related physical events or trends or their physical impacts.

Note 3 to entry: Hazard comprises slow-onset developments (e.g. rising temperatures over the long term) as well as rapidly developing climatic extremes (e.g. a heatwave or a landslide) or increased variability.

[SOURCE: EN ISO 14090:2019 [6], Definition 3.7]

4 Policy and standardization frameworks

4.1 General

The construction ecosystem is central to the European Union's (EU) strategic goals, underpinning societal wellbeing and economic resilience. As detailed in Annex A, the EU's response to escalating climate risks involves multiple initiatives to integrate climate adaptation into buildings and infrastructure. The European Green Deal and the legally binding European Climate Law set the framework for achieving climate neutrality by 2050, mandating Member States to reduce vulnerabilities and build adaptive capacity. The EU Adaptation Strategy highlights the need for climate-resilient infrastructure, updated standards, and risk-aware spatial planning.

Complementary initiatives include the EU Missions on Climate Adaptation, aiming to support 150 regions in becoming climate-resilient by 2030, and the New European Bauhaus, which promotes sustainable, inclusive, and aesthetic solutions.

The European Climate Risk Assessment (EUCRA) provides a comprehensive assessment of the major climate risks facing Europe today and in the future. It identifies major 36 climate risks that threaten our energy and food security, ecosystems, infrastructure, water resources, financial systems, and people's health. The report also seeks to help identify priorities for future adaptation-related investments and provide an EU-wide point of reference for assessing climate threats, urging climate-proof designs change related risks and updated standards. The revised Construction Products Regulation of 2024 facilitates sustainability while easing burdens on SMEs. Infrastructure-specific strategies such as the TEN-T Regulation and the Critical Entities Resilience Directive integrate climate risk and adaptation into trans-European networks.

Standardization plays a key role in achieving a climate neutral, resilient and circular economy in the context of infrastructure and the built environment, with the Eurocodes forming the backbone of EU construction safety standards. Updated guidance will mandate the integration of future climate data into infrastructure design. Research by the Joint Research Centre of the European Commission support the uptake of climate adaptation into standardization for the built environment by elaborating pilot studies on climatic loading trends on structures and on adverse phenomena triggered by the climate change. Results highlight the need to update the climatic loading for structural design in Europe and address climate-change induced corrosion. These coordinated efforts, underpinned by the European Preparedness Union Strategy and the EU Strategic Agenda 2024–2029, affirm the EU's commitment to building a climate-resilient built environment.

4.2 Structural Eurocodes

The Structural Eurocodes (often referred to as 'Eurocodes') are a series of 10 European Standards, EN 1990, EN 1991 to EN 1999, providing a common approach for the design of buildings and other civil engineering works and construction products. The European Commission has supported, from the very beginning in 1975, the development and elaboration of the Eurocodes, and contributed to the funding of their drafting. The publication of the Eurocodes by CEN in May 2007 marked a major milestone in the European standardization for the construction sector, since the Eurocodes introduced common technical rules for calculating the mechanical and fire resistance, and the stability of constructions and construction products. The Eurocodes are also distinguished as a tool for accelerating the process of convergence of different national and regional regulatory approaches. In the Commission Recommendation 2003/887/EC2 on the implementation and use of Eurocodes for construction works and structural construction products, the European Commission recommends that Member States:

— Adopt the Eurocodes as a suitable tool for designing construction works, checking them mechanical resistance of components, or checking the stability of structures.

— Refer to the Eurocodes in their national provisions for conformity assessment.

In fact, the Eurocodes are the recommended means of giving a presumption of conformity with the basic requirements of the Construction Products Regulation (CPR) for construction works and products that bear the CE Marking, in particular the Basic Requirements "Mechanical resistance and stability" and "Safety in case of fire". The objective of the CPR is to achieve the proper functioning of the internal market for construction products by establishing harmonized rules on how to express their performance. In addition, the Eurocodes are the preferred reference for technical specifications in public work contracts in the EU and EFTA countries. Voluntary application of standards is one of the founding principles of the European Standardization. However, the national legislative provisions can refer to standards making the compliance with them compulsory. Thus, in relation to the implementation procedure of the Eurocodes Parts, it is important to stress that the regulatory environment in each country is very important. In the different regulatory environments, the national regulations either refer to standards – thus making the compliance with them compulsory – or introduce directly a set of design rules. In the latter case, no National Standards exist, and hence there is no need to withdraw conflicting standards. Contrary, there are countries where the rules for structural design are enforced by legislative acts, i.e., national regulations.

An enquiry performed by the European Commission in 2014 to 2015 aiming to establish the state of implementation of the Eurocodes in the EU Member States in their specific regulatory and standardization environment, and their place in Public Procurement, showed that the Eurocodes were already accepted as National Standards in the EU Member States by that period [10]. In more than half of the analyzed countries, the National legislative provisions referred to standards and, in many cases, made compliance with them compulsory. The enquiry clearly showed two main approaches in the national implementation of the Eurocodes: as voluntary National Standards and via a Regulatory Framework, which encompasses different number of Parts in the different countries. Furthermore, more than a half of the analyzed countries reported a good place of the Eurocodes in Public Procurement at a national level. The Eurocodes recognize the responsibility of regulatory authorities in each Member State and have safeguarded their right to determine values related to regulatory safety matters at a national level. The National Standard transposing the Eurocode Part, when published by a National Standards Body, is composed of the Eurocode text (preceded by a National Title page and by a National Foreword), generally followed by a National Annex (NA) that contains the Nationally Determined Parameters (NDPs) to a given Eurocode part. The Eurocodes provide minimum requirements and National Annexes can give additional requirements and recommendations. It is worth underlining the role of the National Standards Bodies of the countries implementing the Eurocodes which are responsible for setting up the NDPs values and publishing the National Annexes, on behalf of and with the agreement of the national competent authorities. Currently, EN 1991 Actions on structures contains 127 NDPs relevant for the definition of the climatic actions in the Eurocodes. The concerned NDPs are present in three parts of EN 1991, namely parts 1-3 General Actions – Snow loads, 1-4 – General Actions – Wind actions and 1-5 General Actions – Thermal actions. Examples of NDPs related for the definition of the climatic actions in the Eurocodes are maps of the characteristic value of snow load on the ground (snow load maps), maps for the fundamental value of the basic wind velocity (wind maps) and maps of annual minimum and annual maximum shade air temperature (thermal maps).]

4.3 Second Generation of Structural Eurocodes

In 2012, the European Commission issued the Mandate M/515 for amending existing Eurocodes and extending the scope of structural Eurocodes. In 2014, CEN/TC 250 on Structural Eurocodes embarked on a large-scale project anticipated to last six years or longer to answer the request of Mandate M/515, which is leading to the development of the second generation of the structural Eurocodes. CEN/TC 250 successfully completed the largest Standardization Request under M/515 at the end of 2022, and the definitive text of the second generation of the structural Eurocodes parts approved by formal vote, will be available for National Standard Bodies no later than 30 March 2026. The date of publication for all 2G Eurocode parts will be for all the 30 September 2027.

The Mandate M/515 recognised climate change effects as a key aspect for structural design, to be embraced within the second generation of the structural Eurocodes with the aim to increase resilience of long-life infrastructure assets. An Ad Hoc Group (AHG) "Climate Change" was established by CEN/TC 250 in 2020 to elaborate a common approach to cover climate change impact across EN 1991 parts related to climatic actions. The AHG developed a set of recommendations based on the latest available research outcomes, clarifying that current climatic action maps or other guidance didn't cover climate change and proposing the use of the factors of change. The above recommendations were approved by CEN/TC 250 and passed to its Sub-Committee 1 to be implemented in the climatic action standards.

The treatment of climate change was thus included in the second generation of the structural Eurocodes parts related to climatic actions by introducing the factor of change approach as the default method. This method consists of applying a scaling or delta factor to the characteristic values of the action given by the code, and can be adopted, further detailed or modified by the CEN member states. Factors of change to address the impact of a changing climate are introduced in the second generation of the Structural Eurocodes final drafts of EN 1991-1-3 [11] for ground snow loads, EN 1991-1-4 [12] for fundamental basic wind velocity, EN 1991-1-5 [13] for maximum and minimum shade air temperature, and in EN 1991-1-9 [14] for atmospheric icing. These parts of EN 1991 include a clause with additional project-specific requirements to account for the effects of climate change which can be specified by the relevant authority or agreed upon by relevant parties for specific projects. At the time of publication of this document, these EN standards have not yet been published by the national standardization bodies.

The second generation of Structural Eurocodes, and more in detail EN 1990-1:2023+A1:2026 [7] ,include specific requirements for providing sufficient levels of robustness to structures designed according to the Eurocodes. EN 1990-1:2023+A1:2026 [7] in paragraph 4.4 states: “*A structure should be designed to have an adequate level of robustness so that, during its design service life it will not be damaged by unforeseen adverse events, such as the failure or collapse of a structural member or part of a structure, to an extent disproportionate to the original cause.*”. Climate change related effects on structures can be interpreted as “*unforeseen adverse events*” due to the uncertainties in their quantification, therefore provisions in the Eurocodes to provide robustness are carefully considered.

Further guidance on the achievement of adequate level of robustness is given in the informative Annex E to EN 1990-1:2023+A1:2026 [7] , and more detailed guidance is expected to be given in the National Annexes to the Eurocodes. CEN member states are thus invited to consider a detailed implementation framework at national level of robustness provisions also in view of the limitation of the impact of climate related adverse events.

5 Other standardization deliverables

European Standards have historically been developed through the European Committee for Standardization (CEN) and the European Committee for Electrotechnical Standardization (CENELEC) in response to mandates issued by the European Commission. In 2012, the European Commission issued for example Mandate M/526 to enhance climate resilience by emphasizing alignment with EU policies such as the Green Deal and climate adaptation, integrating new knowledge and technologies, and incorporating safety, resilience, and sustainability into energy, transport, and the built environment. These mandates are driven by regulatory or policy objectives, such as harmonising the internal market or addressing societal challenges like climate change.

Key milestones in their development include:

— 1980s–1990s: Concentration on harmonizing product and safety standards to support the Single Market.

— 2000s–2010s: Growing emphasis on sustainability, performance-based design, and digitalisation, such as Building Information Modeling (BIM).

— Post-2010s: Transition towards resilience, lifecycle thinking, and alignment with climate adaptation and mitigation goals.

Additionally, 'other standards' encompass any written instruction, rule, specification, or guideline not drafted by national standards bodies like NSBs or CEN/CENELEC. They can be drafted internally by an organization for their own specific use or for application across a sector or industry. Examples of organizations that draft their own standards and codes of practice are given in Annex B. The standards can be drafted by consensus across a wide set of stakeholders and can be imposed or applied voluntarily or they can be issued without agreement. Such documents can apply to supply chains and be written to contracts.

Other standards can refer to climate data or processed climate data, e.g. return periods for flood risk and drainage assessments, heat thresholds for buildings, wind speed limits for safe operation of airport equipment and durability specifications for cabling. Standards' users can wish to familiarise themselves with the methodologies used to derive such data. These other standards would benefit from adopting the counsel offered in this Technical Report.

In addition, organizations like ISO, IEC, ITU, and ASHRAE develop essential global standards for infrastructure, covering areas such as construction, energy systems, and smart technologies. National bodies such as UNE (Spain), BSI (UK), and DIN (Germany) typically adopt or adapt these international standards, ensuring alignment with local regulations while maintaining global consistency. NSBs would:

a) Directly adopt international standards as national standards;

b) Adapt them with modifications for local relevance; or,

c) Translate and harmonize them to ensure consistency with national legislation.

This process ensures technical coherence, supports international interoperability, and promotes global best practices in infrastructure development.

6 How climate data are used in standards

6.1 General

Climate and weather data are crucial for implementing standards related to climate impacts. Research conducted during the preparation of this Technical Report identified three common approaches employed by standards writers:

— Climate and weather data are featured in the standard;

— Standards' users are required to source relevant data;

— Standards set thresholds that are not affected by the climate.

These approaches are described further below.

6.2 Climate and weather information are featured in standards

The second generation of Structural Eurocodes promote the method of featuring climate and weather information in standard, specifying climate criteria for infrastructure designers to adhere to. The criteria relate to variables directly computed by climate models such as temperatures, wind speeds and snow loading where characteristic loadings are given in the codes.

In this way, work for infrastructure designers is reduced as relevant data are offered, which can be set out in annexes as nationally determined parameters (NDPs). National standards' bodies (NSB) have a right to determine NDPs and these annexes can be useful as local conditions are specified.

In the Second Generation Structural Eurocodes, there are clauses about additional project-specific requirements to account for the effects of climate change. These clauses permit requirements to be specified by relevant authorities and climate experts including methods to be agreed for specific projects as mentioned in 4.3. This approach is considered as a model for other standards as it offers ways to keep track of developing science and knowledge.

Benefits:

— Flexibility in approach enables highly detailed, place-specific data for projects

— At its simplest application, standards users do not need to carry out research into the relevant thresholds and ranges of climate data, as these are predefined in standards

— For more general application, data will be available that allows the standard user to take into account future climate hazards

Disadvantages:

— Uncertainties in climate projections and downscaling limits can result in extreme values from granular approaches

— Potential inconsistencies arise when different projects in similar areas or sectors employ varying approaches, impacting design data consistency

— NDPs can lack consistency, posing challenges for international infrastructure systems across national boundaries

6.3 Standards' users are required to source relevant data

This is where standards guide users to source a range of climate or weather data then analyze, for instance, the averages and extremes, which can be at a location. An example is the series of standards under ISO 15927 *Hygrothermal performance of buildings - Calculation and presentation of climatic data*.

Benefits:

— Standards users can determine the best way, for them, to determine the relevant data for their project