TAILORED GUIDANCE FOR STANDARDIZATION TECHNICAL COMMITTEES:

HOW TO INCLUDE ADAPTION TO CLIMATE CHANGE (ACC) IN EUROPEAN INFRASTRUCTURE STANDARDS

March 2022

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Foreword

The European Union Strategy on Adaptation to Climate Change [COM(2013) 216 final] has identified standards as an effective instrument for improving the climate resilience of infrastructures across Europe. The sectors identified as priority sectors in the EU Strategy are:

- Transport infrastructure;
- Energy infrastructure;
- Buildings/construction;
- ICT infrastructures that are closely interconnected with and support the functioning of the sectors mentioned above.

This resulted in the Standardization Request (Mandate M/526) addressed to the European Standardization Organizations (ESOs) in support of implementation of the EU Strategy on Adaptation to Climate Change [COM (2014) 3451 final] issued by the European Commission (EC) and addressed to the European Standardization Organizations. Part of the work identified under this mandate includes the drafting, testing, and issuing of this guide. This guide has been designed specifically for standard writers of CEN-CENELEC infrastructure standards (and similar documents).

As infrastructure is of particular importance in addressing Adaptation to Climate Change (ACC), this guide has been produced to help accelerate the transition to a more climate resilient Europe. This document differs significantly from previous guides which deal with embedding ACC within standards in general. CEN-CENELEC Guide 32, *Addressing climate change adaptation in standardization* (2016) and ISO Guide 84, *Guidelines for addressing climate change in standards* (2020) have been influential in the writing of this document. However, both CEN-CENELEC Guide 32 and ISO Guide 84 provide more general guidance and include numerous aspects which are not necessarily relevant to infrastructure standards. The guidance contained in this document has been streamlined and tailored specifically for infrastructure standards writers in Europe. For example, this guidance focusses upon the risks and opportunities presented by changes in climate upon physical infrastructure and how people interact with that infrastructure. It does not however provide guidance on management approaches; behavioural change or human capacity assessments, nor does it focus on climate change mitigation (the need to manage the levels of greenhouse gases in the atmosphere), although climate change mitigation remains an essential principle throughout.

During the development of this guidance document, the project team has worked closely with Technical Committees (TCs) and/or Working Groups (WGs) under the direction of the Adaptation to Climate Change Coordination Group (ACC-CG). The contributions, feedback, and continued support of respective TC and/or WGs have been vital to ensuring that this guidance is relevant, pragmatic, and accessible. The hard work of all the TCs and/or WGs who have supported the development of this guidance is to be acknowledged and applauded.

Introduction

There is scientific consensus that climate change is occurring and that human activity is the root cause. No matter what humans manage to achieve through the reduction and management of greenhouse gas emissions, Europe, along with the rest of the world, is already experiencing climatic changes. Moreover, these changes are set to significantly increase into the future and will impact most infrastructure decisions.

The extent of climate change that we can expect will be a result of how effective we are at reducing our emissions and removing carbon (or the equivalent) from our atmosphere. Not knowing how effective we will be at doing so creates considerable uncertainty about what we can expect. This is compounded by the fact that there are unavoidable uncertainties in predicting how the climate and earth's eco-systems will react.

Technical Committees (TCs) and/or Working Groups (WGs) working on infrastructure standards are usually very familiar with ensuring weather risks have been considered appropriately. However, climate change brings an additional dimension to these considerations. Weather and climate are not the same thing. 'Climate' refers to the expected weather over decades (usually 30 years or more). Climate change also causes secondary impacts that are not normally understood as "weather", such as sea level rise, subsidence, rises in water temperature, fluvial flooding, ocean acidification etc. Since the intensity and/or frequency of these secondary impacts are a product of climatic changes, it is important to appreciate not just the impact that changes in climate might have on thresholds of a specific standard, but also upon those standards that a particular standard is dependent upon, or that a particular standard will affect.

When to use this Guidance

Standards writers are encouraged to consider climate change issues in their work at all stages in the standards development process. If climate change issues have not yet been considered, this can be a valid reason to start the revision of a standard. In addition, the significance or relevance of specific issues might have changed since the previous edition of a standard was drafted or reviewed.

Adaptation to Climate Change (ACC) is of particular relevance to infrastructure standards, as infrastructures tend to have long lifespans. New and existing parts of Europe's infrastructure have design lives of decades and more. The actual life of much of Europe's infrastructure is often far greater than its design life. Some parts of our infrastructure are expected to last (and have lasted) for hundreds of years, while other parts may have relatively shorter life cycles (e.g. nuclear installations, and/or ICT components). The longer infrastructure is intended to last, the more changes in climate such as higher peak and mean temperatures, increased storminess, changes in rainfall distribution (as well as associated impacts such as flooding, subsidence, sea-level rise, etc.) they can expect to have to withstand and/or adapt to.

Aim of this guidance

- To enable Technical Committees and their respective Working Groups to determine if the standards they are responsible for should explicitly consider vulnerabilities, impacts and risks and/or opportunities associated with climate change.

- To provide standards writers with a systematic approach to address climate change issues and opportunities in a coherent and consistent manner, with regard to both new and revised standards, and in a manner related to the objective and scope of the standard being developed. This includes consideration during the conception/design phase of infrastructure, as well as during the operation phase (i.e. management, maintenance, emergency procedures) and it's end-of-life.

- To promote consistency and compatibility among European infrastructure standards that directly or indirectly address climate change and their wider uptake in support of sustainability.

- To ensure that the words selected within infrastructure standards guide standards users to be able to interpret delivery of the standard with adaptation to climate change in mind. For example, when the range of climate change scenarios is so broad at a pan-European level that thresholds for a given standard are better addressed locally where standards users are applying the standard. This often negates the need to have detailed explanations within the standard itself. In such cases, the emphasis shifts to standards writers ensuring they provide the best kind of guidance to support those standards users on how to conduct localized interpretations of climate scenarios.

Terms and definitions

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: ISO 14090:2019, 3.4]

climate change

change in *climate* 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 forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use.

[SOURCE: ISO 14090:2019, 3.5]

adaptation to climate change

climate change adaptation

process of adjustment to actual or expected climate and its effects

Note 1 to entry: In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities.

Note 2 to entry: In some natural systems, human intervention can facilitate adjustment to expected climate and its effects.

[SOURCE: ISO 14090:2019, 3.1]

infrastructure

set of interacting or interdependent structural elements (system) that provide basic physical and organizational structures needed for the functional operation of society, enterprise or the services and facilities necessary for an economy

Note 1 to entry: These vital functions are generally ensured by products, systems and processes that are often subject of standards.

Note 2 to entry: As examples of functional operation of society and economy following demands can be called: basic supply (e.g. production, storage and distribution of water, food, energy, and products), habitation, communication, finance, health including emergency service and public administration including civil protection and public security.

[SOURCE: CEN-CENELEC Guidance 32: 2.11]

impact

effect on natural and human systems

Note 1 to entry: In the context of climate change, 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 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: ISO 14090:2019, 3.8]

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: ISO 14090:2019, 3.15]

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: ISO 14001:2015, 3.2.10, modified — Note 1 to entry has been modified. Notes 3 and 4 to entry have been deleted.]

life cycle

consecutive and interlinked stages of a product (or service) system, from raw material acquisition or generation from natural resources to final disposal

Note 1 to entry: The life cycle stages include acquisition of raw materials, design, production, transportation/ delivery, use, end-of-life treatment and final disposal.

[SOURCE: ISO 14001:2015, 3.3.3]

Scope

This guidance provides infrastructure standard writers with a step-by-step process to ensure new and existing infrastructure standards appropriately address current and future changes in climate resulting from greenhouse gas emissions and other anthropogenic activities. It is relevant to European infrastructure standard writers, as well as to infrastructure operators (and other infrastructure organizations) who are engaged in designing, developing, maintaining, and managing infrastructure. This includes those that have, or are, adopting formal asset management systems. It is therefore not just the design phase of infrastructure that is relevant to this guidance, but also the whole infrastructure life cycle (from inception to decommissioning) that need to be considered.

This guidance is targeted towards all types of CEN Infrastructure Standards. These include:

- *Fundamental standards* – which concern terminology, conventions, signs, and symbols;
- *Test methods and analysis standards* – which measure characteristics (e.g., temperature and chemical composition);
- *Specification standards* – which define characteristics of a product (product standards), or a service (service activities standards) and their performance thresholds such as fitness for use, interface and interoperability, health and safety, environmental protection, etc.
- *Management Standards* – where guidance on localized interpretations of climate scenarios and relevant infrastructure thresholds can be of critical importance.

How to use this guide

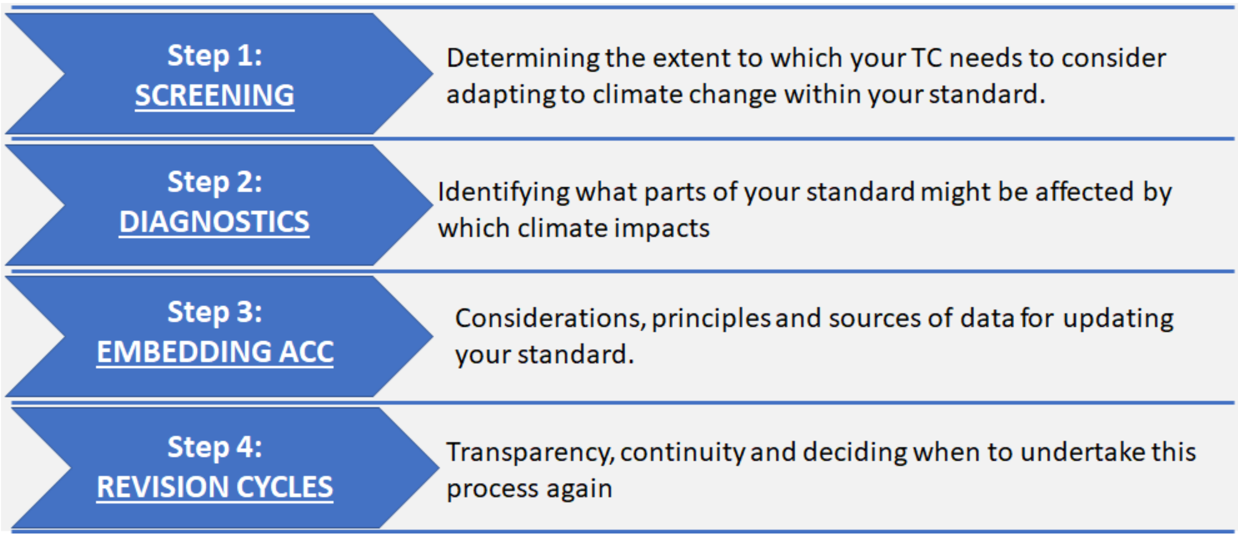
Addressing weather risks is already an integral part of writing many infrastructure standards. This is fully recognized and appreciated throughout this guidance. The focus of this guidance is therefore upon how the risks from climate change may (or may not) have an impact upon existing standards.

This guide consists of four distinct steps. The first step (Step 1) is designed to facilitate Technical Committees (TCs) and/or their respective Working Groups in screening their standards to determine to what extent the need to adapt to climate change is a factor requiring consideration.

If the conclusion to Step 1 is that work on Adaptation to Climate Change (ACC) is needed, then Steps 2 to 4 are designed to guide the TC and/or WG through the following:

- *Identifying* which parts of a standard might need to be updated because of climate change information;
- *Understanding* which climate change information is relevant and reliable;
- *Assessing* how and when to update a standard (e.g. whether it is direct climate change scenario information that needs articulating or whether it is guidance to standards users on how to conduct localized interpretations of thresholds that is more useful);
- *Navigating* the different sources of climate change information; and,
- *Determining* how to proceed as new information becomes available into the future.

Figure 1: 4-Step Process



Step 1: Screening

Step 1: SCREENING — Determining the extent to which your TC needs to consider adapting to climate change within your standard.

Step 1 “Screening” is designed to help your TC and/or WG understand the extent to which climate change is likely to have an impact upon your standard. To determine this, **your Technical Committee (TC) and/or Working Group (WG) is encouraged to follow the flow chart (Figure 2, on page 12) to determine what the next step within this guidance should be.**

The principal premise of this step is that if your standard has already defined direct and indirect weather parameters, then these parameters are likely to change as a result of climate change. Likewise, the longer the life cycle of the infrastructure your standard is designed for, the higher the likelihood that there will be significant changes in weather patterns over the life of the infrastructure.

Even where relatively short life cycles are involved (e.g., less than 20 years), it remains very important that the historical weather datasets that have been used for your standard are as up to date as possible. It is not uncommon for infrastructure standards to still be using historical weather data from decades ago. Due to current climate change, these older historical datasets are rapidly becoming obsolete. We therefore strongly recommend that the end point of any historical dataset used falls within the past five years. For example, if you are using 20 years’ worth of historical data, those 20 years of data should include recent years.

In order to stay abreast with inevitable changes in climate, shorter lifespan standards need to be updated regularly as new ‘historical data’ becomes available. This also ensures that long lifespan infrastructure standards (20 years or more) that look at climate change across the full life cycle of the infrastructure are continually supported by shorter lifespan infrastructure that will be regularly updated with the most recent historical data.

For infrastructure standards that define test methods, calculations, and analysis, where timeframes of less than 20 years may form the key focus of the standard, longer-term lifespans will usually remain relevant. This is because the infrastructure that the standard is designed to affect will normally have a life expectancy of well beyond 20 years in the built environment.

NOTE “Life expectancy” is usually significantly longer than ‘design life’, and it is the longer of the two time horizons that is critical in any calculation.

It is also important to consider the extent to which your standard may impact upon the delivery of other infrastructure. This includes, but is not limited to, infrastructure where consequences of any failure may potentially have significant or serious and/or irreversible consequences for wider society (e.g., data centers, power suppliers, hospitals, water processing plants, transport hubs, etc.).

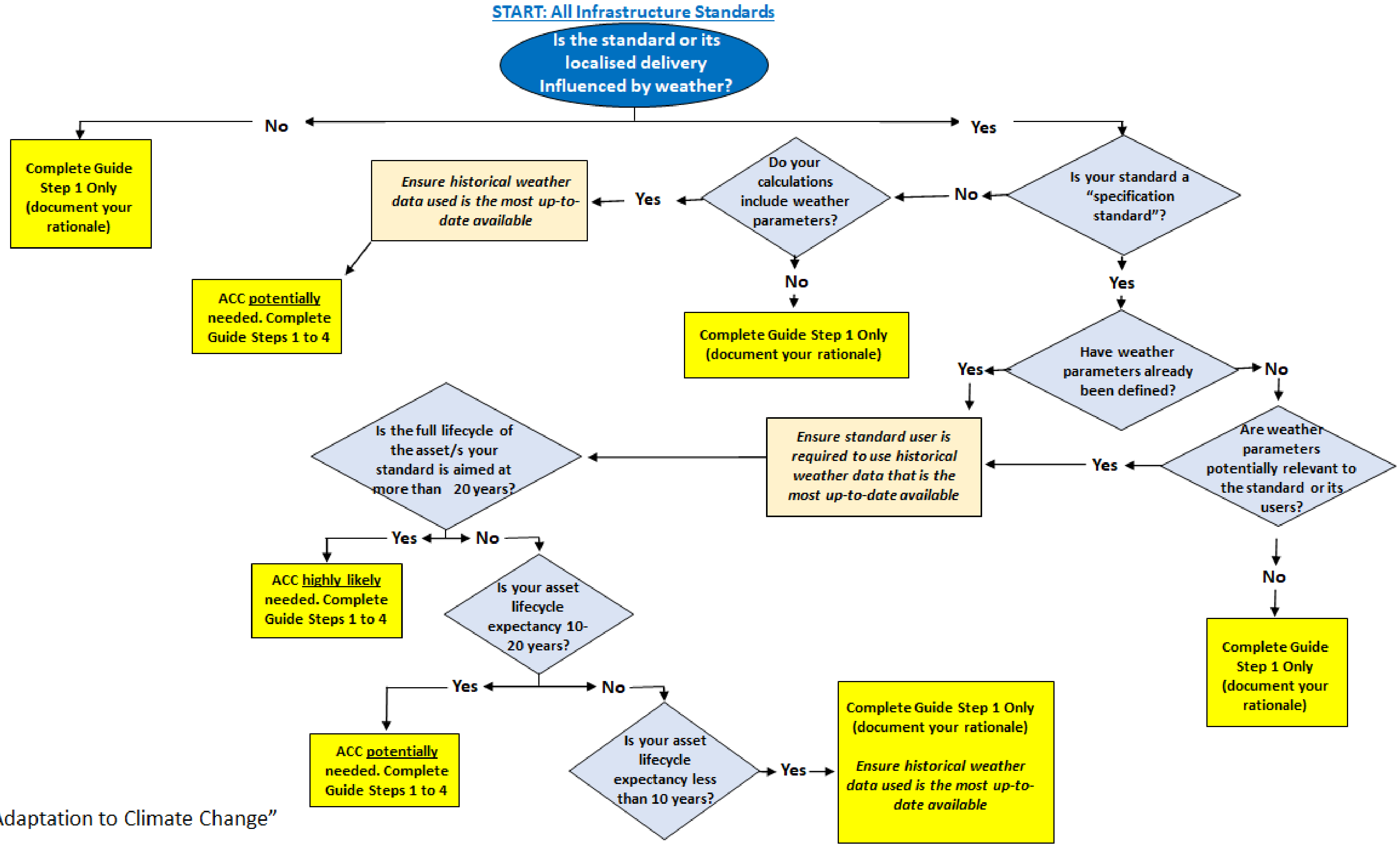
Annex 2 provides a list of climate change impacts to support you in reviewing which might be of relevance to your standard.

Identifying the weather-related parameters within your standard helps to identify which climate scenarios you should begin looking at. The following list provides a set of questions that your TC and/or WG should be prepared to answer for each of these components within your standard: (*adapted from CEN-CENELEC Guide 32 "Addressing climate change adaptation in standardization"*):

- Are there weather (e.g. temperature, wind, rain) thresholds in your infrastructure that beyond which your infrastructure would be compromised?
- Are there climate change impact (e.g. floods, subsidence, sea-level rise) thresholds in your infrastructure that could compromise your infrastructure?
- Does the production of your infrastructure (or infrastructure system) depend on the supply of water (high volumes or specific quality), energy, agricultural or forestry products?
- Is the climate, or water, a key input into the production process?
- Does production involve any outdoor activities?
- Are there any climate, weather or temperature or humidity sensitive production processes, such as those reliant on cooling, water use or energy supply?
- Is the effectiveness of the infrastructure affected by the weather or climate?
- Does weather or climate influence what properties are required of the infrastructure?
- Is production likely to rely on staff occupying premises where health, safety and comfort could be compromised by weather?
- Does your standard deal with transportation methods in any stage of the asset life-cycle that might be impacted by changes in weather parameters?
- Is there the potential for supplier disruption due to extreme weather events (in particular where suppliers are in vulnerable locations, such as near rivers, on flood plains or in areas of water scarcity)?
- Could the production of the necessary raw materials be affected by climate change?
- Are any disposal or reprocessing activities affected by changes in weather parameters (e.g. temperature sensitive)?
- Could the infrastructure, or their respective components, be damaged or degraded during transport due to changes in weather parameters (e.g. temperature or humidity)?

On the completion of this step, your TC and/or WG should record its decisions, sources of data, and reasoning behind taking any action (or indeed the rationale behind deciding not to take action). ***Please note: Annex 1 "Climate Effects to Consider" and Annex 2 "List of climate change impacts" – although not exhaustive lists – can provide some valuable support for working groups thinking through this step.***

Figure 2: The extent to which you need to consider climate change in your standard



ACC = "Adaptation to Climate Change"

Step 2: Diagnostics

Step 2: DIAGNOSTICS — Identifying what parts of your standard might be affected by which climate impacts

This step guides your Technical Committee (TC) and/or Working Group (WG) through the process of identifying the relevance of considering climate change adaptation. Your TC and/or WG has reached this step because you have already identified (in Step 1) that weather parameters play a significant factor in the successful delivery of your standard/s. The parts of your standard that you have identified as potentially impacted by weather, will also be susceptible to changes in climate. The weather parameters are likely to change, and so could impact the resilience of the infrastructure your standard is aimed at delivering.

Your TC and/or WG should produce a list of each of these weather sensitive elements, and where possible, their respective weather thresholds (i.e. the point at which a weather event could render that [asset / service or component] compromised or inoperable). The TC should keep these as an audit trail of your decision-making processes to help with continuity between revisions of your standard. While, in practice, it is not always possible to provide this level of continuity between revision cycles, it is strongly recommended that there is a realistic attempt to do so. New information and experiences are evolving in this field, and it is important to keep abreast with these developments.

Changes in weather parameters because of climate change could also affect elements of your standards that as yet, have not been considered. It is therefore important to identify any other areas of your standard that might be impacted. Annexes 1 and 2, with their lists of weather variables and climate change impacts, can be of particular value here. This should also be documented for future reference.

Proactive vs reactive management

There have been significant developments in recent years in the way that infrastructure is being designed and delivered, and standards are playing a vital role. Due to the pace at which climate variables are affecting weather, combined with the inherently long-life cycles within many infrastructures, it has become clear that we need to embrace new ways of ensuring Adaptation to Climate Change (ACC) is properly factored into infrastructure standards and their delivery by the standards users. Until now, approaches to managing infrastructure have often relied heavily upon *reactive* responses (e.g. checking whether an infrastructure has been compromised following an extreme weather event). The emphasis has been upon observing the extent to which it has been impacted by an event, followed by maintenance interventions where required. For many infrastructures, this is becoming insufficient to ensure they remain viable now, and into the future.

Responses to extreme weather events are therefore becoming much more *proactive* (i.e. anticipating more frequent or more extreme weather events and ensuring resilience is factored in to their design and management of the infrastructure). The objective of this proactive response is to prepare for more extremes (often referred to as "climate change resilience"), so that less reactive recovery is required.

Similarly, for many, but not all infrastructure standards, how the infrastructure is managed and how it sits within its own or other systems is becoming increasingly important. This includes the behaviors of those using the infrastructure, the impact upon the services it helps to provide, and the interdependencies between technical components (and therefore, potentially, the interdependencies between other specific infrastructure standards).

It is of paramount importance that infrastructure standards are explicit about the need to address adaptation to climate change. Where direct descriptions of thresholds and different climate change scenarios cannot adequately be addressed within the standard itself (e.g. there are too many potential climate outcomes to be covered in one standard), then guidance is required for standards users to be able to conduct their own localized analysis of thresholds using localized climate change predictions. This will ensure that worst case scenarios are adequately considered.

Adaptive design

By their very nature, standards are used to normalize good practices. They are not therefore always best placed to capture and reflect innovations that are still emerging. Prematurely scaling responses that later are found to be ineffective in many areas can be a very real risk. However, the good news is that innovations to mitigate the risks from the impacts of climate change have been developing for decades now, and there is much that many infrastructure standards can already accommodate.

Some infrastructure standards are embracing the concept of "adaptive design", whereby those who are delivering the standard recognize that climatic conditions will change over the life of the infrastructure and so they alter their design now to be able to make further alterations later. A simple example of adaptive design is in the design of a flood defense, where the standard user now makes sure that they have laid foundations that accommodate a higher defense barrier in the future.

Ensuring the standard contains and promotes adaptive design can be an invaluable way of increasing the usefulness of the standard.

Identifying the relevant climate parameters

There are two main climate change considerations that are likely to impact the elements of your standard/s that are already recognised as being impacted by weather parameters. These are:

- **Extreme weather events**: depending on the areas of Europe where you operate, climate change is likely to bring changes in extreme weather events (e.g. more heatwaves, fewer low-temperature extremes, intensification of rainfall events, higher temperatures, floods, droughts, and increased storminess).
- **Shifts in averages**: Consideration is needed for slow-onset changes such as mean summer temperatures, average rainfall over a given season, and sea-level rise.

Identifying which climate change parameters are relevant to your standard and/or it's localized delivery by standards users is usually a function of the weather parameters your standard already considers. While these weather parameters are likely to continue to change into the future, they nonetheless form the basis against which your standard's future vulnerability is assessed – both in the day-to-day use or application of the infrastructure – as well as the issues that arise only occasionally under very specific circumstances.

Your TC and/or WG should also pay particular attention to the historical data that you have been using. Datasets are being updated constantly, and it has been noted that some standards have remained using historical datasets that are already decades out of date. It is important therefore to ensure that historical trends data is up to date, prior to researching current and future trends.

There is also a need to look more at the combined effects of different weather and climate impacts (e.g. intense rainfall following a drought). This is often referred to as "compound hazards". The reason for this is that, for Europe, these compound hazards have not necessarily been so critical in the past but could be of significant importance in the future. Thus, it is also recommended to go through the long list of potential impacts and combined ones, not just focusing on what have been identified as relevant parameters previously. Annex 2 provides more information on potential impacts.

Working with climate change data

Data on future climate are usually based on *climate projections*. These projections include such things as changes in regional precipitation patterns, temperature fluctuations, weather extremes, and other events. Datasets with climate projections usually contain a wide range of information. They consist of numerous parameters which represent different climate variables, typically providing information about average values as well as extremes. You may also find data with different timelines (e.g. up to the year 2100) and resolutions (e.g. 50 x 50 km, or 10 x 10 km). This data can be illustrated in different ways (e.g. maps, graphs or tables). Often projections are given for different scenarios.

NOTE Data are based on models, and do by definition contain uncertainty. To examine uncertainty, several climate models are usually used. The range between the scenarios provides an indication of the uncertainty in the future. Thus, for the selected future climate conditions, a meteorological parameter is given within an uncertainty range.

Climate models and scenarios

Climate projections are based on *climate models*. These are numerical models that simulate the climate system at the global scale. Climate models are the most advanced tools available for modelling the state of the climate system and simulating its response to changes in atmospheric concentrations of greenhouse gases and aerosols. Models differ in their complexity, in the number of spatial dimensions and in the detail of description of physical, chemical or biological processes. For more detailed regional climate impact assessments, Regional Climate Models (RCMs) have been used. RCMs are limited in area but can provide information on the climate in higher spatial resolution than GCMs. RCMs typically have a horizontal resolution of between 2 km and 50 km, which allows for a better representation of topographic features (e.g. mountain ranges) and of regional-scale climate processes. As a result, they can provide more detailed projections of changes in regional precipitation patterns, weather extremes and other climate events.

Climate projections contain uncertainties as there are many variables that cannot be accurately predicted. Furthermore, substantial differences exist between outcomes of different models. Nevertheless, the scientific community is confident that climate models provide credible quantitative estimates of future climate change, as these models are based on fundamental physical laws and are able to reproduce the key features of observed climate change. These projections are usually presented as a multi-model ensemble, in order to represent the spread of possible future climate change.

The input for a climate model is an *emission / concentration-scenario*. Most commonly used are Representative Concentration Pathways (RCPs). The RCPs provide a consistent set of trajectories for future atmospheric composition and land-use change up to the year 2100.

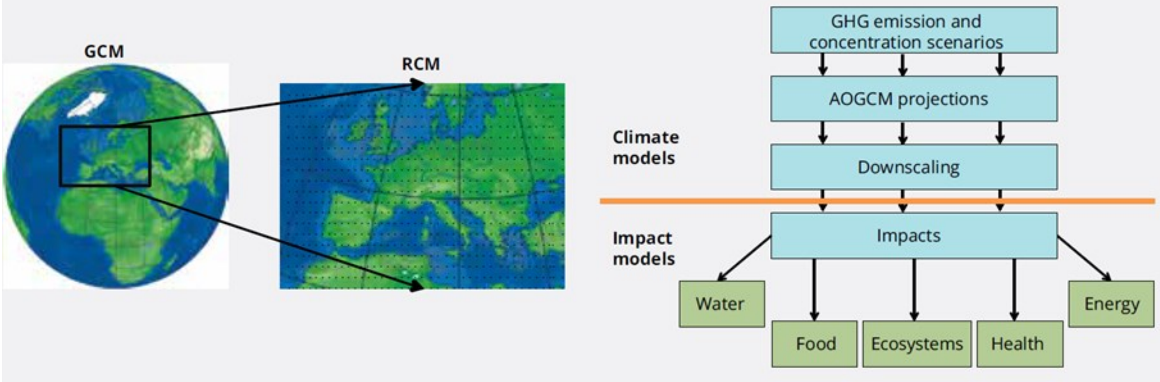
There are four RCPs, named from RCP2.6 to RCP8.5. The primary characteristics of the four RCPs are as follows:

- RCP8.5 is a high-emissions scenario;
- RCP6.0 is a stabilization scenario in which total radiative forcing is stabilized at approximately 6.0 W/m2 shortly after 2100;
- RCP4.5 is a stabilization scenario in which total radiative forcing is stabilized at approximately 4.5 W/m2 shortly after 2100;
- RCP2.6 is a “peak-and-decline” scenario that leads to very low greenhouse gas concentration levels. In this scenario greenhouse gas emissions (and, indirectly, emissions of air pollutants) are reduced substantially, leading to net negative carbon dioxide emissions at the end of the 21st century.

More recently, there has been considerably more focus upon Shared Socioeconomic Pathways (SSPs) being used. This socio-economic data is used to create an integrated analysis of future climate vulnerability. These integrated models, often referred to as Integrated Assessment Models (IAMs), provide projections for such things as changing demographics, urbanization, GDP, energy supply, energy use, pollution, greenhouse gas emissions, land-use, and the economic costs of reducing emissions.

The newest set of climate scenarios underlying the CMIP6 modelling exercise and the recently published International Panel on Climate Change AR6 use SSPs. Future data sources are likely to use these more commonly in the future.

Figure 3



Note: AOGCM, atmosphere–ocean general circulation model; GHG, greenhouse gas.

Source: EEA.

It is critical that your TC and/or WG and/or standard user is able to navigate their way through this information to determine which data is most relevant for the future conditions that the infrastructure will have to cope with. The relevant parameter should link to the results of the previous step (i.e. the climate parameters that are most relevant for your infrastructure). Where it is not practical to write all possible climate change parameters into the standard itself, then it is important that the standard provides sufficient guidance for the standard user to be able to look at more localized climate change projections to provide localized responses.

We strongly advise that TCs, WGs and users pay special attention to the extreme climate change scenarios (i.e. the worst-case scenarios) as these are the points that thresholds need to be able to withstand. Average scenarios are unlikely to prove as useful, as they do not give a sufficient range of possible outcomes.

For the shorter term, up to about 2040, differences between the outcomes of different scenarios are relatively small. On larger timescales differences are larger. Therefore, infrastructures with longer lifespans than 20 to 30 years require assessment using scenario of a similar time dimension.

In looking for the most appropriate scenario, several considerations can be taken into account, for example:

- Cost of investments;
- Possibilities for adaptation of infrastructure during lifetime;
- Possibilities for adaptive designs which mean they can be altered in the future as climatic changes take place; and,
- Impacts in case of failure of infrastructure.

Example:

For infrastructure with a relatively long life cycle (e.g. 20+ years) that requires significant investments and few possibilities to adapt the infrastructure during its lifetime, it is wise to look at the severe scenarios (RCP 8.5). This is because there is a serious possibility that such a scenario might occur within the design criteria it has been built to. It is therefore better to be prepared for that eventuality. Otherwise, there is significant risk that the infrastructure will be confronted with damage or vast additional investments during its lifetime.

On the other hand, for an infrastructure which can easily be upgraded during its lifetime, it might be reasonable to look for the lighter scenario (e.g. RCP 4.5) as this could avoid unnecessary costs.

The assessment of a most appropriate scenario is not an easy task due to the complexity of the climate models. For complex installations and/or large investments it can be wise to consult a climate expert.

On the completion of this step, your TC and/or WG should record the following:

- **Which specific parts of the standard your TC and/or WG has identified as potentially being affected by climate change;**
- **The climate impacts that have been selected as needing to be addressed (and where appropriate, the cascading impacts);**
- **The rationale behind these decisions / selections.**

Step 3: Embedding ACC Responses

Step 3: EMBEDDING ACC — Considerations, principles and sources of data for updating your standard.

Sources of data

Advice on where an organization can source historic and future climate data can be found at national and international climate data centres e.g. national regulatory authorities, state and local agencies, universities, national weather service providers. Information can also be obtained from other sources such as scientific reports, relevant climate change impact assessments, governmental and intergovernmental publications and databases.

NOTE 1 The following links are valuable and reliable source of Pan-European climate data:

- European Climate Data Explorer
- Copernicus Climate Change Services (C3S) Climate Data Store
- IMPACT2C Web-Atlas

NOTE 2 New datasets are being developed, and many countries have their own higher resolution data sets. TC and/or WGs are encouraged to document the data and information sources used and the criteria used for their selection. Advice on the use, utility and relevance of data and information sources should be made by competent persons or organizations, either internal or external to the TC and/or WG.

Online climate change data sources for each European country can be found in Annex 3 of this document.

Considerations and Principles

Once your TC and/or WG has completed the previous step (Step 2) you will have identified which parts of your standard are likely to be impacted by climate change. Likewise, your TC and/or WG will have developed an understanding of which climate change impacts are relevant to those parts of the standard. This next step (Step 3) is therefore designed to assist Your TC and/or WG in understanding what changes you should make to your standard. When action is required for adaptation, standards writers should adopt a systematic process for the identification and evaluation of options, in order to plan the most appropriate adaptation strategies.

NOTE The experts within your TC and/or WG will be best placed to understand what potential technical responses are appropriate/possible. Where this is not the case, then your TC and/or WG is also the group best placed to understand and identify what additional expertise you may need to bring in to assist your TC and/or WG in identifying appropriate solutions. Approaches to identifying appropriate solutions are specific to each respective standard. This means it is not possible to cover every potential approach within this guidance. Suitable technical responses will need to be determined by your specific TC and/or WG.

To assist the sharing of good practice between TC and/or WGs, Annex 3 provides some case examples of other TC and/or WGs and their projects who have already been through the challenge of embedding ACC in standards and specifications.

Clause 5 of CEN-CENELEC Guide 32 "Addressing climate change adaptation in standardization"

This "Checklist of Relevance" is a very good resource to assist your TC and/or WG in this step (Step 3). Table 7 (on page 24) is particularly useful as it can be used by your TC and/or WG to work out which things are relevant to your particular standard. For example:

- Identify a range of adaptation options that could be incorporated in product design;
- Identify any thresholds that are described or implied in existing climate information;
- Consider carrying out or commissioning research to identify thresholds;
- Identify the projected change in relevant climate variables, including the range of uncertainty throughout the design lifetime and end-of-life;
- Check whether existing information covers everything that you need;
- Identify the climate related impacts on the acquisition and production stages that may occur in other regions of the world;
- Define what level of risk or what level of impact the product needs to be resilient to;
- Consider "designing for degraded performance": check what happens if the product/ component performs at below design capacity;
- Consider the requirement for labelling that indicates thresholds relevant for use and end-of-life phase impacts;
- Agree when climate information will need updating;
- Set out a process for incorporating the outputs of research as part of standards revision (including how and when);
- Make time for a discussion of uncertainty and roles in decision-making; and,
- Aim to create adaptive designs that can be adapted in the course of the lifetime of the infrastructure (i.e., try not to lock-out future options).

Further considerations

The following considerations provide a useful framework for how to address those decisions (adapted from ISO Guide 84 "Guidelines for addressing climate change in standards"):

- **There is no one-size-fits-all solution.** Your TC and/or WG may need to adopt your own approaches in order to appropriately reflect your specific standard.
- **Learn from the experience of other TCs and/or WGs:** It can be extremely worthwhile to work together with other TCs and/or WGs who have developed standards for infrastructure in other areas of Europe (and the world) where the extremes of weather that your TC and/or WG might expect have already been experienced.
- **Adopt Integrated Approaches:** Adaptation components should be incorporated into the core steps and practices, of the standard.

- **Provide meaningful guidance for localized interpretation by standards users:** Where it is not practical to use Pan-European climate change scenarios within the standard, and localized interpretation by the intended standards users is the more useful approach, then it is critical to provide useful and pragmatic guidance for those users. Guidance must include what the important elements of the standard that require local interpretation of climate change scenarios are, and what climate change scenarios are most important to interpret for the local context.

- **Prioritize the Most Vulnerable:** The standard should identify the intervention point for prioritizing people, places and infrastructure that are most vulnerable to climate impacts related to the standard.

- **Use Best-Available Science:** Adaptation measures in the standard should be grounded in the best-available scientific understanding of relevant climate change risks, impacts, and vulnerabilities.

- **Build Strong Partnerships:** Adaptation requires coordination across multiple sectors and scales and should build on the existing efforts and knowledge of a wide range of public and private stakeholders who are involved in the application of the standard.

- **Apply Ecosystem-based Approaches:** Where standards are related to ecosystems, then adaptation measures should, where relevant, take into account strategies to increase ecosystem resilience and protect critical ecosystem services.

- **Maximize Mutual Benefits:** The standard should encourage the use of relevant strategies that complement or directly support other related climate or environmental initiatives, such as efforts to improve disaster preparedness, promote sustainable resource management, and reduce greenhouse gas emissions including the development of cost-effective technologies.

- **Use Adaptive Designs:** Ensure that the design that is to be delivered now is able to be upgraded later if changes in climate will reach thresholds. This can be a good way of building resilience to the higher emissions scenarios (e.g., RCP 8.5) which inherently contain more uncertainty with regards probability, while avoiding higher costs in the short-term.

On the completion of this step, your TC shall document its chosen process and its rationale behind its choice of approach.

Step 4: Revision Cycles

Step 4: REVISION CYCLES — Transparency, continuity and deciding when to undertake this process again

New data and information about climate change are evolving all the time. For example, at the point of writing this guidance there are already significant shifts in using SSPs. As the future unfolds, and as new technologies, policies, finance mechanisms and data become available, it is important that your standard/s can stay relevant and viable. This means approaches to embedding ACC consideration within standards must remain as flexible as possible, to allow approaches to evolve over time.

If you have followed Steps 1 to 3 of this guidance and have found that changes have been necessary to your standard, it is highly likely that further changes will need to be made in the future as new learning (especially from delivery experience as the climate changes), new data, new information and new technologies become available and inform what needs to be done.

We therefore recommend that climate change resilience of the standard/s is reviewed with every revision phase. This can be done by repeating Steps 2 to 4 of this guidance.

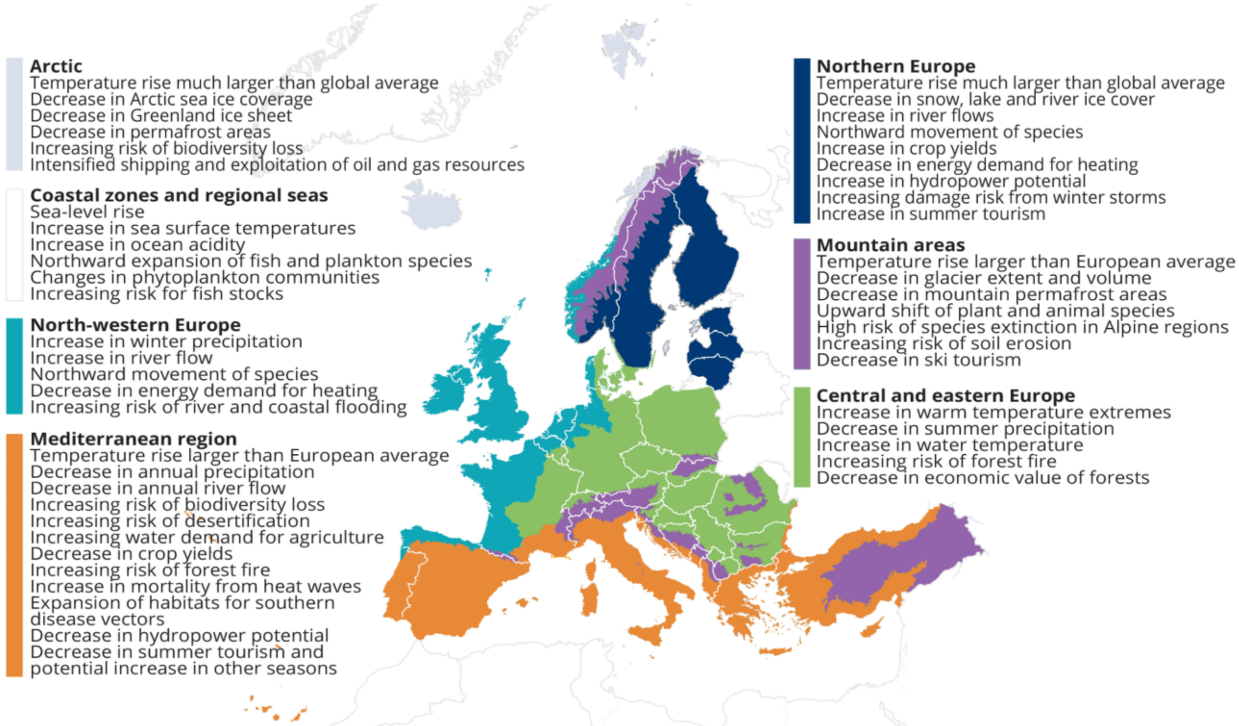
In each step, your TC and/or WG has been requested to document your decision-making processes, approaches, and rationale for what you decide to do. These are essential steps in ensuring transparency in your work and permits continuity between revision cycles. Showing your workings in this way ensures new people are able to understand where you left off, making it easier for them to identify, process and embed new learning and data when it becomes available.

It is recognized that there is often no official process in standards writing to ensure continuity between revision cycles. However, with such an important topic as climate change, and our rapidly changing and ever evolving responses, we strongly advise TCs and WGs to do their utmost to document what they can for future standards writers to learn from.

Assessments should be made by competent persons or organizations, either internal to your TC and/or WG, or external.

Annex 1: Climate effects for consideration

- Changes to long-term averages
- Severe weather events
- Rainfall
- Droughts
- Heatwaves
- High Temperatures
- Snow
- Melt
- Hail
- Wind
- Floods – sea, flash, fluvial, groundwater
- Subsidence
- Salination
- Fire
- Health risks
- Humidity



Ref: https://www.eea.europa.eu/publications/climate-change-impacts-and-vulnerability-2016 (Map ES.1)

Annex 2: Table of Impacts (non-exhaustive)

Parameter	Potential consequences and impacts					
	Effects/direct impacts	**Other potential impacts**	**Buildings/construction sector**	**Transport sector**	**Energy sector and ICT sector**	**Other (i.e. cross cutting)**
High temperature	Impact on materials (thermal expansion)	Overheated buildings, persons inside	Roads and bridges, pavements	Rail infrastructure (rail buckles, transmission efficiencies) Discomfort for staff and passengers	Power plants (lower efficiency)	
Urban heat Island	*Idem as high temperature*					
Low temperature	Impact on materials: expansion/ contraction	Ice accumulation	Buildings and construction operational conditions. Ice accumulation on buildings, overload on construction	Rail infrastructure (traction/ grip, broken rails, icing of equipment) Roads and bridges, pavements Ice accumulation on vehicles	Electricity infrastructure: freezing of distribution lines Freezing of water supplies Accumulation of ice on the electricity aerial distribution grid	

Parameter	Potential consequences and impacts					
	Effects/direct impacts	**Other potential impacts**	**Buildings/construction sector**	**Transport sector**	**Energy sector and ICT sector**	**Other (i.e. cross cutting)**
Rain	Local flood, due to undersized sewage water systems/ reservoirs	Landslides / erosion	Moisture damage	Train delays, due to landslip, flood, scour/ erosion	Changes in hydro-generation	Higher ground water level, impact on soil stability
Snow	Roof structures: Stresses and collapse Note: especially if followed by rain	Slippery surfaces, reduced visibility, Falling trees due to extra loads	Overload on buildings and construction infrastructures	Blocking of the track/ problems with switches/ burden on traction/ grip	Accumulation of snow on the electricity aerial distribution grids and related assets	Cumulative effect with ice, potential of severe flooding, especially when cumulated with ice and rain
Hail	Dangerous impacts on equipment and people	Roofs and windows: damage	Slippery surfaces, reduced visibility	Icing of equipment / burden on traction / grip	Photovoltaic systems: damage	
Solar radiation	Material degradation (plastics)		Damage to roofs	Rail buckling / workforce welfare		
Lightning	Structural damages, fire		Damage to cable supported bridges (cables, pylons) Disruption of electronic systems in vehicles	Delays in rail-transport	Disruption of electrical systems	

Parameter	Potential consequences and impacts					
	Effects/direct impacts	**Other potential impacts**	**Buildings/construction sector**	**Transport sector**	**Energy sector and ICT sector**	**Other (i.e. cross cutting)**
Drought (from sustained dry spells and/or higher temperatures)	Desiccation of earthworks, foundation movement	Soil vulnerability and extra flooding when a drought is followed by rain (even with "normal rain")		Rail transport/ delays, due to desiccation of earthworks	Impact on hydro electricity generation Heating and cooling of thermal power plants	Inland shipping – reduction of transport via water
Flooding (from higher levels of rainfall, or from higher temperatures causing snow melt)	Property loss, Material damages, loads on structures Disruption of operations Scour to foundations	Security of population	Bridges and assets foundations	Train delays due to landslip, erosion, scour, damaged equipment Hardship in use of all transport modes (land, water, air) Damage to vehicles	Problems with energy supply Difficulties in the work of natural gas network facilities Damages to ICT and control systems	
Sea level	Flood; Impact on coast infrastructures; Scour to sea defences; Security of the population	Impact on bridges with piers in the sea	Note: many cities are along or close to seas, thus vulnerable to elevation of sea level	Railways in coastal areas; delays to flood, landslip, erosion, scour	Flooding of coastal energy infrastructures, such as power plants, refineries, oil and LNG terminals	

Parameter	Potential consequences and impacts					
	Effects/direct impacts	**Other potential impacts**	**Buildings/construction sector**	**Transport sector**	**Energy sector and ICT sector**	**Other (i.e. cross cutting)**
Extreme wind (storm)	Stresses, mechanical stability, higher waves, destruction of infrastructures and buildings, Property loss	security of people (direct [fall] and indirect [flying/ falling objects])	Severe stresses on constructions; Risks for long span bridges	Train delays, line blockages, power liens brought down, damaged equipment; Problem for all transport modes Loss of control of vehicles	Damage and disruption from trees (or their branches) falling on infrastructure / asset	
Wind gusts	*Same as extreme wind*					
Spread of Pests and Diseases	Impact on materials (e.g. termites compromising building materials or soil structures)	Workforce welfare	Damage and disruption from trees (or their branches) falling on infrastructure / asset	Damage and disruption from trees (or their branches) falling on infrastructure / asset	Damage and disruption from trees (or their branches) falling on infrastructure / asset	Critical for health and vulnerable people

Annex 3: Online climate change data sources for each European country

Country	Website
Austria	• https://www.zamg.ac.at/cms/de/klima/informationsportal-klimawandel • https://data.ccca.ac.at/ • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Belgium	• www.kuleuven.be/hydr/cci/CCI-HYDR_rp.htm • https://www.meteo.be/fr/climat/changement-climatique-en-belgique/en-belgique • https://klimaat.vmm.be/welkom • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Bulgaria	• https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Croatia	• https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Cyprus	• https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Czechia	• https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Denmark	• https://www.dmi.dk/klimaatlas/ • https://www.dmi.dk/klima-atlas/data-i-klimaatlas/ • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Finland	• www.ilmasto-opas.fi/en/ilmastonmuutos/suomen-muuttuva-ilmasto/-/artikkeli/74b167fc-384b-44ae-84aa-c585ec218b41/ennustettu-ilmastonmuutos-suomessa.html • www.geophysica.fi/pdf/geophysica_2016_51_1-2_017_ruosteenoja.pdf • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home

Country	Website
France	• www.drias-climat.fr/decouverte • https://ilmasto-opas.fi/en/datat/vaikutukset#SykeDataPlace:vaikutukset • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Germany	• https://www.dwd.de/EN/climate_environment/climateatlas/climateatlas_node.html • www.climate-service-center.de/products_and_publications/maps_visualisation/csm_regional/index.php.en • https://www.klimafolgenonline.com/ • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Greece	• http://climatlas.hnms.gr/sdi/?lang=EN • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Hungary	• https://map.mbfsz.gov.hu/nater/ • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Iceland	• https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Ireland	• http://erc.epa.ie/safer/iso19115/displayISO19115.jsp?isoID=3050 • https://www.climateireland.ie/#!/tools/climateDataExplorer • https://www.climateireland.ie/#!/tools/statusReport • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Italy	• http://www.scia.isprambiente.it/wwwrootscia/scia_eng.html • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Latvia	• https://www4.meteo.lv/klimatariks/en/ • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/

Country	Website
Liechtenstein	• https://cds.climate.copernicus.eu/#!/home • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Lithuania	• http://www.meteo.lt/en/climate • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Luxembourg	• https://www.climatology.lu/ • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Malta	• https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Netherlands	• www.climatescenarios.nl/ • https://www.klimaateffectatlas.nl/en/ • https://www.knmi.nl/klimaat • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Norway	• https://klimaservicesenter.no/climateprojections?index=air_temperature&period=Annual&scenario=RCP85&area=NO • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Poland	• https://climateimpact.sggw.pl/geoportal/catalog/main/home.page • https://klimada2.ios.go https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home v.pl/klimat-scenariusze-portal/
Portugal	• http://portaldoclima.pt/pt/ • www.ipma.pt/pt/oclima/servicos.clima/index.jsp?page=cenarios21.clima.xml • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home

Country	Website
Romania	• https://www.meteoromania.ro/clima/ • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/https://cds.climate.copernicus.eu/#!/home
Slovakia	• http://klimat.shmu.sk/kas/ • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Slovenia	• http://kazalci.arso.gov.si/en/indicators-trend? • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Spain	• www.aemet.es/es/serviciosclimaticos/cambio_climat • http://escenarios.adaptecca.es/#&model=EURO-CORDEX-EQM.average&variable=tasmax&scenario=rcp85&temporalFilter=year&layers=AREAS&period=MEDIUM_FUTURE&anomaly=RAW_VALUE • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Sweden	• https://www.smhi.se/q/Stockholm/2673730 • https://www.smhi.se/en/climate/future-climate/climate-scenarios/ • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Switzerland	• https://www.nccs.admin.ch/nccs/en/home/data-and-media-library/data/ch2018-web-atlas.html • https://www.meteoswiss.admin.ch/home/climate/climate-change-in-switzerland.html • https://hydrologicalatlas.ch/ • www.ch2011.ch/ • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
Turkey	• https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home
United Kingdom	• https://www.metoffice.gov.uk/research/approach/collaboration/ukcp/about • https://climate-adapt.eea.europa.eu/knowledge/european-climate-data-explorer/ • https://www.atlas.impact2c.eu/en/ • https://cds.climate.copernicus.eu/#!/home

Annex 4: Case Examples

Case Example 1: Standards for the transport sector

EN 50125, ***Railway applications —Environmental conditions for equipment***

- **Part 1: Equipment on board rolling stock**
- **Part 2: Fixed electrical installations**
- **Part 3: Equipment for signalling and telecommunications**

Background:

The EN 50125 series are used to specify environmental conditions within Europe for rolling stock, electrical installations, and signalling and telecommunications equipment. The standards cross refer to other standards, such as the IEC EN 60721 *Classification of environmental conditions* series. The parent TC for this standard is TC9X.

Proposal for revision:

EN 50125 Parts 1 and 3 are set for review in 2023, however TC9X are undertaking a review across the EN 50125 series (see below).

For EN 50125 Part 2, TC9X applied this guidance for standards writers, via a paper outlining steps and issues to discuss for a TC9X AHG to consider, as potential input to the New Work Item.

The WG noted that some of the weather information that have been used for EN 50125-2 are sourced from IEC EN 60721. IEC EN 60721 uses weather data including the MIL210 ExPERT database data that were collected during 1973 to 1992. It was realized that this data was perhaps not relevant for current or future climate conditions. Also, whilst these analyses relate to temperature, other weather and environmental parameters appear in EN 50125-2, some were based on IEC 60721; therefore there was a recognized opportunity for the AHG to revise all weather-related parameters in EN 50125 Part 2.

TC9X are now considering setting up an AHG that reviews all weather and environmental parameters currently in EN 50125-2 with a view to:

- confirming the validity of the parameters used;
- considering specifying useful product/ component/ infrastructure lifetimes;
- identifying sources of relevant weather and climate datasets for the expected useful lifetimes;
- provide considered input to a potential New Work Item proposal.

A TC9X Survey Group (SG33) was created in January 2020. The survey group has been set up noting the adaptation to climate change requirements (TC9X/Sec1138/INF).

"The SG is tasked to prepare a report identifying which data are to be updated or created and what should be the data set sources of the new values. The aim is to update EN 50125 series regarding climatic changes."

SG33 Main objectives are:

- Analysis of climate changes impact on EN 50125-1 and EN50125-3
- Work done by SG 08 on EN 50125-2 to be integrated to WG 33;
- Checking of all requirements;
- Mutualization of EN series to be studied.

Standard EN 15723, *Closing and locking devices for payload protecting devices against environmental influences —Requirements for durability, operation, indication, maintenance, and recycling*

Background:

Previously, EN 15723 was noted as being about new and upgraded freight railway wagons and defines the requirements for the durability of the closing and locking devices that hold payloads on to the wagons. The parent TC for this standard is TC 256.

Proposal for revision:

TC 256 reviewed the "climate" effects applicable to this standard. TC 256 decided that when the standard is next due for revision, the title and the reference to climatic effects within the document will be amended. Noting that it was in fact more appropriate to refer within EN15723 to the environmental conditions as set out in EN 50125-1:2014 *Railway applications —Environmental conditions for equipment — Part 1: Rolling stock and on-board Equipment*.

EN 1915, *Aircraft ground support equipment —General requirements*

Part 1: Basic safety requirements

Part 2: Stability and strength requirements, calculations, and test methods

Background:

The EN 1915 series specify the technical requirements for aircraft ground support equipment to address various hazards. In terms of climate, there are references including wind and snow loading. The parent TC for this standard is TC 274.

Proposal for revision:

TC 274 sees wind as a priority. A TC 274 Plenary meeting in Hamburg in 2019 discussed the use of this guidance in supporting and guiding revision of EN 1915 Part 1. Following that meeting, no major revisions were necessary and advice was given to standards users on recording wind speeds at airports and monitoring for local issues. Proposals for further editing are ongoing to revise EN1915-1:

- Consider changes to the wording of section 15.19.1 'General requirements' to draw users' attention to the need to consider changes in wind speeds and extreme event frequencies, during the useful design lifetime of equipment, owing to climate change;
- Gathers recent, and continues to monitor and evaluate, wind speed data for a selection of airports, in order to inform a) any future revision of EN1915-1; and b) changes to design windspeeds to satisfy local conditions.

Additionally, the AHG is considering how best to advise airports to consider changing local operational rules to cater for increased UV radiation affecting operational staff.

Case Example 2: Interlinked standards for Gas Infrastructure

CEN TC 234 "Gas Infrastructure" standards :

EN 16348, *Gas infrastructure — Safety Management System (SMS) for gas transmission infrastructure and Pipeline Integrity Management System (PIMS) for gas transmission pipelines — Functional requirements*

EN 15399, *Gas infrastructure — Safety Management Systems for gas networks with maximum operating pressure up to and including 16 bar*

EN 17649, *Gas infrastructure — Safety Management System (SMS) and Pipeline Integrity Management System (PIMS) — Functional requirements*

EN 1594, *Gas infrastructure — Pipelines for maximum operating pressure over 16 bar — Functional requirements*

Background:

In CEN TC 234, both EN 16348 and EN 15399 have been merged into one document. In doing so, CEN/TC 234 decided to start with Adaptation to Climate Change (ACC) of this management and integrity standard, as these explicitly relate to existing infrastructure which is designed and constructed prior to ACC considerations. The design and construction standards take climate change aspects at the time of implementation. It is now planned to include ACC in all further revisions.

Proposal for revision:

The Working Group has decided to introduce ACC requirements in the merged document and has followed this guidance to do so. As a basis for the ACC work, an enquiry was carried out with the CEN/TC 234 members and stakeholders to get an insight in companies experiences with weather/climate effects and related legal/technical frameworks in the CEN countries.

As a final decision, CEN TC 234 has launched a dedicated WG to tackle and work on considering ACC issues in all relevant/concerned standards. In less than a year, this dedicated working group has led to the review of EN 17649, and EN1594.

EN 17649 has now been published and fully agreed terminology to accommodate ACC has been included. Examples of terminology used can be found in Case Study 2 of this document "Examples of useful ACC terminology in standards". During its writing, the working group also noted that it referred as a "normative reference" and, in its guidance, to the merged document of EN 16348 and EN 15339. However, as each standard had been written for a slightly different audience, this highlighted the need to change some of the terminology in the merged document. This was done by widening the scope of the merged document so that it was no longer relevant only to the infrastructure operator, but also to those designing, constructing and decommissioning the asset.

At the time of publishing this document, the relevant WG was still to agree on the recommended terminology changes for EN1594. Comments generated from applying this guidance document had however been produced in association with some TC and WG members, ready for their next WG meeting. This is due to where the document was in its revision cycle when the comments were produced and submitted. It was out for public enquiry. However, this highlights that entry points for ACC to be included in standards can be numerous. This public enquiry has been used, in association with the WG secretary and chair, to collate and submit ACC comments to whole WG for consideration.

Other entry points have been when:

- ACC has been used as a trigger to begin revisions;
- ACC has been included as comments within existing revision cycles;
- ACC comments have been developed outside of normal revision cycles by a select group in a TC and or WG, ready to be processed at the next WG meeting of experts;
- A climate change adaptation expert attends a number of working group meetings to take them through this guidance;
- A climate change adaptation expert works in collaboration with the WG at their meetings to identify the most appropriate ACC words from the comments provided.

All of the above approaches have been successfully applied within CEN TC 234 “Gas Infrastructure”.

Case Example 3: Examples of ACC generic terminology in infrastructure standards

The following examples of terminology changes that help to embed Adaptation to Climate Change (ACC) have been developed in collaboration with TCs and WGs. The applied use of climate change scenarios is so specific to each standard that these examples have been selected because they do not require climate change scenarios to have been used in much detail. They provide examples of relatively generic options which have been used to place adaptation to climate change within respective standards. This is irrespective of whether the climate scenarios data is required by the standards writer, or the standards user. The table uses the same format as the two columns "comments" and "proposed change" in the standards commenting process that most users of this guidance will be familiar with.

Comments	Proposed Change
The definition for "design working life" is critical to the delivery of climate change resilient infrastructure, as it refers to the full life of a drainage component (its actual expected life) and not its "design life" (which can often be significantly shorter than its actual expected life). There are instances of the term "design life" being used in this standard (in Table NA.1 – page 96, and Table NA.2 – page 97 – which is designed to specifically address adaptation to climate change). To emphasize that "design life" is insufficient for this purpose, it could be wise to add a note to this definition.	Add: <u>Note: "Design Working Life" can often be significantly longer than "design life" and is of critical importance when calculating the longer-term resilience of drainage infrastructure, to, for example, climate change impacts.</u>
It has been useful in ENXXX to include a definition for "design working life". It could prove useful to bring the same definition over to this standard. The concept is directly relevant to the delivery of climate change resilient infrastructure, as it refers to the full life of an infrastructure component (its actual expected life) and not its "design life" (which can often be significantly shorter than its actual expected life). NB. Section 5.2.2 (page 8) refers to "design horizon" in reference to "population served". This similar concept (more explicitly presented as "design working life" – please also see proposed additional note) could be used within the relevant clauses to harness the concept of looking at climatic changes over the full life of infrastructure components.	Suggest adding the definition used in ENXXX: **<u>Design working life</u>** <u>assumed period for which a structure or part of it is to be used for its intended purpose with anticipated</u> <u>repair and maintenance but without renovation or replacement being necessary</u> <u>[SOURCE: EN 1990:2002, modified to provide consistency with the terminology in EN 16323]</u>

Comments	Proposed Change
NB. In subclause 5.5g (page 12) the term “design service life” (of equipment) is used. This may reflect the same concept as “design working life”. If so, then the term “design service life” could be used as a suitable substitute in other relevant clauses.	…And consider expanding this with the additional note: Note: “Design Working Life” can often be significantly longer than “design life” and is of critical importance when calculating the longer-term resilience of drainage infrastructure, to, for example, climate change impacts.
The impact of climate change over the design working life of the sewerage system could be explicit here. Many people using standards can end up using historical data that is already out of date (e.g. representative of weather patterns to 1970s and not to today). This is even before consideration of changes in weather that could occur over the design working life of the sewerage system.	Suggest adding two sentences following the bullet points (or perhaps a 7th and 8th bullet): Dry weather conditions and fluctuations in storm water flow will be impacted by climate change. Local interpretation of average and worst-case climate change scenarios over the design working life of the sewerage system will be assessed to determine their potential impact. When historical weather data is used to determine existing conditions, the data shall include the most recent weather data available.
There is an opportunity here to get more explicit about the need to factor climatic changes into the decision-making process. I do not currently have access to normative reference to look at the emphasis on climatic changes from global warming within the risk assessment. Nonetheless, even if it is adequately covered, it could still prove useful to this standard’s users to understand the relationship between the full life asset life cycle and the relevant timescales to look at climate change over. Also, the recommendation that they do not just look at average emissions scenarios, but a range that includes medium as well as high scenarios. This is seen by most as good practice.	Add the following sentences to the end of the second paragraph: …risk in the flood risk assessment. Flood risk should be calculated across the full asset life of the building and be aligned with relevant climate change scenarios over that timeframe. This should include analysis of both medium and high greenhouse gas emissions scenarios.
If the comments and proposed changes in this document are taken into consideration, then it may be valuable to explain what is meant by “medium greenhouse gas emissions scenario” and “high greenhouse gas emission scenario”.	Add the following two definitions to clause 3: **Medium Greenhouse Gas Scenario** – climate change scenarios that use a relatively optimistic future greenhouse gas emissions scenario that limits, for example, global warming to an average global temperature increase of 2ºC. **High Greenhouse Gas Scenario** – climate change scenarios that use a future greenhouse gas emissions scenario that reflect global warming to an average global temperature

Comments	Proposed Change
	increase of 4°C. Could use the term RCP: 8.2 and RCP 4.5 Could use "GHG Emissions scenarios"
The definition for "design working life" is critical to the delivery of climate change resilient infrastructure, as it refers to the full life of a drainage component (its actual expected life) and not its "design life" (which can often be significantly shorter than its actual expected life). There are instances of the term "design life" being used in this standard (in Table NA.1 – page 96, and Table NA.2 – page 97 – which is designed to specifically address adaptation to climate change).	Add: Note: "Design Working Life" can often be significantly longer than "design life" and is of critical importance when calculating the longer-term resilience of drainage infrastructure, to, for example, climate change impacts.
Could final effluent discharge point with maximum, minimum and average water level of receiving water be impacted by a changing climate over its design working life? If so, consider making that explicit.	Add to 8th bullet the additional sentence: …average water level of receiving water. This shall include any variations to these from climate change impacts over the design working life of the sewerage system. Average and worst-case climate change scenarios shall be used.
These sustainable development credentials are of course good. The three particular objectives used deal well with the impact of drainage interventions on the environment. There is however currently a missed opportunity here to include the impact of the environment on drainage – i.e. such as that caused by climatic changes.	Add a fourth objective: d) can remain resilient to changes in weather patterns, extreme weather events, and other impacts caused by climate change over its design working life.
Climate impact risk mitigation is not the same as climate change mitigation. Climate change risk mitigation is about adaptation to climate change and is not the same as managing climate change emissions (climate change mitigation). Risk mitigation is about managing the effects of climate change on your infrastructure, climate change mitigation is about managing the impacts your infrastructure has on the environment.	Add sentence: Risk mitigation is about managing the effects of climate change on your infrastructure, climate change mitigation is about managing the impacts your infrastructure has on the environment.
The term "foreseeable increases in flow" is used. In legal terms "risks from climate change" are now viewed as "reasonably foreseeable". There is an opportunity to remind people of that here. Interpretation of increases in flow from environment agency bodies and other modelers are often available. Rougher estimates can also be made by infrastructure providers using localised and regional climate change data. It would therefore be the responsibility of the standard user to ensure that they have	"…capacity shall allow for foreseeable increases in flow, including those from climate change impacts, over the design working life of the system"

Comments	Proposed Change
understood these foreseeable changes to flow where possible, relevant to the location they are working. I am not suggesting that the standard describes how this is done, as it would be different for different parts of Europe.	
1 in 100 year events may need reviewed if significantly altered by changes in climate over the full life of the proposed infrastructure.	Add sentence to note 2 (the underlined text below): *"NOTE 2 National or local criteria for new surface water drainage systems are likely to set requirements for development site run-off volumes to be controlled to* *pre-development equivalents, for the 1 in 100 year event, when discharging either to sewerage or directly to water bodies. In many cases, meeting this criterion might require water harvesting and reuse systems for attenuation. 1 in 100 year events may need reviewed if potentially and significantly altered by changes in climate over the full life of the proposed infrastructure."*
te Consider adding a new sub-clause about "adaptation to climate change". This may eliminate the need for comments on 5.2.1 (above). It would be best added prior to the existing 5.2.6 (i.e. not to replace the current 5.2.6 "Carbon reduction targets"). The current 5.2.6 would become 5.2.7, with the knock affect increasing each proceeding sub-clause.	Add a new 5.2.6 that reads: 5.2.6 Adaptation to climate change Information about the potential impacts of climate change should be taken into account. When assessing climate change impacts, they should be aligned with the full asset lifecycle of the infrastructure. *For example: If the infrastructure is intended to have a full life cycle of 30 years, then climate change scenarios should be reviewed over that 30-year period.* Climate change is likely to affect water reuse in numerous ways, including the long-term availability of water supplies within the catchment, changes in soil structure, attenuation options, drainage requirements, and water treatment processes. Potential climate change impacts over the full lifecycle of the intended water reuse project should be considered using both medium and high greenhouse gas emissions scenarios from climate data from a robust data source. Climate parameters can include temperature, precipitation, humidity, sea-level rise, wind speed and direction, and freeze–thaw cycles.
It could be useful here to remind the 'standard user' that averages need to be up to date with changes from current climate change (it is not unusual for people to still be using historical datasets that were produced in the 70s and are no-longer sufficiently relevant today). Likewise, it is important to be thinking about how	Add text (underlined below) after the equation (i.e. last sentence in the sub-clause) – it could be a note – but currently has the verb "*should*" in it: Climate change is likely to alter averages over the full lifecycle of the infrastructure.

Comments	Proposed Change
averages could change over the full intended life of the asset. Please note: AAR is perhaps therefore a challenge, for even if the same amount of average rainfall in a year were to b expected, the likelihood is that it will fall in significantly different intensities (e.g. periods of drought followed by torrential rain, etc). The annual yield could of course remain the same, but the ability to harvest it could be changed considerably.	Historical weather data on averages should therefore be up to date (to include current climate change) and forecasting should include climate change predictions over the full lifecycle of the intended infrastructure.
The temperature ranges mentioned may be altered due to climatic changes over the life of the pipeline.	Add sentence: This includes how these might be impacted by changes in weather patterns from climate change over the life of the pipeline components.
Could any of these be impacted by a changing climate (i.e. historical weather data is no longer relevant) over the full life cycle of the components? If so, should we make it a requirement that the designer must also consider local changes in weather patterns and extreme events such as floods from climate change?	Add an extra bullet: • Locally specific changes in weather patterns and extreme events from climate change
Could also be explicit here about future changes in reliability of supply due to climate change over the full life cycle of the relevant components.	Add an extra bullet: • Reliability of supply, including the consequences of a changing climate affecting water capture, storage, and use.

Case Example 4: Using climate change scenarios to influence infrastructure

UK – Somerset Levels

Background:

Somerset is an English county which is vulnerable to both fluvial and coastal flooding. Fluvial flooding, and to some extent surface flooding, had caused major disruption in 2007, 2012 and 2013/14.

A collaborative scenarios-based exercise was convened by the County Council and local civil society organizations to start the process of developing an adaptation pathways plan for integrated flood resilience in the County. Key infrastructure operators and other organizations who make decisions that impact on flood resilience were invited. Infrastructure operators attended from a range of sectors: roads, rail, drinking and waste water, power generation and distribution, waterways, and shoreline protection were represented in the process.

Scenarios:

In line with good adaptation pathways planning process a high case scenario was used against which to test current resilience plans. The objective was to find the thresholds at which current plans were no longer sufficient to provide resilience to flooding.

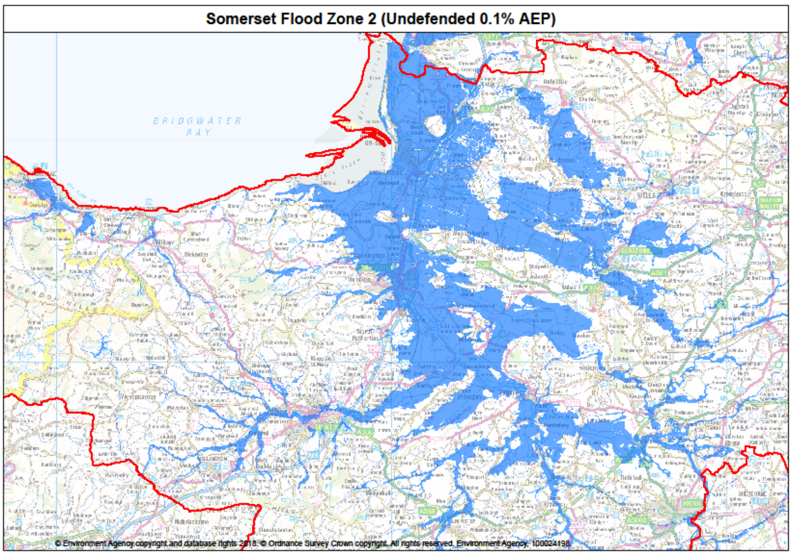
The UK's High++ scenarios for sea level rise of over 2 m by the end of the century (possible but unlikely). This is higher than the UKCP18 projections provided by the UK Government which projects a high case of 1.13 m sea level rise by the end of the century along the Somerset coast. The High++ scenarios are acknowledged by the UK Met Office as a good practice figure to "stress test" resilience levels to what is possible, if not probable.

A 100 % increase in peak river flows compared to the present by the end of the century was used based on high case scenario under the UK Government's UKCP18 projections.

The flooding scenario against which plans were tested was a combined 2 m sea level rise and 100 % fluvial flood event compared to current levels.

The UK Environment Agency provided maps that served as a useful proxy for those flood conditions if current flood protection plans are implemented (see Figure 4). These equate to the current flooding in a 1 in 1 000 probability event if all current flood protection were removed.

Figure 4: Proxy for a combined High++ sea level rise and high case peak fluvial flood by 2100



Findings:

Current plans are to provide shoreline flood protection to key areas for up to 1m sea level rise. The driver for this threshold was planning guidance to plan for 0.5m sea level rise by the end of the century for shoreline protection during initial vulnerability analysis 10 years previously. Projections have changed since then and guidance for sea level rise resilience significantly increased. Under the scenario chosen for this exercise, the threshold of current flood protection plans would be reached at 1 m sea level rise, causing extensive flooding of towns, roads, motorways and railways. 1 m is lower that the high case scenario of 1.13 m sea level rise under the UK Government's UKCP18 projections, and therefore considered a significant vulnerability.

Utilities compared their current plans against the scenario. There was a varied level of resilience. Power distribution had measures that were likely to be able to retain services under these conditions. Others did not have plans for this level of impact. Not all of these infrastructure providers were mandated to change current plans at County level. Decisions would need to be made at other levels in the organization about how to respond.

The systemic impact of the scenario suggested that beyond 1 m sea level rise, more strategic decisions would need to be made about the viability of current communities, land use and other factors that were beyond the scope of individual utilities to address. The outcome of those decisions would be likely to affect the options that utility companies needed to consider. County level planners would need to consider how they wished to respond before utilities could assess all of the measures that they might need to make, since their role is to service communities and if they change, utilities need to change with them.

Case Example 5: A high-level assessment that does not use climate data

DIN 4108-2:2013, *Thermal protection and energy economy in buildings — Part 2: Minimum requirements to thermal insulation*

Relevance:

This case example illustrates how it was possible to review whether a standard had to be altered as a result of changes in a climate parameter, without having to apply complex climate data. Following this approach made it possible to determine that for this specific parameter (i.e. temperature increase), it was not necessary to take any further action. Please note that before reading this approach, if the result had been that action was indeed needed, then deeper analysis using climate data would have been needed. This case study may therefore provide a useful starting point, but may not necessarily lead to the same conclusion that "no action is needed".

This example looks into the normative provisions on summer thermal insulation to explore whether an acceptable summer indoor climate requires further consideration of air moisture. This therefore depended upon:

- Summer climate condition in Germany (Climatic regional zones based on Test Reference Years of German Weather Service); and
- permitted over-temperature hours per year of residential and non-residential buildings (as national definition of resilience).

These provisions are affected by expected increasing of summer temperature in general.

Findings of the vulnerability assessment (and determining what action is needed):

Existing standard parameters were used, i.e.: building use; sun light entry; construction type (light, middle, and heavy); windows (size, direction, slope, and design functions); shading device for windows; and, possible night-time ventilation.

A number of relevant parameters could not be considered, also due to limited knowledge for calculation related to indoor climate, e.g. air moisture, effects of green roof and façade, water area, air and noise pollution, health status of building users. In addition, the vulnerability assessment could only be conducted using available technical data that describes the interactions on current outdoor climate. Due to defined conditions, described above, the vulnerability was determined by buildings or rooms that are already equipped with effective shading device for windows, especially by light constructions.

A single solution for adaptation of the normative provision could not be found in general. The essential reasons include:

- Constructional measures (construction type, functions and addition devices of windows) were not the only technical possibility to ensure an acceptable indoor climate in summer; indoor climate in summer can be also be controlled by air condition and ventilation systems that could affect the mitigation and are not part of the DIN 4108-2;
- In addition to promoting specific changes in behaviour of building users, (e.g. activities, clothing, hydration), authorities in Germany have now drawn up a guideline for development and implementation of local emergency plans for heat waves - particularly for vulnerable person groups (e.g. the elderly and sick).

NOTE The performed vulnerability assessment in the frame work of the responsible DIN KU working group is nevertheless useful, e.g. in order to raise the awareness by practical discussion, to check and optimize the approach and to identify further research demand related to concerning technical data as basis of provisions.

Annex 5: List of references

CEN-CENELEC Guide 32, *Addressing climate change adaptation in standardization* ftp://ftp.cencenelec.eu/EN/EuropeanStandardization/Guides/32_CENCLCGuide32.pdf

ISO 14090:2019, *Adaptation to climate change — Principles, requirements and guidelines*

ISO 14091:2021, *Adaptation to Climate Change — Vulnerability, impacts and risk assessment* [1]

ISO/TS 14092:2020, *Adaptation to climate change — Requirements and guidance on adaptation planning for local governments and communities* [1]

ISO Guide 73:2009, *Risk management — Vocabulary*

ISO Guide 84, *Guidelines for addressing climate change in standards* [1]

ISO Guide 82, *Guideline for addressing sustainability in standards*

EUFIWACC, 2016, *Integrating Climate Change Information and Adaptation in Project Development* http://www.ebrd.com/cs/Satellite?c=Content&cid=1395250899650&d=&pagename=EBRD%2FContent%2FDownloadDocument

RESIN: Three of the references are products of the H2020 RESIN project, directed at making European cities more resilient to the effects of a changing climate. In this project, facilitated by the EC, a consortium including four European cities (Manchester, Bratislava, Bilbao and Paris), research institutes (e.g. Fraunhofer, TNO, universities) and NEN developed supporting tools for addressing CCA. The project also had a focus on standardization. It was finalized by the end of 2021. You find more information here: http://www.resin-cities.eu/home/. Three key reports are:

- **Standardization in urban climate adaptation:** This report describes how results of the RESIN-project have been addressed in standardization processes. It includes a description of 30 concrete adaptation options (ranging from green roofs to demountable water barriers), and provides a concise overview standards and specifications that are currently available for these. http://www.resin-cities.eu/resources/deliverables/ (deliverable 2.2)

- **Decision support tools for climate change adaptation - User Guide:** This report describes a set of concrete tools for cities to address ACC in decision making. The tools include: a decision-making approach (related to ISO 14092), a tool for vulnerability approach (related to ISO 14091), an overview of adaptation options and a typology of Europe regarding risks for climate change. http://www.resin-cities.eu/resources/deliverables/ (deliverable 4.3)

- **Design IVAVIA: supporting vulnerability analysis (VA).** This report describes a tool for vulnerability analysis for urban areas and their critical infrastructures regarding the impacts of climate change. This tool has been used in a case study in Bratislava, and key elements have been implemented in the ISO 14091 standard. https://resin-cities.eu/resources/deliverables/ (deliverable 2.1)

Copernicus Climate Change Services **Climate data needed to address resilience to climate change in standards for infrastructures.** This report provides an overview of future climate data needed for standards for infrastructures. It was developed by NEN and BMGI for Copernicus Climate Change Services, after a broad consultation of experts in standards.

[1] To be published.