European Climate-Resilient Energy System – Enhancing adaptation and resilience indicators in the ENTSO-E TYNDP CBA framework – Part 3

Expert workshop summary report

DISCLAIMER

All statements in this document have been summarised by Renewables Grid Initiative and ENTSO-E based on the common understanding of the discussions carried out at the workshop. The opinions expressed in this document shall not be used to reflect the view of specific participants.

1. Background

The climate crisis poses immediate effects on energy systems. Frequent changes in climate patterns and increasing extreme weather events like heatwaves, droughts, or floods, as well as coastal erosion from rising sea levels, affect not only electricity generation but also electricity transmission and distribution systems. These impacts result in financial implications deriving from investments in preventive or reactive measures to keep electricity systems in operation, as well as other social and economic implications deriving from power outages.

The Cost-Benefit-Analysis (CBA) methodology is a Ten-Year Network Development Plan's (TYNDP) tool that aims at appraising the benefits and the costs of electricity infrastructure projects from a pan-European perspective. The outcome of the CBA assessment is an important input for the selection process of Projects of Common Interest (PCIs) as well as Projects of Mutual Interests (PMIs), that are key for the interconnection of the energy infrastructures across Europe. The European Network of Transmission System Operators for Electricity's (ENTSO-E) CBA Guideline is used for the assessment of the TYNDP projects portfolio.

According to the 2022 revised TEN-E Regulation, the CBA Guideline shall include aspects related to *climate adaptation and resilience*. This message has been further reinforced in two reports from 2022 and 2023 of the European Scientific Advisory Board on Climate Change (ESABCC). However, clarity was lacking on how exactly adaptation and resilience indicators, the quantified factors for their development, and these aspects overall shall be incorporated into the CBA methodology.

To bridge this gap, ENTSO-E and Renewables Grid Initiative (RGI) have been working since 2023 on developing **a framework** to guide a new, quantitative indicator for climate adaptation and resilience measures under the CBA Methodology. The new indicator had been planned to be incorporated into the 5th edition of the CBA Guidelines, complementing other indicators. Accompanying this process, RGI and ENTSO-E organised two expert workshops: the first workshop in October 2023 initiated the discussions on climate and resilience measures under the CBA methodology. The second workshop in March 2025 assessed a mature version of the framework, while identifying gaps and providing valuable perspectives from grid operators, policy makers, regulators, financial sector, researchers and civil society.

Toward completing the framework, RGI and ENTSO-E organised a third expert workshop on **13 November 2025** to assess and test advancements made in the framework, its adjustments to evolving policy needs and its applicability in electricity grid planning processes. The workshop aimed to address the following, interlinked points:

1. Receiving feedback on the steps taken so far

2. Identifying knowledge gaps and examining perspectives to assess combinations of probabilities concerning climate risk and hazards under the new indicator, including assumptions on costs and duration of impacts on the asset(s)

3. Considerations of inputs from RGI – ENTSO-E's survey on climate adaptation as well as from policy, industry, research and civil society perspectives

4. Exploring further developments and implications of the framework's development process for future adaptation needs

The workshop took place in ENTSO-E's premises in Brussels on 13 November 2025 (09:30-15;45 CET), with 30 participants in total (14 in-person, 16 online), including European regulators and policy makers, grid operators, researchers and representatives of civil society. This document presents a summary of the discussions and main takeaways from the workshop. Section 2 of this summary report elaborates on key insights from each session of the event, while sections 3 and 4 provide a list of participants and the workshop's agenda, respectively. A dedicated webpage for this workshop with speakers' presentations can be found here.

2. Summary of discussions and key insights

The following provides key insights from the presentations and discussions that took place during the workshop following the order of the original sessions.

2.1. Session 1: Background and setting the scene

Introduction (Andrzej Ceglarz, RGI)

- Participants received a brief review of the process leading to the workshop, starting with identifying needs as early as 2022.
- The goal of the workshop was clarified: the first part focused on the said framework and its last version before public consultation and implementation in the 2026 TYNDP update. The second part looked forward, aiming at linking parallel projects and initiatives of climate risk assessments by different expert organisations in Europe and beyond, eyeing policy developments such as the Grid Package and the planned

European climate and resilience and risk management - Integrated Framework, in 2026.

New European framework for climate resilience: State of play and next steps (Andras Toth, DG CLIMA)

- EUCRA-1 is the main reference DG CLIMA is currently relying on. Economic losses are (currently) the main indicator for policy considerations.
- Presenting the planned Integrated Framework for the European Climate Resilience (previously Climate Adaptation Plan):
    - Related already adopted initiatives: Vision for agriculture, Competitiveness, Compass, Water Resilience Strategy. Highlighting the State of the Union (September 2025) that included climate adaptation (with clear reference to nature-based-solutions)
    - 5 key elements in the framework as currently envisaged within the Directorate-General for Climate Action of the European Commission (not yet a formal Commission position):
        - Deploying resilience by design across sectors
            - Mainstreaming resilience across sectors and policies
            - Upfront and proactive effort is needed
        - Proposal for a legal Framework for Climate Resilience (possibly with indicators): Guiding Principle: resilience by design; Risk assessment (EUCRA, national, sectors); Climate resilience and adaptation governance at EU and national levels (including transboundary considerations); Monitoring, reporting evaluation and learning
        - Risk awareness digital tools & businesses and citizens empowerment
        - Competitiveness and innovation
        - Finance and insurance
    - Policy package under consideration: impact assessment report (early stages of drafting as of November 2025), Commission communication, a legislative proposal, a digital European Climate Hazard Viewer guidance on implementing climate reference scenarios, streamlining climate proofing and avoiding maladaptation.
    - Framework timeline: public consultation ends on 23 February 2026; adoption of the policy package planned for Q4-2026.
- Questions:
    - Are there plans to harmonise the policy package with the TEN-E Regulation? Or is this an independent process?
        - No Decision yet on how to handle sector specific regulation.
        - Revision on the Energy Security Framework was set to consultation earlier.
        - The policy package will not redraw all parts from sector specific regulations to a single package, but it could trigger an amendment of the TEN-E Regulation (to be decided).

- Will the digital European Climate Hazard Viewer follow just after the publication of the policy package? What are the timeline and objective of the policy package? How do they work with the overall legislation – or are they intended more for interested parties?
  - A meeting to plan the availability of the hazard viewer with the Copernicus team and EEA was planned for 14 November. The plan is to make the viewer publicly available.
- A suggestion was made to streamline the RGI and ENTSO-E's process related to dataset development with the planned hazard viewer.
- Referring to the 5 elements in the integrated framework, what will be the connection between "resilience by design" and "climate proofing guidance"?
  - The climate proofing guidelines document is intended to be the main tool for achieving climate resilience by design. Plans include updating the technical notice of the guidelines and developing interactive tools to help with decision-making on which climate resilience options to apply for specific projects, ensuring climate risk assessment happens from the design stage in a streamlined and assisted process.

Understanding and quantifying climate risks in the EU – EUCRA 2 (Hans-Martin Füssel, European Environment Agency [EEA])

- EUCRA process is coordinated by DG CLIMA, DG ENV, DG ECHO and EEA
- EUCRA-1 impact chain includes the following elements: climate-related risk drivers, non-climatic risk drivers, direct / indirect impacts, ecosystem exposure, major climate risks and links to other "storylines", e.g. the built environment.
- Planned EUCRA-2:
  - Quantitative modelling for selected risks, providing improved regional resolution:
    - Planned for more quantitative base for specific risks with improved regional resolution
    - Key partner organisations: the EC's Joint Research Centre (JRC) and ECMWF
  - Expanded stakeholder involvement
    - Learning from latest national climate risk assessments
    - Stronger Involvement of sectoral stakeholders

Recap: developing a framework to guide the new indicator (Benedict Englisch, ENTSO-E)

- A summary of the framework and the proposed formula to calculate cost-effectiveness benefits for assets with and without adaptation measures was presented.
- Questions:
  - Are the long-term effects of climate (chronic events), which might not materialise in a specific outage event but affect lifetime parameters (e.g., shorter lifetime or reduced Return of Investment), considered in this approach?

- This indicator aims to provide insights in the benefit brought through adaptation measures and to compare the situation with the measures in place to the situation of an unprotected asset, where the hazardous event forces an outage of the asset. Therefore, this benefit should not be seen as additional benefit brought on top of the other indicators used in the CBA analysis, but as a share of the benefit that can be attributed to the adaptation measure.
- For other climate effects, the TYNDP scenarios are based on the PECD (Pan European Climate Database) providing historical and projected datasets. However, the current methodology faces a bottleneck exactly at this point, since the effect of long-term effect on the parameters duration of outage and rebuild time have to be further examined.

- Does the mentioned outage mean the outage of power for the end consumer?
  - No, the outage here refers to one single project (non-operating of the asset) and does not indicate a power outage for consumers. Other monetised parameters, such as Energy Not Served (ENS) could be also used following this approach.
- Does the calculation of the indicator require an entire TYNDP run (with and without the asset/measure) and under which TYNDP scenario?
  - In the current TYNDP cycle one scenario, National Trends (NT), will be considered. Since this indicator compares the situation with the climate adaptation measures in place to the situation without, no new explicit simulation must be run for this indicator.
- How is the duration of outage estimated? Is it normalised between 0 and 1?
  - The factor “d” determines the duration of the outage, normalised between 0 and 1 in relation to a full one-year span.
- What is meant by year of hazard occurrence? How is it calculated?
  - The year of hazard occurrence stems from the main assumption that in every year of the asset-lifetime an outage could occur. Therefore, the indicator covers all possibilities and retrieves the benefit brought in average over all situations. How to account for varying probability of an outage over time is one of the open needs by this methodology.
- Benefits and Costs: Are the benefits and costs referring only to the promoter? What is the impact on end-consumers?
  - Benefit is the benefit calculated as the others for the project.
  - Power outage for the *consumer* is not considered as with/without benefits, but outage of the *transmission project*.

RGI – ENTSO-E resilience and adaptation survey: relevant insights to the framework (Ira Shefer, RGI)

- Key insights from the survey were presented, with an initial qualitative assessment of some of the results. Individual cases of climate resilience and adaptation measures by grid operators were put into RGI database of good practices.
- Questions:
    - Does the database also cover data that provides more information in the share of resilience in the investments in terms of affordability, and could standardised values per asset category be derived?
        - Missing data cannot provide information on designing projects with/without adaptation measures. Therefore, no standard assumptions are derived.
        - Additionally, the data shows “no approach fits all” limiting the usage of standardised values.

Knowledge gaps: assessing combinations of probabilities and assumptions of cost and duration of impacts on grid assets & Open discussion: addressing knowledge gaps toward completing the framework (Philipp Fortenbacher, Amprion and Benedict Englisch, ENTSO-E)

- Questions:
    - Do you consider other approaches for dealing with uncertainty, e.g., giving a threshold of NPV value to be reached across all options or is there a certain NPV threshold value that should be considered when dealing with uncertainty?
        - The current approach covers only one single value. Broadening the approach to a range of NPV values to account for uncertainty is one of the open needs for this methodology.
    - What use can be made of this planned indicator framework?
        - Whilst this indicator shows the benefit brought for one specific project, there is also the need to have a system wide indicator developed at the European level. The scope of further indicators could be a potential further development.
        - DG CLIMA aims for an indicator at the energy system level, not the project level.
    - Including probability and linking it to intensity of weather events / climate hazards is necessary.
        - The occurrence and the intensity of the events might be interdependent and the combination of both should be accounted for. Additionally, in a theoretical sense, this then can be condensed in one probability of the outage.
        - Asset specific adaptation measures might be only for reoccurring events, not necessarily for long-term rise of intensity. Therefore, also the intensity must be accounted for when assessing the outage, since over a certain threshold of intensity an outage could still occur.

- Is there any chance that the Integrated Framework for European Climate Resilience and the common climate scenarios and tools mentioned before help with this kind of decisions or is it too granular in a sense to help?
  - Having a common reference scenario and tools might help to reduce uncertainties brought by future modelling. In the meantime, limited insights are available for whether the Climate Hazard Viewer will support political decisions.
  - How the resilience targets and measurements are designed is currently an open question for EU lawmakers.
- The duration of a power outage might not always be similar to the same specific asset outage.
  - The approach considers climate adaptation and outage of one individual asset and, therefore, does not consider the consequences of power outage on consumers. This could be elaborated in further developments of the indicator.
- Does the approach consider the occasion of multi-hazard events?
  - The current approach does not cover this assessment but will be taken into account when further developing this indicator.

2.2. Session 2: Deep dive session – experts' view

Research perspective: CBA Methodology and multi-climate hazards scenarios (Elco Koks, Vrije Universiteit Amsterdam [VUA])

- Presenting NG INFRA, a new project started with all the big infrastructure operators
- Presenting the MIRACA project:
  - Risk assessment of different hazard types and interactions (multi-level, multi-hazard and multi-system).
  - Asset level exposure and vulnerability of multi-hazard events analysed on time (Cascading events) and geography (Regional occurrence of different hazards)
    - Exposure at the asset level
    - Providing data on measures against flooding for substations
    - Estimating how quickly can the substations be accessed? How can another grid operator be influenced by the action of another (e.g., no access to the substation due to the flooding of the street)
  - A Study by the Scottish and Southern Electricity Networks Distribution (SSEN-D) on nature-based solutions for substations was presented. Based on discussions following this presentation, RGI added these points regarding this study after the workshop:
    - The damage factor shows that even with adaptation measures (engineered and nature-based), there will be a threshold where these measures will not be sufficient anymore. Adaptation measures can reduce the exposure on a time perspective or the vulnerability (intensity faced) or a combination of both.

        - Estimations of nature-based-solutions against physical (engineered) solutions proved to provide social value (monetary and non-monetary).
- System level adaptation options:
    - Presenting estimation for electricity-flexibility options, including batteries, load shifting, peak shaving etc., using combination of multiple scenarios, now in a paper by Peregrina et al. (Daniel Peregrina Gonzalez, who attended the workshop), under review as of 13 November 2025.
    - A question raised by one participant: it makes sense to use benefit-cost ratio (BCR), but what is accounted for under “benefits”, as benefits can be manipulated?
- Assessing multi-hazard events:
    - The proposed approach can be described as a step-by-step algorithm: first, the asset’s protection against one hazard is assessed; then, the consequences for other hazards are considered. If multiple alternatives (adaptation options) are being compared, this algorithm is applied to each option.

    - This approach distinguishes between single- and multi-hazard BCRs:
        - If only one hazard is considered, trade-offs and synergies with other hazards may be overlooked.
        - If multiple hazards are considered, the BCR calculation can better reflect the expected outcomes of the alternatives.
- Final remarks:
    - Uncertainties of events must be respected. Academia can provide decision makers with a broad range of calculations, but a remaining question is which information is needed in the end for investment decisions.
    - Additionally, the presenters stressed the need to collaborate between policy makers, industry and research/academia to reach more accurate and relevant results.

Global perspective (Christine Brandstatt, International Energy Agency [IEA])

- Analysis on exposure and vulnerability for the energy sector in an IEA’s report "National Climate Resilience Assessments".

- IEA is working on a collection to overlay climate hazards risks with infrastructure at a national level, with measures to enhance resilience of existing grid infrastructure in high-risk zones.

- Work is undergoing concerning ways and methods for grid operators to address climate hazards, including exploration of further collaborations with different types of stakeholders.

- Questions:

- Is the collection for extreme weather events and impacts on energy infrastructure publicly available, and does it include cost estimates?
  - The collection is still under development and is not publicly available. Only aggregated results are currently published in the World Energy Outlook. It builds on EM-DAT disaster records, which the IEA has further analysed to identify impacts on energy infrastructure. It is still too early to confirm whether the collection will be made public, but the intention is to release it in the future. However, the data is not expected to provide very detailed or asset-specific cost numbers.
- Will the wildfire assessment include Europe?
  - Technically the analysis performed is on a global level and therefore includes Europe in the assessment. The presentation showed selected country results but to which granularity the data on specific regions and countries are provided remains open.
- Will the collection include assessments of cost of adaptation?
  - It is less developed than impact collection. It is too early to tell if the cost-estimates will be made publicly available. IEA does not expect to have specific costs, but rather a range of estimated costs.

Industry perspective (Valerie Van der Wal, TenneT / Innovation Alliance [IA])

- The Innovation Alliance (IA) is a group of 8 European TSOs collaborating on practical solutions for secured and climate-proofed electricity infrastructure. The IA published tenders for 2 pilot projects ("challenges") to be implemented by March 2026, on 1) contributing to forecasting of extreme weather events and a decision support system for TSOs control rooms, and 2) contributing to climate-proof network planning and investments. Out of the IA eights members, 1 or 2 TSO(s) will host the pilot, with other TSOs choosing whether to also implement the end-product or not following the pilot-results.
- Questions:
  - What is the long-term plan / focus of the Innovation Alliance?
    - Speeding up processes and solutions.
    - Potential collaboration with ENTSO-E.
  - Will the results of the 2 challenges be made publicly available?
    - The IA could share with the workshop's participants which TSO is accounting for which challenge, and (some of) the results of the pilot projects.

2.3. Session 3: The next steps

Open discussion: Lessons learned from the CBA methodology and its applications towards future adaptation needs (Andrzej Ceglarz, RGI and Philipp Fortenbacher, Amprion)

The following points represent selected insights that were brought up by the workshop's participants in an interactive session:

- Development of an open-source model of the framework should be considered.
- Implementation of the framework (make it "practical") should be considered: a lot of theoretical work is done so far, and therefore the assessment needs to be tested with several **business cases.**
- Policy makers showed interest in the work presented concerning climate risk assessment and a special interest was shown in end results.
- Amendment of the framework and testing of projects: ENTSO-E will need to reach out to project promoters who have submitted information on climate adaptation measures.
- There are clear expectations regarding quantifying the benefits of selected adaptation measures in EUCRA-2.
- A key shortcoming of the topic, identified by participants, is the limited availability of cost assumptions for climate adaptation measures.
- The framework seems to be useful for distribution networks and even for other infrastructures such as water and gas utilities.
- The workshop participants have together a great deal of experience, and this should be an opportunity to further explore future collaborations.

The next steps (Andrzej Ceglarz, RGI and Benedict Englisch, ENTSO-E)

- Plans to use the knowledge gained in the work on the framework beyond CBA methodology alone
- Streamlining of efforts: Many initiatives / efforts are done by different sectors from policy (EC), industry (ENTSO-E, RGI and Innovation Alliance) and academia (e.g., VUA). Collaboration would be beneficial for all.
- Next concrete steps:
    - Publishing a summary report of the workshop by mid-December / early January on RGI website.
    - 12 February 2026: RGI and ENTSO-E will present the work on the new indicator in a webinar organised by the World Bank, aimed for global Audience.
    - The option for another expert workshop will be **discussed** in Q1-2026.

3. List of participants

Name	Organisation
Elco Koks	MIRACA project/ Vrije Universiteit Amsterdam
Hans-Martin Füssel	EEA
Andras Toth	DG CLIMA
Christine Brandstatt	IEA
Valerie Van der Wal	TenneT (NL) / Innovation Alliance
Andrzej Ceglarz	RGI

Ira Shefer	RGI
Sara Gaçe	RGI
Benedict Englisch	ENTSO-E
Philipp Fortenbacher	Amprion
Nils Schindzielorz	TenneT GR
Bjørn Slettan	Statnett
Franck Dia Wagoum	ENTSO-E
Lisa Zeyen	Open Energy Transition
Katrien Prins	European Commission
Pieter Smet	Elia
Daniel Peregrina Gonzalez	Vrije Universiteit Amsterdam
Holger Ruf	Ulm-Netze
Federico Falorni	Terna
Raffaele M Della Croce Di Dojola	Imperial College London
Jose Moreira	REN
Kamila Paquel	ESABCC
Emmanouil SANTORINAIOS	ACER
Carmen Reittinger-Humber-Ruck	APG (Austrian Grid Operator)
Carlos Gaete	Open Energy Transition
Quentin Paletta	IEA
Alexandra Kaatz	Bundesnetzagentur
Giedrius Blagnys	VERT (Lithuania)
Christophe Dauloudet Fleureau	CINEA
Dionysis Spiropoulos	RAAEY (Greece)

4. Agenda

Time	Activity
09:30 – 10:00	Registration and coffee
Session 1: Background and setting the scene	
10:00 – 10:15	Welcome notes and introduction to the workshop Andrzej Ceglarz, RGI and Benedict Englisch, ENTSO-E
10:15 – 10:25	Current policy developments at the EU level: the European Climate Adaptation Plan Andras Toth, DG-CLIMA
10:25 – 10:40	Understanding and quantifying climate risks in the EU – EUCRA 2 Hans-Martin Füssel, European Environment Agency (EEA)
10:40 – 10:50	Recap: developing a framework to guide the new indicator Benedict English, ENTSO-E
10:50 – 11:10	RGI – ENTSO-E adaptation survey: relevant insights to the framework Ira Shefer, RGI
11:10 – 11:35	Knowledge gaps: assessing combinations of probabilities and assumptions of cost and duration of impacts on grid assets Philipp Fortenbacher, Amprion and Benedict Englisch, ENTSO-E
11:35 – 12:15	Open discussion: addressing knowledge gaps toward completing the framework Philipp Fortenbacher, Amprion
12:15 - 13:15	**Lunch break**
Session 2: Deep dive session – experts' inputs	
13:15 – 13:40	Research perspective: CBA Methodology and multi-climate hazards scenarios Elco Koks, Vrije Universiteit Amsterdam
13:40 – 14:05	Global perspective Christine Brandstatt, International Energy Agency (IEA)
14:05 – 14:30	Industry perspective Valerie Van der Wal, TenneT / Innovation Alliance
14:30 – 14:50	**Coffee break**
Session 3: The next steps	
14:50 – 15:30	Open discussion: lessons learned from the CBA methodology and its applications toward future adaptation needs Andrzej Ceglarz, RGI and Philipp Fortenbacher, ENTSO-E
15:30 – 15:45	Announcing next steps and wrapping up Andrzej Ceglarz, RGI and Benedict Englisch, ENTSO-E