European Climate-Resilient Energy System – Enhancing adaptation and resilience indicators in the ENTSO-E TYNDP CBA framework – Part 2

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 options expressed in this document shall not be used to reflect the view of specific participants.

1. Background

Climate adaptation means taking action to prepare for and adjust to both the current effects of climate change and the predicted impacts in the future. Its importance is related to the awareness that, despite the European commitment to reduce the greenhouse gases emissions and to keep the global temperature below 1.5 °C, in line with the Paris Agreement, the electricity system will face immediate and near future effects of the climate crisis. These impacts vary from more frequent and intense extreme weather events like heatwaves, droughts, or floods, to coastal erosion from rising sea levels, which affect not only energy infrastructure but the entire energy system as well, including supply and demand sides. Hence, each of these impacts results in financial implications deriving from investments in preventive or reactive measures to keep electricity systems in operation.

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 transmission 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 in across Europe. ENTSO-E's 4th CBA Guideline shall be further used for the assessment of the TYNDP projects portfolio.

According to the TEN-E Regulation, the CBA Guideline shall include aspects related to *climate adaptation and resilience*. However, clarity is lacking regarding the required indicators for adaptation and resilience, quantified factors for their development, and their incorporation into the CBA methodology.

To bridge this gap, ENTSO-E and Renewables Grid Initiative (RGI) organised in October 2023 an expert workshop titled "European Climate-Resilient Energy System – Enhancing climate adaptation and system resilience in the ENTSO-E TYNDP CBA Framework" to initiate discussions on climate and resilience measures under the CBA methodology and allowing for knowledge exchange between different actors in the field dealing with these aspects. Following this workshop, ENTSO-E and RGI have been working to develop a framework for adaptation and resilience quantitative indicator, aiming at its application in the 2026 TYNDP process, and in the planned, 5th edition of the CBA Guidelines.

To enhance the quality and relevance of the indicator and assess its potential application in the TYNDP CBA context, RGI and ENTSO-E organised a second expert workshop to collect and incorporate stakeholders' perspective on the framework's development. The workshop aimed at: 1) presenting the framework and the methodology behind the development of the indicator; 2) receiving feedback on this framework from relevant experts involved in climate resilience and adaptation topics, including civil society actors, financial institutions and regulators; and 3) facilitating expert community to continue the exchange of knowledge and discussion around the development of the indicator during 2025.

The workshop took place in ENTSO-E's premisses in Brussels on 20 March 2025 (09:30-16:00 CET), with 31 participants in total (17 in-person, 14 online), including EU regulators and policy makers, TSOs, researchers and representatives from the finance sector and civil society. A dedicated webpage for this workshop with speakers' presentations can be found here. Section 2 of this summary report elaborates on key insights from each session of the workshop, while sections 3 and 4 provide a list of participants and the workshop's agenda, respectively.[1]

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. Introduction

- Continuing changes in climate patterns and extreme weather events call for proactive electricity grid planning, with regulatory recognition of the need to integrate climate adaptation and resilience measures in the planning process. Participants agreed that these measures must be embedded in long-term investment plans and strategies rather than optional "add-on" elements in grid projects. This notion led to the following points:
    1. How to accurately assess the costs and benefits of adaptation measures? Should both direct and indirect costs (e.g., social and environmental impacts) be differentiated and assessed?
    2. The need to assure that resilient grid planning goes beyond individual projects and is addressed more systematically. The workshop organisers assured that the methodology is coherent with system-wide resilience efforts.

2.2. Session 1: The framework

This session presented the framework that guides the integration of a climate adaptation and resilience indicator and guidance under the CBA methodology.

2.2.1. Framework's overview

- The framework answers the need for a new climate adaptation and resilience indicator to justify potential additional investment costs. The methodology must be adjusted to

[1] We share only the names of participants who provided their consent before and during the workshop.

asset-specific characteristics, and should allow complementarity with other CBA indicators.

- Project promoters will need to define the needed adaptation and/or resilience measures according to local conditions and needs, to then apply the assessment accordingly. Integrating emergency preparedness in the assessment is under consideration.
- Adaptation costs will be treated as a separate indicator (i.e., separately of the general Net Present Value [NPV] calculation).
- A key issue is to define the assessment criteria for effectiveness of the proposed measures (e.g., historical data on past adaptation projects or creating benchmarks for future planning).

2.2.2. Climate Hazards Dataset

- A dataset of climate hazards has been developed to support the calculation of corresponding adaptation and resilience measures costs and benefits per hazard, considering different factors such as: classification of hazards (e.g., floods, extreme temperatures, wildfires, storms), geographic probability assessments, estimated duration and downtime caused by each hazard, adaptation measures suitable for hazards and broadly categorised by prevention (before the hazard), response (during the hazard), reaction (after the hazard) and monitoring (throughout these phases), as well as cost assessments (including investment and inaction costs). The dataset is sourced from research, reports from European agencies, and direct input from TSOs.
- Key considerations when further development of the dataset:
    - The dataset requires more reliance on climate projections and scenario-based risk assessments (probability approach) to improve predictive accuracy. Some historical hazard data may not be relevant for future scenarios and, therefore, reliance on modelling could provide more accurate and effective predictions of future risks/hazards.
    - The dataset may need to address potential conflicts between co-benefits and adaptation measures (e.g., certain measures may mitigate multiple risks, while others could introduce unintended vulnerabilities).
    - The dataset should distinct between chronic climate impacts (e.g., rising average temperatures over the years) and extreme events (e.g., heatwaves), as different adaptation strategies may be required.

2.2.3. A methodology for climate adaptation Cost-Benefit Analysis

- The methodology's applies monetised NPV to compare projects with and without adaptation measures. Key elements include:
    - Baseline assumption: Without adaptation, an outage is likely to occur within a project's 25-year assessment period.
    - Cost-benefit assessment process: Identifying the relevant hazard → Linking the hazard to the project → Defining the adaptation costs → Comparing the NPV of projects with and without adaptation measures. The NPV of a project with adaptation is compared to an estimated NPV of the project if it were to experience an outage due to climate hazards → Establishing whether the adaptation investment is justified or not.

- Key considerations for further development of the methodology:
  - Should the methodology consider also broader grid resilience rather than just individual projects? Would a system-wide approach provide more accurate picture of adaptation needs?
  - The assessment might benefit from including overall system resilience of an impact (i.e., not only per project), potentially incorporating network stress tests to evaluate cascading failures.
  - A need to differentiating between network-level adaptation planning and asset-level interventions.
  - It was suggested that investments shall align with national climate resilience strategies to ensure consistency.
  - In relation to the dataset, there is a need to clarify / solve how probability and severity of hazards are factored into cost estimates. A potential solution within the scope of the TYNDP process: integrating geospatial risk models to improve accuracy at a regional level and identifying interdependencies where feasible.

2.3. Session 2: Sectoral perspectives

2.3.1. Research perspective: European Scientific Advisory Board on Climate Change (ESABCC)

- Adaptation needs should be integrated into both the project-level and system-planning → under standardised indicators to ensure consistency across European grid projects.
- Upcoming ESABCC's report(s) is expected to address these gaps.

2.3.2. Financial sector's perspective European Investment Bank (EIB):

- EIB is also facing challenges how to quantify adaptation measures within its investment decisions. Currently, it uses a taxonomy-based approach (i.e., whether the project meets adaptation criteria), and risk and vulnerability assessments.
- Examples of adaptation investments include undergrounding power lines, upgrading technical specifications to withstand extreme temperatures, and installing cooling systems in substations. These measures were presented for distribution systems, but were said to apply to transmission systems as well.
- The distinction between adaptation and general resilience planning was debated; some suggested that investments in grid flexibility and redundancy should also be considered adaptation measures (at grid level).
- A key challenge is data availability for quantification of financial impacts of adaptation measures; hence, improving data collection and transparency are necessary.
- While synergies / cooperation between EIB financing and EU funding mechanisms such as the Connecting Europe Facility (CEF) exist, the methodologies each organisation uses differ, which require further alignment efforts.

2.3.3. TSO's perspective: Elia (Belgium's transmission system operator)

- Elia identifies 4 main risks related to climate change adaptation in decreasing order of risk after a study performed in 2023:
    1. flooding (increasing risk),
    2. heatwaves (increasing risk)
    3. high winds (storms, downbursts,…) (equal risk)
    4. cold & winter incident (decreasing risk)

    → The risk of wildfires impacting the TSO's infrastructure is considered low today and is evaluated not to increase in Belgium due to climate change with current insights.
- No urgent additional actions are determined but current mitigation policies suffice:
    - Short and long term flooding risk actions and monitoring for some substations
    - Temperature monitoring in all buildings with equipment like protections, datacom, switchgear to assess potential future impacts
    - Heatpumps for heating of new buildings also useable for cooling
    - Gradually reinforcing the 380kV grid to a higher wind standard
- Many design standards for electricity infrastructure are based on historical climate data, which may no longer be valid for future climate impacts and events → A good example of the need for models / scenario-based risk assessments.
- Availability of high-resolution climate data seems to be lacking / insufficient in electricity grid planning; and there is ongoing research to improve local climate projections. In this regard, the need for enhanced collaboration between TSOs and meteorological institutions was discussed, particularly regarding storm forecasting and climate risk modelling → This calls for facilitating collaboration with other RGI's established projects, such as DestinE.

2.3.4. Private sector's perspective: Marsh McLennan (Consultants)

- Marsh McLennan introduced their framework for assessing climate risks, incorporating financial, physical, and transition risk factors. Climate scenario modelling was highlighted as a tool to estimate financial impacts on energy infrastructure and case studies illustrated how adaptation measures, such as undergrounding power lines and upgrading cooling systems, can be evaluated through cost-benefit analysis.
- The integration of climate risk modelling into financial planning was discussed, with some participants suggesting that standardised methodologies should be developed to enhance comparability across projects.
- A debate emerged regarding the balance between proactive adaptation and reactive resilience measures. While some advocated for immediate investment in adaptation,

others emphasised the need for flexible strategies that evolve with emerging climate data.

- The challenge of obtaining reliable data for risk assessment was reiterated, with calls for closer collaboration between financial institutions, insurers, and TSOs to improve climate adaptation planning.

2.3.5. Concluding remarks for Session 2:

- There is a need for standardised climate adaptation indicators to ensure consistency across EU infrastructure projects.

- Greater collaboration between TSOs, financial institutions, meteorological institutions, and policymakers to align methodologies for adaptation cost assessments is required.

- Improved data collection and modelling efforts to enhance the accuracy of climate risk assessments.

- Regulatory support is important to facilitate financing of adaptation measures.

2.4. Session 3: Summary of key takeaways and next steps

2.4.1. Discussion & general comments:

- Efforts will be made to integrate into the framework forward-looking climate projections instead of relying solely on historical data.
- Efforts will be made to adopt a probabilistic approach, with suggestions to assess different climate hazard scenarios rather than using deterministic assessments. → Whether this data is available or does it have to be generated for the specific requirements and features of the framework, remains to be investigated.
- A crucial next step is to define clear thresholds for when adaptation intervention is necessary.
- The complexity of the methodology was discussed but without a principle decision / conclusion: some participants favoured a highly detailed and precise approach, while others stressed the importance of ensuring that the tool remains practical and easy to use for project developers.

2.4.2. Data Requirements for Climate Adaptation Assessments:

- Multi-hazard risk assessments should be addressed as well, particularly for extreme weather events occurring in rapid succession (e.g., consecutive storms or a drought followed by flooding).
- The distinction between "incremental adaptation" (small adjustments to existing infrastructure) and "transformative adaptation" (fundamental changes to infrastructure planning) was debated. While the current framework focuses on incremental adaptation, transformative strategies should not be overlooked.

2.4.3. Sectoral and Policy Considerations:

- Investments in adaptation measures should not inadvertently penalise projects by increasing costs without clear financial benefits.
- Defining "materiality thresholds" for adaptation investments was seen as an important step in ensuring clarity on when adaptation measures should be required → this relates, even if indirectly, to the previous point on clarifying which climate hazards and impacts are relevant / crucial for developing adaptation measures. In this regard, some climate hazards may require monitoring measures only.
- Cross-sectoral collaboration was emphasised as a key factor in successful adaptation planning, particularly in coordinating efforts between energy, water management, and transport sectors.

2.4.4. Conclusion & Next Steps

- Further refinement of the climate adaptation and resilience framework, focusing on improving data sources and methodological approaches.
- Continued stakeholder engagement to address usability challenges and gather additional feedback. In this regard, a follow-up workshop may take place in Q4-2025 to collect final feedback and/or address other elements related to the framework and/or to adaptation and resilience in electricity grids.
- Continued work on ensuring alignment between climate adaptation considerations and broader EU regulatory discussions.
- Participants were informed that workshop materials and sample dataset prepared would be shared with them for further input. The participants would be consulted to refine the climate adaptation assessment methodology. The discussion reaffirmed the importance of maintaining momentum and ensuring practical implementation of adaptation measures in electricity infrastructure planning.

3. List of participants (first name alphabetical order)

Name	Organisation
Alban Pyanet	Marsh McLennan
Alois Thiant	Marsh McLennan
Andrzej Ceglarz	RGI
Bjørn Slettan	Stattnet
Bruno Dotti	Marsh McLennan
Bruno Schyska	DLR
Catherine Banet	Scandinavian Institute of Maritime Law
Daniel Peregrina Gonzalez	Vrije Universiteit Amsterdam

Dennes Mentz	50Hertz
Elco Koks	Vrije Universiteit Amsterdam
Diego Ferraz Castineiras	Fundación Renovables
Emmanouil Santorinaios	ACER
Federico Falorni	Terna
Francesco Celozzi	ENTSO-E
Franck Dia Wagoum	ENTSO-E
Ira Shefer	RGI
João Pedro Castro	REN
John Sinner	EIB
José Moreira	REN
Kamila Paquel	ESABCC
Lena Kitzing	ESABCC
Lothar Brixius	TransnetBW
Marc Le-Bailly	RTE
Maria Belen Segura Diaz	REE
Maciej Grzeszczyk	European Commission
Nils Schindzielorz	TenneT
Philipp Fortenbacher	Amprion
Riccardo Vailati	ARERA
Smet Pieter	Elia
Stefano Astorri	ACER
Thomas Gilon	Open Energy Transition

4. Agenda

Time	Activity
09:30 – 10:00	Registration and coffee
10:00 – 10:15	Welcome notes and introduction to the workshop Andrzej Ceglarz (RGI) and Franck Dia Wagoum (ENTSO-E)
Session 1: The Framework	
10:15 – 10:30	Climate resilience and adaptation framework in the CBA methodology: Background, concept and developments so far Philipp Fortenbacher (Amprion)
10:30 – 11:00	Climate Impacts and Related Costs on Electricity Infrastructure in Europe – proposing Climate Hazards Dataset + Q&A Ira Shefer (RGI)
11:00 – 12:00	A new indicator of climate adaptation and resilience measures: Development status and potential usability + open discussion Nils Schindzielorz (TenneT)
12:00 - 13:00	**Lunch break**
Session 2: Sectoral perspectives	
13:00 – 13:25	Towards climate neutral and resilient energy networks: Insight from the European Scientific Advisory Board on Climate Change (presentation + Q&A) Prof. Lena Kitzing (the European Scientific Advisory Board on Climate Change)
13:25 – 13:50	Climate Adaptation in Grid Financing: The European Investment Bank Perspective (presentation + Q&A) John Sinner (European Investment Bank)
13:50 – 14:15	Resilience of energy infrastructure to climate extremes (presentation + Q&A) Pieter Smet (Elia)
14:15 – 14:40	Climate Stress Testing and Adaptation: Experiences Across Different Sectors (presentation + Q&A) Marsh McLennan
14:40 – 14:50	**Coffee break**
Session 3: Moving forward	
14:50 – 15:50	Open discussion with all participants: Identifying gaps and knowledge needs, and the future collaboration potentials

15:50 – 16:00	Discussing the next steps + concluding remarks Andrzej Ceglarz (RGI), Franck Dia Wagoum (ENTSO-E), Philipp Fortenbacher (Amprion)