User Needs Workshop report

DE_370b_DLR – Use Case Energy Systems

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Change Log

Version	Date	Description
V1.0	14/04/2023	Report summarising the discussions at the User Needs Workshop, organised on 28/02/2023 in Bonn, Germany.
V2.0	03/05/2023	Updated report, according to comments from ECMWF.
V3.0	26/05/2023	Final public version of the report.

Contents

Glossary

ACER	European Agency for the Cooperation of Energy Regulators
AU	Aarhus University, partner of Destination Earth Use Case Energy Systems
Climate DT	Destination Earth's Climate Change Adaptation Digital Twin
C3S	Copernicus Climate Change Service
DestinE	Destination Earth
DESP	Destination Earth Core Service Platform
DEDL	Destination Earth Data Lake
DLR	Deutsches Zentrum für Luft- und Raumfahrt / German Aerospace Center, lead partner of the Destination Earth Use Case Energy Systems
DSO	Distribution System Operator, operator of the medium and low-voltage electrical grid
ECMWF	European Centre for Medium-Range Weather Forecasts, partner of the Destination Earth initiative and lead partner on the implementation of the Destination Earth Digital Twins
EENS	Expected Energy Not Served
ERAA	European Resource Adequacy Assessment
ESA	European Space Agency, partner of the Destination Earth initiative
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites, partner of the Destination Earth initiative
ENTSO-E	European Network of Transmission System Operators for Electricity
EnSyMs	Energy system models
Extremes DT	Destination Earth's Weather-induced and Geophysical Extremes Digital Twin
LOLD	Loss of Load Duration
LOLE	Loss of Load Expectation
RGI	Renewables Grid Initiative, partner of Destination Earth Use Case Energy Systems

PECD	Pan-European Climatic Database of ENTSO-E
SO	Seasonal Outlook
TEN-E	Trans-European Networks for Energy Regulation
TSO	Transmission System Operator, operator of the high-voltage electrical grid
TYNDP	Ten-Years Network Development Plan
User community	User of climate information through energy system models – in the context of the DestinE Use Case Energy Systems, the categories of "users" include, but are not limited to: transmission and distribution system operators, researchers and in energy system modelling, and policy makers using such models.

1 Executive Summary

On February 28th 2023, Renewables Grid Initiative (RGI) together with the German Aerospace Center's Institute of Networked Energy Systems organised a "User Needs" workshop for the benefit of energy system modellers and operators to better use climate information in their modelling workflows. As a partner of the *Destination Earth Use Case Energy Systems,* RGI engages with the community of energy system model users and developers, in order to co-design and provide input to methodologies and tools that make energy systems more climate resilient. This workshop feeds the Work Package 1 *Community Engagement and Co-design,* as a User Meeting aiming at defining the use case's technical developments and initiating collaboration with users.

The Use Case partners invited **multiple actors in the energy sector to share their perspectives on the use of climate data in energy system modelling**, and more specifically in electricity power grid planning and operation. The hybrid workshop was attended by a group of **40 experts** representing several user perspectives, including **Transmission and Distribution System Operators (TSOs/DSOs), researchers in energy and climate modelling, and representatives of the European Commission**.

The participants have identified knowledge gaps and challenges to make full of climate data in energy system models:

- **computational limitations** as a main challenge when considering high-resolution climate data into energy models;
- lack of **guidance for selecting and using climate datasets and representative climate years;**
- lack of **transparent information on validation analyses, quality and reliability of climate data, as well as related standardised tools to reflect climate uncertainty in energy system models**;
- lack of **regional analysis to better evaluate the impact of climate at a very local scale.**

The participants considered the Use Case as a **useful platform for encouraging discussions around the bridge of climate and energy modelling disciplines.** The feedback of participants will guide DLR and AU towards the development of user-oriented innovative tools and methods to integrate climate information in energy system models.

2 Background of the workshop

2.1 Project summary and need for user engagement

The Destination Earth (DestinE), an initiative of the European Commission, is implemented by the European Centre for Medium-Range Weather Forecasts (ECMWF), the European Space Agency (ESA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT). DestinE aims at developing a **highly accurate replica of the planet Earth, to help predicting and building resilience to climate change**. Key components of this EU-funded programme are: the DestinE Core Service Platform (DESP), DestinE Data Lake (DEDL), the Digital Twin Engine, as well as multiple Digital Twins (DTs), that represent different areas of the Earth system (such as *Weather-induced and Geophysical Extremes* DT and *Climate Change Adaptation* DT). Once ready, the available data from these DTs and the DESP are expected to offer great opportunities to improve several research fields and sectors relevant for society at large (e.g., food and water supply, health system, energy). This will allow to better adapt to and prepare for the consequences of climate change and meteorological extreme events.

The German Aerospace Center (DLR), the Aarhus University (AU) and the Renewables Grid Initiative (RGI) are collaborating on the Use Case *Energy Systems* of DestinE, which aims at: (i) evaluating the benefits of using DestinE DTs' capabilities in energy system modelling, and specifically applications for grid planning and resources adequacy assessment, (ii) lowering barriers for adequate use of climate information in workflows of energy system modellers.

With climate change and renewables integration, **energy and climate research are increasingly interlinked**, interdisciplinary and with large societal relevance. Electricity system operators use meteorological data in both operation and planning tasks, from local short-term forecasts to continental long-term climate scenarios. Recent regulations, like the revised Trans-European Networks for Energy (TEN-E) Regulation, and other initiatives, like the update of the Pan-European Climatic Database (PECD) with results from multiple climate models, foster the integration of climate information into energy system models (EnSyMs) to plan a climate-resilient energy system.

However, **a lack of knowledge and standardised tools yet prevent the users of climate-energy models from combining expertise from the two disciplines**. Therefore, the community of EnSyM users, working on energy system planning and operation, would benefit from guidance for more accurate representation of climate information and related uncertainties, as it directly influences several key input parameters of EnSyMs (e.g., as renewable resources, demand side patterns or the statistics of weather extremes).

Through the DestinE Use Case *Energy Systems*, DLR and AU will derive a prototype of a decision-making support tool in the DESP for the energy sector, that builds upon the partners' capabilities in EnSyM development and energy meteorology. Therefore, new integration and data processing methods and tools for meteorological datasets into EnSyMs will be implemented and tested. These modelling developments are meant to be **highly user-oriented** and based on the latest European Resource Adequacy Assessment (ERAA) and Ten-Year Network Development Plan (TYNDP) methodologies. Thus, to make the project's outputs relevant for users and for the external world **regular exchanges with experts and key users of** EnSyMs **are necessary**. During the project preparation phase, the project partners identified the following key EnSyM users to engage with: European Transmission and Distribution System Operators (TSOs/DSOs), climate/meteorological and energy system researchers, and representatives of the energy policy-making sphere. RGI will also

develop a user engagement roadmap that further develops the list of the key users and ways to engage with them.

2.2 Context and objectives of the User Needs Workshop

The User Needs workshop kick started the Use Case's co-design activities, will pave the way towards the development of user-oriented tools for integration of climate information in EnSyMs. The workshop was organised in a hybrid format, on 28th February 2023 in Bonn, Germany, at DLR Projektträger offices. The full agenda is available in Section 5 of this report.

The project partners invited multiple actors from the energy sector to share their perspectives on the use of climate data in energy system modelling, and more specifically in electricity power grid planning and operation. A total number of 40 experts attended the workshop, either online or in person. The list of participants includes several European Transmission and Distribution System Operators (TSOs/DSOs), climate/meteorology and energy system researchers, and representatives of the energy policy-making sphere. The complete list of participants is available in Section 6.

The User Needs workshop of the DestinE Use Case Energy Systems aimed for, and achieved, the following objectives:

- **Presenting the DestinE Use Case Energy Systems to experts**: European TSOs and DSOs, climate and energy system modellers, and policy makers.
- Collecting information about the **specific needs and knowledge gaps in the user community related to integration of large amount of climate information in energy system models**, in order to provide guidance to the consortium on the further development of the prototype.
- **Stimulating exchanges within the user community** of climate-energy science and models and promote the integration of new knowledge into current operational workflows.
- Contributing to the **DestinE Use Case specification and co-design process** and ensuring highly **user-oriented modelling developments**.

3 Summary of discussions

The following sections provide a summary of the discussions held during the User Needs Workshop, of which the agenda is available in Section 5. Presentations and open discussions between project partners and external organisations rhythmed the workshop.

3.1 Opening speech and presentations

Andrzej Ceglarz (Programme Manager – Socio-Energy Systems, Renewables Grid Initiative), **Hans Christian Gils** (Head of Energy Systems Modelling group, DLR), and **Alexander Kies** (Associate Professor, Aarhus University) welcomed the 40 participants and introduced each partner organisation of the Destination Earth Use Case Energy Systems.

3.1.1 Destination Earth: background, status, and plans

Jörn Hoffmann (Application Partnership Lead for DestinE, ECMWF) and **Chiara Cagnazzo** (Manager of the Sectoral Information System, Copernicus Climate Change Service (C3S)) introduced the C3S and the Destination Earth Programme.

- C3S is an EU programme dedicated to the Earth observation from satellites and the C3S Energy operational service focuses on delivering climate and energy variables from reanalysis and multi-model regional projections for the European energy sector.
- Keys users of the Copernicus services are **European Agency for the Cooperation of Energy Regulators (ACER) and ENTSO-E**.
- The Copernicus Thematic Hub facilitates the access to C3S products to specific user communities by offering a single-entry point for the ensemble of C3S services.
- DestinE aims to develop a highly accurate digital model of Earth to monitor the effects of natural and human activity on our planet, anticipate extreme events and adapt policies to climate-related challenges. The DestinE implementation includes the Core Service Platform (led by ESA), the Digital Twins (DT) and Engine (led by ECMWF) and the Data Lake (led by EUMETSAT). The DestinE vision will be developed by 2030, and will deliver an operational cloud-based platform and data lake, and first two DTs (Extreme and Climate Change) in 2024.
- DestinE strives towards an integrated Earth-system and impact-sector modelling.
- DestinE DTs promise:
    - **High quality simulations:** better simulations based on realistic models
    - **Impactful applications:** better ways of combining all observed and simulated information from the entire Earth System (physical + food/water/energy/health supporting action scenarios)
    - **Interactive results:** interactive and configurable access to all data, models, and workflows, though the DestinE Core Service Platform (DESP).

- Among the DestinE DTs, the DT Climate Change Adaptation (Climate DT) will mainly feed the Use Case Energy Systems.

- DestinE Programme timeline is planned as following:
  - 2021 – 2024: Operational cloud-based platform, data lake and 2 DTs (Climate and Extremes DT)
  - 2024 – 2027: Platform integrates the next operational DTs and more services
  - 2027 – 2030: Towards a full digital twin through a convergence of multiple digital twins on the platform

3.1.2 Destination Earth Use Case Energy Systems: a demonstrator for the energy sector

Bruno Schyska (Scientist and Project Coordinator of the Use Case Energy Systems, DLR) presented the status and plans of the DestinE Use Case Energy Systems.

- DestinE offers opportunities for improved energy system modelling, new, innovative approaches for the integration of climate information in standard user workflows in the energy sector, and extended collaboration and exchange between the energy system planners, modellers and results' users.
- The Use Case Energy Systems aims at equipping the community of energy model users with ***methods, tools, and guidance*** to integrate climate information in (European) standard grid planning and assessment applications, and, thus, ***tap the full potential of state-of-the-art climate data.***
- The main outcomes of the Use Case Energy Systems are:
  - A representative **Demonstrator**, based on the core methodology of European Resources Adequacy Assessment, to showcase the use of climate information in the energy system modelling community
  - **New tools and methods** for including the analysis of state-of-the-art climate data in standard user workflows
  - Increased knowledge about **model uncertainties and sensitivities** on different climate data sets
  - An observation-based **validation** of the DestinE Climate DT data
  - Increased **knowledge about data needs and standard use cases** of the energy sector amongst the DT developers
- DLR's technical solution involves:
  - **REMix**: DLR's European energy system model optimisation framework as a base for the Demonstator. REMix will be published open source in 2023.
  - **ENDAT**: DLR's energy data analysis tool
  - **EYE2SKY**: DLR's ground-based measurement network for radiation and clouds, located in North-Western Germany, as a method to validate DestinE data by observation.
- As the Use Case Energy Systems aims at developing user-oriented tools, early user engagement is a key element of the project. Exchanges between project partners and representatives of the energy system modelling and planning community, such as the User Needs Workshop, are important steps towards the co-design of climate and energy models.

3.2 User perspectives

3.2.1 Open discussion 1 – Missing puzzle pieces to enhance climate resilience of energy systems

During this open discussion, participants were encouraged to share their impression on the project approach and the challenges they encounter when processing climate information. This section summarises the discussion. The list of guiding questions to audience is available at the end of this report (see Section 7).

The participants positively welcomed the Use Case, and considered it as a **useful platform for facilitating discussions on how to bridge climate and energy science and modelling**. Specifically, this project is expected to build and confirm confidence of the energy industry in the need of better integrating climate information into energy system models, and in related investments. For instance, the Use Case Energy Systems could inform grid operators on the benefits and impacts related to consideration of climate data into energy models, which would incentivise the industrial actors to invest in more research and developments for making their infrastructure climate-proof.

The workshop's participants indicated the **computational limitations** as a main challenge when considering high-resolution climate data in energy models. TSOs use very complex and computationally expensive optimisation programmes when modelling electricity systems, which limits the addition of other complexity dimensions (climate change and associated uncertainty) – in that case, related to climate data. Among the next steps, the Use Case partners will consider exploring the topic of computational limitation faced by TSOs to better understand how the Use Case can support the reduction of complexity.

The discussion showcased that the grid operators need **guidance for selecting and using climate datasets, as well as transparent information regarding the quality and reliability of climate data**. While participants agreed that climate models and data validation analyses are, and should be, done by climate modellers, they also understand the **need of a harmonized practice that would provide grid operators with the statistical information that they need to reflect climate uncertainty in their models** (e.g., local extremes rather than mean values).

For grid operators, some **regional analysis would be useful to evaluate the impact of climate at a very local scale**, which in turn can influence the renewable power curves, or the risks on grid infrastructure planning. **DSOs could also consider the application of DestinE climate data for several other applications than demand models and impact on grid infrastructure, for instance: district heating, water and gas distribution systems, and related infrastructure.**

3.2.2 On the use of climate data in ENTSO-E's adequacy and long-term planning studies: current practices and upcoming developments

David Radu (TYNDP Scenarios Technical Lead, ENTSO-E) presented the work of ENTSO-E relating to the integration of climate information in the short- and long-term planning.

- "ENTSO-E is legally mandated to periodically deliver **pan-European outlooks of the power system in the short, mid, and long-term**. This allows the TSO community to coordinate actions in an integrated fashion and provides technically-sound and consolidated information to policymakers and stakeholders that supports their decision-making."

- The Seasonal Outlooks (SO), the European Resource Adequacy Assessment (ERAA), the Ten-Year Network Development Plans (TYNDP) and related Scenarios are different pan-European network studies for different temporal horizons. Since the uptake of renewables is significant and climate change threaten the electricity system infrastructure, **considering the climate data and extreme events (e.g., *dunkelflaute*) in such studies is crucial for ensuring a reliable electricity supply.**
- ENTSO-E's short and mid-term adequacy assessments, SO and ERAA, determine adequacy metrics for the considered time period ("loss of load expectation" – LOLE, "loss of load duration" – LOLD, "expected energy not served" - EENS). Climate data, related renewable generation, demand data, and possible outages patterns, are sampled to constitute a set of climate years. Based on these climate years, the Monte Carlo method is used as a probabilistic assessment of the adequacy metrics.
- To limit the complexity of multi-year optimisation problems, and specifically for ERAA and TYNDP studies, ENTSO-E uses a selection methodology for representative climate years.
- **The Pan-European Climate Database (PECD) is ENTSO-E's reference (open access) dataset for climate variables.** The current PECD v3.1 only relies on historical climate conditions, however, several climate projection models and greenhouse gases emission scenarios will shape the next PECD v4.0.

3.2.3 A new methodology for the evaluation of grid resilience on Italian Transmission Network

Federico Falorni (Senior Engineer in Resilience and Security Grid Planning, Terna) and **Emanuele Ciapessoni** (Leading Scientist, RSE) presented the Resilience Methodology developed jointly by Terna and RSE, which was approved by the Italian Regulatory Authority in 2022.

- In response to the increase of meteorological events disrupting the Italian transmission network in the last four decades, and to mitigate the consequent increasing risk of adequacy loss, Terna and RSE have developed a resilience methodology. This methodology aims to **assess the network's vulnerability to extreme natural events and identify an optimal portfolio of resilience enhancement measures** (or resilience interventions).
- **The resilience methodology is based on three pillars: (i) prospective analysis of climate hazards, (ii) assessment of asset vulnerability, (iii) weather-induced contingency analysis.** Strong wind and wet snow weather conditions were identified as the most impactful phenomena to analyse, due to both their direct and indirect effects on the grid infrastructure. CESM-LENS and Euro-CORDEX climate models were used for defining the prospective climate hazards assessment of the grid. The contingency analysis also includes a cascading failure simulation that allows for a more realistic load shedding representation during an extreme event. This prospective and probabilistic approach allows to assess the benefit of resilience interventions, through the EENS and the power outage risk of substations.
- As next steps, Terna and RSE will investigate other impactful natural events (e.g., floods and landslides), new vulnerability models, and the modelling and benefit assessment of new resilience enhancement measures.

3.2.4 Open discussion 2 – Current trends and challenges: methodologies and tools to integrate climate analysis into energy system models

During this open discussion, participants were encouraged to ask questions to the speakers and share their experience in considering climate information in EnSyMs. This section summarises the discussion. The list of guiding questions to audience is available at the end of this report (see Section 7).

- On Terna-RSE's resilience methodology:
  The methodology requires **high resolution climate data** (approximatively 4x4 km), as the hazards are mapped for each overhead line separately. The climate data based on projection models can be updated, but access to dataset with higher resolution would be useful. **Terna-RSE's resilience methodology can, so far, only be applied to assess resilience of existing power lines**, potential future lines are hard to define from an engineering perspective. However, the methodology outputs can feed into the definitions of preventive (e.g., line rebuilding), mitigation (e.g., anti-tortional devices or ice-phobic paint on transmission lines) and restoration measures (e.g., emergency plans).

- On ENTSO-E's adequacy and long-term studies:
  The grid operators agreed that the **selection/clustering of climate years and models is a difficult task** and shall be done differently depending on the time span and the grid need study (for instance: representative stress years are different in ERAA and TYNDP). The type of data that the PECD provides and that the DestinE Programme promises are different: the PECD data are static, while DestinE will provide access to continuously updated datasets based on observation.

3.2.5 Destination Earth: Climate Adaptation Digital Twin

Aleksander Lacima (Scientist in Natural Science and Meteorology, Barcelona Supercomputing Center) gave an overview of the status and plans of the Climate Adaptation Digital Twin.

- "**Adaptation is the action that leads to limiting the consequences of a warming climate and requires, among many other elements, climate information about climate hazards."** The Climate DT is a new type of climate information system that can be used to assess **impacts of climate change and different adaptation strategies at local and regional levels over multiple decades**. This climate information system puts the users at the front and considers an operational use for the climate data.
- A first version of the Climate DT, which is being developed and deployed by a consortium of institutions in collaboration with ECMWF, will be available by mid-2024. Its main key features are:
  - User-driven approach focused on user interactivity
  - Global climate simulations at unprecedented horizontal resolution
  - Novel streaming framework of climate model output to applications
  - Quality assessment and uncertainty quantification based on observations
  - Deployment on two European pre-exascale supercomputers

- Climate DT will employ two Earth System Models: ICON and IFS-NEMO/FESOM. During the 1st phase of DestinE the ClimateDT will focus on multi-decadal simulations on a 5 km global mesh, while working towards finer scales. Users will have access to the full generic state vector (GSV) at high frequency and native resolution, and may request simulation based on their needs (relevant regional and local information).
- DestinE envisions a **streaming framework** that would overcome the access issue to the significant volume of data generated by the Climate DT.

3.2.6 Climate resilience of DSO infrastructure: based on the Go4Flex report

Juan Marti Rodriguez (Electrical and Control System and Automation Engineer, IBERDOLA - Technology Task Force on Active Network Management, E.DSO) represented the perspective of the DSO, and explained how DSOs leverage climate and weather information into their workflow, taking the example of grid flexibility services.

- **DSOs and TSOs operate different part of the electricity grid, and their observability on the networks differs.** The observability of medium-voltage and low-voltage grid is low compared to the observability of TSOs on the high-voltage grid, nevertheless, the observability is key for managing flexibility sources for network operation.
- There are different types of flexibility that can help solving congestions: (i) technical (or grid) flexibility, (ii) market flexibility, (iii) investment and planning flexibility. **Climate information comes into play in both operation and planning**, for instance: in load forecasting, renewable generation forecasting, or prediction models.
- Practical weather-dependent grid applications are transmission/distribution lines, of which the thermal capacity changes in function of ambient weather conditions. Dynamic Line Rating is a grid flexibility measure commonly used by both TSOs and DSOs to optimise the capacity of lines, by measuring the local weather conditions.

3.2.7 Open discussion 3 – Looking forward: the DestinE opportunity for the energy sector

During this open discussion, participants were encouraged to ask questions to the speakers and reflect on other possible application of Destination Earth data in considering climate information into the workflow of energy system models. This section summarises the discussion. The list of guiding questions to audience is available at the end of this report (see Section 7).

- DLR and Climate DT partners have agreed to **exchange on the definition of the streaming framework and storage of Climate DT's data**, as this data access may impact the usefulness of DestinE data for grid operator applications (e.g., the temporal window of data availability should match with the investment decision step and temporal horizon of a capacity expansion model).
- Climate and Extremes DT also feed **other DestinE Use Cases focusing on renewable energy generation potentials**, which could also be of relevance for grid operators to consider.
- Grid operators try to include flexibility options in grid development plans. DLR will investigate the **relevance of including flexibility options in the Demonstrator** (energy system model), and the required level of detail.

4 Conclusions and outlook

The active engagement from the audience highlights the relevance of the Destination Earth initiative, and specifically the urgent need for more collaboration between climate and energy science and system modellers. The workshop reached its initial objectives, and moreover, the participants considered the Use Case as a **useful platform for facilitating discussions which could bridge climate and energy modelling fields.**

The participants identified the main knowledge gaps in the current state-of-the-art of climate data integration in EnSyMs as:

- **computational limitations** as a main challenge when considering high-resolution climate data into energy models;
- lack of **guidance for selecting and using climate datasets and representative climate years;**
- lack of **transparent information on validation analyses, quality and reliability of climate data, as well as related standardised tools to reflect climate uncertainty in energy system models**;
- lack of **regional analysis to better evaluate the impact of climate at a very local scale.**

The Use Case Energy System is a promising initiative for supporting users in addressing the listed challenges, as well as for providing evidence that grid operators should plan and invest in more climate-resilient infrastructure, that includes efforts in better integration of climate data in their workflows. This workshop triggered the interest of project partners and participants to continue exchanges and discussions within the framework of the Energy System Use Case. Therefore, the Use Case partners will deepen the collaboration on the following topics of interest, aligned with the workshop's discussions:

- DLR, AU and the Climate DT partners have planned to exchange on the DT developments, the implications on the Use Case Energy Systems (including the climate data saving and access window), and other potential synergies in modelling developments.
- DLR, Terna and RSE could engage on the topic definition of grid infrastructure vulnerability matrix.
- DLR and RGI will engage with TenneT, Amprion and TransnetBW (and other interested users) on the technical design specification of the Use Case.
- DLR and RGI will engage with interested grid operators on their needs regarding the climate data validation, to ensure the compatibility of climate and energy tools.

The discussion also showcased the **discrepancy in the needs of guidance between different TSOs and DSOs.** To investigate the relevance of orientating the Use Case modelling developments towards the medium- and low-voltage levels, the Use Case partners will focus on improving their knowledge on the DSOs' needs in the context of climate data use. For example, RGI will join a workshop organised by E.DSO, to learn more about the state-of-the-art of the integration of weather models into the DSOs' EnSyMs.

In addition to the next steps mentioned above, the Use Case partners will also keep contact with the interested workshop participants and share information about and invitations to the next relevant DestinE activities.

Figure 1 pictures a timeline that presents the next steps of the Use Case Energy Systems. **EnSyM users are invited to engage into the Use Case modelling developments**, and specifically during the processes of technical design specification (due May 2023), and Performance and Impact Assessment (due April 2024).

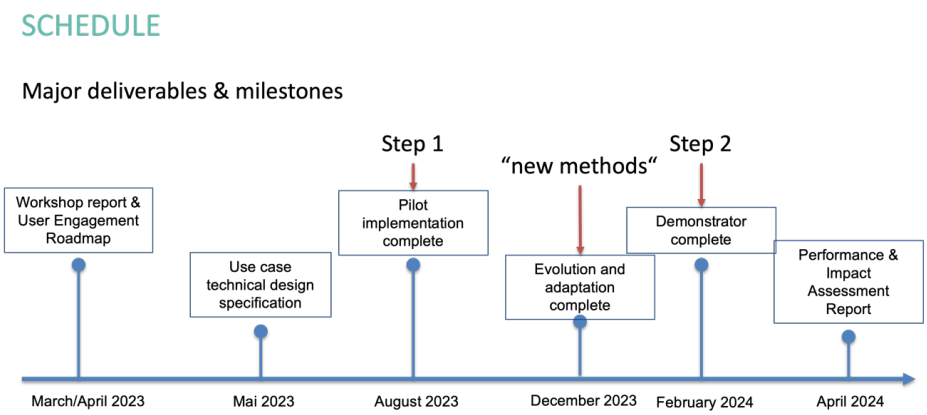

Figure 1: Workplan of the Use Case Energy System

5 Workshop agenda

Time	Session
9:30 – 10:00	Registration and coffee
10:00 – 10:15	Welcome – Renewables Grid Initiative & DLR & Aarhus University Presentation – *Workshop objectives and agenda*
10:15 – 10:35	Presentation – Jörn Hoffmann & Chiara Cagnazzo, ECMWF *Destination Earth – background, status and plans*
10:35 – 10:55	Presentation – Bruno Schyska, DLR *Destination Earth Use Case Energy Systems: a demonstrator for the energy sector*
10:55 – 11:20	Open discussion 1 *Missing puzzle pieces to enhance climate resilience of energy systems*
11:20 – 11:35	**COFFEE BREAK**
11:35 – 11:40	User perspectives: introduction and setting-the-scene – Bruno Schyska, DLR
11:40 – 12:00	Presentation – David Radu, ENTSO-E *On the use of climate data in ENTSO-E's adequacy and long-term planning studies: current practices and upcoming developments*
12:00 – 12:20	Presentation – Federico Falorni, Terna & Emanuele Ciapessoni, RSE *A new methodology for the evaluation of grid resilience on Italian Transimission Network*
12:20 – 12:50	Open discussion 2 *Current trends and challenges: methodologies and tools to integrate climate analysis into EnSyMs*
12:50 – 13:50	**LUNCH BREAK**
13:50 – 14:05	Presentation – Aleksander Lacima, Barcelona Supercomputing Center *Climate Adaptation Digital Twin*
14:05 – 14:20	Presentation – Juan Martí Rodriguez, Iberdola Distribucion Eléctrica / E.DSO *Climate resilience of DSO infrastructure based on the Go4Flex report*
14:20 – 14:50	Open discussion 3 *Looking forward: the DestinE opportunity for the energy sector*
14:50 – 15:00	Wrap-up and outlook

6 List of participating organisations

1	Aarhus University
2	Barcelona Supercomputing Center
3	E.DSO
4	ECMWF
5	ENTSO-E
6	Eurelectric
7	European Commission DG CNECT
8	European Commission DG ENER
9	European Commission Joint Research Center
10	German Aerospace Center
11	German Federal Ministry for Digital and Transport
12	HEDNO
13	Iberdrola Distribución Eléctrica
14	MinesParisTech
15	Rabo Research
16	Reiner Lemoine Institut
17	Renewables Grid Initiative
18	RSE
19	RTE
20	Stadtwerke Ulm/Neu-Ulm
21	TenneT
22	Terna
23	TransnetBW

7 List of guiding questions

The list of questions below structured and guided the discussions during the workshop:

- *Which obstacles do you encounter in obtaining, using and processing climate model information?*
- *What is in your opinion still missing in order to include climate change / use climate data in your modelling? Which are your next steps in this regard? What are future directions for R&D?*
- *Which effects of climate change/variability do you already consider/model/investigate in your work?*
- *Which climate information do you use? How is uncertainty in the meteorological input (data) you use represented?*
- *Which pre-processing do you apply to the meteorological data before including it in your modelling?*
- *Do you already use climate information from scenarios originating from climate models?*
- *How do you select climate model runs among the large number of model runs and scenarios available nowadays? What are your selection criteria, if any?*
- *Climate model output is often a lot of data (big data). Do you currently apply any data reduction strategies/methods? If yes, which are they? and do you think they are sufficient?*
- *If you have to choose individual reference years in the past and future years from the 1980 to 2050 time range, which ones would you chose? Is there any group of years more relevant to you than others and why? Is there additional value to have all the years?*
- *How can we support you with the issues/challenges which you are currently facing? What should be the capabilities of our Demonstrator (i.e. a potential Future DestinE service for the energy sector)?*
- *In your opinion how will the ideal DestinE energy service look like in order for you to make use of it? What would be its capabilities/properties?*
- *Assume ERAA could be run in the cloud, directly coupled to the climate model providing the most accurate climate information on all relevant scales, what would you use it for? What is needed to improve it further to provide answers to your questions?*
- *How should the coupling between the DestinE service and your model look like in your opinion?*

8 Relevant literature

ENTSO-E's seasonal Outlooks (entsoe.eu)

ENTSO-E's ERAA | European Resource Adequacy Assessment (ERAA) (entsoe.eu)

ENTSO-E's planning the future grid - TYNDP (entsoe.eu)

ENTSO-E's scenarios - TYNDP (entsoe.eu)

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