**Destination Renewable Energy (DRE)**

Software Verification and Validation Plan (SVVP)

Ref.: DestinE\_ESA\_DRE\_SVVP\_v6.0



**Author's Table**

|  |  |  |
| --- | --- | --- |
| Written by: | George Koutalieris  Symeon Symeonidis  Vasillis Perifanis  Iphigenia Kapsomenaki  Athanasios Drivas | ENORA INNOVATION  ENORA INNOVATION  ENORA INNOVATION  ENORA INNOVATION  NOA |
| Verified by: | Theodora Papadopoulou | NOA |
| Approved by: | Haris Kontoes | NOA |

**Change Log**

|  |  |  |  |
| --- | --- | --- | --- |
| Issue | Date | Reason for change | Section(s) changed |
| 1.0 | 15 December 2023 | Creation of the document |  |
| 2.0 | 13 February 2024 | Second version | Edits in the entire document |
| 3.0 | 14 May 2024 | Third version | Edits in the entire document |
| 4.0 | 27 July 2024 | Fourth version | Edits in the entire document |
| 5.0 | 24 October 2024 | Fifth version | Edits in the entire document |
| 6.0 | 12 May 2025 | Sixth version | Edits in the entire document |

**Table of** **Contents**

[**1 Introduction 5**](#_heading=h.v65sdd3td6vf)

[1.1 Scope 5](#_heading=h.ixkizkmn3vfq)

[**2 Glossary 6**](#_heading=h.1i8p498zfxr0)

[**3 System Overview 7**](#_heading=h.c3dsdgrunszv)

[3.1 System Description 7](#_heading=h.hly4jmghnb2l)

[**4 Verification Strategy 9**](#_heading=h.w833tgsoq83h)

[4.1 Risk Assessment 9](#_heading=h.4n45pew75wnw)

[**5 Validation Strategy 13**](#_heading=h.ca217nq3czao)

[5.1 Validation Project Team 13](#_heading=h.uectefrx2id6)

[5.2 Partners and Responsibilities 13](#_heading=h.dlz0mbog4nfv)

[**6 User acceptance testing 16**](#_heading=h.376tt7ba0dkk)

[**7 Reporting and Documentation 18**](#_heading=h.5l8v784pg0ly)

[7.1 Reporting 18](#_heading=h.w1maqppijz0x)

[7.2 Documentation Standards 18](#_heading=h.gzkmpves8otd)

[**8 Conclusion 19**](#_heading=h.th7pwz1wi70g)

# Introduction

The purpose of the SVVP version 6.0 for the DRE Use Case is to ensure the validity, accuracy, reliability, and robustness of the DRE Use Case application. The SVVP outlines a structured plan to validate and verify that the digitised models faithfully represent their physical counterparts and that the system's assessment, forecasting, and simulation capabilities align with real-world conditions.

This validation process includes rigorous quality control procedures, well-defined testing scenarios, and comprehensive user acceptance testing (UAT) to evaluate the usability and performance of the DRE platform under realistic operating conditions. Furthermore, structured feedback loops will be established to capture user experiences and insights, which will inform continuous improvements and refinements of the system.

The Destination Renewable Energy (DRE) Use Case software application is also referred to as the Hybrid Renewable Energy Forecasting App (HYREF). As such, the terms DRE Use Case and HYREF are used interchangeably throughout this document.

## Scope

The scope of the SVVP encompasses a comprehensive set of activities designed to ensure the DRE Use Case application's quality, performance, and reliability. This includes validating and verifying the system's simulation, forecasting, and projection services to confirm they deliver accurate, timely, and actionable insights for energy producers and policymakers. The scope also covers the implementation of quality control procedures, the execution of detailed testing scenarios, and the conduct of user acceptance testing (UAT) to evaluate system behavior in real-world conditions. Additionally, structured user feedback collection mechanisms are integrated to support continuous system improvement and user-driven enhancements.

# Glossary

To ensure the success and reliability of the DRE Use Case, the following Glossary presents some Terms and Descriptions that will be used.

|  |  |
| --- | --- |
| **Abbreviation / Term** | **Description** |
| Deliverable | A tangible or intangible object produced due to project execution is part of an obligation. In validation projects, deliverables are usually documents. |
| End-User | A person who uses the validated system |
| Expected Result | What a system should do when a particular action is performed |
| Requirement | Something a system must be able to do |
| System | Object or process undergoing validation. In these pages, the system is intended to be a generic term, meaning computer system, equipment, method, or process to be validated. |
| Test Case | A documented procedure used to test that a system meets a particular requirement or collection of requirements |
| Test Plan | A general testing methodology is established to ensure that a system meets requirements. |
| Traceability | The ability to ensure that requirements outlined in the specifications have been tested. This is usually recorded in a Requirements Traceability Matrix. |
| Validation | Establishing documented evidence that provides a high degree of assurance that a specific process will consistently produce a product meeting its predetermined specifications and quality attributes |
| DS | Design Specification |
| FS | Functional Specification |
| RTM | Requirement Traceability Matrix |
| SDS | Software Design Specification (See Design Specification) |
| Spec | Specification |
| TM | Traceability Matrix |
| UAT | User Acceptance Testing |
| URS | User Requirement Specification |
| VP | Validation Plan |

# System Overview

## System Description

**Data Sources and Integration**

The DRE Use Case leverages many high-resolution data sources to support the advanced forecasting and modeling of renewable energy systems. These include DestinE Digital Twin (DT) forecast data, the Weather-induced Extremes Digital Twin, Global Ocean 1/12° Physics Analysis and Forecast, the Copernicus Digital Elevation Model (DEM), Vegetation Indices, CORINE Land Cover, and the Global 10-daily Fraction of Vegetation Cover dataset.

These diverse datasets are integrated to construct a robust digital model that assesses both solar and wind energy systems' production potential and environmental impacts. The service also utilises Digital Twin and DEDL data to simulate realistic scenarios and support user-specific assessments. Due to current limitations in data availability from certain DESP services, the exact data inputs are further detailed in the relevant deliverables of the Use Case.

**Challenges to be Addressed**

The DRE system addresses the critical challenge of climate change and the urgent need to transition to clean energy systems. Because the last seven years have been the hottest on record, there is a growing demand for reliable and scalable climate services. Renewable energy systems—particularly solar and wind—are inherently sensitive to atmospheric conditions, making accurate forecasting essential.

The DRE tackles this challenge by offering advanced assessments and 2-day solar radiation forecasts, wind speed, and power production forecasts. It also supports hybrid energy scenarios and "what-if" analyses within the Hybrid Renewable Energy Forecasting App (HYREF), empowering users to make informed decisions about system design, optimisation, and resilience to climate-induced risks.

**Proposed Solution: Hybrid Renewable Energy Forecasting System (HYREF)**

At the core of the DRE system is the HYREF, a user-friendly web application that digitises and simulates solar and wind energy production systems through Digital Twin technologies. HYREF combines real-world data, historical meteorological records, and high-resolution forecast models to create a Virtual DRE System for advanced simulations and scenario analysis.

The system supports user-specific data collection, including ingesting custom time series, enabling personalised forecasts and dynamic visualisations via time-series plots and dashboards. DRE Use Case software also ensures secure access through an Identity and Access Management (IAM) system while offering continuous support through a structured user helpdesk and comprehensive documentation

**Impact and Long-term Benefits**

The DRE system enhances short-term forecasting accuracy for solar and wind power, supporting the effective management of power grids with high penetration of renewables. These capabilities are vital for energy market operations, optimised asset allocation, and reducing integration costs.

Through active co-design with key stakeholders—including energy providers, policymakers, and researchers—the DRE maximises its relevance and usability across different sectors.

In the long term, the DRE contributes to the 2030 Agenda for Sustainable Development goals and the Paris Agreement, supporting data-driven energy policy and climate adaptation strategies. It aligns with major EU initiatives, such as the European Green Deal, promoting renewable energy adoption and climate resilience. Integrating DestinE's advanced data infrastructure highlights the transformative role of digital modeling in achieving sustainable energy goals and supporting informed environmental decision-making.

# Verification Strategy

A Software Verification and Validation Plan (SVVP) is proposed to ensure the successful, reliable, and high-quality development of the DRE Use Case software. The plan defines a structured approach for verifying and validating the application's core functionalities, forecasting accuracy, and system performance. It includes quality control procedures, detailed testing scenarios, and user acceptance testing (UAT) to assess the software in realistic operational conditions. The SVVP also outlines the roles and responsibilities of the project team, supporting an efficient and collaborative validation process. User feedback will be actively collected and used to guide improvements, ensuring that DRE Use Case software meets the expectations of its end users and is ready for effective deployment.

## Risk Assessment

According to the guidelines, the strategy and extent of validation have to be identified following a risk-based approach. The risk level is determined through the Risk Assessment Index (RAI), whose evaluation is based on the application of the below two-dimensional parametric model, which foresees the assessment of the system:

* Criticality (High, Medium, Low)
* Complexity (High, Medium, Low)

The criticality and complexity of the system can be evaluated based on the answers to the questions defined in the following table:

Table 1: Assessment of Criticality

|  |  |
| --- | --- |
| **Criticality Elements** | **Evaluation  (Yes/No)** |
| The System/application is an integral part of the equipment/instrumentation used in the manufacturing, testing, release and/or distribution of the product. | No |
| The system handles data that could impact product purity, strength, efficacy, and identity. | Yes |
| Reports produced or elaborated by the system are used for regulatory purposes. | No |
| The stability of products strongly depends on Environmental Conditions managed by the system. | No |
| The controlled process has no additional checks or verifications to detect failures. | No |
| **Complexity Elements** | **Evaluation  (Yes/No)** |
| The Control System is interfaced with other systems. | No |
| The Integrity of the data managed by the system is protected through an access control mechanism (e.g. password). | Yes |
| The system is the only available instrument for a specific typology on the site. | Yes |
| The system is subject to a preventive maintenance program. | No |
| The system shares security devices with other systems. | Yes |

Evaluation of Criticality and Complexity is determined according to the following criteria:

Table 2 Criticality Result

|  |  |
| --- | --- |
| **Number of positive answers** | **Criticality/Complexity** |
| 0-2 | Low |
| 3-4 | Medium |
| 5-6 | High |

Based on Criticality and Complexity values, the system RAI is determined according to the following table:

Table 3: Risk Assessment Index

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | | **COMPLEXITY** | | |
| **HIGH** | **MEDIUM** | **LOW** |
| **CRITICALITY** | **HIGH** | **HIGH** | **HIGH** | **MEDIUM** |
| **MEDIUM** | **HIGH** | **MEDIUM** | **LOW** |
| **LOW** | **MEDIUM** | **LOW** | **LOW** |

This analysis (see Table 1) provides criticality and complexity results depending on the provided conditions.

# Validation Strategy

The selected validation approach defines the key activities required to demonstrate that the system operates correctly, meets established quality standards and compliance requirements, and is capable of maintaining reliable performance over time. It ensures that all validation tasks are aligned with the overall objectives of the DRE Use Case. The roles and responsibilities associated with the validation process are detailed in the following subsection.

## **Validation Project Team**

The following subsection describes the roles involved in the planning and executing validation activities and relevant tasks.

## **Partners and Responsibilities**

1. **NOA & ENORA Innovation:**

* Lead the overall Verification and Validation (V&V) process, ensuring alignment with project goals, quality standards, and regulatory requirements.
* Coordinate across technical teams and stakeholders, regularly reporting progress to project management.
* Prepare and manage relevant datasets for validation, including both historical and real-time data.
* Ensure data quality and integrity in collaboration with the development team to support accurate testing scenarios.
* Implement software components according to specifications, incorporating findings and user feedback from the V&V process.
* Collaborate with the V&V team to address identified issues, optimise system performance, and refine key functionalities.
* Conduct thorough quality control procedures and functional testing to ensure system reliability and stability.
* Execute simulated user scenarios and perform user acceptance testing (UAT) to verify the application's ability to support decision-making under realistic conditions.

1. **WeMET & QUEST ENERGY**

* Provide domain-specific insights and practical requirements to inform system design and testing.
* Participate actively in scenario-based testing and UAT to ensure the system meets real-world operational needs and user expectations.
* Offer feedback on usability and performance, contributing to the continuous improvement of the DRE Use Case application platform.
  1. **Validation Activities**

The DRE Use Case validation process is designed to ensure the system's accuracy, reliability, and usability in modeling and forecasting wind and solar energy production. It focuses on meeting user requirements and supporting real-world energy planning and management applications. The process includes requirement verification, performance evaluation, reliability checks, and scalability testing. Complete test scenarios are defined to cover key areas such as data integration, model precision, interface functionality, and forecast accuracy. Combining manual and regression testing methods ensures consistent system behavior under various conditions.

User Acceptance Testing (UAT) is conducted with participation from DRE stakeholders, emphasising practical usability through scenario-based evaluations. Structured feedback is collected and used to refine the system, ensuring that the DRE application remains robust, intuitive, and aligned with end-user needs. The ultimate goal is to deliver a dependable tool that supports accurate renewable energy forecasting and informed decision-making.

The following Table 4 presents the milestones and the validation process.

Table 4: Risk Assessment Index

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Milestone Name** | **Date** | **Input(s)** | **Description** | **Validation** | **Verification** |
| MS1 (RR1) | KO+3 | First Use Case SW release and related documentation | Review to take place after the first SW release for the acceptance of the delivered software and related documentation. | NOA & ENORA | WeMet & Quest |
| MS2 (RR2) | KO+6 | Second Use Case SW release and related documentation | Review to take place after the second SW release for the acceptance of the delivered software and related documentation. | NOA & ENORA | WeMet & Quest |
| MS3 (RR3) | KO+9 | Third Use Case SW release and related documentation | Review to take place after the third SW release for the acceptance of the delivered software and related documentation. | NOA & ENORA | WeMet & Quest |
| CCN-1 MS1 (FR) | KO+12 | Final Use Case SW Release | * A review will take place by the end of the contract to assess the performance of the Project critically, provide the final version of all the deliverables, and provide lessons learned for DestinE Phase 2. * A Final Presentation (preferred delivery via public webinar) will follow. | NOA & ENORA | WeMet & Quest |
| MS4(WP5) | KO+18 | DRE Operationalization and User Support | * A review will take place after the fifth SW release to assess the acceptance of the delivered software and related documentation. * The review will evaluate both the free and advanced versions of the release. SERCO and ESA will conduct a final assessment before the go-live phase to ensure operational readiness | NOA & ENORA | SERCO & ESA |

# User acceptance testing

Prior to initiating User Acceptance Testing, key features will be developed and integrated into the DRE Use Case application to enhance its decision-support capabilities in renewable energy management. This structured approach ensures that the system effectively meets the operational needs of energy producers and policymakers.

**Participants:** DRE Partners and Technical Teams

**Methodology:**

* **Scenario-Based Testing**: Validate the accuracy of solar and wind energy forecasts over a two-day horizon.
* **Interface Verification**: Confirm reliable and error-free data transmission across communication interfaces.
* **Data Accuracy Checks**: Ensure correct integration and processing of atmospheric, weather, Digital Twin (DT), and DEDL datasets.
* **Decision Support Evaluation**: Assess the quality and practicality of the system’s energy planning and management recommendations.

**Acceptance Criteria:**

* Accurate simulation of solar and wind energy production
* Robust and error-free interface communication
* Reliable integration and processing of all relevant data sources
* Practical and consistent decision-support output for energy management

**Test Environment:** A representative test environment will be set up, replicating operational conditions and incorporating all necessary data inputs and system interfaces.

**Feedback and Iteration:** User feedback will be systematically collected and analysed. Identified issues or usability concerns will guide iterative improvements until all acceptance criteria are fully satisfied.

**Documentation:** All test cases, results, user feedback, and subsequent system modifications will be thoroughly documented to ensure traceability and continuous improvement.

As part of DRE release 5, the final deployment of the DRE Use Case application will be accompanied by a structured quality control and testing process to ensure the system meets operational standards. This includes end-to-end validation of features, performance, and usability under realistic conditions prior to its full operational launch on the DestinE platform.

A series of clearly defined testing scenarios will be executed, focusing on the accuracy of solar and wind energy forecasts, seamless integration of atmospheric, weather, DT, and DEDL data, and the robustness of system interfaces. These tests will verify the application's reliability, responsiveness, and ability to support renewable energy planning and management decision-making. A dedicated User Acceptance Testing (UAT) phase will follow, involving DRE partners and technical teams. Testing will be scenario-based and aligned with real user needs, ensuring that the application delivers actionable insights and meets expectations for usability and performance.

All acceptance criteria will be clearly defined and evaluated. User feedback will be collected through structured forms and direct interaction, reviewed carefully, and used to guide final adjustments. Any identified issues will be addressed through iterative improvements. All testing activities, results, user input, and system updates will be thoroughly documented to ensure full traceability and support continuous improvement.

# Reporting and Documentation

The reporting process for the Software Verification and Validation (V&V) activities will follow a structured, transparent, and standardised approach to ensure timely, accurate, and traceable dissemination of information.

## Reporting

All V&V reports will be prepared in a standardised digital format to ensure consistency, ease of distribution, and compatibility with various platforms. Each report will include a summary of validation and verification activities, test results, identified deviations from the plan, and key performance indicators such as error rates, test coverage, and system performance metrics.

Reports will be distributed to relevant DRE digital ecosystem teams, energy policymakers, and project managers for long-term traceability. Regular review meetings will be scheduled to discuss findings, address any issues, and align ongoing validation activities with the objectives of the DRE Use Case. This collaborative approach supports informed decision-making and continuous improvement.

## Documentation Standards

Documentation throughout the V&V process will adhere to strict standards for consistency, clarity, completeness, and compliance. All related documents—including test plans, test cases, test results, and validation reports—will follow a unified structure using standardised templates to promote clear communication and ease of interpretation.

Key principles include:

**Comprehensive Coverage:** Documentation will cover the full V&V lifecycle, including testing strategies, methodologies, environments, tools used, results, and encountered issues.

**Version Control:** A versioning system will be applied to maintain document integrity, track changes over time, and ensure reference to the most current data.

**Regulatory Compliance:** All documentation will comply with applicable industry standards and best practices, particularly those related to renewable energy systems, forecasting platforms, and digital twin technologies.

This approach guarantees that the V&V process remains transparent, traceable, and aligned with project quality expectations.

# Conclusion

This deliverable presents the final version of the Software Verification and Validation Plan (SVVP) for the DRE Use Case, ensuring robustness, accuracy, and operational readiness. It outlines the comprehensive procedures and criteria used to verify that the system’s Digital Twin-based models accurately represent real-world solar and wind energy systems and that its forecasting outputs align with actual environmental and operational conditions. The plan incorporates quality control measures, scenario-based testing, and UAT, supported by feedback-driven iterations and full documentation. It also reflects the integration of DRE into the DestinE platform, including the use of DT and DEDL data, workflows, and secure user interfaces.

As the final version, this document consolidates the complete validation strategy, incorporating all updates, refinements, and outcomes from the project lifecycle. It serves as a reference for the successful deployment and ongoing use of DRE as a decision-support tool in renewable energy management.