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D1.3 – Data specification requirements framework Part 1

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Executive summary

The deliverable D1.3 - *Report on data specification requirements framework Part 1* is the first version of the report on the data specification requirements for the RETIME project. It covers data protocols, data schemas, and user interfaces to enable accurate object-related digital information exchange, specifically tailored to the needs of the key stakeholders and users of the tools developed within the project scope across the RETIME pilot sites. This report also outlines adaptation solutions for data collection, usage, and management, defining key parameters such as source, volume, format, frequency, privacy, and security, to ensure scalability, effective model monitoring, and evaluation within the project framework.

An updated version of this report, D1.5 (Part 2), will be submitted to the European Commission through the official portal in Month 18 of the project (October 2025).

This report is intended for a diverse audience, including RETIME consortium members, the research community, industrial stakeholders, and representatives of SMEs.

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List of acronyms and abbreviations

ADE	Application Domain Extensions
ADENE	Agência Nacional de Energia I National Energy Agency (in Portugal)
APE	Identification code of the energy performance certificate
API	Application Programming Interface
BaaS	Building-as-a-service
BIM	Building Information Modelling
BREEAM	Building Research Establishment Environmental Assessment Methodology
BRL	Business Readiness Level
BRP	Building Renovation Passport
bSDD	building Smart Data Dictionary
CAMS	Copernicus Atmosphere Monitoring Service
CEMS	Copernicus Emergency Management Service
C3S	Copernicus Climate Change Service
DBT	Digital Building Twin
DTST	Digital Twin Simulator Tool at buildings
EN	European Norm
EPC	Energy Performance Certificate
EU	European Union
GDPR	General Data Protection Regulation
GIS	Geographic Information System
GWP	Global Warming Potential
HTTP	Hypertext Transfer Protocol
HVAC	Heating, Ventilation, and Air Conditioning
IAQ	Indoor Air Quality
IFC	Industry Foundation Classes
IPCC	Intergovernmental Panel on Climate Change
KPI	Key Performance Indicator
LCA	Life-Cycle Assessment
LiDAR	Light detection and ranging
LOD	Level of Detail
MEP	Mechanical, Electrical, and Plumbing
MQTT	Message Queuing Telemetry Transport
NbS	Nature-based Solution
OAS	OpenAPI Specification
OGC	Open Geospatial Consortium
PM	Particulate matter
SECClasS	Sustainability Enhanced Construction Classification System
SME	Small and Medium-sized Enterprise
TRL	Technology Readiness Level
VOC	Volatile Organic Compound

1. Introduction

The deliverable D1.3 - *Report on data specification requirements framework Part 1* outlines the data specification requirements related to RETIME solutions and services, to ensure that feasibility, interoperability, privacy, security, and inclusiveness are guaranteed across the three pilot areas (Lisbon, Žilina, and Tartu).
This report is organised by each RETIME solution and service, as follows: *Section 2* outlines the data requirements related to the sensor-based IT automated alert system, which includes the installation and monitoring of a set of sensors, or integration of existing data across the three pilot areas (Lisbon, Žilina, and Tartu). It also covers the deployment of the RETIME hardware totem in the three pilot areas (Lisbon, Žilina, and Tartu) to be tested in each RETIME environment under conditions that simulate real-world scenarios (TRL6). *Section 3* defines the data requirements on the RETIME Digital Twin simulator tool at building, an interoperable platform that includes (hygrothermal and structural) data-centric algorithms (TRL 8). *Section 4* details requirements related to the RETIME Digital Building Renovation Passport (BRP) tool, which is nearly ready for full deployment or commercial use (TRL8), while *Section 5* focuses on the RETIME Resilience Knowledge Hub and Decision Support platform (TRL 8).
An updated version of this report, D1.5 (Part 2), will be submitted to the European Commission via the official portal in Month 18 of the project (October 2025). This deliverable will present the refined data requirements framework, developed through co-design with key local stakeholders across the three pilot sites (as part of T2.2). Additional refinements (particularly related to 3D data semantics, OGC-based API integration, time-enabled spatial datasets, and CityGML Advanced Data Extensions) will also be addressed in D1.5. The aim is to ensure that RETIME solutions and services effectively address local stakeholders' needs and priorities while supporting broad scalability.

1.1. Purpose of report D1.3

RETIME will develop a suite of four innovative adaptation solutions for reducing risk in urban areas:

1) ***A sensor-based IT automated alert system*** to inform citizens, building inhabitants, managers and owners about extreme climatic events;

2) ***A Digital Building Twin***, a real-time, virtual representation of the building that integrates multiple hazard alerts, monitoring systems, and occupant-specific adaptation needs, utilising Machine Learning techniques and data from the Copernicus Climate Data Store, among others;

3) ***A digital Building Renovation Passport*** to help stakeholders in defining specific actions to be implemented at different scales;

4) ***A Resilience Knowledge Hub and Decision Support platform*** to visualise and explore data on interventions for hydro-meteorological risk reduction, using Geographic Information System (GIS)-based mapping tools. It allows users to browse successful Nature-based Solution (NbS) case studies, access relevant policies, and define cost-benefit analysis.

This deliverable provides a comprehensive overview of data requirements that integrates all technological and technical information aspects of RETIME solutions and services. Its main objective is to ensure the interoperability, consistency, and feasibility between the RETIME innovation solutions (both physical and digital), particularly regarding infrastructure resilience plans and innovative adaptation measures, while also ensuring inclusiveness and usefulness across all three pilot sites. Additionally, this report is the handbook for guarantying privacy, security, scalability, model monitoring, and evaluation of RETIME solutions throughout the project, that complement the information related to demo and micro-data sets (related to several RETIME deliverable, namely D3.1, D3.2- D3.6-D3.7, D3.3, D3.5, D4.1, D4.2, D4.3, D4.5, D4.6, D4.7, D4.8, and D6.3).
This report outlines the data requirements, data protocols, data schemas, and user interfaces to deploy the four RETIME solutions. While each solution will be developed within specific tasks, as shown in Figure 1, the stakeholder design and co-design strategies developed within T2.2 and T2.3 are applicable across all RETIME solutions. Suitable data and metadata creation standards and appropriate vocabulary will be followed, adapted or developed. Data interoperability is a significant aspect of RETIME, as it is intended to create semantic Data Models and ontologies to ensure interoperability. The analysis of standards and interoperable Data Models will be approached under the scope of this deliverable, facilitating data sharing from different sources.

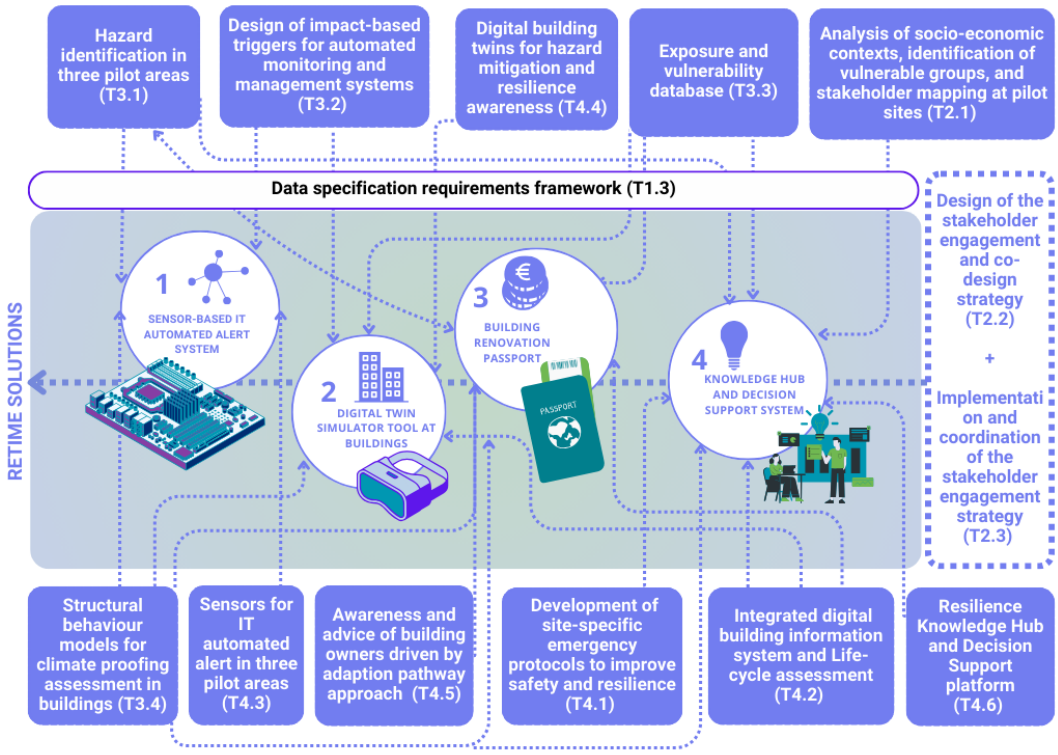


Figure 1. RETIME solutions and key interrelated activities.

2. RETIME Sensor-based IT automated alert system

The implementation of a sensor-based IT automated alert system in RETIME involves the installation and monitoring of a set of indoor and outdoor sensors in Lisbon and the test of hardware totems that simulate the conditions of the three pilot areas (Lisbon, Žilina, and Tartu). Collecting information from sensors and external sources is the first step in creating a solution with relevant outputs. It requires addressing several operational limitations, such as power autonomy, communication network coverage, sensor sampling period, and data volume. Each of these limitations can be mitigated using different technologies. For instance, battery-operated sensors can use the LoRa protocol due to its low power consumption, whereas grid-connected sensors can leverage 5G to transmit large volumes of data.

Different hazards and critical events are specific to each housing unit and the context of the pilot areas. Therefore, in the RETIME project, cellular (3G/4G/5G), LoRa, WiFi, cabled sensors, and external data sources will be utilised to meet the specific requirements of the pilot areas and end-users. The data communication protocols used throughout the project must ensure interoperability, while the sensor specifications must guarantee accurate event detection and reliable data transmission. Figure 2 represents the overview of the data paths and protocols from sources within RETIME (e.g., cellular sensors, indoor sensors) to the final outputs (e.g., alerts, Key Performance Indicators-KPIs).

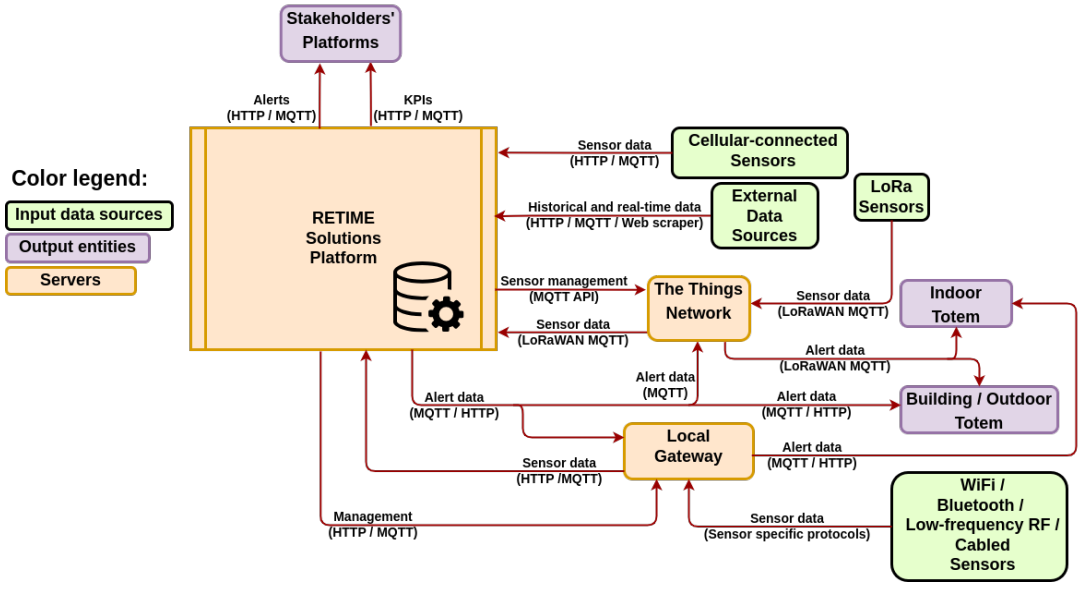


Figure 2. RETIME data paths and protocols.

2.1. Communication Architecture and Data Transmission

Sensor data can be transmitted to the main server through three primary methods:

- Sending data to a third-party cloud service – This approach requires a client-side process to retrieve data using the platform's specific cloud Application Programming Interface - API (e.g., Tuya IoT).
- Sending data to a custom endpoint – Direct transmission to the main server via HTTP(S) or MQTT protocols, ensuring lower latency and greater control over data processing.
- Using local relay nodes for transmission – Sensors communicate via WiFi, ZigBee, Bluetooth, LoRa, or low-frequency RF to a local node, which then forwards the data to the main server.

In indoor environments with multiple sensors, it is best practice to implement local relay nodes, which act as gateways to manage the sensors and ensure efficient data transmission to the main server. In RETIME, indoor sensors will be integrated with Home Assistant, one of the most comprehensive, customisable, and sensor-compatible platforms available, supporting a wide range of hardware, including Home Assistant Green, Raspberry Pi, ASUS Tinker, Generic x86-64, and Generic aarch64. This topology will be used with Indoor Environmental Quality (IEQ), energy consumption, water consumption, seismic, and hygrothermal and structural characteristics sensors, allowing the best possible data rates and real-time information for hazard identification and alerts.

Outdoor sensors will communicate using cellular networks, LoRa, WiFi, or other wireless technology, or cabled, depending on signal coverage and data rate/volume requirements. For example, Lisbon pilot has LoRa coverage, but the transmission limits are a maximum of 1% of transmission time per hour and a maximum of 30 seconds per day. Since transmission time depends not only on data volume but also signal strength, the evaluation of what sensors can operate on LoRa networks has to be verified in field experiments during task *T4.3. Sensors for IT automated alerts in three pilot areas*.

It is the most reliable option in locations where outdoor sensors are connected to existing indoor gateways via Ethernet cable, such as in *Bairro da Boavista* in Lisbon, virtually eliminating volume and data rate constraints. Finally, cellular networks will be used in locations with no LoRa network coverage, or LoRa limitations are unsuitable, and the sensors' location does not allow connection to an indoor gateway. Data rates and volume are high in this case, providing fast response on hazard identification and alert.

Besides sensors installed and managed by RETIME Beneficiaries, external data sources will be used from public and private platforms, providing real-time and/or historical data. Some of the sources provide an API and allow easy access to the data.

2.2. Data Processing and Interoperability

Once sensor data is stored in the main server database, it is processed to generate alerts and KPIs that are outputs to key stakeholders' platforms (i.e., policy-and-decision-makers, building users, owners, managers in the three pilot areas, environmental practitioners, research community, industrial stakeholders, and representatives of SMEs).
Open standards and standardised protocols will ensure interoperability across the RETIME system's different components, enabling seamless integration between sensors, databases, and external platforms.
Data access and distribution will follow two methods:

- HTTP API – This method is ideal for handling large volumes of low-frequency data, allowing structured queries and access to historical information.
- MQTT server – This approach is particularly suitable for alert systems, as it provides real-time event responsiveness and avoids network congestion caused by frequent polling requests.

If the above solutions are not feasible, additional alternatives include:

- Exposing an HTTP API on the client side, allowing the server to retrieve data actively.
- Providing an MQTT server on the client side, enabling the main server to subscribe to relevant data streams.

The choice of data access method depends on the operational constraints and infrastructure available in each pilot area. The RETIME main server API is implemented using Django and OpenAPI, ensuring scalability, security, and compatibility with third-party platforms.
To guarantee seamless interoperability between sensors, services, and external platforms, the following technical guidelines will be followed:

- OpenAPI Specification (OAS) – The server's RESTful API is designed in compliance with OpenAPI standards, ensuring easy integration with third-party applications and simplifying documentation and maintenance.
- JSON Schema for data validation – Data models follow a structured schema to enforce consistency and compatibility across different systems and services.
- Support for OGC SensorThings API – This optional implementation facilitates standardisation and efficient querying of sensor data, enhancing compatibility with other existing smart city platforms and IoT frameworks.
- Use of open protocols (MQTT, HTTP, WebSockets) – This contributes to avoid reliance on proprietary technologies to promote long-term flexibility and interoperability.

By implementing these standardised data schemas, open communication protocols, and real-time processing architectures, RETIME ensures that sensor data remains accessible, structured, and interoperable across different solutions and services.

2.3. Sensor and external data sources specifications

Besides the public and reliable data sources available for Europe (e.g., Copernicus CDS platform) that will be used on RETIME solutions, local sensors, and external data sources with sensor data for the regions of the pilot areas, will be used to achieve faster response on hazard detection and alert as better and more reliable data. This approach is essential to assess Indoor Environmental Quality and occupants' well-being due to the specificities of each dwelling and occupant. Table 1 shows the preliminary indoor and outdoor parameters to be monitored for deploying the sensor-based IT automated alert system.

Table 1. IT automated alert system parameters.

Parameters	Field of studies	Units
Indoor		
Temperature	Thermal comfort	ºC
Relative humidity	Thermal comfort / IAQ	%
CO_2	IAQ	ppm
Formaldehyde	IAQ	ppb
Light	IEQ	lux
Wind speed	IEQ	m/s
$PM_{1.0}$	IAQ	$\mu g/m^3$
$PM_{2.5}$	IAQ	$\mu g/m^3$
PM_{10}	IAQ	$\mu g/m^3$
Sound pressure	Acoustic comfort	dB
Atmospheric pressure	IAQ	Pa
Water consumption	-	L/min
Power consumption	-	Watt
VOC	IAQ	ppm
Acceleration xyz	Structural and seismic	m/s^2
Outdoor		
Wind speed		m/s
Wind direction		º
Precipitation		mm
Temperature		ºC

Relative humidity		%
Atmospheric pressure		%
Solar radiation		W/m^2
UV index		-
$PM_{2.5}$		$\mu g/m^3$
Precipitation		mm
Fire detection		logical
Water level		%

Table 2 outlines a set of technical information about the sensors installed in Lisbon for IEQ.

Table 2. Specifications of the sensor installation in Bairro da Boavista (Lisbon).

Parameters	Range	Resolution	Repeatability	Response Time [s]	Accuracy
Indoor					
Temperature	-40 - 105	0.01	0.04	< 2	±0.1 ºC
Relative humidity	0-100 %	0.01 %	0.08	8	±1.5 %
CO_2	0 – 10000 ppm	0.01 ppm	-	20	±30 ppm
Formaldehyde	0 – 1000 ppb	1 ppb	+/- 5 ppb	< 120	±20 ppb
Light	188µ - 88000 lux	0.01 lux	-	-	-
Wind speed	0 – 65 m/s	1e-15 m/s	-	-	-
$PM_{1.0}$	0 - 500 $\mu g/m^3$	1 $\mu g/m^3$	-	<10	98 %
$PM_{2.5}$	0 - 500 $\mu g/m^3$	1 $\mu g/m^3$	-	<10	98 %
PM_{10}	0 - 500 $\mu g/m^3$	1 $\mu g/m^3$	-	<10	98 %
Sound pressure	55–110 dB	0.1 dB	-	-	±3 dB
Atmospheric pressure	30000 Pa	110000 Pa	-	< 1	±60 Pa
Water consumption					
Power consumption	0 – 11500 W	0.1 W	-	-	1 %
VOC	-	-	-	1.4	-
Acceleration xyz	-	-	-	-	-
Outdoor					
Wind speed	1 – 67 m/s	0,1 m/s	-	-	±5 %
Wind direction	0 – 360 °	1°	-	-	±3 °
Precipitation	0 – 9999 mm	0,2 mm	-	-	±4 %
Temperature	-40 – 65 ºC	0,1 ºC	-	-	±0,5 ºC
Relative humidity	0 – 100 %	1 %	-	-	±3 %
Atmospheric pressure	540 – 1100 hPa	0,1 hPa	-	-	±0,5 hPa
Solar radiation	0 – 1800 W/m^2	1 W/m^2	-	-	±5 %
UV index	0 – 16	0,1	-	-	±5 %

$PM_{2.5}$	0 - 500 µg/m^3	1 µg/m^3	-	<10	98 %
Precipitation	-	-	-	-	-
Fire detection	0 – 1	1	-	0 – 1 h	-
Water level	0 – 100 %	0,01 %	-	< 1	±5 %

Table 3 outlines the key information on the sensor installation in Zástraine in Žilina.

Table 3. Specifications of the sensor installation in Zástraine in Žilina.

Data type	Geographical scope	No. of sensors	Variables	Access method
Air Quality Data	Žilina city - central districts	8	PM 1, PM 2.5, PM 4, PM 10, Nitrogen dioxide (NO2), Sulphur dioxide (SO2), Carbon monoxide (CO), average noise, maximum noise	API
Weather Data	Žilina city - central districts	8	Atmospheric pressure, wind direction, wind gust, wind speed, precipitation, Illuminance, air humidity, air temperature	API
Weather Data	National - measuring stations installed in most Slovak towns and cities	18	Air temperature, atmospheric pressure, relative humidity, wind speed, wind gusts, precipitation	Official data
Weather Radar	National	-	Reflectivity, rain intensity	Official data
Weather Satellite Data	National	-	Satellite images	Official data
Ozone Layer Status	National - 1 measuring station	-	Daily value	Official data
UV Index	National - 5 measuring stations	-	UV index	Official data
Flood alerts	National, 2 areas defined for Žilina district, 12 for Zilina region	12	Flood alert level (0-3)	Official data
3-day Weather forecasts per city	National - measuring stations installed in most Slovak towns and cities	-	Temperature, cloud cover, precipitation, atmospheric pressure, wind speed, wind gusts, wind direction	Official data

10-day Weather forecasts per city	National - measuring stations installed in most Slovak towns and cities	-	Temperature, cloud cover, precipitation, atmospheric pressure, wind speed, wind gusts, wind direction	Official data
Traffic disruptions	National	-	Traffic restrictions, accidents, traffic jams	Official data
Public transport RT data	City of Žilina	every vehicle (approx. 87)	GTFS-RT data stream updated every 20 seconds	API
Regional bus transport	Žilina, Bytča, Čadca, Kysucké Nové Mesto, Martin and Turčianske Teplice districts	-	-	API
Traffic signal data	City of Žilina	-	-	Official data
Road cameras data	Žilina region (50 stations)	50	Air temperature, roadway temperature, air humidity	Official data
Weather and Air quality data	Žilina region (50 stations)	50	Air temperature at 4m, road surface temperature, roadway temperature at 3cm depth under the surface, air humidity at 4m, sensor battery voltage, wind speed, concentration of salt at the roadway, dew point, sensor battery charging power, atmospheric pressure, air temperature measured by the pressure sensing unit at 4m, frequency of roadway analysis sensor, GSM signal strength, PM at 4m, Volatile Organic Compounds (VOC) Index at 4m, NOx at 4m, soil temperature at 7cm depth, soil PH at 7cm depth, nitrogen volume at 7cm depth, phosphorus volume at 7cm depth, potassium volume at 7cm depth, salt volume in the soil at 7cm depth, soil conductivity at 7cm depth	Desktop client app DriveMet accessible from ŽSK network
Traffic counts	City of Žilina	25	Traffic safety index, total vehicle counts, counts per vehicle category (cars, vans, trucks, not categorized), counts per	-

			vehicle speed (<30 kph, 30-60 kph, >60 kph)	
Mobile air quality station			NO, NO_2, NOx, CO, SO_2, O_3, PM10, PM2.5, PM1, dust 2.5 um, dust 10 um	Desktop client app
Bicycle counters	City of Žilina, 3 locations	3	Cyclists counts	-
Meteorological station Davis Vantage Pro2	Research Centre building	1	Air temperature, relative air humidity, atmospheric pressure, wind speed, wind direction, precipitation, solar radiation, UV index	Local access
Intelligent building management system	Research Centre building	-	Interior temperature, air humidity, CO_2 level, illumination intensity Exterior: temperature, wind speed, illumination of external construction elements	Local access

In Tartu, RETIME will leverage the Smart Home solution by utilising the sensors installed in the pilot building at Tähe 2 during the SmartEnCity project.[1] The solution includes the following components:

- *Gateway:* Connects with meters, sensors, and devices in the apartments via wired or wireless communication.
- *Control Panel:* A tablet used to manage devices and operate the EnLife-developed smart home application.
- *Smoke Detector:* Installed on living room ceilings for fire safety.
- *Impulse Counters:* Attached to electricity, water, and gas meters to transmit consumption data.
- *Smart Thermostats:* Enable temperature regulation in individual rooms.
- *CO_2 Detector:* Monitors air quality to manage ventilation.

For official data (indicated in Table 3, last column), relevant environmental and city management data can be sourced from government websites, open data portals, or third-party services. These sources should be reliable, transparent, and adhere to clear protocols, ensuring that critical thresholds are met. The use of this data depends on the trustworthiness of the data providers.

[1] http://smartencitynetwork.eu/

2.4. Hardware Totem

A signage totem, functioning as an ambient display (a type of interface that conveys information through visually appealing changes) will be deployed at the three RETIME pilot sites. More specifically, it integrates different plug and play IoT hardware and it will relate to existing devices to inform local inhabitants and other citizens about extreme climatic events, and other natural disasters. To ensure its effectiveness, robustness, and feasibility in addressing local-based climate-related challenges, it is essential to determine key data specification requirements in advance, working with potential end-users, IT providers, local representatives of public authorities, and solution designers to determine the type and frequency of alerts, the appropriate output modalities (such as visual or audio signals), and the technical and environmental requirements needed to ensure reliable operation in diverse conditions. Figure 3, shows the key information for the design of the ambient design related to the mechanism and accessibility.[2] Legal framework, regulating provision of public warnings will be assessed to guarantee compliance of the totem notification with local policies.

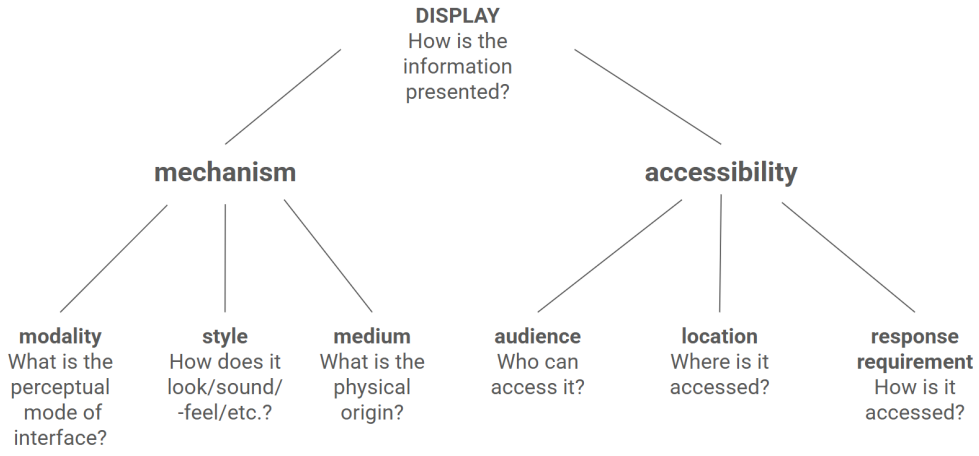


Figure 3. Key information for the design of the ambient design, adapted from Sanguinetti et al. (2018).

Mechanism: **Modality, style, medium:** This may include tactile inputs like using a keyboard or touchscreen, where physical touch is translated into commands and the system responds to them. To be discussed with LDMs. Voice interaction where devices receive and processes

[2] adapted from Sanguinetti, Dombrovski, & Sikand, 2018, Information, timing, and display: A design-behavior framework for improving the effectiveness of eco-feedback. In *Energy Research and Social Science* (Vol. 39, pp. 55–68). Elsevier Ltd. https://doi.org/10.1016/j.erss.2017.10.001

spoken commands. Visual output or sounds to transmit information or alerts. To be discussed with LDMs.

Type of Information: The information alerts displayed are defined following the findings in workpackage *WP3/T3.1. Hazard Identification*. Other aspects that need to be defined in advance are 1) the protocol to follow in case of disasters or emergencies and 2) how the totem receives the information and the communication technology that will be used. The alarm can be a simple electrical signal with any code. The hardware totem in each pilot area will integrate different plugs and play IoT hardware.

Language: The information will be in the official national languages of RETIME pilot sites (Portuguese, Slovak, Estonian).

Accessibility: **Target Audience:** The goal is to notify both a responsible person in charge of raising the alarm and reach citizens directly. In the latter case, how many citizens will be reached and where they will be located must be defined. In addition, we need answers to the following questions: the profiles of potential target audiences are related to the work done by ISCTE and ICONS key stakeholders. Other information will be provided by LDMs. The profiles of the potential target audience are linked to the stakeholder mapping conducted during co-design activities in the TRETIME pilot sites. These profiles will be further refined in Deliverable D1.5, based on information gathered from Local Desk Members.

- *Who needs to be informed?*
- *Should the totem provide detailed evacuation instructions specifically for a responsible evacuation coordinator?*
- *Alternatively, should it deliver more straightforward, more general information accessible to a broader group of people?*

Totem Location: The totem will be placed in the building (inside or outside). To be discussed with LDMs based on existing legal requirements and procedures related to public equipment in the public space.

Response required: Whether the intended audience should perform any interaction with the display or if the display only triggers alerts by using a designed modality.

3. RETIME Digital Twin Simulator tool at buildings

The Digital Twin Simulator Tool at buildings (DTST) is a core component of the RETIME project, acting as a virtual replica of a real-world building. It integrates diverse datasets from environmental sensors and structural models to BIM metadata and LCA indicators, allowing for simulation, monitoring, and forecasting of building performance under various hazard scenarios. This section consolidates all relevant data requirements, protocols, and stakeholder interfaces necessary for the successful operation of the DTST.

3.1. Data inputs from RETIME components

To ensure the operability and reliability of the DTST, the following inputs are required from other RETIME tasks and services:

- *Sensor-based IT alert system (*task *T4.3):* Real-time streams and historical datasets from environmental sensors (e.g., temperature, humidity, CO_2, VOCs, PM levels, water/power consumption) as well as structural and hygrothermal monitoring sensors are critical.
- *External datasets (T3.1, T3.2, T3.3):* Hazard identification, hazard forecasting and exposure databases will provide context-specific climate risks (e.g., flood, heatwave, seismic events), coming from Copernicus platforms (CEMS, CDS, CAMS), and regional open data portals.
- *Structural modelling (T3.4):* The DTST requires physical modelling data for simulating different structural response scenarios, including material properties, building typologies, and retrofitting parameters, to enable different scenarios testing of building vulnerability and mitigation strategies using Eurocode-based simulation frameworks, integrating climate hazard forecasts.
- *Building information models (T4.2):* BIM models (LOD 300 or above) are integrated into the DTST to define geometry, systems, materials, and usage patterns. These are used to spatially and temporally map sensor data and simulate behaviour over time. BIM data is harmonised via IFC formats and may be further integrated into CityGML for urban-scale applications.
- *LCA data (T4.2):* Offers insight into embodied carbon, energy usage, material impacts, and life-cycle emissions. It supports the evaluation of renovation interventions based on sustainability and carbon footprint indicators.

3.2. Exposure and vulnerability integration

The DTST is linked to the RETIME exposure and vulnerability database. This spatial database aggregates hazard maps, digital elevation models, CityGML building footprints, and socio-demographic indicators. Its structure ensures compatibility with BIM inputs and supports risk-based simulations at building and neighbourhood scale.
The data is processed using PostGIS-based 3D databases and exposed via WMS/WFS endpoints for integration with the DTST simulation environment.

3.3. Building Information Modelling

Building Information Modelling (BIM) models serve as the spatial and semantic foundation of the DTST. They provide structured geometric and parametric data needed to map sensor locations, simulate physical behaviour, and assess renovation scenarios at pilot sites. 3D BIM models[3] that integrate data from multiple formats, sources, and information into a single data environment (SDE) to facilitate infrastructure management and monitoring throughout the design and construction phase, as well as during building management phase.[4] RETIME project focuses on the use of BIM to define strategic solutions and actions during the management and potential project retrofitting solutions related to selected buildings. RETIME BIM models require the following data:

i) geometric data; parametric and materials/properties data;
ii) installations and systems;
iii) sustainable (CO_2) and energy data; and
iv) maintenance plans data.

[3] BIM extends far beyond the commonly perceived scope of 3D modelling. It represents a transformative, collaborative methodology that brings together architects, engineers, contractors, and other key stakeholders to optimise the planning, design, construction, and management processes of the building blocks or a single building. One of the core strengths of BIM lies in its ability to facilitate seamless collaboration, ensuring that every stage of a project lifecycle is efficient and well-coordinated. This is achieved by integrating rich datasets into 3D models, encompassing diverse information such as material properties, energy performance metrics, financial forecasts, and logistical details.
Beyond its collaborative nature, BIM stands out by making these data-rich models not only visual but also actionable. This actionable data enables teams to convey design intent more effectively, bridging the gap between conceptual planning and practical implementation on-site. Furthermore, BIM enhances knowledge transfer across stakeholders, fostering continuity and reducing information loss from one phase of the project to the next.
[4] https://buildingsmart.pt/o-que-e/#:~:text=O%20Building%20Information%20Modeling%20(BIM,manipula%C3%A7%C3%A3o%20virtual%20dessa%20mesma%20constru%C3%A7%C3%A3o.

The BIM models are developed to at least Level of Development (LOD) 300, encompassing architectural, structural, mechanical, electrical, and plumbing systems (MEP). They also include semantic annotations aligned with classification systems such as bSDD and SECClasS, supporting integration with other RETIME solutions including Life Cycle Assessment (LCA) assessment, building renovation passports, and city-level planning platforms.

The acquisition of BIM models is tailored to the conditions of each pilot site. In Bairro da Boavista (Lisbon), source material includes 2D drawings provided in digital or printed form by Lisbon City Council (CML). These will be complemented by LiDAR laser scanning using the Trimble X9 Core device, producing a point cloud representation of the geometry and enabling comparison between planned and as-built conditions. In the Zástraine district (Žilina), the Faro Focus X330 LiDAR scanner will be employed to generate a similar point cloud model of the selected building. These scanning techniques are essential for buildings with limited or outdated documentation, allowing accurate 3D reconstructions for BIM model development.

Additional BIM data is gathered through photogrammetry, legacy DWG or PDF blueprints, and on-site inspection. Generated models include not only building envelope components such as walls, floors, windows, and roofs, but also MEP systems and metadata relevant to maintenance, occupancy, and retrofit options. All BIM models are exported in IFC format to ensure interoperability and may be further transformed to CityGML Level of Detail 3 (LoD3) for integration with RETIME's 3D urban simulations. BIM data is used to spatially anchor environmental and structural sensor data and to drive scenario-based simulations within the DTST interface.

Table 4 shows the type, format, and size of data required for the BIM models across the RETIME pilot sites.

Table 4. BIM models source data formats of each RETIME pilot site.

RETIME pilot site	Type of Data	Format	Size
Bairro da Boavista (Lisbon)	Vector data	DWG, DWF, DWFx, and DXF	10MB – 100MB
	Spatial 3D data	TDX, TZF, E57, PTX, RCP, LAS, POD, ASCII and GeoTIFF	6GB – 30GB
	Image	JPEG	150MB – 500MB
Zástraine (Žilina)	Spatial 3D data	FLS, E57, PTX, PTS and XYZ	10GB - 20GB
	Photogrammetry (raw)	JPEG, DNG and Geotags (EXIF metadata)	700 – 1000 photos
	Photogrammetry (processed)	LAS, XYZ and OBJ	-
Tartu's historic centre	Vector data	PDF	1MB - 4MB

Once the geometric data has been collected, the software Archicad will be used to develop the LOD 300 BIM models and standardise the various data formats into the universal IFC file format. Promoted by buildingSMART, IFC enables seamless interoperability and minimises the loss of data and metadata during information exchange between different software platforms.
RETIME will also explore the possibility of integrating BIM data into CityGML models. While CityGML models typically cover larger areas—such as neighbourhoods and municipalities—with a lower level of detail, BIM models provide high-detail information at the building scale.
The objective is to incorporate more detailed data into CityGML frameworks guaranteeing at least a LoD3, where the architectural models have detailed wall and roof structures, balconies, bays and projections and when possible, a LoD 4 where the interior structures are also represented. This approach aims to enhance overall robustness and preparedness against natural and human-induced disasters, not only at the building level but also across entire urban areas, leveraging BIM models as a valuable input.

Parametric and material properties data are essential for characterising the 3D geometric model elements in certain classes, properties, functions, and relationships, thus making the model editable and interactive, and allowing for simulation, structural, energy and maintenance analysis and LCA.
Formats: IFC; RFA (Revit); GDL and XML (ArchiCAD) and CSV
Size: 500KB – 3MB
It is customary for manufacturers and suppliers to provide specific data about certain products, which are aggregated in online portals, such as bimobject.[5] Additionally, RETIME will leverage the buildingSmart Data Dictionary (bSDD)[6] which contains definitions of classes and properties to enrich the model and the SeCClasS Classification System[7] which contains information organised hierarchically, starting from broader levels such as compounds and infrastructure, down to more detailed levels such as individual products, as detailed in Table 5.

Table 5. SECClasS Classification System.

Information	Description	Interactions
Activities	Activities that can be carried out in complexes, entities or spaces or related to project	Complexes Entities Rooms and places

[5] https://www.bimobject.com/en
[6] https://www.buildingsmart.org/users/services/buildingsmart-data-dictionary/
[7] https://secclass.pt/pesquisa/

	management, prospecting or maintenance	
Complexes	Describe in general terms the model	Activities Entities
Entities	Describe a building or an infrastructure	Activities Complexes Room and places Elements and functions
Room and places	Describe the type of rooms and places in an entity	Activities Entities
Element and functions	Describe the function of the elements in an entity	Entities Systems
Systems	Defines sets of elements that fulfil a function (e.g., ventilation)	Elements and functions Products
Products	Defines the individual products that make up the systems	Systems

3.4. Life cycle assessment

Life Cycle Assessment (LCA) is a key component integrated into the DTST, allowing for the quantification of environmental impacts associated with the entire building lifecycle. This includes the evaluation of embodied carbon, operational energy and water use, material extraction, transport, construction, maintenance, and end-of-life processes. The integration of LCA within the DTST is essential to support sustainability assessments, prioritise retrofit interventions, and align with EU decarbonisation targets.

LCA modelling in RETIME follows standardised methodologies according to ISO 14040, ISO 14044, EN 15804, and EN 15978. Indicators are calculated using tools such as the SECClasS Carbon Calculator and are linked directly to BIM elements, enabling automated extraction of quantities and material properties. LCA datasets are sourced from recognised databases including the ICE database and national environmental product declaration (EPD) registries. These datasets include characterisation factors, impact categories, and typical environmental loads for common building materials and systems.

Outputs from the LCA process are formatted in CSV, XLSX, and IFC-compatible structures, allowing direct integration with the BIM models used in the DTST. The platform will enable comparative simulations of different retrofit scenarios, visualising outcomes in terms of energy savings, embodied carbon reduction, and life-cycle cost optimisation. This supports building owners, managers, and local authorities in selecting renovation strategies that maximise climate resilience and cost-effectiveness while minimising environmental impact.

3.5. Virtual reality data integration

The conversion of BIM models into a Virtual Reality (VR) environment involves multiple steps may require additional data storage capacity, as VR environments can become larger, owing to their interactive nature and the extra data associated with high-resolution textures and enhanced visual elements.

To successfully create a VR environment, it is essential to first prepare the 3D BIM model. This preparation may involve simplifying the geometry and removing elements that are not relevant to the VR experience, thereby optimising the model for better performance.

Subsequent steps involve exporting BIM model from the authoring software and importing into the chosen VR environment software. Direct translator might be used, otherwise the FBX file format is widely used for exporting geometry, as it retains data related to geometry, materials, and textures. If text information transmittal is needed, other file formats such as CSV, JSON or XML might be used. The file size of the exported model depends on the size of the original 3D BIM model and its Level of Geometric Detail.

For example, regarding an architecture model of a 6-floor building, a model with low geometric level of detail, where dimensions are correctly represented but elements detail may not correspond to reality, may take from 200 MB to 500 MB, and could result in VR environment files sized between 750 MB and 1 GB, depending on the level of interactivity. An as-built model with highly detailed graphical representation may lead to VR files as large as 5 GB, especially when incorporating game-like extensive interactivity, advanced lighting, and dynamic effects.

3.6. Exposure and vulnerability database

The Exposure and Vulnerability Database is a core component of the DTST, enabling the spatial analysis and simulation of risk scenarios under various climate hazards. This database aggregates and harmonises multi-scale geospatial and building-level data to assess the exposure of buildings and the vulnerability of their occupants. It is designed to integrate seamlessly with the BIM-based models and simulation engines of the DTST.

The database includes hazard-specific data such as flood risk maps, temperature anomalies, wildfire probability layers, and digital elevation models, sourced from the Copernicus programme (CEMS, CDS, CAMS), local municipalities, and national authorities. Socio-demographic indicators such as age, health status, income level, and mobility constraints are also included to estimate social vulnerability. These datasets are processed using spatial analysis tools in QGIS and PostGIS, ensuring high-resolution overlays with BIM and sensor data. Building geometries are represented using CityGML footprints at LoD3 level or extracted directly from IFC models. The database also supports Advanced Data Extensions (ADEs) for custom schema mapping between BIM and GIS layers. Exposure calculations are carried out using

spatial queries and buffer analysis in PostgreSQL/PostGIS, while results are exposed to the DTST through Web Map Services (WMS) and Web Feature Services (WFS).
This exposure framework enables DTST users to visualise risk scores for individual buildings, simulate hazard impact under compound scenarios, and identify priority zones for renovation or emergency planning. The system supports integration with evacuation modelling and structural safety assessment, contributing directly to the automated alert system and the BRP decision layers.
The exposure and vulnerability database is providing data for the RETIME solutions Digital Twin, Building Renovation Passport, and Knowledge Hub and Decision Support System. It enriches existing open datasets with complementary data to derive information relevant for decisions on building and neighbourhood level. The database is combining geospatial data with BIM data. Basic requirements for the database are the ability to access various data portals, process and store various geospatial formats and Industry Foundation Classes (IFC) data. In addition, several output formats and access ways are needed to allow further use of data in RETIME solutions.
The proposed data flow is visualised in Figure 4 and described below.

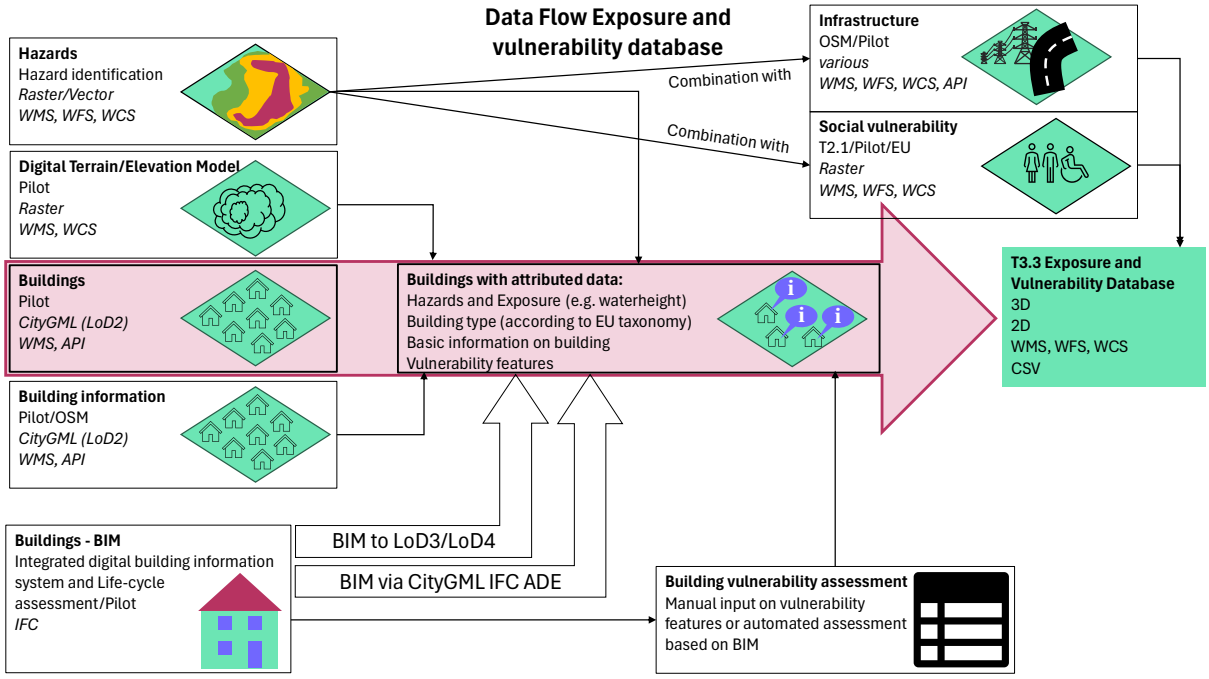


Figure 4. Data flow RETIME exposure and vulnerability database.

As shown on the left in Figure 4, various geospatial datasets provide the basis for the exposure and vulnerability database. Each box represents a specific dataset and is labelled from top to bottom: 'Name of dataset', 'data source', 'data format', 'type of OGC web service' or 'API used to access dataset'. These include hazard maps created in RETIME, enabling the assessment of

buildings' exposure to hazards. In addition, digital terrain/elevation models extracted from existing open datasets enable the visualisation of the environment and can provide additional exposure information. Building shapes derived from existing CityGML models of the pilots will, together with building information from OpenStreetMap or other open-access sources, provide basic information on buildings in the pilot sites.

The combination of digital terrain/elevation models with hazard maps and building shape and information will enable an initial hazard exposure assessment of all buildings located in the pilot sites.

The described data flow can be managed with a 3D database based on Postgres/PostGIS including 3DCityGML scheme and relevant Application Domain Extensions (ADE). This ensures interoperability with both geospatial and BIM data. OGC web services (WMS, WFS, WCS) and 3D tiles are integrated, to enable the access on data from existing open data platforms in the pilot sites. Data provision to the RETIME solutions building on the database will be enabled using standardised data exchange formats, including OGC web services, amongst others. Whenever suitable and possible, open-source software and standards are used.

3.7. Protocols and interoperability

Interoperability is key to ensuring that data coming from distributed sources can be processed in a coherent manner. The DTST must adhere to the following protocols and guidelines:

- OpenAPI Specification (OAS) for RESTful API access and integration.
- MQTT protocol for subscribing to real-time events such as hazard alerts.
- OGC SensorThings API and Web Feature/Map Services (WFS/WMS) for environmental and spatial data.
- JSON schema for validation and standardisation of input data.
- Industry Foundation Classes (IFC) and CityGML for BIM-GIS integration and semantic mapping of building features at various scales.
- 3D Tiles and PostGIS, for managing 3D data flows in the exposure and vulnerability database, which feeds the DTST.
- JSON, XML, FBX, and CSV for VR and LCA data exchange.
- FBX, JSON, XML for integration into VR environments where DTST visualisations are needed.
- ISO 14040, EN 15804, EN 15978 and ISO 21929-1 & 21931-1 standards for LCA compliance.

3.8. Stakeholder outputs and interactions

The DTST will be accessed by multiple stakeholders and must respond to their differing needs through flexible data interfaces:

- Building owners and managers to assess current vulnerabilities and simulate retrofitting scenarios.
- Local authorities and emergency planners to test evacuation strategies or early alert response based on structural simulations.
- Researchers and industrial partners to evaluate environmental and structural interdependencies over time.

To support these interactions, a layered output system is planned:

- High-level dashboards with key indicators and simulations.
- Exportable reports with performance metrics under hazard exposure and LCA profiles per building.
- API endpoints for real-time data consumption by third-party platforms, BRP and Knowledge Hub solutions.

All interfaces will enforce GDPR compliance and define access rules for private, public, and research stakeholders. Future integration into immersive environments (e.g., Virtual Reality) will also support stakeholder engagement in co-design activities.

4. RETIME Building Renovation Passport

4.1. Introduction and functionalities

Based on the literature,[8] the Building Renovation Passport (BRP) is a document or web tool outlining a long-term (15 to 20-year time horizon) step-by-step building renovation roadmap resulting from an on-site energy audit and bringing reduced heating bills, improved comfort and reduced CO_2. It suggests the installation of selected measures in a certain order/sequencing to avoid preventing any additional renovation improvement. A preliminary schema of RETIME BRP[9] functionalities is displayed in Figure 5, where each circle corresponds to a main section of the BRP tool (accessible through a user menu): i) administration; ii) BIM data; iii) maintenance; iv) performance; v) monitoring; vi) EPC; vii) roadmap; viii) documents & certificates; and ix) surveys.

- The area of the BRP showing BIM-based data will be built on the Digital Building Logbook (DBL) set up within the Horizon Europe (HE) BuildON project,[10] where ONE is also taking part. BIM models (task T4.2) are expected to feed most of the building information to the BRP.
- Some relevant meter or dynamic data coming directly from buildings (or their digital twin models implemented in T4.3) will be made available in the BRP too. This might include both energy consumption as well as indoor climate or Indoor Air Quality (IAQ) information. Further dynamic messages (e.g., received by the interactive hazard map from WP3) could be shown by the BRP as well.
- Energy Performance Certificates (EPCs) of RETIME pilot buildings will be stored and displayed by the BRP to showcase their energy performance and provide a preliminary understanding of potential technical improvements.
- The BRP will be accessible from the Resilience Knowledge Hub and Nature-Based Solutions (NBS) platform (T4.6), while its inputs to develop specific renovation roadmaps for RETIME assets will arrive from different sources – considering exposures, vulnerabilities and hazards associated with neighbourhoods, energy simulations of buildings and financial feasibilities to install selected measures: e.g., Energy Plus-built

[8] Understanding Building Renovation Passports: customised solutions to boost deep renovation and increase comfort in a decarbonised Europe, Building Performance Institute Europe (BPIE)'s Mariangiola Fabbri
[9] The RETIME BRP will be developed by ONE (T4.5 leader) as a standalone web platform. This task will start in Month 13 (May 2025) and will finish in Month 36 (April 2027), when *D4.5. Digital Building Renovation Passport (BRP) tool* – will be submitted to EC portal as a demonstration deliverable (DEMO). A close collaboration with other RETIME tasks will be essential to ensure the successful implementation of this solution.
[10] https://cordis.europa.eu/project/id/101104141

simulations and product cost catalogue-based Decision Support System (DSS) from T3.4, exposure and vulnerability database (T3.3) and other RETIME partners' risk analysis tools.

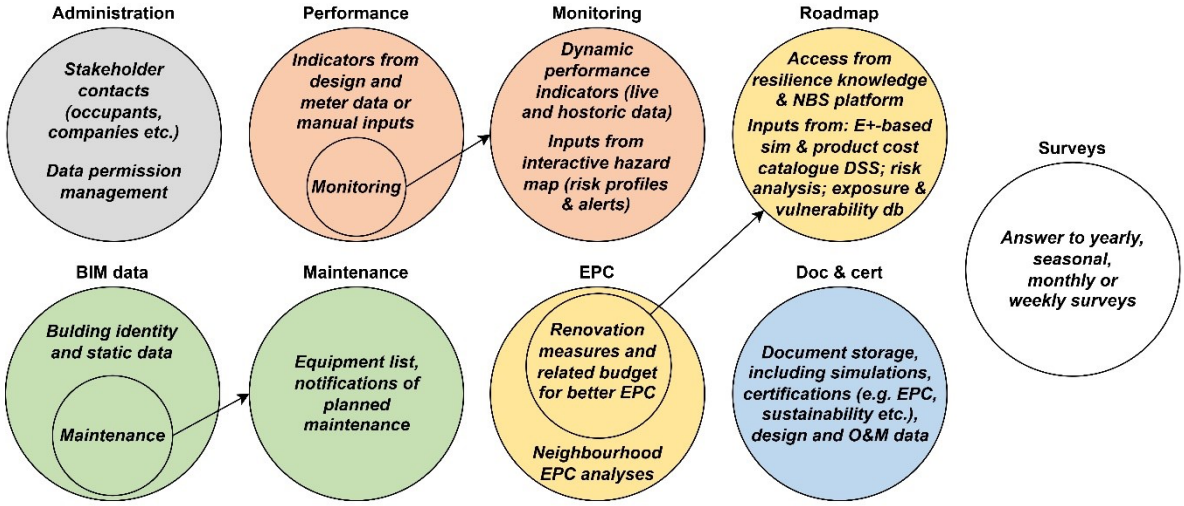


Figure 5. Preliminary schema of the RETIME Building Renovation Passport functionalities.

4.2. European Directive and Energy Performance Certificate contributions

European regulation and the EPC framework laid the foundation for RETIME BRP requirements (presented in the next chapter). The Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings[11] in fact foresees the full decarbonisation of buildings by 2050 and defines a roadmap for EU Member States. This regulation features a template that EU Member States can leverage for their own national building renovation plans. Specific indicators are defined as "mandatory" or "optional". Based on this legislation, Annex A (Table 7) outlines some parameters that the BRP will use to set up renovation roadmaps for its pilots. An EPC instead validates the energy performance of a building. Thus, the BRP will register in its database all the required data to calculate an energy rating. Annex B shows EPC fields based on Italy's CENED framework[12] (publicly available online), which are also common in other European countries such as Portugal, Slovakia, and Estonia.

The ADENE entity manages the Energy Certification System (ECS) in Portugal: qualified experts assess a building energy performance through calculation software, which generates a file in the

[11] https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32024L1275
[12] https://www.dati.lombardia.it/Energia/Database-CENED-2-Certificazione-ENergetica-degli-E/bbky-sde5/about_data

.xml format; the EPC[13] is officially provided after submitting the file to the ADENE platform. The Estonian 3D Twin[14] service of the Estonian open data portal is instead associated with building register datasets,[15] guaranteeing open access to relevant information – including permits, notices, energy labels and EPCs. Such a web tool (focused on energy ratings) is unfortunately not available in Slovakia, although the Statistical Office of the Slovak Republic's DATAcube database[16] offers insights into energy statistics (at the national and local levels).

4.3. Database and requirements

The RETIME BRP will be built starting from ongoing activities in other HE projects, including BuildON – where BRP developer ONE is working on a DBL up to Technology Readiness Level (TRL) 8. This DBL consists of a digital data repository for both commercial and residential buildings, even featuring a direct link with the digital twin environment where BIM models of pilots are hosted. Since the BRP must provide step-by-step building renovation roadmaps, proposing adaptation measures that make buildings less vulnerable and more resilient to climate risks, BuildON DBL fields will be enriched with new ones. Most of the asset data will be retrieved by a BIM model with an average Level of Development (LoD), but not all since some information must be uploaded to the platform manually too. Other relevant data sources will include meters, energy simulations, Life Cycle Assessment (LCA). When BRP fields in the database are compiled, building information to calculate the asset energy performance or simulate its renovation scenarios can be gathered by engineers or architects.
Seven user groups of the BRP tool will interact with building data in read-only and write modes depending on authorisation levels. They correspond to stakeholders usually involved in a single flat or full building project: (i) building or flat tenant; (ii) building or flat owner; (iii) building manager; (iv) utility or service provider; (v) design studio, construction company or certification body; (vi) financial institution or insurance; (vii) municipality or other public authorities (e.g. region, police etc.).
The BRP interface will depict the BRP database as much as possible, without compromising a user-friendly and inclusive experience for all. Following the BIM approach, each parameter is categorised under a specific object, which is also matched with three User Interface (UI) hierarchy levels – namely chapter, topic and sub-topic.

[13] https://it.scribd.com/document/767481267/ADENE-SCE-SCE0000304583326
[14] https://avaandmed.eesti.ee/usage-stories/eesti-3d-kaksik
[15] https://avaandmed.eesti.ee/datasets/ehitisregister
[16] https://datacube.statistics.sk/#!/lang/en

- Objects refer to the building, level, unit, space, equipment (split into architecture, electrical, mechanical and plumbing), company, user and Common Data Environment (CDE).
- Chapters are instead divided into address book, building elements, building identity, building structure, energy, Operation & Maintenance (O&M) and sustainability.
- Building elements topics: levels, units, spaces and equipment (architecture, electrical, mechanical and plumbing).
- Energy topics: metered energy or resource, energy summary, energy simulation and EPC.
- Sustainability single topic: emissions.
- Numerous sub-topics include further asset details, such as total energy needs, renewable and non-renewable energy needs, metered energy or resource consumption, metered generated or exported energy on-site and roadmap to 2030, 2040, and 2050.

Sections 4.3.1, *4.3.2* and *4.3.3* explain how various local stakeholders can benefit from the BRP.

4.3.1. Energy Performance Certificate use case

An owner aiming at obtaining or updating the EPC of a single flat will authorise the company carrying out the activity (an engineering or architecture firm) to access specific BRP data.

- In general, all the BRP fields describing the entire building identity will be made available: destination, construction year, location, climatic zone, general dimensions, number of units and, if available, existing EPC rating, plans for the next renovation (year and targets) and feasibility to achieve nearly zero-energy and/or zero-emission levels.
- A lot of relevant information to generate the flat EPC will be retrieved from the BRP's energy chapter, including: (i) total, renewable and non-renewable energy needs per scope (ventilation, cooling, domestic water heating, elevators and escalators, heating, lighting and electrical appliances); (ii) metered energy consumptions per scope and distinguishing different forms of heating (heat pump, photovoltaic, solar thermal and wind energy); (iii) metered solid and liquid or gaseous resource consumptions (e.g., water, natural gas, LPG); and (iv) exported photovoltaic energy generated on-site.
- Additional data of the single unit will come from the following BRP fields: (i) identity and dimensions; (ii) performance (total primary energy); (iii) energy-influencing factors (lighting load density, gross heated volume and gross dispersing surface area); (iv) CO_2 emissions; (v) Heating Ventilation Air Conditioning (HVAC) system (cooling and heating loads, cooling, heating and humidity setpoints, natural ventilation rate and supply airflow).

- Further information will be gathered from specific architecture, electrical, mechanical and plumbing equipment, namely: i) floor, ceiling, walls, doors and windows (whose thermal resistance, heat transfer coefficient and thermal mass impact the asset envelope); ii) lighting fixtures, meters, electrical fixtures and, if installed, fire alarm devices; iii) duct design, mechanical control devices, HVAC system and boilers; and iv) pipe design and plumbing fixtures.

After obtaining the EPC, the company will register the following data about the flat in the BRP: (i) EPC rating, type, number, issue date, summer and winter emoticons; (ii) major restructuring execution (yes or no); (iii) summer equivalent solar area per useful surface; (iv) EPC rating and non-renewable energy performance reachable after the next renovation (including time on Return of Investment) or all suggested renovations; (v) EPC classification of similar units when new. The information associated with the company (e.g., name, VAT, address) and certifier (name, surname and qualification) will be registered in the BRP as well, e.g., by the owner, company itself or building manager.

4.3.2. Unit renovation use case

The other two examples concern an owner planning a flat renovation and a manager planning a full building renovation, assuming in both circumstances a 60-year-old asset and a targeted jump from energy class G to D. Supposing that the building has four levels, we will consider that the single unit is positioned in the middle (at level 2).
Regarding the first renovation scenario, companies designing or installing selected renovation measures (i.e. firms in the Architecture, Engineering and Construction sector) will read only generic building data from the BRP, as follows: destination, construction year, location, climatic zone, general dimensions, number of units and, if available, existing EPC rating, last renovation depth, plans for the next renovation (year and targets), feasibility to achieve nearly zero-energy and/or zero-emission levels and possible exemptions. Generic flat information that must be retrieved instead consists of identity and dimensions, plus energy-influencing factors (lighting load density, gross heated volume and gross dispersing surface area).
Assuming an improvement in energy consumptions from 200 to 120 kWh/(m^2 year), reducing non-renewable energy needs by 40%, photovoltaic panels producing 50 kWh/(m^2 year) and an efficient HVAC system (in place of an older one) will be installed for cooling, heating and domestic water heating. The thermal envelope will also be enhanced with internal wall insulations (for two exposed surfaces) and new windows. In closing the electrical and plumbing equipment will be renovated too. A lot of new asset data will therefore be registered in the BRP by companies working on the project.

- In terms of energy, interested BRP fields will be: i) total, renewable and non-renewable energy needs per scope (ventilation, cooling, domestic water heating, heating, lighting and electrical appliances); ii) metered energy consumptions per scope and specifying the single form of heating (photovoltaic energy); iii) metered solid and liquid or gaseous resource consumptions (e.g., water, natural gas, LPG); iv) exported photovoltaic energy generated on-site.
- Additional flat information subjected to an update will be: i) performance (total primary energy for lighting and electrical appliances, global non-renewable annual primary energy demand, daily HVAC system operating hours and setpoint room temperature for heating and cooling periods); ii) emissions (CO_2 emissions rate for surface and volume units, CO_2 emissions and annual operational Green House Gas emissions and reduction); iii) HVAC system (cooling and heating loads, cooling, heating and humidity setpoints, natural ventilation rate and supply airflow).
- Further revised data will refer to the following architecture, electrical, mechanical and plumbing equipment, namely: i) walls and windows; ii) lighting fixtures, meters and electrical fixtures; iii) mechanical control devices and HVAC system; and iv) pipe design and plumbing fixtures.
- For every new installed element, O&M information will be integrated into the BRP: warranty, required maintenance and job (e.g., frequency, duration).
- BRP fields regarding companies, certifiers and, if generated, the new EPC will be filled out as well.

4.3.3. Building renovation use case

In the second renovation scenario, AEC companies and service providers will gather from the BRP the following generic building data: destination, construction year, location, climatic zone, general dimensions (including level details), number of units and, if available, existing EPC rating, last renovation depth, plans for the next renovation (year and targets), feasibility to achieve nearly zero-energy and/or zero-emission levels and possible exemptions.
Assuming an improvement in energy consumptions from 250 to 125 kWh/(m^2 year), reducing non-renewable energy needs by 50%, photovoltaic panels and a geothermal heat pump concurrently producing 100 kWh/(m^2 year) will be installed for cooling, heating and domestic water heating. The thermal envelope will also be enhanced with roof and external wall insulations (for two exposed surfaces) and new windows. In closing the electrical, mechanical and plumbing equipment will be renovated too. Companies working on the project will register a lot of new data in the BRP, similarly to the unit renovation use case but at the full building scale and with some differences.

- In terms of energy, interested BRP fields will be: i) total, renewable and non-renewable energy needs per scope (ventilation, cooling, domestic water heating, heating, lighting and electrical appliances, elevators and escalators); ii) metered energy consumptions per scope and specifying the two forms of heating (photovoltaic and heat pump energy); iii) metered solid and liquid or gaseous resource consumptions (e.g., water, natural gas, LPG); iv) exported photovoltaic energy generated on-site.
- Additional asset information subjected to an update will be: i) performance (total primary energy for lighting and electrical appliances, global non-renewable annual primary energy demand, daily HVAC system operating hours and setpoint room temperature for heating and cooling periods); ii) current emissions (CO_2 emissions rate for surface and volume units, CO_2 emissions and annual operational GHG emissions and reduction); iii) targeted emissions for the forthcoming years, e.g. 2030, 2040 and 2050 (expected operational GHG emissions and reduction).
- Further revised data will refer to the following architecture, electrical, mechanical and plumbing equipment, namely: i) walls, windows and roof; ii) lighting fixtures, meters, electrical fixtures and fire alarm devices; iii) mechanical control devices and fire protection; iv) pipe design and plumbing fixtures.
- For every new installed element, O&M information will be integrated into the BRP: warranty, required maintenance and job (e.g., frequency, duration).
- BRP fields regarding companies, certifiers and, if generated, the new EPC will be filled out as well.

Compared to the flat renovation example, this is not the only data that will be featured in the BRP when renovating an entire building.

- Companies will also report: i) renewable and non-renewable energy performance; ii) primary and final annual energy consumptions (and combination of both); iii) share of renewable energy on-site and off-site; iv) if the asset has reached nearly zero-energy levels or is still poorly performing; and v) budgetary resources to carry out the refurbishment (by differentiating public and private investments).
- Considering further possible improvements in next years (e.g. 2030, 2040, and 2050), professionals will even specify in the BRP (if feasible and in compliance with local regulations): i) targets for expected primary and final annual energy consumptions; ii) targets for the increase in the share of renewable energy; iii) targets for the deployment of solar energy; iv) cost-optimal minimum energy performance requirements; v) annual primary energy use thresholds; vi) maximum energy performance thresholds; vii)

expected energy savings; viii) total investment needs; ix) for energy poor areas, reduction of affected people.

5. RETIME Knowledge Hub and Decision Support System

The Resilience Knowledge Hub and Decision Support Platform will primarily integrate the results of the tasks from workpackage WP4. Hence, the data requirements are largely aligned with the one's described in *Sections 2, 3*, and *4*. However, CAD and BIM data need to be handled differently.
For components of the hub which are not directly covered in *Sections 2*, *3* and *4*, specific requirements include:

- Hazard, exposure, and vulnerability data as well as sensor and climate indicators will be integrated into the WebGIS following existing OGC standards such as WMS, WFS or WCS. These datasets will be either stored in the backend hosted by KAJO or can be retrieved via API calls.
- CAD data formats are not natively supported in WebGIS applications, and they need to be converted to GIS layers to make them available in a web map.
- 3D data can be visualised as well if they are published in the data format which is supported by Cesium[17] library.
- Data available through standard RESTful (REST) API can be published in the Resilience Knowledge Hub WebGIS interface without additional data management operations.
- For a successful merge of NBS case studies from the GeoIKP and the case study examples identified within RETIME, the information requirements will follow a similar structure as outlined as in the GeoIKP.[18]
- Similarly, policies identified within the RETIME project can be added to the existing policy catalogue and therefore, follow the input form from the GeoIKP including information such as title, summary, link to policy document, policy level, similar policies, and related adaptation examples.
- For citizen stories, the input form will be based on the one from the GeoIKP[19] but may be adjusted to the RETIME project in the future.
- Requirements for the Toolkit are aligned to the requirements of the other Tasks in WP3 and WP4 as these will be the main input features.

Overall, the hub will be publicly available and therefore, follow the European GDPR rules to prevent the leak of sensitive information and data.

[17] https://cesium.com/platform/cesiumjs/
[18] https://geoikp.operandum-project.eu/nbs/crowdsourcing
[19] https://geoikp.operandum-project.eu/data/story

5.1. RETIME Impact-based triggers for an automated monitoring and management system

The data requirements for the automated monitoring and management system (WP3/T3.2) include reliable updated datasets at national and local levels for analysing and predicting climate extremes and their impacts on critical infrastructure. Different data sources (shown in Table 4) include forecasting data, identified in D1.1: Copernicus Emergency Management Service (CEMS), Copernicus Climate Change Service (C3S), Copernicus Atmosphere Monitoring Service (CAMS). Monitoring and forecasting data are based on national and municipal sensor data from RETIME pilot sites. To define Impact-based triggers for an automated monitoring and management system, different data must be incorporated:

- *Relevance to Infrastructure:* Climate indicator datasets will be selected based on their relevance for infrastructure vulnerability and resilience.
- *Existing Data Utilisation*: Only datasets from reliable sources (e.g., Copernicus, municipalities) will be used, adhering to the project's scope limitations.
- *Pilot-Site Specificity*: Sensor data from the pilot sites will be leveraged for localised assessments, at district or neighbourhood level.
- *Automated Triggers*: Data will be processed to establish automated triggers tailored to the specific vulnerabilities of different infrastructure types.

Table 6. Relevant data types and variables for RETIME automated monitoring and management system.

Data Type	Source(s)	Variables	Application
Climate Indicators	C3S	Temperature, precipitation, wind speed, heatwaves, drought indices	Assessment of climatological vulnerabilities
Hazard Data	CEMS	Flood extent, wildfire risk, extreme weather alerts	Hazard-specific responses
Air Quality Data	CAMS	Particulate matter ($PM_{2.5}$, PM_{10}), CO_2, Ozone	Analysis of Infrastructure resilience to air quality impacts
Sensor Data	RETIME Pilot Sites	Please see section 2.3.	Implementation of localised monitoring and early warning mechanisms
Forecast Data	C3S and CEMS	Medium-range forecasts, sub-seasonal and seasonal projections	Planning and response strategies for longer lead times

The implementation strategy for the above introduced datasets can be summarised as follows:

- *Integration:* The framework integrates multiple data streams, ensuring comprehensive coverage of climate, hydro-meteorological, and geological risks.
- *Automation*: Data will either be collected in a ready-to-use form (impact-based forecasting) or will be collected into a temporary storage and feed into algorithms to establish infrastructure-specific alerts.
- *Standardisation:* Forecast layers and outputs will adhere to standardized formats for interoperability and stakeholder usability. Dedicated Application Programming Interface (API) will be proposed to expose and disseminate these alerts in form of Common Alerting Protocol.
- *Co-design with stakeholders:* Collaboration with decision-makers will refine building-centric thresholds and tailored to sectoral needs for each pilot site. Alerts will further used to trigger site specific emergency protocols designed during the activities dedicated for the development of site-specific emergency protocols to improve safety and resilience (WP4/T4.1).
- *Testing & improvement:* The tool will be tested by the pilot sites and their stakeholders to grasp the end-user opinions, concerns, and suggestions for this tool (W5/T5.2). In addition, a multi-criteria performance assessment will be conducted and focusing more specifically on the functionality, user satisfaction, scalability, usability, reliability, performance speed, and lastly, the tools adaptability.

This approach ensures the efficient use of existing data assets to develop robust early awareness systems and resilience strategies for critical infrastructure. By focusing on data availability and stakeholder collaboration, the framework aligns with the overarching goals of WP3/*T3.2 - Design of impact-based triggers for automated monitoring and management systems*.

6. Conclusion and future development

To elevate this data requirement framework and ensure semantic depth, interoperability, and long-term reusability of spatial data, the updated version of this report, D1.5 (Part 2) will target enhancements where possible that integrate: i) Advanced geospatial modelling across 2D and 3D dimensions; ii) Modern OGC APIs for scalable, standards-based data services; iii) Support for temporal dynamics and data quality; and iv) Adoption of relevant CityGML Application Domain Extensions (ADEs) for hazard, energy, and resilience modeling and improved GIS - BIM integration.

3D urban models will be enhanced through the integration of CityGML ADEs, including the Energy ADE and Building Renovation ADE, to incorporate semantic properties related to renovation, energy efficiency, and hazard assessment. Seamless BIM-GIS integration will be achieved via well-defined IFC–CityGML workflows, complemented by synchronisation protocols between LoD3/LoD4 CityGML and IFC models to support advanced spatial analytics and scenario simulations. To ensure interoperability, RETIME will expand the implementation of OGC standards, integrating OGC APIs (Features, Tiles, Processes) and 3D Tiles to enable modular access to vector/raster layers, tiled services, and hazard simulation workflows. OGC API - Processes will be used to expose dynamic modeling chains, such as forecast-triggered alerts or flood simulations.

For advanced spatio-temporal and uncertainty handling, RETIME will support time-enabled PostGIS datasets with timestamped and indexed spatial records, optionally extended with TimescaleDB for high-frequency data ingestion. We will implement uncertainty propagation models for hazard zones, sensor readings, and impact assessments, and adopt ISO 19115/19157 metadata standards for data provenance, quality, and lineage tracking.

The architecture will follow a cloud-native geospatial paradigm, utilsing Cloud-Optimised GeoTIFFs (COGs) for raster hazard layers, SpatioTemporal Asset Catalogs (STAC) for EO/sensor data discovery, and Cesium 3D Tiles (now an official OGC Community Standard) for interactive urban 3D visualisation. Raster and vector tiles will be served via OGC API - Tiles, ensuring modern, RESTful access to RETIME's spatial datasets.

Finally, RETIME will define integrated 2D–3D workflows that link traditional 2D hazard maps (e.g., flood extents) with detailed 3D city models (LoD3), enabling real-world impact simulations. Exposure and vulnerability databases will be extended to support indoor–outdoor 3D continuity, supporting building evacuation modeling, vertical risk assessment, and route optimisation.

Annex A: RETIME Building Renovation roadmap

As indicated in Table 7, RETIME will leverage some of these indicators, based on Directive (EU) 2024/1275's template for national building renovation plans of EU Member States.

Table 7. RETIME Building Renovation roadmap.

Indicators (In *bold and italics* are "optional" for EU Member States in the original Directive (EU) 2024/1275's template)		
Overview of pilot area building stock	Number of buildings and total floor area (m^2)	Per building type (including public buildings and social housing), energy performance class, nearly zero-energy buildings, worst-performing buildings, 43% worst-performing residential buildings (including a definition), estimation of the share of buildings exempted (Article 9(6), point b), ***building age and size, climatic zone, demolition (number and total floor area in m^2)***
	Number of energy performance certificates	Per building type, energy performance class, ***construction period***
	Number of:	***Energy service companies, construction companies, architects and engineers, skilled workers, one-stop shops, SMEs in the construction/renovation sector, renewable energy communities and citizen-led renovation initiatives***
	Annual renovation rates: number and total floor area (m^2)	Per building type, to nearly zero-energy and/or to zero-emission building levels, per renovation depth (weighted average renovation), public buildings
	Primary and final annual energy consumption (ktoe)	Per building type, end use
	Energy savings (ktoe)	Residential buildings, non-residential buildings, public buildings
	Average primary energy use in kWh/(m^2.y) for residential buildings	

	Share of renewable energy in the building sector (MW installed or GWh generated)	For different uses, ***on-site, off-site***
	Annual operational greenhouse gas emissions ($kgCO_2eq/(m^2.y)$)	Per building type
	Annual operational greenhouse gas emission reduction ($kgCO_2eq/(m^2.y)$)	Per building type
	Market barriers and failures (description)	Split incentives, capacity of construction and energy sector, ***administrative, financial, technical, awareness, other***
	Evaluation of the capacities in the construction, energy efficiency and renewable energy sectors	
	Energy poverty (definition)	% of people affected by energy poverty, proportion of disposable household income spent on energy, population living in inadequate dwelling conditions (e.g., leaking roof) or with inadequate thermal comfort conditions
	Reduction in energy costs (EUR) per household (average)	
	Primary energy factors	Per energy carrier, non-renewable primary energy factor, renewable primary energy factor, total primary energy factor
	Primary energy use of a building corresponding to the top 15 % (substantial contribution threshold) and top 30 % (do no significant harm threshold) of the national building stock, as per Delegated Regulation (EU) 2021/2139	
	Definition of nearly-zero energy building for new and existing buildings	
	Cost-optimal minimum energy performance requirements for new and existing buildings	
	Share of heating system in the building sector per boiler/heating system type	
	Life-cycle GWP (kgCO2eq/m2) in new buildings	***Per building type***
	Projections of the construction workforce	***Retiring architects/engineers/skilled workers, architects/engineers/skilled workers entering the market, young people in the sector, women in the sector***
	Overview and forecast of the evolution of prices of construction materials and national market developments	
	Overview of legal and administrative framework	

Roadmap for 2030, 2040, 2050	Targets for annual renovation rates: number and total floor area (m^2)	Per building type, worst-performing buildings, 43 % worst-performing residential buildings
	Information pursuant to Article 9(1)	Criteria to exempt individual non-residential buildings, estimated share of exempted non-residential buildings, estimation of equivalent energy performance improvements due to exempted non-residential buildings
	Targets for expected primary and final annual energy consumption (ktoe)	Per building type, per end use
	Expected energy savings	Per building type
	Targets for the increase in the share of renewable energy in accordance with Article 15a of Directive (EU) 2018/2001	
	Numerical targets for the deployment of solar energy in buildings	
	Targets for expected operational greenhouse gas emissions ($kgCO_2eq/(m^2.y)$	Per building type
	Targets for expected operational greenhouse gas emission reduction (%)	Per building type
	Expected wider benefits	% reduction of people affected by energy poverty
	The Member State's contribution to the Union's energy efficiency targets in accordance with Article 4 of Directive (EU) 2023/1791 attributable to its building stock's renovation (share and figure in ktoe)	
	The Member State's contribution to the Union's renewable energy targets in accordance with Directive (EU) 2018/2001 attributable to its building stock's renovation (share, MW installed or GWh generated)	
	Targets for expected share (%) of renovated buildings	***Per building type, renovation depth***
	Share of energy from renewable sources in the building sector (MW installed or GWh generated)	
	Split between emissions covered by Chapter III [stationary installations], Chapter IVa [emissions trading system for buildings, road transport and additional sectors] of Directive 2003/87/EC, and other stock	
	Targets for expected whole-life-cycle greenhouse gas emission ($kgCO_2eq/(m^2.y)$ in new buildings	***Per building type***
	Creation of new jobs	

	Increase in GDP (share and billion euros)
Outline of the investment needs, the budgetary sources and the administrative resources	Total investment needs for 2030, 2040, 2050 (million EUR)
	Public investments (million EUR)
	Private investments (million EUR)
	Budgetary resources
Thresholds of new and renovated zero-emission buildings, referred to in Article 11	Operational greenhouse gas emissions thresholds of new zero-emission buildings
	Operational greenhouse gas emissions thresholds of renovated zero-emission buildings
	Annual primary energy use thresholds of new zero-emission buildings
	Annual primary energy use thresholds of renovated zero-emission buildings
Minimum energy performance standards for non-residential buildings	Maximum energy performance thresholds, pursuant to Article 9(1)
Local trajectory for the progressive renovation of the residential building stock	The local trajectory for the progressive renovation of the residential building stock, including the 2030 and 2035 milestones for average primary energy use in kWh/(m2.y), pursuant to Article 9(2)

Annex B: Energy Performance Certificate fields

Table 8. EPC fields based on Italy's CENED EPC.

EPC field name	EPC field description
EPC_CODE	Identification code of the Energy Performance Certificate (EPC)
ENTRY_DATE	Registration date of the EPC in the regional/local building energy cadastre
RESIDENTIAL	The field contains the value "True" if the building is residential
NON_RESIDENTIAL	The field contains the value "True" if the building is not residential
CADASTRAL_MUNICIPALITY	Cadastral identification of the building subject to energy certification
PUBLIC_PROPERTY	The field contains the value "True" if the building is publicly owned
PUBLIC_USE	The field contains the value "True" if the building is for public use
ENTIRE_BUILDING	The field contains the value "True" if the EPC refers to the entire building
REAL_ESTATE_UNIT	The field contains the value "True" if the EPC refers to a single real estate unit
GROUP_OF_REAL_ESTATE_UNITS	The field contains the value "True" if the EPC refers to a group of real estate units
NUMBER_OF_REAL_ESTATE_UNITS	Total number of heated and unheated real estate units of the entire building in which the subordinate object of EPC is located
NEW_CONSTRUCTION	Reason for which the EPC was produced
CHANGE_OF_OWNERSHIP	Reason for which the EPC was produced
RENT	Reason for which the EPC was produced
DEEP_RENOVATION	Reason for which the EPC was produced
ENERGY_UPGRADING	Reason for which the EPC was produced
OTHER_OBJECT	Reason for which the EPC was produced
OTHER_OBJECT_TXT	Reason for which the EPC was produced
REGION	Address of the building subject to energy certification
MUNICIPALITY	Address of the building subject to energy certification
ADDRESS	Address of the building subject to energy certification
FLOOR	Address of the building subject to energy certification
INTERIOR	Address of the building subject to energy certification
CLIMATIC_ZONE	Climatic zone
YEAR_OF_CONSTRUCTION	Year of construction of the building
HEATED_USEFUL_AREA	Heated useful area of the building [m2]
COOLED_USEFUL_AREA	Cooled useful area of the building [m2]
GROSS_HEATED_VOLUME	Gross heated volume of the building [m3]
GROSS_COOLED_VOLUME	Gross cooled volume of the building [m3]
WINTER_AIR_CONDITIONING	Energy services of the building

SUMMER_AIR_CONDITIONING	Energy services of the building
MECHANICAL_VENTILATION	Energy services of the building
SANITARY_HOT_WATER_PRODUCTION	Energy services of the building
LIGHTING	Energy services of the building
PEOPLE_AND_GOODS_TRANSPORT	Energy services of the building
WINTER_EMOTICON	Energy performance of the building in the winter season
SUMMER_EMOTICON	Energy performance of the building in the summer season
NEAR_ZERO_ENERGY_BUILDING	The field contains the value "True" if the EPC refers to a Nearly Zero Energy Building
ENERGY_CLASS	Energy class of the building
EP_GL_NREN	Non-renewable energy performance index EPgl, nren [kWh/(m^{2}year)]
Y	Index of non-renewable energy performance EPgl, nren of similar buildings if new
Z	Classification of similar buildings if new
EP_GL_REN	Renewable energy performance index EPgl, nren [kWh/(m^{2}year)]
CO2_EMISSIONS	CO2eq emissions relating to the building [kg/(m2year)]
ELECTRICITY_CONSUMPTION	Annual quantity of electricity consumed in standard use [kWh/year]
NATURAL_GAS_CONSUMPTION	Annual quantity of natural gas consumed in standard use [m^3/year]
LPG_CONSUMPTION	Annual quantity of LPG consumed in standard use [l/year]
COAL_CONSUMPTION	Annual quantity of coal consumed in standard use [kg/year]
DIESEL_CONSUMPTION	Annual quantity of diesel fuel consumed in standard use [l/year]
SOLID_BIOMASS_CONSUMPTION	Annual quantity of solid biomass consumed in standard use [kg/year]
LIQUID_BIOMASS_CONSUMPTION	Annual quantity of liquid biomass consumed in standard use[l/year]
GASEOUS_BIOMASS_CONSUMPTION	Annual quantity of gaseous biomass consumed in standard use [l/year]
PHOTOVOLTAIC_SOLAR_CONSUMPTION	Annual amount of solar photovoltaic energy consumed in standard use [kWh/year]
THERMAL_SOLAR_CONSUMPTION	Annual amount of solar thermal energy consumed in standard use [kWh/year]
WIND_CONSUMPTION	Annual amount of wind energy consumed in standard use [kWh/year]
DISTRICT_HEATING_CONSUMPTION	Annual quantity of district heating energy consumed in standard use [kWh/year]
DISTRICT_COOLING_CONSUMPTION	Annual amount of district cooling energy consumed in standard use [kWh/year]

OTHER_CONSUMPTION	Annual quantity from free cooling and heat pumps consumed in standard use [kWh/year]
ACHIEVED_CLASS_UPGRADING	Energy class achievable in case of carrying out all the recommended interventions
ACHIEVED_EP_GL_NREN_UPGRADING	Non-renewable energy performance index achievable in case of carrying out all the recommended interventions
DS_INTERVENTION_CODE_n	Recommended intervention code
DS_INTERVENTION_TYPE_n	Type of recommended intervention
FL_INVOLVES_RENOVATION_n	The field contains the value "True" if the recommended intervention involves a major restructuring
NM_INVESTMENT_RETURN_TIME_n	Time of return on investment related to the recommended intervention
DS_ACHIEVABLE_CLASS_n	Energy class reachable after carrying out the recommended intervention
NM_ACHIEVABLE_EP_GL_NREN_n	Index of the non-renewable global energy performance of the building that can be reached following the implementation of the recommended intervention [kWh/(m^2year)]
EXPORTED_ENERGY	Annual amount of energy exported [kWh/year]
ENERGY_VECTOR	Energy carrier of the exported energy
DISPERSING_SURFACE	Dispersing surface of the building [m^2]
SV_RATIO	Ratio between the dispersing surface and the gross volume of the building [m^{-1}]
EP_H_ND	Thermal performance index useful for winter air conditioning [kWh/(m^2year)]
SUM_SOL_A_USEFUL_SUR_U	Summer equivalent solar area per unit of useful surface
Y_IE	Periodic thermal transmittance
X_PLANT_TYPE_1	Type of plant for: CI=winter air conditioning, CE=summer air conditioning, PA=production of domestic hot water, IC=combined implants, PFR=production from renewable sources, VM=mechanical ventilation, ILL=lighting, TPC=transport of people or things
X_INSTALLATION_YEAR_1	Year of installation of the system
X_CADASTRAL_CODE_1	Code associated with the winter air conditioning system in the regional cadastre of thermal systems
X_ENERGY_VECTOR_1	Energy carrier used
X_POWER_RATING_1	CI, CE, PA, IC: nominal power of the system for winter and summer air conditioning, domestic hot water production and combined systems [kW], PFR=peak power for solar photovoltaics [kW], nominal electrical power for mini-wind power plants [kW], useful power for heat pumps [kW], area of solar thermal collectors [m^2], VM=total power of the fans in the building [kW], ILL=total power for the internal lighting of the rooms [kW], TPC=power of systems for transporting people or things [kW]
X_AVERAGE_EFFICIENCY	Average seasonal efficiency of the plant

X_EPREN	Energy performance index expressed as renewable primary energy referred to the single energy service [kWh/(m^{2}year)]
X_EPNREN	Energy performance index expressed as non-renewable primary energy referred to the single energy service [kWh/(m^{2}year)]
INSPECTION	The field contains the value "True" if at least one site inspection was carried out on the building for the drafting of the EPC
SW_REQUIREMENTS	The field contains the value "True" if, for the production of the EPC, a software meeting the requirements of maximum deviation of the results achieved with respect to the values obtained by means of the regional reference tool was used
SW_SIMPLIFIED	The field contains the value "True" if, for the production of the EPC, a software that uses a simplified calculation method was used
PUBLIC_ENTITY	The field contains the value "True" corresponding to the type of certifying subject
TRAINED_TECHNICIAN	The field contains the value "True" corresponding to the type of certifying subject
COMPANY	The field contains the value "True" corresponding to the type of certifying subject
CERT_NAME	Name and surname of the certifier
CERT_TITLE	Qualification of the certifier
CERT_ORDER	Order at which the certifier