



**Building Performance Digitalisation  
and Dynamic Logbooks  
for Future Value-Driven Services**

**Deliverable 6.4**

**Policy reform and regulatory  
recommendations**



**Funded by  
the European Union**

<b>PROJECT</b>	CHRONICLE
<b>GRANT AGREEMENT</b>	101069722
<b>PROJECT DURATION</b>	42 months (01/07/2022 – 31/12/2025)
<b>WORK PACKAGE</b>	WP6 Dissemination, Communication, Exploitation & Innovation
<b>TASK</b>	T6.6 Policy reform, Regulatory & Standardization recommendations
<b>DUE DATE</b>	31/12/2025
<b>SUBMISSION DATE</b>	26/01/2026
<b>DELIVERABLE LEAD</b>	Manuela Freté, Smart Innovation Norway
<b>DISSEMINATION LEVEL</b>	<input checked="" type="checkbox"/> Public
<b>DOCUMENT NATURE</b>	<input checked="" type="checkbox"/> R-Report
<b>AUTHORS</b>	Manuela Freté (SIN) Aitor Aragon Basabe (UNE)
<b>REVIEWERS</b>	Leon Nielsen (CIRCE)
<b>STATUS</b>	<input checked="" type="checkbox"/> Final <input checked="" type="checkbox"/> Submitted

REVISION	DATE	AUTHOR	DESCRIPTION
Version 1	05/11/2025	Manuela Freté (SIN)	First draft sent to WP leader for review
Version 2	10/12/2025	Manuela Freté (SIN)	Second draft sent to WP and to project coordinator
Version 3	13/01/2025	Manuela Freté (SIN)	Third draft for final review to WP leader and Project Coordinator
Version 4	26/01/2025	Leon Nielsen (CIRCE)	Final review, formatting, minor corrections.

## Disclaimer

The information and views expressed in this publication are the sole responsibility of the author(s) and do not necessarily reflect the views of the European Commission. The responsibility for any error or omissions lies with the editor. The European Commission shall not be liable for any consequences stemming from the use of the information contained herein.

# Contents

Abbreviations .....	5
Executive Summary .....	6
1. Introduction .....	7
2. EU building energy efficiency and sustainability policies.....	8
2.1. Overview of EU framework .....	8
2.2. Policies, research and standardisation .....	10
2.3. Implementation in Pilot Countries .....	11
2.3.1. General.....	11
2.3.2. Spain .....	12
2.3.3. Greece.....	12
2.3.4. Ireland .....	13
2.3.5. Switzerland.....	13
2.3.6. Denmark.....	14
2.4. Coordination with sister projects.....	15
2.5. Carbon bill of the refurbishment of buildings .....	16
3. Regulatory and standardisation barriers for CHRONICLE adoption .....	17
3.1. Policy and regulatory implementation barriers.....	17
3.2. Standardisation barriers .....	18
4. Policy drivers enabling CHRONICLE’s digital solutions adoption .....	19
4.1. Policy drivers .....	19
4.2. Standardisation as policy enabler .....	20
5. Conclusions .....	22
6. References.....	23

## Abbreviations

TERM	DESCRIPTION
AI Act	Artificial Intelligence Act
BER	Building Energy Rating (Ireland)
BIM	Building Information Modelling
BRP	Building Renovation Passport
BPIE	Buildings Performance Institute Europe
CECE / GEAK / CECB	Cantonal Energy Certificate of Buildings (Switzerland)
CEN	European Committee for Standardization
CENELEC	European Committee for Electrotechnical Standardisation
CTE	Código Técnico de la Edificación (Spanish Technical Building Code)
CWA	CEN Workshop Agreement
DBL	Digital Building Logbook
DPP	Digital Product Passport
DoP	Declaration of Performance
DoPC	Digital Declaration of Performance and Conformity
EED	Energy Efficiency Directive
EPC	Energy Performance Certificate
EPBD	Energy Performance of Buildings Directive
EPB	Energy Performance of Buildings (standards framework)
ESPR	Ecodesign for Sustainable Products Regulation
EU	European Union
FADP	Federal Act on Data Protection (Switzerland)
GDPR	General Data Protection Regulation
HVAC	Heating, Ventilation and Air Conditioning
IEQ	Indoor Environmental Quality
IoT	Internet of Things
JRC	Joint Research Centre (European Commission)
LCA	Life Cycle Assessment
Level(s)	EU Framework for Sustainable Buildings
Minergie	Swiss Voluntary Building Energy Standard
MoPEC	Model of Cantonal Energy Requirements (Switzerland)
nZEB	Nearly Zero-Energy Building
NECP	National Energy and Climate Plan
RED III	– Renewable Energy Directive (Recast)
SRI	Smart Readiness Indicator
UNE	Spanish Association for Standardization
WG	Working Group

## Executive Summary

The CHRONICLE project develops an integrated approach to digitalising building-performance assessment and enabling data-driven renovation strategies through advanced monitoring, interoperable data infrastructures and Digital Building Logbooks (DBLs). In a context where European and national policies increasingly emphasise whole-life sustainability, operational performance and transparent building information, CHRONICLE aims to demonstrate how high-quality data and interoperable tools can support more effective renovation decisions and long-term management of building stock.

This deliverable (D6.4) provides an assessment of the policy and regulatory landscape that influences the adoption of CHRONICLE's digital building-performance solutions. Its main objectives are to (i) analyse the EU framework relevant to building energy efficiency, sustainability and digitalisation, (ii) examine how these policies are implemented in CHRONICLE's pilot countries, (iii) identify regulatory and standardisation barriers that limit the deployment of digital renovation tools, and (iv) highlight policy drivers and enablers that support CHRONICLE's scalability and long-term impact.

The analysis shows that the EPBD, EED and RED III form the central legislative backbone guiding Europe's building-renovation agenda, strengthened by emerging frameworks such as CPR/ESPR, Level(s), the EU Taxonomy and data-governance instruments including GDPR and the AI Act. These policies collectively promote digitalisation, whole-life environmental assessment and transparent renovation planning—areas directly addressed by CHRONICLE.

Across CHRONICLE's pilot countries (Spain, Greece, Ireland, Switzerland and Denmark), the deliverable identifies common challenges: uneven transposition of EU directives, fragmented EPC and building-data infrastructures, limited integration of operational performance data, and slow deployment of Digital Building Logbooks, Building Renovation Passports and the Smart Readiness Indicator. These findings are consistent with insights from Horizon projects in the Next Generation EPCs Cluster.

The deliverable also incorporates results from D6.3 Standards analysis and contribution to standardisation, showing that several standardisation gaps such as fragmented BIM–LCA–EPC data models, insufficiently digital environmental-product information, and the lack of mature standards for DBLs and operational ratings create additional obstacles for implementing EPBD requirements. At the same time, ongoing developments in CEN committees (e.g. DoPC, EN 15978 revision, CHRONICLE's CWA 18304:2025) are emerging as important policy enablers that can support harmonisation and improve data quality.

Overall, D6.4 concludes that while policy ambitions for digital and sustainable renovation are strong, regulatory fragmentation and data-interoperability challenges still hinder implementation. CHRONICLE contributes valuable technical evidence, monitoring methodologies and standardisation inputs that can inform future policy design and strengthen the transition toward an integrated, performance-driven and climate-aligned European building stock.

# 1. Introduction

This deliverable provides a structured analysis of the policy, regulatory and standardisation environment that shapes the adoption of CHRONICLE solutions. It reviews the main EU directives and initiatives governing building energy performance, sustainability, circularity and digitalisation, and examines how these are implemented in the CHRONICLE pilot countries (Spain, Greece, Ireland, Switzerland and Denmark). The deliverable identifies regulatory and standardisation barriers that hinder the deployment and scaling of digital building services, and highlights policy drivers and enabling factors that can support the uptake of CHRONICLE's approaches in different national contexts.

The analysis builds on several complementary sources. First, it draws on recent assessments by EU institutions, observatories and Horizon (2020/Europe) projects working on next-generation EPCs, Smart Readiness Indicators, digital logbooks and renovation passports. Second, it integrates insights from the CHRONICLE pilots, which provide concrete examples of how EU and national frameworks influence renovation strategies, monitoring practices and data-governance choices at building and portfolio level. Third, it leverages the project's standardisation work documented in D6.3, including CHRONICLE's contributions to CEN technical committees and the development of the CWA 18304:2025, to connect technical standardisation efforts with regulatory design and implementation.

The deliverable is also informed by CHRONICLE's active participation in the Next Generation EPCs Cluster, a collaboration platform bringing together multiple European projects working on digital EPCs, smart-readiness, digital logbooks and operational building performance. Through this cluster, CHRONICLE has contributed to joint policy briefs, cross-project workshops and technical exchanges that seek to harmonise methodologies, strengthen EPBD implementation and support the emergence of interoperable, user-centred building-performance schemes across Europe.

The document is organised as follows. **Chapter 2** provides an overview of the European policy and regulatory framework for building energy efficiency and sustainability, followed by an analysis of how these policies are implemented in the CHRONICLE pilot countries and a description of CHRONICLE's coordination with sister projects. **Chapter 3** focuses on regulatory and standardisation barriers affecting the adoption of CHRONICLE's digital solutions, synthesising cross-cutting challenges related to implementation gaps, data fragmentation, interoperability and compliance complexity. **Chapter 4** then identifies key policy drivers and standardisation developments that act as enablers for long-term sustainability strategies and support the wider deployment of digital building logbooks, operational performance metrics and life-cycle based renovation tools. Finally, **Chapter 5** presents the main conclusions, highlighting how CHRONICLE's results can inform future policy development, regulatory harmonisation and standardisation activities, and outlining the project's contribution to the broader European transition toward a climate-neutral and digitally enabled building stock.

## 2. EU building energy efficiency and sustainability policies

Chapter 2 provides an overview of the policy and regulatory landscape that shapes the adoption and implementation of CHRONICLE's digital building-performance solutions. The chapter begins in Section 2.1 by outlining the key elements of the European Union's regulatory architecture including the **Energy Performance of Buildings Directive** (Directive (EU) 2024/1275 on the energy performance of buildings (recast)), **Energy Efficiency Directive** (Directive (EU) 2023/1791 on energy efficiency)), **Renewable Energy Directive** (Directive (EU) 2018/2001, as amended by Directive (EU) 2023/2413 – "RED III"), **Construction Products Regulation** (Regulation (EU) 2024/3110 laying down harmonised rules for the marketing of construction products), **Ecodesign for Sustainable Products Regulation** (Regulation (EU) 2024/1781 establishing a framework for the setting of ecodesign requirements for sustainable products), **General Data Protection Regulation** ((Regulation (EU) 2016/679 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data), highlighting how these directives and initiatives influence data governance, renovation strategies and the deployment of digital building logbooks and operational-performance tools. Building on this foundation, Section 2.3 examines how these policies are transposed and implemented within CHRONICLE's pilot countries, identifying national differences, bottlenecks and opportunities based on insights from EU observatories and Horizon Europe sister projects. Finally, Section 2.4 describes CHRONICLE's collaboration with the Next Generation EPCs Cluster and other related projects, illustrating how shared policy discussions and coordinated activities contribute to methodological coherence and regulatory alignment across Europe.

### 2.1. Overview of EU framework

The European Union has progressively developed a comprehensive policy framework to support the decarbonisation, digitalisation, and circular transformation of the building sector. This framework builds on an interconnected set of directives and initiatives that collectively address building performance, energy efficiency, sustainability, and data governance.

The Energy Performance of Buildings Directive (EPBD) is the core legislative instrument shaping the energy performance of the European building stock. It establishes minimum energy performance requirements, cost-optimal calculation methodologies, and the roadmap toward nearly zero-energy buildings (nZEBs). Central to its implementation is the Energy Performance Certificate (EPC), which the EPBD mandates as the primary tool for informing building owners, occupants, and market actors about a building's energy efficiency and renovation needs. The directive defines the minimum content of EPCs including energy classes, calculated energy use, CO<sub>2</sub> emissions, and targeted renovation recommendations and specifies the situations in which they must be issued, such as new constructions, major renovations, and property transactions. The EPBD further requires Member States to maintain national EPC databases, ensure independent control systems, and guarantee assessor competency.

In its latest recast, the EPBD strengthened the strategic role of EPCs by linking them to emerging instruments such as Digital Building Logbooks (DBL), Building Renovation

Passports, and the Smart Readiness Indicator, aiming to enhance data reliability, harmonisation, and the integration of operational performance insights. The DBL initiative, introduced under the EPBD recast, aims to integrate data from the energy, sustainability, and smartness domains to enable data-driven renovation and operation (Malinovec Puček et al., 2023).

Complementing the EPBD, the Energy Efficiency Directive (EED) provides the overarching framework for improving energy efficiency across the European Union. The EED establishes binding EU and national energy-efficiency targets, strengthened annual energy-savings obligations, and requirements for updated National Energy and Climate Plans (NECPs), long-term renovation strategies, and systematic monitoring of progress (European Commission/JRC, 2023; Economidou et al., 2022). It reinforces the role of Member States in promoting efficient renovation, metering, billing, and energy-management systems and supports the deployment of energy-service models and financing mechanisms in line with the EU's decarbonisation trajectory.

Alongside this, the Renewable Energy Directive (RED III) sets increased renewable-energy targets for 2030 and introduces provisions that promote the integration of renewables in buildings, including self-consumption, renewable-based heating and cooling, and the expansion of district energy systems (European Commission, 2023). Together, the EPBD, EED and RED form a coherent policy architecture governing the energy transformation of the European building stock. They constitute the regulatory backbone of the EU's Fit for 55 package, providing a unified legislative pathway toward a highly energy-efficient, flexible, and climate-neutral building sector.

At the same time, the revised Construction Products Regulation (CPR) and Ecodesign for Sustainable Products Regulation (ESPR), both published in 2024, are redefining transparency and accountability in construction-product markets. Their introduction of Digital Product Passports (DPPs) aims to standardise environmental and material data across the supply chain, directly supporting the life-cycle assessment and digital-logbook approaches developed in CHRONICLE. The DPP is a set of digital containers related to a product. The information can refer to a model, a batch or an individual item. Data sharing is based on a data carrier, linked to a unique product identifier physically attached to the product or the accompanying documentation. The DPP will include LCA-based environmental information, to be defined for each product family in European Delegated Acts.

CHRONICLE was interested in these DPPs as all products covered by the CPR, and many of the products covered by the ESPR, will be installed in buildings (precast concrete, bricks, windows, light sources or space heaters). Therefore, any calculation at building level will require information from DPPs. One of the papers published as a result from CHRONICLE addressed this integration of environmental information into the digital models used by architects and engineers. The hypothesis in Aragón, Spudys, Pupeikis, D., Nieto & Alberti were tested in one of the BIM models of CHRONICLE's pilots. Sustainability and circular-economy aspects are operationalised through the Level(s) Framework, which provides harmonised indicators for life-cycle assessment (LCA), resource efficiency, and carbon performance. Initiatives such as the Renovation Wave, the New European Bauhaus, and the EU Taxonomy for Sustainable Activities further reinforce this policy ecosystem by linking environmental performance metrics with financial-disclosure and investment frameworks.

At the same time, the Artificial Intelligence Act, General Data Protection Regulation (GDPR), and Cybersecurity Act define a complex regulatory environment for smart-

building applications, introducing overlapping requirements on data privacy, system integrity, and liability (Jørgensen and Ma, 2025).

Across these frameworks, several patterns emerge. First, the EPBD and EED remain the most influential mechanisms for steering national building-performance improvements. Second, digitalisation initiatives such as the DBL and the regulatory triad of AI Act – GDPR – Cybersecurity Act introduce both opportunities for smarter energy management and new compliance complexities. Third, sustainability instruments like Level(s) and the EU Taxonomy promote convergence between environmental and financial regulation but reveal ongoing needs for data quality and methodological harmonisation.

The Directive (EU) 2024/1275 on the energy performance of buildings (recast) will introduce important changes to the energy efficiency in Europe, as it should be considered a cornerstone of the EU policies such as "Renovation Wave." The EPBD recast aims to achieve a fully decarbonized, zero-emission building stock by 2050. For Member states, the implementation into their national policies will require a transition from merely "efficient" new buildings to a consideration of deep renovations for the existing building stock.

The EPBD recast changes the requirements from "Nearly Zero-Energy Buildings (NZEB)" to "Zero-Emission Buildings (ZEB)". It includes the obligation of addressing "whole life carbon" based on the European standard EN 15978. All new buildings will have to apply it since 2030.

For construction products, the Regulation (EU) 2024/3110 laying down harmonised rules for the marketing of construction products changes the approach, compared to the previous regulation from 2011, from focusing solely on safety and technical performance (structural integrity, fire safety, energy efficiency, etc.) to consider sustainability as a critical requirement, including the use of life cycle assessment (LCA).

The new CPR will require the declaration of environmental sustainability characteristics (currently included in voluntary EPDs according to EN 15804) in the Declaration of Performance and Conformity (DoPC). This information will be managed via Digital Product Passport (DPP), accessible via QR code or RFID.

The new CPR includes specific provision to enhance the connection with the European standardization system, improving the process.

## 2.2. Policies, research and standardisation

The successful implementation of these EU policy frameworks relies heavily on the availability of European and international standards. As described in Deliverable D6.3, standards provide the technical backbone required for applying the EPBD, EED, RED III, CPR/ESPR and Level(s) in practice—by defining common data models, calculation rules, testing procedures, nomenclature and interoperability requirements. In this sense, policy and standardisation evolve in a mutually reinforcing cycle: EU directives establish the regulatory objectives, while CEN and ISO standards operationalise them through measurable, comparable and verifiable methods.

UNE, a CHRONICLE partner, has significantly contributed to the implementation to digitalization in the new CPR, by participating in the feasibility study of the CPR-DPP system, published by the Commission in May 2025. This report is independent from CHRONICLE but the same experts from UNE participated both in CHRONICLE and in the feasibility study, ensuring the connection between research and practical applications.

Aitor Aragón (UNE) participated in the presentation of the new CPR hosted by DG Grow in Brussels in October 2024, in the panel debate for digitalization. The information and presentations are available in the website of the European Commission, in the site dedicated to the [Conference on the new Construction Products Regulation 2024](#).

CHRONICLE contributes to this ecosystem not only through its engagement with European standardisation bodies but also through its scientific work. Two peer-reviewed publications developed within the project address key challenges at the interface between policy requirements, digitalisation and standardisation.

- Bridging Interoperability Gaps Between LCA and BIM (Aragón et al., 2025) examines the limitations of integrating Environmental Product Declaration (EPD) data into the IFC data model, highlighting structural and semantic gaps that currently hinder workflows required for whole-life carbon assessments under Level(s), EPBD and upcoming CPR/ESPR requirements.
- Seeking a Definition of Digital Twins for Construction and Infrastructure Management (Aragón et al., 2025) analyses conceptual and standardisation inconsistencies shaping the emerging field of digital twins, proposing elements that support alignment with CEN/TC 442 and ISO work on digital built-environment data.

The first paper is based on previous research (Aragón & Alberti, 2024), and both are part of a PhD thesis proposing improvements to automate the incorporation of LCA base environmental information into BIM, to be presented in 2026.

These publications illustrate how CHRONICLE's technical findings complement the broader policy and standardisation landscape, providing evidence to improve interoperability, strengthen data quality and support the development of digital building logbooks and operational-performance tools aligned with EU regulatory expectations.

## 2.3. Implementation in Pilot Countries

### 2.3.1. General

Implementation of the EPBD, EED, RED and associated sustainability and digitalisation frameworks remains uneven across the CHRONICLE pilot countries. Comparative analyses from recent Horizon Europe projects—such as D<sup>2</sup>EPC (Fokaides et al., 2023), SMARTLivingEPC (Tsemekidi-Tzeiranaki et al., 2023), iBRoad2EPC (Filippidou et al., 2022), EPC RECAST (Arcipowska et al., 2023), CrossCert (Georgiou et al., 2023), SRI2Market (Pucek et al., 2023) and DigiBUILD (JRC, 2022), consistently highlight systemic challenges:

- heterogeneous transposition and enforcement of EU directives,
- fragmented national data infrastructures,
- constrained administrative capacity at local level, and
- slow uptake of digital tools such as Digital Building Logbooks (DBLs), Building Renovation Passports (BRPs), and the Smart Readiness Indicator (SRI).

These cross-cutting findings shape the regulatory and market contexts in which the CHRONICLE pilots operate. The following analysis synthesises the status in each pilot

country based on existing research, EU observatories, and lessons from relevant sister projects.

### 2.3.2. Spain

Spain has formally transposed the EPBD, EED and RED, yet implementation remains regionally fragmented, reflecting the decentralised governance of energy performance certificates (EPCs). Evidence from CrossCert and D<sup>2</sup>EPC shows substantial variability in EPC methodologies, data quality, and verification practices between Autonomous Communities (Georgiou et al., 2023; Fokaides et al., 2023).

Although Spain has initiated early actions towards BRPs and DBLs through regional pilots under iBRoad2EPC, the national ecosystem remains underdeveloped and characterised by inconsistent data structures and non-interoperable information systems.

Additionally, SMARTLivingEPC and JRC analyses document persistent administrative bottlenecks and low digitalisation in municipal permitting workflows—issues that directly affect renovation timelines and the deployment of data-driven solutions (Tsemekidi-Tzeiranaki et al., 2023).

These shortcomings highlight significant opportunities for CHRONICLE to showcase the benefits of unified monitoring infrastructures, data standardisation and actionable performance feedback.

The Chronicle Zaragoza pilot at Ecce Homo, implemented by Zaragoza Vivienda, operated within a robust set of national and EU regulatory frameworks, including the Energy Performance of Buildings Directive (EPBD), the Spanish Technical Building Code (CTE), and EU-level methodologies such as Level(s) and the Smart Readiness Indicator (SRI). These frameworks directly shaped the renovation strategy, performance assessment, and monitoring approach applied in the pilot. Importantly, Zaragoza Vivienda considered the pilot as a scalable demonstrator, with potential replication across more than 2,300 social housing dwellings in its building stock, reinforcing the strategic alignment between CHRONICLE outcomes and municipal long-term renovation planning.

### 2.3.3. Greece

Greece has transposed the EPBD and RED, but research consistently characterises implementation as constrained by structural challenges. Studies under D<sup>2</sup>EPC, SRI2Market and the EPB Center point to:

- low deep-renovation rates,
- uneven EPC reliability,
- limited enforcement of energy performance requirements, and
- low digital maturity of building data infrastructures (Fokaides et al., 2023; Pucek et al., 2023; van Dijk & Kießling, 2022).

The Greek EPC remains primarily static and asset-based, an issue emphasised in SMARTLivingEPC, where lack of operational data hinders accurate performance assessment and limits user engagement (Tsemekidi-Tzeiranaki et al., 2023). Emerging

initiatives related to BRPs and digital logbooks are positive but currently fragmented and lack harmonisation with EU guidance.

CHRONICLE's deployment in Greece—particularly its comfort monitoring, operational data collection, and digital logbook components—can therefore provide critical evidence and methodological support for national digitalisation pathways.

#### 2.3.4. Ireland

Ireland has made substantial progress in implementing EPBD requirements and is often cited as a relatively advanced Member State in terms of EPC quality and digitalisation momentum. According to X-tendo and iBRoad2EPC, Ireland's Building Energy Rating (BER) system demonstrates high methodological consistency and comparatively strong quality assurance, supported by the Sustainable Energy Authority of Ireland (SEAI), which manages a centralised national EPC database (Economidou et al., 2021; Filippidou et al., 2022).

The country's National Retrofit Plan and Climate Action Plan (2023) set ambitious targets for upgrading 500,000 homes to a B2 rating by 2030, reflecting strong alignment with EPBD long-term renovation strategies.

Despite this, research from EPC RECAST and JRC assessments highlights several challenges, including limited integration of operational (in-use) performance data into EPCs, limited interoperability between digital systems, and uneven uptake of smart-meter data for building performance optimisation (Arcipowska et al., 2023)

Ireland has begun exploring Building Renovation Passports (BRPs) through EU pilots (iBRoad2EPC; BuiltHub), but national roll-out has yet to materialise. Similarly, deployment of the Smart Readiness Indicator (SRI) is still at an exploratory phase, with pilots conducted under SRI2Market, but no national assessment framework adopted (Pucek et al., 2023).

Administrative capacity remains strong, but data fragmentation and lack of a Digital Building Logbook (DBL) architecture continue to be identified as barriers.

CHRONICLE's data harmonisation, digital monitoring, and operational-performance approaches can therefore provide valuable insights for Ireland's evolving digitalisation strategy and support future integration of SRI and DBL concepts.

#### 2.3.5. Switzerland

Switzerland, though not an EU Member State, closely aligns its building and digitalisation policies with European trends. Energy and renovation regulation is defined federally but implemented through cantonal laws, creating variation across regions. This decentralised framework results in strong technical assessment practices (e.g., GEAK/CECB) but limited national harmonisation.

A key element shaping CHRONICLE's deployment is the revised Federal Act on Data Protection (FADP), in force since 1 September 2023. It strengthens privacy rights and aligns broadly with the EU GDPR while maintaining specific Swiss provisions. With its

extraterritorial scope and obligations for foreign controllers, the FADP is directly relevant to CHRONICLE's operational data collection, logbook design, and data-governance strategy.

Building-renovation requirements are guided by cantonal energy laws and the MoPEC 2014 framework. Switzerland also relies heavily on the voluntary Minergie standards, which promote high-efficiency and renewable-based buildings. Minergie-A requires a positive annual energy balance, Minergie-P aligns with passive-house performance, and Minergie-ECO adds criteria for indoor environmental quality and material sustainability. These labels strongly influence renovation practices.

The Cantonal Energy Certificate of Buildings (CECE/GEAK/CECB) provides envelope and overall efficiency ratings (A–G) and is often required for subsidised financing. The enhanced CECE Plus offers renovation scenarios, cost estimates and eligible incentives, supporting evidence-based decision-making.

Federal and cantonal incentives are substantial: baseline refurbishment subsidies start at CHF 60/m<sup>2</sup>, rising to 140–240% for Minergie or top CECE categories. New Minergie-A/P buildings receive CHF 100/m<sup>2</sup>, plus bonuses for Minergie-ECO compliance. Heating-system replacement programmes support transitions to heat pumps, pellets or district heating, though secondary system upgrades are often not covered.

Despite strong technical standards and digital maturity (e.g., BIM uptake, smart metering), Switzerland lacks a national Digital Building Logbook and harmonised renovation-passport framework. Data remain fragmented across cantonal and utility systems, and the Smart Readiness Indicator (SRI) has yet to be adopted.

This mix of ambitious standards, strong incentives and fragmented data governance creates a favourable environment for CHRONICLE. Its interoperable logbook model, monitoring-based performance insights and multi-source data integration offer a clear added value for supporting Switzerland's next generation of digital renovation tools.

### 2.3.6. Denmark

Denmark is widely regarded as a frontrunner in energy efficiency and sustainability, with consistently high EPBD implementation performance. Studies from X-tendo, D<sup>2</sup>EPC, and EPC RECAST identify Denmark's EPC system as one of the most robust in Europe, supported by a national digital registry, mandatory quality checks, and strong enforcement mechanisms (Economidou et al., 2021; Fokaides et al., 2023; Arcipowska et al., 2023).

Ambitious national policies—including the Danish Climate Act, Energy Agreement, and extensive district heating integration reinforce alignment with EU long-term renovation objectives.

However, despite advanced EPC practices, Denmark faces challenges similar to other highly digitalised countries. Research from iBRoad2EPC and SRI2Market shows that integration of Building Renovation Passports, national DBL frameworks, and operational (real-time) performance data is still under development (Filippidou et al., 2022; Pucek et al., 2023).

Denmark has piloted SRI methodologies, and national stakeholders have shown strong interest, but a formal assessment framework has not yet been fully adopted. Moreover, JRC and BuiltHub studies highlight persistent fragmentation between metering data, EPC databases, BIM environments, and municipal digital systems, despite Denmark's strong digital governance tradition (Groezinger et al., 2022; JRC, 2022).

These factors indicate that CHRONICLE's interoperable measurement-and-verification services, digital logbook structures, and multi-source data integration capabilities can contribute meaningfully to Denmark's next phase of building digitalisation and performance-based renovation strategies.

## 2.4. Coordination with sister projects

CHRONICLE collaborated closely with EU sister projects through its active participation in the Next Generation EPCs Cluster, a structured collaboration platform bringing together 13 Horizon projects working on digital EPCs, smart-readiness, digital logbooks, and operational building performance. The cluster included: U-CERT, X-tendo, QualDeEPC, ePANACEA, D<sup>2</sup>EPC, E-DYCE, EPC RECAST, CrossCert, EUB SuperHub, iBRoad2EPC, TIMEPAC, SmartLivingEPC, and CHRONICLE itself.

Throughout the project lifetime, CHRONICLE engaged in annual cross-project workshops, joint technical exchanges, and policy alignment activities as required under Task 6.3, which mandated the establishment of relationships with EU-funded projects "to share obstacles and solutions and ensure interoperability and fine-tuning among projects". These interactions enabled CHRONICLE to systematically compare its building logbook architecture, data models, and operational-performance monitoring approaches with the methodologies developed by SmartLivingEPC and the other cluster partners.

During 2022–2025, CHRONICLE took part in a series of cluster-organised technical meetings coordinated by EPB Center and the Horizon Results Booster, where project representatives exchanged insights on EPC harmonisation, digitalisation challenges, sensor-based assessment practices, and user-centric certification design. CHRONICLE contributed its perspectives on digital building logbooks, IoT-enabled data streams, and dynamic operational metrics, while benefiting from lessons learned by SmartLivingEPC (on integrating building sustainability parameters and IEQ considerations), D<sup>2</sup>EPC (on next-generation dynamic EPC architectures), and EPC-RECAST (on regulatory coherence and EPBD alignment).

CHRONICLE also contributed to the joint policy-recommendation activities of the cluster, which culminated in the development of the EPBD Recast Policy Brief (2023). This brief synthesised shared positions on EPC reform and included recommendations originating from all 13 projects including CHRONICLE and SmartLivingEPC, covering themes such as deep-renovation alignment, harmonised calculation methodologies, smart-readiness integration, and the use of digital logbooks and renovation passports to improve accuracy and user relevance .

Finally, CHRONICLE participated in joint dissemination and visibility actions, including cluster-wide public events, technical webinars, and Horizon Results Booster sessions, strengthening the visibility of digital EPC innovation at EU level. Through this sustained

collaboration, CHRONICLE ensured that its outputs were aligned with ongoing European efforts, benefited from common methodological insights, and actively contributed to a more interoperable and harmonised EU building-performance digital ecosystem.



**Image 1: Manuela Freté from SIN presented at the Final even of the SmartLivingEPC project in Brussels, 06.05.2025**

## 2.5. Carbon bill of the refurbishment of buildings

One of the main results of CHRONICLE in the standardization system has been the publication of CWA 18304:2025, which provides rules and criteria for the calculation of the “carbon bill” of building refurbishments.

The document is available for free download in this link:

[https://www.cenelec.eu/media/CEN-GENELEC/CWAs/RI/2025/cwa-18304\\_2025.pdf](https://www.cenelec.eu/media/CEN-GENELEC/CWAs/RI/2025/cwa-18304_2025.pdf).

The Convenor of the Workshop was Miguel Gómez (CIRCE) and the Secretariat was Aitor Aragón (UNE), and the Workshop had the active participation of several partners.

The CWA is aligned EPBD and relevant European standards such as EN 15978 or EN 15804.

More information is available in D6.3.

## 3. Regulatory and standardisation barriers for CHRONICLE adoption

### 3.1. Policy and regulatory implementation barriers

Recent assessments indicate that despite the strengthening of the EPBD, EED and RED, their implementation remained uneven across Member States. Deep-renovation rates continued to stagnate at 0.4–1% per year, far below levels required to achieve the EU's 2030 and 2050 climate objectives (BPIE, 2023; JRC, 2022, IEA 2022). A major barrier was the heterogeneity of national transpositions and definitions, including divergent interpretations of nZEB requirements and calculation methodologies, which reduced comparability and slowed harmonisation across jurisdictions (EPB Center & REHVA, 2023). Member States also faced limited administrative capacity and varying enforcement mechanisms, which affected the consistency of EPCs, quality-control systems, and compliance monitoring (Economidou et al., 2022).

Digitalisation gaps remained significant. Studies highlighted fragmented EPC databases, the limited integration of operational in-use performance data, and slow deployment of Digital Building Logbooks, Building Renovation Passports, and the Smart Readiness Indicator (Next Gen EPCs Cluster, 2023; JRC, 2023). These challenges were compounded by issues related to interoperability with national EPC systems, data-access restrictions, and emerging concerns around data security and governance all of which constrained the effective use of building-performance data infrastructures.

Additional barriers emerged around the broader digital regulatory landscape. The interplay of the AI Act, GDPR and Cybersecurity Act introduced new layers of compliance complexity, raising issues related to privacy, liability, data integrity, and the need for robust cross-system interoperability. These overlapping regulatory requirements created uncertainty for stakeholders seeking to deploy smart-building technologies and AI-driven building-performance services.

Challenges were also present in sustainability frameworks linked to the building sector. Under the Level(s) Framework, Member States faced difficulties related to the harmonisation of LCA tools, inconsistent environmental-data quality, and limited training and user-support mechanisms for practitioners (De Wolf et al., 2023). Similarly, the deployment of national nZEB roadmaps was hindered not only by high investment needs and technical feasibility constraints but also by limited stakeholder engagement and insufficient administrative capacity (Zangheri et al., 2022), particularly in smaller municipalities (Iavorschi et al., 2025).

Finally, although RED III strengthened the role of renewables in buildings, several structural obstacles persisted, including grid constraints, long permitting procedures, and discrepancies between local frameworks for integrating on-site and district-level renewable systems. Financing constraints and administrative bottlenecks also remained a considerable obstacle under the broader framework of the EU Renovation Wave, limiting scaling of deep renovation and slowing transition towards a climate-neutral building stock.

## 3.2. Standardisation barriers

In addition to the regulatory, technical, and market barriers identified across pilot countries, several standardisation-related challenges highlighted in D6.3 also affect the uptake and scalability of CHRONICLE solutions. A first barrier concerns fragmented data models and limited interoperability between existing standards used for BIM, LCA, EPCs and Digital Building Logbooks. As described in D6.3, current standards such as IFC 4.3 and EN ISO 22057 do not yet fully support machine-readable environmental data, creating inconsistencies in how information flows across tools and hampering seamless whole-life carbon assessments. This fragmentation complicates the practical implementation of the EPBD recast's requirements on digitalisation and data availability. CHRONICLE successfully contributed to bridge the interoperability gaps between environmental product information and IFC with the publication of a specific paper on the topic. By automating the data flow from the manufacturer to the BIM model, the industry can shift human resources from "manual data entry clerks" to "sustainability strategists" who add value through real-time design optimization. The objective is to have reliable data to reduce environmental impacts over the building's entire lifecycle.

A second barrier relates to the slow integration of operational performance in standardised frameworks. National EPC systems remain largely based on calculated performance and current "operational" methodologies are "local" and not harmonized. This delays the transition toward real-performance indicators and limits evidence-based renovation decisions. CHRONICLE proposed a European standard on operational in CEN/TC 371/WG 5 to solve this limitations, which should be drafted in 2026. In addition, environmental product information remains insufficiently harmonised and insufficiently digital. The absence of consistently formatted and machine-interpretable EPDs continues to hinder the integration of material data into DBLs and renovation planning tools. CHRONICLE participated in the first proposals related to the Digital Declaration of Performance and Conformity (DoPC) in CEN/TC 442/WG 12, to bridge these gaps. More information is available in D6.3.

Finally, the lack of mature standards for Digital Building Logbooks and Digital Twins creates uncertainty for national implementation. Several relevant EN standards are emerging, but Member States currently rely on divergent logbook formats and data protocols. This limits the transferability and comparability of building-level data, reducing the scalability of CHRONICLE outputs across Europe. CHRONICLE participated in a paper related to the definition of digital twins in the built environment (Aragón, et al.) and also participate in CEN/TC 442/WG 9 "digital twins applied to the built environment".

## 4. Policy drivers enabling CHRONICLE's digital solutions adoption

### 4.1. Policy drivers

A set of strong policy drivers has emerged at EU level that collectively accelerate the decarbonisation and digitalisation of the European building stock and directly support the type of data-driven solutions developed in CHRONICLE. At the highest level, the European Green Deal and the Fit for 55 package set the political ambition to reduce greenhouse gas emissions by at least 55% by 2030 and achieve climate neutrality by 2050, framing energy-efficient and climate-resilient buildings as central to Europe's transition (European Commission, 2020; Renovate Europe, 2023). The Renovation Wave Strategy (COM(2020) 662) further operationalises these ambitions by calling for doubling annual renovation rates by 2030 and promoting deep renovation through regulatory, financial and enabling measures (European Commission, 2020).

At legislative level, the recast Energy Performance of Buildings Directive (EPBD-2024) is a major driver. It strengthens minimum energy-performance requirements, introduces zero-emission building objectives, and mandates national building renovation plans, while also promoting digital instruments such as Digital Building Logbooks (DBLs), Building Renovation Passports (BRPs) and the Smart Readiness Indicator (SRI) to support more transparent, data-driven renovation pathways (European Union, 2023a; JRC, 2023). The EPBD recast also promotes stronger policy integration across Member States, including more harmonised definitions, national reporting requirements, and coordinated legislative updates.

The recast Energy Efficiency Directive (EED) (Directive (EU) 2023/1791) provides an additional layer of policy momentum by introducing a legally binding EU-wide final-energy consumption reduction target of 11.7% by 2030, strengthening annual energy-savings obligations, expanding the scope of energy-efficiency requirements for public buildings, and reaffirming the centrality of long-term renovation strategies (European Union, 2023b; Economidou et al., 2022). Meanwhile, the revised Renewable Energy Directive (RED III) increases the 2030 renewable-energy target to 42.5% (with a 45% aspiration) and introduces a dedicated sub-target for the use of renewable energy in buildings, driving the uptake of on-site renewables, renewable district heating and cooling, and integrated energy systems (European Union, 2023c).

Several supporting instruments create additional drivers for digitalisation and standardisation. The Level(s) Framework acts as a pan-European reference for life-cycle assessment, resource efficiency and circular-economy performance in buildings, increasingly linked to EU Taxonomy reporting and sustainable finance compliance (JRC, 2021; Zero Consulting, 2023). At national level, growing use of state-published standards, templates and calculation methodologies—including national EPC guidelines, BRP templates, LCA guidance and DBL specifications—helps align local practices with EU requirements and improves comparability across Member States.

Furthermore, the European Commission's work on a European framework for Digital Building Logbooks (DBLs) is emerging as a significant enabler, providing a common

architecture for collecting, storing and exchanging building-related data throughout the building life cycle (JRC, 2023). This initiative is complemented by the broader evolution of European data spaces, especially the “common European data space for energy” and ongoing discussions around the built environment, which aim to improve access to interoperable, high-quality building data while ensuring compliance with GDPR, the AI Act and the Cybersecurity Act (European Commission, 2023).

Finally, cross-project collaboration platforms—such as the Next Gen EPCs Cluster, of which CHRONICLE is a participating member—act as additional policy drivers by contributing technical guidelines and policy recommendations that support the EPBD recast, EPC harmonisation and next-generation building-performance assessment frameworks (Next Gen EPCs Cluster, 2023). Together, these policy developments form a strong and coherent set of drivers that encourage Member States, market actors and technology providers to overcome existing barriers and adopt solutions aligned.

## 4.2. Standardisation as policy enabler

Beyond regulatory ambition and national commitments to climate-neutral buildings, ongoing standardisation developments provide an important set of drivers that enable long-term sustainability strategies. As outlined in D6.3, several emerging European standards directly support the implementation of the EPBD recast and the digital transformation of the building sector.

A key driver is the evolution of operational energy performance standards within CEN/TC 371/WG 5. These efforts explicitly referencing CHRONICLE, advance the shift from calculated to measured building performance. This enables more reliable EPCs, strengthens the evidence base for renovation decisions and supports the introduction of monitoring-based approaches promoted at EU level.

CHRONICLE spearheaded the publication of a CWA dedicated to the calculation of the “carbon bill” of the refurbishment of buildings, which should enable the allocation of costs related to GHG emission and can be used for public or private procurement, or for incentives related to renovations.

At the same time, the digitalisation of construction-product information through the development of the Digital Declaration of Performance and Conformity (DoPC) in CEN/TC 442/WG 12 provides a structured, machine-readable way of capturing environmental and technical characteristics of products. This is a significant driver for scalable Digital Building Logbooks, transparent renovation planning and alignment with emerging requirements under the CPR and ESPR.

Work on Digital Twins and Digital Building Logbook related standards in CEN/TC 442 further reinforces these drivers. By defining common terminology, data structures and interoperability expectations, these initiatives reduce fragmentation across countries and ensure that digital tools developed by CHRONICLE can be adopted more easily within diverse national ecosystems.

Finally, the revision of whole-life carbon assessment standards, including EN 15978 and the publication of CHRONICLE’s own CWA 18304:2025, strengthens Europe’s capacity to integrate life-cycle metrics into building policy. This alignment between pre-normative

research and evolving standards acts as a driver for more harmonised carbon reporting, improved comparability of renovation scenarios and clearer guidance for market actors.

Together, these developments demonstrate how progress in standardisation functions as a critical policy enabler, creating the technical foundation needed for consistent data governance, interoperable digital tools and the wider deployment of performance-based renovation strategies across Europe.

## 5. Conclusions

The analysis presented in this deliverable demonstrates that the European policy landscape is moving decisively toward a more digitalised, performance-oriented and sustainability-driven building sector. The EPBD recast, together with the EED, RED III, CPR/ESPR and complementary frameworks such as Level(s), the EU Taxonomy and emerging data-governance regulations, establishes a clear direction for the transformation of Europe's building stock. These instruments create strong political and regulatory momentum for the adoption of Digital Building Logbooks, Building Renovation Passports, operational performance indicators and interoperable data infrastructures—areas where CHRONICLE provides direct, practical contributions.

However, the findings from both EU-level analysis and pilot-country assessments reveal that implementation remains uneven and often constrained by regulatory fragmentation, inconsistent national transposition practices and persistent gaps in data integration. Many Member States continue to face challenges related to EPC comparability, limited uptake of operational performance data, fragmented or siloed digital infrastructures and varying levels of administrative and technical capacity. These barriers delay the realisation of the EU's renovation and digitalisation objectives and hinder the emergence of a coherent, interoperable European building-data ecosystem. CHRONICLE successfully addressed some of these barriers by participating in the development of methodologies related to the reduction of emissions of buildings or the digitalization of environmental product data. A remarkable result is the publication of CWA 18304:2025 providing a calculation method for the “carbon bill” of the refurbishment of a building. CHRONICLE also participated in the digital declaration of performance and conformity for construction products (CEN/TC 442/WG 12) and presented a proposal for the assessment of the operational energy performance of buildings in CEN/TC 371/WG 5. CHRONICLE participated in the publication of several scientific papers related to standards and policies, covering the digitalization of EPDs or the concept of digital twin when applied to the built environment. These outcomes are the result of intense work in CEN technical committees and in policy related groups, and will “outlive” the project and be used by industry in the coming years.

Overall, D6.4 concludes that while policy ambitions for digital and sustainable renovation are strong, regulatory fragmentation and data-interoperability challenges still hinder implementation. CHRONICLE has provided valuable technical results to bridge the gaps, in particular evidence, monitoring methodologies and standardisation inputs that can inform future policy design and strengthen the transition toward an integrated, performance-driven and climate-aligned European building stock. By bridging gaps between technical innovation, regulatory needs and emerging standards, CHRONICLE helps lay the groundwork for more coherent renovation strategies, improved decision-making and a resilient, high-performance building environment across Europe.

## 6. References

- Aragón, A.; Alberti, M.G. (2024). Limitations of machine-interpretability of digital EPDs used for a BIM-based sustainability assessment of construction assets, *Journal of Building Engineering*, 96, 110418. <https://doi.org/10.1016/j.jobe.2024.110418>.
- Aragón, A., Spudys, P., Pupeikis, D., Nieto, Ó., & García Alberti, M. G. (2025). Bridging interoperability gaps between LCA and BIM: Analysis of limitations for the integration of EPD data in IFC. *Buildings*, 15(15), 2760. <https://doi.org/10.3390/buildings15152760>
- Aragón, A., et al. (2025). Seeking a definition of digital twins for construction and infrastructure management. *Applied Sciences*, 15(3), 1557. <https://doi.org/10.3390/app15031557>
- Arcipowska, A., Bertoldi, P., Economidou, M., & Palermo, V. (2023). *EPC RECAST: Improving EPC reliability and comparability*. Horizon 2020 Project EPC RECAST (Grant Agreement No. 893118).
- Buildings Performance Institute Europe (BPIE). (2014). *Energy Performance Certificates across the EU: A mapping of national approaches*. Brussels: Buildings Performance Institute Europe. Brussels: BPIE
- Buildings Performance Institute Europe (BPIE). (2020). *Is Europe on track for nearly zero-energy buildings?* Brussels: BPIE.
- Buildings Performance Institute Europe (BPIE). (2023). *Deep renovation: Tracking the gap to 2030*. Brussels: BPIE.
- Economidou, M., Filippidou, F., & Bertoldi, P. (2022). *Assessment of energy efficiency policy implementation across Member States*. Joint Research Centre (JRC).
- EPB Center & REHVA. (2023). *EPBD implementation and EPC harmonisation: Insights and gaps*. Brussels.
- European Commission. (2020). *A renovation wave for Europe: Greening our buildings, creating jobs, improving lives* (COM(2020) 662 final).
- European Commission. (2023). *Common European data spaces: Energy and the built environment*. Brussels.
- European Commission (2025). *Feasibility study on the establishment of the Construction Products Regulation (CPR) Digital Product Passport (DPP) system*. <https://data.europa.eu/doi/10.2873/7605332>
- European Commission, Joint Research Centre (JRC). (2021). *Level(s): A common EU framework of core sustainability indicators for office and residential buildings*. Luxembourg: Publications Office of the European Union.
- European Commission, Joint Research Centre (JRC). (2022). *DigiBUILD: Data-driven services for enhanced building performance*. Horizon 2020 Project DigiBUILD (Grant Agreement No. 101033911).

- European Commission, Joint Research Centre (JRC). (2022). *The renovation wave: Data gaps and implementation challenges*. Ispra: JRC.
- European Commission, Joint Research Centre (JRC). (2023). *Digitalisation of energy performance data and digital building logbooks*. Ispra: JRC.
- European Union. (2024a). *Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast)*. Official Journal of the European Union.
- European Union. (2024b). *Regulation (EU) 2024/3110 of the European Parliament and of the Council of 27 November 2024 laying down harmonised rules for the marketing of construction products and repealing Regulation (EU) No 305/2011*.
- European Union. (2023b). *Directive (EU) 2023/1791 of the European Parliament and of the Council on energy efficiency (recast)*. Official Journal of the European Union, L 231/1.
- European Union. (2023c). *Directive (EU) 2023/2413 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources (RED III)*. Official Journal of the European Union.
- Filippidou, F., & Economidou, M. (2021). Renovation needs and compliance with the EPBD across EU Member States. *Energy Policy*, 156, 112427.
- Filippidou, F., Economidou, M., & Maciulyte, R. (2022). *iBRoad2EPC: Enhancing EPCs with building renovation passports*. Horizon 2020 Project iBRoad2EPC (Grant Agreement No. 101033781).
- Fokaides, P., Strati, K., Iakovou, E., & Papadopoulos, A. (2023). *D<sup>2</sup>EPC: Methodological framework and pilot insights*. Horizon 2020 Project D<sup>2</sup>EPC (Grant Agreement No. 892984).
- Georgiou, K., Gutierrez, A., Nowak, H., & Brecq, I. (2023). *CrossCert: Cross-country harmonisation of EPC schemes*. Horizon Europe Project CrossCert (Grant Agreement No. 101033778).
- Groezinger, J., Klobasa, M., von Roon, S., & Reuter, M. (2022). *Data integration challenges in digital building ecosystems: Lessons from European pilots*. Joint Research Centre (JRC) / BuiltHub.
- International Energy Agency (IEA). (2022). *Energy efficiency 2022: Buildings sector insights*. Paris: IEA.
- DAGOSTINO, D., MADUTA, C., TSEMEKIDI TZEIRANAK, S., PACI, D. and CASTELLAZZI, L., Assessing the progress of Nearly Zero Energy Buildings (NZEBs) implementation in Europe, Publications Office of the European Union, Luxembourg, 2025, <https://data.europa.eu/doi/10.2760/3333880>, JRC138771.
- Jørgensen, N., & Ma, Z. (2025). Digitalisation, data protection and smart-building compliance under the AI Act. *Industry publication*.
- Malinovec Puček, A., Schweiger, G., Matejka, F., & Ferreira, M. (2023). *Digital building logbooks and smart readiness: Policy insights from the SRI2Market project*. Horizon 2020 Project SRI2Market (Grant Agreement No. 101033743).

Next Generation EPCs Cluster. (2023). *EPBD recast policy brief: Next generation EPCs*. ICONS / Horizon Results Booster.

Olasolo-Alonso, J., Salom, J., & Ortiz, J. (2022). Energy performance of buildings in Southern Europe: Implementation barriers and data-integration gaps. *Sustainable Cities and Society*, 87, 104172.

Pucek, A., Schweiger, G., Matejka, F., & Ferreira, M. (2023). *SRI2Market: Uptake of the Smart Readiness Indicator in European markets*. Horizon 2020 Project SRI2Market (Grant Agreement No. 101033743).

Renovate Europe Campaign. (2023). *Renovation wave: Policy brief*. Brussels.

Tsemekidi-Tzeiranaki, S., Gynther, L., Attaianesi, E., & Pederiva, M. (2023). *SmartLivingEPC: Integrating smartness and sustainability into EPCs*. Horizon Europe Project SmartLivingEPC (Grant Agreement No. 101069639).

van Dijk, D., & Kießling, S. (2022). *EPBD implementation and EPC quality assurance: Structural challenges and national approaches*. EPB Center.

Zero Consulting. (2023). *What is Level(s)? The EU framework for sustainable buildings and its link to the EU taxonomy*.

Zangheri, M., Economidou, M., & Bertoldi, P. (2022). *Energy renovation rate and nZEB implementation in the EU: Progress and outlook*. Joint Research Centre (JRC).

[chronicle-project.eu](https://chronicle-project.eu)