

## **D2.8 CrossCert Benchmark Repository**

Task 2.4 CrossCert Benchmark Repository WP2 Cross assessing EPC paradigms

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### **EXECUTIVE SUMMARY**

This document presents the crossCert building repository created by the crossCert consortium within Task 2.4 crossCert Benchmark Repository (WP2). This document describes the data included in the repository, how the data were obtained and structured, where they were hosted and how users can access them.

The crossCert building repository is aimed at researchers and modellers. It offers detailed data on buildings that they can use to test and validate their EPC models. The data provided by this repository are, in general, hard to obtain by researchers and modellers. Other existing databases, such as (<u>the EU Building Stock Observatory</u>) or (<u>the BuiltHub Platform</u>, still in development), contain building data or a more general nature, geared towards monitoring the evolution of the building stock towards decarbonisation, and as an aid for the design of building renovation policies. These data are relevant for policymakers and public authorities (EU, national or local). However, the level of detail offered by these databases is not sufficient for the development of building energy models (for validation or sensitivity analysis) or for use as a testbench of new EPC procedures.

The crossCert building repository helps address this need with very detailed building data (such as (building envelope characteristics and technical systems), results of energy certificates, energy consumption data and even examples of dynamic models for some of the buildings. These data have been curated and, where needed, anonymised to circumvent restrictions on its use.

crossCert aims to contribute, with this database, to the development and validation of building energy models, a core component of the energy certificates.

The data were generated during crossCert testing activities in Task 2.3 and were contributed by the partners in the crossCert consortium. Mirroring the geographical dispersion of crossCert partners, the repository contains data for buildings with different typologies and located in very different climates. This variety in climates and typologies enriches the repository, allowing for a broader testing and validation of building energy models.

The files are organised in the following categories (for each building): main data and results, energy consumption data, drawings, other data, and dynamic model. The data have been hosted on the Zenodo platform <a href="https://zenodo.org/">https://zenodo.org/</a>, a general-purpose, open-access data repository developed under the European OpenAire program and operated by CERN (the European Organization for Nuclear Research). In addition to allowing open and fast access, hosting on Zenodo ensures access to data beyond the conclusion of the crossCert project.

There are two possible routes to access the information contained in the building repository: 1) through the <u>crossCert Knowledge Exchange Centre</u>, and 2) directly through <u>Zenodo</u>. The <u>crossCert Knowledge</u> <u>Exchange Centre</u> main webpage includes a direct link to the <u>crossCert Building Repository</u>, where the user can filter the data according to several criteria (country, typology or data available). Accessing through <u>Zenodo</u> requires searching the term <u>crossCert\_building</u> or <u>crossCert</u> in <u>Zenodo</u> or going to Zenodo Communities and searching the crossCert community.



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# crossCert<sup>1</sup>

## **1** Introduction

This document presents the <u>crossCert benchmark repository</u>. Its main objective is to support developers and researchers in testing EPC paradigms, and creating and improving models for the simulation of the energy performance of buildings.

One of the main barriers model developers faces is the lack of data to test and validate their models. This repository benchmark aims to overcome this problem by providing curated data of buildings in sufficient detail to simulate their energy performance.

The repository was created with contributions from all the crossCert partners. The geographical dispersion of crossCert partners has resulted in the repository containing data on buildings with different typologies and located in very different climates. This variety in climates and typologies enriches the repository, allowing for broader testing and validation of building energy models.

Next, we put this repository in the context of other building databases, discussing the differences among them, and concluding why this database covers a specific need not fulfilled by other databases. After that, we indicate how the data were obtained and the structure in which we organised them. Subsequently, we describe the process of uploading the data into the <u>Zenodo repository</u>, the associated metadata and, finally, how the data can be accessed through <u>Zenodo</u> and the <u>crossCert Knowledge Exchange Centre</u>.

## 2 Other building databases

The building repository created by crossCert is different from other building databases that are already in operation (<u>EU Building Stock Observatory</u>) or are being developed (<u>BuiltHub Platform</u>).

The EU Building Stock Observatory provides national-level information on building stock (building typologies, renovation rates) and energy consumption. In future updates of this database, the information provided will be expanded, providing data on building elements and technical building systems installed, energy performance certificates, nearly zero-energy buildings and renovation rates, and also areas like energy poverty and financing aspects.

The <u>BuiltHub Platform</u> is a platform under construction that will allow data collection (building performance and characteristics-related data) on the building stock at the district level throughout Europe. Furthermore, it will contain a series of services and utilities that will allow the analysis of the current situation of the building stock at different levels (district, municipal, regional or national), identify the existing renovation potential, define and evaluate the implementation of policies for the renovation of buildings and monitor progress towards the decarbonisation of buildings. In addition to data related to the stock of buildings (building characteristics, energy performance and emissions), this platform will contain other types of information, such as socioeconomic data (income, living conditions) or climate.

These databases are mainly aimed at policymakers and public authorities (EU, national and local). They offer a series of interesting data for monitoring the evolution of building stock towards decarbonisation and for defining building renovation policies.

The crossCert building repository is aimed at researchers and modellers. It offers very detailed data on certain buildings so that users can test and validate their models or carry out sensitivity studies of their models. The data provided by this repository are, in general, complicated to obtain for researchers and modellers. Therefore, crossCert aims to contribute, with this database, to the development and validation of building energy models, a core component of the energy certificate.

### **3** How data are contributed to the crossCert repository

The first round of cross testing consisted of the following tests:

<u> 1220'</u>

• Project-wide ensemble, the buildings of which were termed P-buildings.

The P-building ensemble consisted of typically one building in each major building typology in the crossCert building portfolio, totalling seven buildings in all.

These seven buildings were tested project-wide in each testing country, in the same climate conditions as the original building or in a climate as similar as possible within the country EPC climate set.

To make the building portable across climates, a detailed energy model (or dynamic model) for each of these seven buildings is created by crossCert partner HWU.

• Climate clusters, the buildings of which were termed C-buildings.

Climate-cluster ensembles (C-buildings) were the basis for comparative testing among crossCert testing partners and shared testing experiences.

Buildings in a cluster were chosen based on the similarity of the climate at the building location and paired across countries. Thus, a building originally located in country C1 is tested using the EPC method of another country C2 with a similar climate. In this way, language and climate barriers are minimised, and testing experiences across countries can be compared.

Partner local building ensemble, the buildings of which were termed L-buildings.

In the L-building ensemble, each partner tested the remaining buildings in their own countries.

The main goal of testing the L-building ensemble was to draw quantitative conclusions about the EPC, such as the performance gap, that can be later compared among countries; other qualitative indicators, such as robustness against user input error, were assessed, too.

These tests required the exchange of data and results among the participating countries, especially in the P-building and C-building tests. To facilitate this exchange, UNIZAR generated country-neutral data and result inventories. In these inventories, each partner entered data about their buildings (for example, envelope characteristics or properties of the building's technical systems) in a standard format. Partners used them to prepare the energy performance certificates of buildings of other countries with their own EPC methodologies. In some cases, additional information was necessary, such as building drawings, the energy certificate of the country where the building is located or the actual energy consumption data (L-buildings).

It follows that the testing procedure generated information and data that can be used to develop and validate energy models of buildings. Furthermore, this information is curated since partners participating in the tests reviewed and analysed the data and information exchanged. To allow for the unrestricted use of the data, confidential items or items or for which permissions for publication have not been secured have been eliminated prior to publication by the contributing partners. We have arranged the information and data in a coherent structure and uploaded them to the Zenodo repository.

As a result of this process, a repository with buildings from ten European countries has been generated, and has been made available for the building energy performance community.



## 4 Data structure

In this section, we describe the data structure created to organise the data in the benchmark repository.

The files are organised in the following folders or categories (see **;Error! No se encuentra el origen de la referencia.**)

- Main data and results
  - $\circ \quad \text{Neutral data inventory.}$
  - Neutral results report.
  - Original EPC certificate.
- Energy Consumption Data:
  - Files, where available, with energy consumption data for the building, which can be used for validation of models and EPC results.
- Drawings
  - Building drawings which can be used as an aid for generating the EPC or for creating dynamic energy consumption models.
- Other Data
  - Any other data that can be useful for the purposes of creating or validating an EPC or an energy consumption dynamic model for the building.
- Dynamic Model
  - $\circ~$  Data to run a dynamic model of the building, if available.





Figure 1. Data structure in the crossCert benchmark repository

The neutral data inventory, in a spreadsheet format, includes most of the information necessary for the energy modelling of a building. The following information is included in this inventory:

- General info
  - $\circ$  Year of construction
  - Building typology
  - Surface (habitable area, conditioned)
  - Volume
  - Location
  - Climate data (HDD, CDD)
  - Occupancy data (occupancy schedule, ventilation schedule)
- Envelope (walls)
  - Surface of walls, roof and floors
  - U-value
  - o Orientation
  - Envelope (windows, doors and thermal bridges)
    - Surface of windows and doors
    - Thermal transmittance (W/m<sup>2</sup>K) of windows and doors
    - Solar factor
    - o Orientation
    - Length of thermal bridges
    - Thermal transmittance (W/m<sup>2</sup>K) of thermal bridges
    - Thermal conductivity (W/mK) of thermal bridges
- HVAC/DHW system infiltration
  - HVAC/DHW system, efficiency and energy source



- Indoor temperatures (normative, setpoints)
- Water demand
- $\circ$  Ventilation system (fans, energy consumption)
- $\circ$  Pumping system (energy consumption)
- $\circ$  Infiltration (renewals / hour)
- Lighting system
  - Installed power
  - Energy efficiency (W/m2/1000 lux)
  - Average maintained illuminance (lux)
- Internal heat gains/ internal loads
  - Internal heat gain equipment
  - Internal heat gain occupants
- Renewable energy installed
  - Solar PV (% final energy consumption covered)
  - Solar thermal (%final energy consumption covered)
  - Biomass boiler (%final energy consumption covered)

The neutral inventory results include:

- Total primary energy consumption, broken down into:
  - Space Heating
  - Cooling
  - Domestic hot water
  - Lighting
- CO<sub>2</sub> emissions
  - o Total
  - Space Heating
  - Cooling
  - Domestic hot water
  - Lighting
- Primary energy label
- CO<sub>2</sub> emissions label
- Recommendations to improve the energy efficiency
  - $\circ$  Description
  - o Investment
  - Savings
  - Payback
  - $\circ$   $\hfill \hfill \hf$
  - $\circ\quad$  CO\_2 emissions after the application of the measure
  - New heating / cooling demand
  - New energy /CO<sub>2</sub> emissions label

In the folder corresponding to energy consumption data, drawings and other data categories, the information contained might be in diverse formats (depending on which is available for the contributor partner). In most cases, the information is presented in .pdf or .xls files.

In the folder corresponding to dynamic models, we include the information needed to develop a dynamic model of the buildings (P-buildings) for which a dynamic model has been created. Additionally, the results obtained with the dynamic model are included, too. The file that contains this information is in .cab format. This format is generated by the software with which the dynamic model has been created (Virtual Environment Software, developed by IES - Integrated Environmental Solutions https://www.iesve.com/).

## crossCert^

## 5 Zenodo upload and storage

The data and information for the buildings have been uploaded to Zenodo, <u>https://zenodo.org/</u>, specifically to the <u>crossCert community</u>, where other results of the crossCert project are also being hosted.

Zenodo is a general-purpose, open-access data repository developed under the European OpenAire program and operated by CERN (the European Organization for Nuclear Research). In addition to allowing open and fast access, hosting on Zenodo ensures access to data beyond the conclusion of the crossCert project.

In this section, we describe the data associated (metadata) with the crossCert building repository, defined during the uploading of the information to Zenodo. These data are:

• Digital Object Identifier, DOI.

Code that uniquely represents each dataset.

• Resource type.

We choose a dataset since, for each building, we upload a series of structured data.

• Title

We indicate the title of the dataset with the following encoding:

XX -YY - Typology - Location - (Country), where

- XX is the code of the Country where the building is located (ISO 3166-1 alpha 2)
- YY is an internal number set in crossCert
- Typology is the typology in which the building is assigned
- $\circ$   $\;$  Location is the city or town where the building is located
- Country is the country where the building is located.

Examples of codes used as the title are as follows: BG01 - Multi-apartment building - Gabrovo (Bulgaria) or PL11 - Single family house - Czerniewice (Poland).

- Publication date
- Creators

Here, we indicate, by default, crossCert consortium.

• Description

In this field we describe the data structure and the folders content in each dataset.

• License

We select, by default, Creative Commons Attribution 4.0 International. This license allows the free access and use of the data contained in the repository.

Contributor

Here, we indicate the name of the partner who has provided the dataset.

• Keywords and subjects

The typical keywords are the typology of the building, the country where the building is located, and others such as crossCert\_building or EPC, Energy Performance Certificates.

Languages

In general, English and the language of the country where the building is located.





- Version
- Publisher

By default, it is Zenodo.

• Funding

The project that funds the repository, in this case, crossCert.

The following screenshots show the different steps in uploading data and information to Zenodo and how the data associated with each dataset (building) is entered.

Basic information
IIIII Digital Object Identifier*
Do you already have a DOI for this upload? O Yes <ul> <li>No</li> </ul>
10.5281/zenodo.10013087 🗙
Reserve a DOI by pressing the button (so it can be included in files prior to upload). The DOI is registered when your upload is published.
Resource type *
Dataset
Title *
ES01 - Educational - Arroyo de la Encomienda (Spain)
+ Add titles
Publication date*
2023-10-17
In case your upload was already published elsewhere, please use the date of the first publication. Format: YYYY-MM-DD, YYYY-MM, or YYYY. For intervals use DATE/DATE, e.g. 1939/1945.

### Creators\*

crossCert consortium Data curator

Remove

Figure 2. Metadata associated to crossCert benchmark repository data

## crossCert<sub>1</sub>

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Data files		B	Ι	$\mathcal{O}$	:=	1 <u>-</u> 2 <u>-</u>	<u> </u>	<u></u>	"	$\leftarrow$		$\rightarrow$
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These file	es are par	of the p	ublic	benc	hmar	k repo	ository	creat	ed as	a pa	rt	of the crossCert EU project.
This repo results. T Certificat	sitory cor he reposi e (EPC) p	tains cu ory is pu rocedure	rated ublicly es.	buildi avail	ing da able	ata, ce so tha	ertifica t it car	ite res n be u	ults ar Ised a	nd, w s a te	vh es	ere available, measured performance stbench for new Energy Performance
The files a	are organ	sed in th	ne foll	owing	g folde	ərs (n	ote tha	at not	all file	s are	e a	always provided):
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5. Dy	namic Mo 1. Data t	del o run a c	dynam	nic ma	odel c	of the l	buildir	ng, if a	vailab	ole.		
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#### 🖽 Licenses

E Creative Con The Creative work on the c	mmons Attributi Commons Attrib condition that the	on 4.0 International ution license allows re-distribution and re-use of a licensed creator is appropriately credited. Read more	Remove
+ Add sta	andard +	Add custom	
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<b>≗+ Contributors</b>	al de la Energía c	e Castilla y León (EREN) Data collector Edit	Remove
+ Add co	ntributor		
Keywords and	d subjects		
Suggest from	All 👻	Educational × crossCert_building × Spain ×	×
		EPC, Energy Performance Certificates ×	
Languages			
Spanish ×	English ×		×





#### P Version

231017			

Mostly relevant for software and dataset uploads. A semantic version string is preferred see semver.org, but any version string is accepted.

III Publisher
Zenodo
The publisher is used to formulate the citation, so consider the prominence of the role.

Funding	~
<ul> <li>Awards</li> <li>Cross Assessment of Energy Certificates in Europe 101033778</li> <li>European Commission</li> </ul>	Edit Remove
+     Add award       +     Add custom	

Figure 5. Metadata associated to crossCert benchmark repository data

## 6 Accessing the data

There are two possible routes to access the information contained in the building repository:

- 1) through the crossCert Knowledge Exchange Centre, or
- 2) directly through <u>Zenodo</u>.

Below, we indicate how the data can be accessed through either route.

### 6.1 Accessing the data from crossCert Knowledge Exchange Centre (KxC)

The building repository can be accessed from the main KxC website (see Figure 6, yellow square). At the top of the building repository section, there is a direct link to the Zenodo repository, where the data for all buildings are hosted (see Figure 7, "Link to Zenodo Building List").

Buildings on the database can be filtered from this page using a series of push buttons. Filtering options are as follows:

- By countries where the buildings are located,
- According to the information uploaded to the repository. For example, if "Dynamic Model" is selected, only the buildings for which dynamic building models have been developed and uploaded to the repository will be listed.
- By building typologies

Once the building of interest has been located, the user can access more detailed information about the building (see Figure 8) by clicking on the building code (for example, AT02). A link to the data on Zenodo is then provided, from where the user can download the building information. The link is placed on an image of the Data Object Identifier, DOI, of the dataset for the building.



crossCert

Themes V Topics V Forum Who we are Contact us Q



Web-based repository of information on next generation EPCs



Figure 6. crossCert Knowledge Exchange Centre (homepage)



							Carlos Para a tracerta		
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Link t	Zenod	b Building	List						
			All Countries	0	ll data	All typologies	Multi-Api	rtment	
			Austra	Catalon Can	to and Decide	Antoniosintertrative			
						Administrative		2	
			Bulgaria	Energy Co	nsumption Data	Cultural	oth	15	
			Span		awings	Educational	Primary	School	
			Greece	01	her Date	Healthcare	Single Farm	ly House	
			Poland	Dyna	mic Model	High School	Social H	ousing	
ATO	2								
AIU	2								
Single f	amily hou	se – Schönk	irchen (Austria)						
2011	Austria	Drawings	Energy Consumptio	n Data M	ain Data Results	Single family hou	se		
ΔΤΩ	4								
Multi-ap	oartment t	ouilding – Br	unn am Gebirge (A	ustria)					
2000	Austria	Drawings	Main Data Results	Multi-apa	rtment building				
ATO	5								
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	partment b	ouilding – Br	unn am Gebirge (A	ustria)					
Multi-ap					the second se	and the second second second second	Contract and Contract of Contr		





oligie failing flot	use – Schonklichen (A	(usulu)					
Typology			Single fa	mily house			
Construct	tion year		2011				
Heated s	urface (m²)		466				
Data avai	lablo		Main Dat	a Results, Energy Consum	ntion Data Drawing	P	
Data avai	lable		indir Du	a neodro, Energy concarn	stion bata, brannige	3	
Link to Bui	Iding Data				Jon Data, Dramiya	3	

Figure 8. Accessing building data from the crossCert Knowledge Exchange Centre

### 6.2 Accessing the data from Zenodo

To access the building repository directly through Zenodo (<u>https://zenodo.org/</u>), the user can follow two routes:

- 1. Searching the terms *crossCert\_building* or *crossCert* in Zenodo (this keyword is associated with all datasets). See Figure 9.
- 2. Going to Communities in Zenodo and searching the crossCert community. See Figure 10.

Once the user has accessed the building data list, Zenodo offers options to filter the data and information according to the user's interests (see Figure 11, left menu).



Communities My dashboard		+9 Log in 🛛 🕼 Sign up
Featured communities		
Python in Astronomy Conference Series	Browse	
Recent uploads         Eventer 7, 202 (VB)       Cuter         Carter       Cuter         SEALD Package List         Saxo, Paul Complex         The package list for the SEAMM environment, also complete conda environment files with and without the version pinned.         Upleaded on November 7, 2023         44 more versions exist for this record	Why use Zenodo?  Safe — your research is stored safely for the future in CERN's Data Centre for as long as CERN exists.  Tusted — built and operated by CERN and OpenAIRE to ensure that everyone can join in Open Science.  Citaebe — every veloaid a sasigned a Digital Object Identifier (DOI), to make them citable and trackable.  No waiting time — Upicads are made available online as soon as you hit publish, and your DOI is registered within seconds.  Open or closed — Share e.g. anonymized clinical trial data with only medical professionals via our restricted access mode.	
November 7: 2023 (v0.16)       Dataset       Copen         Topic Model October 2023 (2000 texts, 40 topics)       Kiee, Anne: Rottgermann, Julia         Topic Model of the MiMoText roman18 corpus (Oct 2023)       Uploaded on November 7, 2023	⊕ 0 ± 0	Versioning — Easily update your dataset with our versioning feature.     GitHub integration — Easily preserve your GitHub repository in Zenodo.     Usage statistics — All uploads display standards compliant usage statistics

Figure 9. Accessing crossCert Benchmark Repository data from Zenodo homepage

Zenodo Search records	a Q. Communities My d	lashboard		+) Log in 🛛 🖉 Sign up				
Created and curated by Zenodo users. Read more								
	crossCert	۹ +	New community					
Featured communities	Tomofast-x This is a placeholder for platform Tomofast-x.	code and datasets related to publications or dev	Browse velopments associated with the geophysical inversion					
New communities See all								
Science Research Library	Evolutive Meshed Compact		HCSL	FACSA LIM				
Science Research Lidfary				FACSA UM				

Figure 10. Accessing crossCert Benchmark Repository data from Zenodo Communities

# crossCert<sup>1</sup>

Zenodo 🖪	rossCert_bu	iding Q Communities My dashboard	🛛 Login	
		43 result(s) found	Sort by Best m	atch -
Versions		October 17, 2023 (231917) Dataset 🔒 Open		
View all versions		ES07 - Others - Galende (Spain) crossCert consortium		
Access status		Data files for building: ES07 - Others - Galende (Spain) Languages: Spanish, English These files are part of the public benchmark repository created as a part of the cre contains curated building data, certificate results and, where available, measured performance results. The repository is publicly available s	ossCert EU project.	This repository
Open	43	Uploaded on October 25, 2023		@ 17 ± 1
Resource types		October 17, 2023 (2310)77) Dataset 🖉 Open		
Dataset	43	ES10 - Healthcare - Villagonzalo/Pedernales (Spain)		
Subjects		Data files for building: ES10 - Healthcare - Villagonzalo/Pedernales (Spain) Languages: Spanish, English These files are part of the public benchmark repository create This repository contains surged building data, cartificate results and where available measured performance results. The repository is	d as a part of the cro	ossCert EU project.
EPC, Energy Performance Certificates	43	That reporting commanics barriers barriers denotes reading and, where wramber, measured performance readers. The reporting is Uploaded on October 25, 2023		@ 12 🛓 1
crossCert_building	43			
Spain	14	October 17, 2023 (231017) Dataset 🕒 Open		
Educational	10	BG05 - Cultural - Gabrovo (Bulgaria) crossCert consortium		
Poland	10	Data files for building: BG05 - Cultural - Gabrovo (Bulgaria) Languages: Bulgarian, English These files are part of the public benchmark repository created as a part of contains curated building data, certificate results and, where available, measured performance results. The repository is publicly ava	the crossCert EU pr	oject. This repository
Bulgaria	9	Uploaded on October 25, 2023		@ 19 🛓 2
Multi-apartment building	8			
Single family house	7	October 17, 2023 (231017) Dataset 🔒 Open		
Greece	6	ES16 - Office - Salamanca (Spain) crossCert consortium		
Office	6	Data files for building: ES16 - Office - Salamanca (Spain) Languages: Spanish, English These files are part of the public benchmark repository created as a part of the contains curated building data, certificate results and, where available, measured performance results. The repository is publicly available	crossCert EU projec	t. This repository
File type		Uploaded on October 25, 2023		@ 15 🛓 0
PDF	43			
ZIP	43	October 18, 2022 (23918) Butaset _ ≙ Open PL03 - Educational - Wyszków (Poland)		

Figure 11. crossCert Benchmark Repository data at Zenodo