ePANACEA

Smart European Energy Performance Assessment & Certification

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Report on the use of (energy) data within Energy Performance Certificates (EPCs) schemes

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Authors: Evi Lambie (VITO), Yixiao Ma (VITO), Theresa Urbanz (EASt), Elpida Polychroni (CRES), María Fernández Boneta (CENER), Teemu Vesanen (VTT)

Reviewers: Irena Kondatenko (VITO), Iná Eugenio Noronha Maia (TU WIEN), Krzysztof Klobut (VTT)

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HISTORY OF CHANGES

Version	Month Year	Organisation	Comments
1.0	18/03/2021	VITO	First draft section 1 and section 2
1.1	15/04/2021	VITO	First draft of the full report
1.2	03/05/2021	VITO	Final draft report for internal review
1.3	12/05/2021	TUWien	Final draft for first review
1.4	25/05/2021	VTT	Final draft for second review
1.5	31/05/2021	VITO	Final version after review, ready for upload by project coordinator to Funding & Tenders portal

TABLE OF CONTENTS

OVERVIEW OF THE ePANACEA PROJECT

After 10 years of track record, the current EPC schemes across the EU face several challenges which have led to a not full accomplishment of their initial objectives: lack of accuracy, a gap between theoretical and real consumption patterns, absence of proper protocols for inclusion of smart and novel technologies, little convergence across Europe, lack of trust in the market and very little user awareness related to energy efficiency.

The objective of the ePANACEA project is to develop a holistic methodology for energy performance assessment and certification of buildings that can overcome the above-mentioned challenges. The vision of ePANACEA is to become a relevant instrument in the European energy transition through the building sector.

ePANACEA comprises the creation of a prototype (the Smart Energy Performance Assessment Platform) making use of the most advanced techniques in dynamic and automated simulation modelling, big data analysis and machine learning, inverse modelling or the estimation of potential energy savings and economic viability check.

A relevant part of the project is to have a fluent dialogue with European policy makers, certification bodies, end-users and other stakeholders through two types of participatory actions: a feedback loop with policy makers, carried out through the so-called Regional Exploitation Boards (REBs) covering EU-27+UK+Norway on the one hand, and dialogue with end-users, established by means of specific thematic workshops, on the other.

Thanks to these participatory actions, the acceptance of the ePANACEA approach will be tested and validated in order to become aligned with and meet the needs of national public bodies, end-users and other stakeholders.

ePANACEA will demonstrate and validate reliability, accuracy, user-friendliness and cost-effectiveness of its methodology through 15 case studies in 5 European countries.

EXECUTIVE SUMMARY

This document describes the outcome of ePANACEA task T2.4 "*Supplementing EPCs with additional measured or calculated data*". An inventory of data is presented, which is an overview of all data that can be used to supplement or replace the current energy performance certificate. Various types of data are explored, related to building geometry, building envelope, boundary conditions, occupant behaviour, HVAC systems and energy performance. Moreover, a literature review has explored the potential impact of the incorporation of this data.

A scoping analysis is performed, in which we start from an inventory of all data that can be measured, after which the scope is narrowed to only the data variables that can be relevant to incorporate in the EPC. Next, the selected data variables are further analysed via their nature and accessibility, as well as their post-processing methods.

Furthermore, the literature review shows that several types of data have an influence on the uncertainty of building performance analyses, which can be overcome by calibrating the performance assessment model. However, the occupant behaviour related inputs have one of the most important impacts on the energy performance calculation.

GLOSSARY

BACS – Building automation and control system

DHW – Domestic hot water

EPC – Energy Performance Certificate

EPBD – Energy Performance of buildings directive

EV – Electric vehicle

GDPR – General data protection regulation

IoT – Internet of Things

RES – Renewable energy system

SH – Space heating

1. INTRODUCTION

The issuing of EPCs has been imposed by the EPBD since 2002, for all buildings that are constructed, sold or rented. Since then, EPCs are an important instrument in Europe to facilitate the energy performance assessment of buildings, to inform home owners and raise awareness on the performance of their building property. The EPC includes a standardized evaluation of the building, incorporating default boundary conditions and user behaviour. However, a significant gap is found between the standardized performance according to the EPC and the actual energy use, most commonly known as the energy performance gap.

Therefore, EU legislation is fostering implementation (or usage) of smart meters and IoT devices which allow monitoring of various energy flows and building occupancy. The information derived from the smart meters and IoT devices enable development of new services and approaches for building performance assessments. Methods using measured data with limited post-processing can serve as an informative aspect additional to the theoretical assessment.

In this task, we have explored various data sources that can supplement an energy performance certificate (EPC) and related aspects which can influence the feasibility of including such data in EPC assessments. Hereto, the following elements are elaborated in the inventory of data variables (section 2) and the literature review (section 3):

1. Inventory of data variables (section 2)
    - The nature of data available on individual building energy use (section 2.1)
    - The accessibility of the data for the use within EPC schemes, including an exploration of (energy) databases availability (section 2.2)
    - Identification (measurement) and post-processing methods (section 2.3)
2. Literature review regarding the impact of incorporating the data into the EPC methodology (section 3)
    - Identification of the uncertainty in building performance analyses (section 3.1)
    - Identification of the impact of occupant behaviour (section 3.2)
    - Incorporation of measurement data in the EPC assessment (section 3.3)

To build the inventory of data variables, we started from a wide perspective and listed all possible data variables that can be monitored, controlled and estimated in a building. This resulted in a spreadsheet (see the Annex of this report) including 175 data variables, related to the building geometry, building envelope, boundary conditions, occupant behaviour, HVAC systems and energy performance. The resulting data variables were then aligned with other ePANACEA tasks that elaborated on the EPC inputs (tasks T2.3 "*Linking EPC and Smart Readiness Indicator*" and T2.5 "*Linking EPCs with building passports and roadmaps*"). However, this deliverable mainly focuses on the "measured/calculated" data variables, while ePANACEA tasks T2.3 and T2.5 list all inputs of the EPC methodology.

After the full inventory of data has been established, we have focused on two categories of data inputs: (1) measurable varying data variables and (2) measurable fixed data variables to supplement or replace EPC inputs – as will be explained in the next chapter.

2. INVENTORY OF DATA VARIABLES

The complete list of data summarized in the spreadsheet (see the Annex of this report) was categorized into four categories:

1. **Measurable varying data variables to supplement or replace EPC inputs.** These data variables are measured as a time series and vary in time (e.g. consumption data). The data frequency can range from detailed minute-data to aggregated daily or even yearly data.
2. **Fixed data variables to supplement or replace EPC inputs.** These data variables can only be identified once, because they are constant or follow a repetitive pattern. Examples of these variables are aspects of the building envelope (e.g. air tightness or measured U-values), or variables that quantify user behaviour (set points and schedules).
3. **Data variables that cannot be used to improve the current EPC.** These data variables are relevant for EPC calculations, but cannot be elaborated or monitored in detail. These variables are for instance some aspects of the building geometry (e.g. surface areas, thickness of materials, etc.) or the HVAC system (e.g. system type, boiler volume, etc.).
4. **Data variables that are considered to be out of scope or overlap with other variables.** These are detailed variables that are used typically in more detailed simulations (dynamic simulations), but are considered to be out of scope for the identification of a static building performance (e.g. single control units).

In this report, the data variables of the first two categories are prioritized. Since the aim is to explore data sources that can be incorporated in the EPC assessment, the latter two categories are disregarded. Three topics are discussed: (1) the nature of the data, (2) the data accessibility and (3) identification and normalization methods.

2.1. Nature of data

The nature of data variables can be discussed from different perspectives:

1. The **type** of the data variables can be discussed. Hereto, four main groups of data types are defined in this task: (1) building envelope, (2) boundary conditions and occupant behaviour, (3) HVAC systems and (4) energy efficiency. For each type of data, a list of parameters is established, which are each quantified by means of the data variables.
2. The nature of the data can be discussed according to the **units and frequency.**
3. Third, the data can be specified as a **varying or a fixed variable**.

The data types and corresponding parameters identified in this task are summarized in Figure 1. These data types are now further elaborated, discussing their nature in detail. It is emphasized that the discussed data variables are only the ones that can be measured and that can be incorporated in or supplemented to the EPC.

Type	**Building envelope**	**Boundary conditions and occupant behaviour**	**HVAC systems**	**Energy efficiency**
Parameters	• Opaque building components • Transparent building components • Air tightness	• Outdoor climate • Occupants • Setpoints for a zone or a building • Building control • Indoor climate • Domestic hot water use • Domestic energy use	• Air handling unit • Building zone • DHW system • Space heating system • Space cooling system • Photovoltaic system • Solar thermal system • Distribution system	• Energy need • Energy use • On-site renewable energy system

Figure 1: Summary of data types and corresponding parameters (Source: VITO)

2.1.1. Building envelope

The data variables regarding the building envelope, which can be measured and incorporated in the EPC, are summarized in Table 1. The table shows that data variables that quantify the building envelope are identified from measurements as fixed variables. This is a simplification of reality, as the data variables listed in Table 1 are only constant in stationary conditions, for a building with constant boundary conditions (indoor temperature, outdoor climate…). However, measuring the variation of the data variables in time is almost impossible, as the gathered data needs to be processed before the data variable can be identified. As an alternative, the variation of the data variables in time can be simulated, like the infiltration rate that varies with the wind pressure and thermal stack effect.

Parameter	Data variable	Unit	Nature
Opaque building components	Coefficient of total linear thermal transmittance, Ψ	W/K	Fixed
Opaque building components	Thermal transmittance, U-value	$W/(m^2K)$	Fixed
Transparent building components	g-value	-	Fixed
Transparent building components	Thermal transmittance, U-value	$W/(m^2K)$	Fixed
Air tightness	Infiltration air change of the building	1/h or $m^3/(h.m^2)$	Fixed

Table 1: Data variables regarding building envelope and geometry

2.1.2. Boundary Conditions and Occupant Behaviour

The data variables regarding the boundary conditions and occupant behaviour, which can be measured and incorporated in the EPC, are summarized in Table 2. Of course, all measured data variables regarding the outdoor climate are varying in time, but regarding the occupant behaviour, it depends on the parameter:

- All data variables that quantify the occupants and the setpoints are considered to be fixed, except for the number of occupants, which can vary in time when it is logged with presence sensors. Although setpoints can vary during the day, they are also considered to be fixed, as their variation can be captured in a repetitive schedule.
- All measured temperatures are varying in time.
- All remaining data variables can be fixed or varying, depending on the identification method. When the data variable is queried by means of a questionnaire, repetitive schedules are obtained, which are considered to be fixed. When the data variable is continuously measured by means of sensors, it is varying in time.

Parameter	Data variable	Unit	Nature
Outdoor climate	Temperature, solar radiation, wind, rain	°C, °, mm, W/m^2,	Varying
Occupants	Activity level per occupant	met	Fixed
Occupants	Number of occupants	-	Fixed or varying
Occupants	Type of occupants	-	Fixed
Setpoints for a zone or	Gross heated/cooled volume	-	Fixed

Parameter	Data variable	Unit	Nature
building			
Setpoints for a zone or building	Heating set point (schedule)	°C	Fixed
Setpoints for a zone or building	Cooling set point (schedule)	°C	Fixed
Setpoints for a zone or building	Maximum CO_2-level of the zone when CO_2-controlled ventilation, in ppm	ppm	Fixed
Setpoints for a zone or building	Maximum RH of the zone when RH-controlled ventilation, in %	%	Fixed
Setpoints for a zone or building	Schedule of the room unit, e.g. fireplace 2 h in the evenings	schedule	Fixed
Building control	Blind control	-	Fixed or varying
Indoor climate	Indoor comfort: Indoor Temperature	°C	Varying
Indoor climate	Temperature in neighbouring zones	°C	Varying
Domestic hot water use	Use of hot water	Liters	Fixed or varying
Domestic energy use	Cooking	Mins/day or W	Fixed or varying
Domestic energy use	Big energy consumers (pool, hot tub, sauna, EV)	Use/week or W	Fixed or varying
Domestic energy use	Use of dishwashers, washing machines and dryers	Use/week or W	Fixed or varying
Domestic energy use	Use of lighting	Mins/day or W	Fixed or varying

Table 2: Data variables regarding boundary conditions and occupant behaviour

2.1.3. HVAC systems

The data variables regarding the HVAC systems, which can be measured and incorporated in the EPC, are summarized in Table 3. Most of the variables, such as efficiencies, power consumptions, capacities or air flows, are varying in time (i.e. not constant over a time period) when they are measured. The remaining data variables are fixed. These include system specifications such as the angle, orientation and surface area of solar panels, the type of distribution system or the constant thermal losses of a DHW system. It is emphasized that the efficiency of a system cannot be measured directly, but should be derived from the measurements as a ratio between the input and the output of the system.

Parameter	Data variable	Unit	Nature

Parameter	Data variable	Unit	Nature
Air Handling unit	Exhaust air heat recovery efficiency (0-1)	-	Varying
Air Handling unit	Specific power consumption in kW/(m3/s)	kW/(m3/s)	Varying
Air Handling unit	Heating capacity of the AHU	W	Varying
Air Handling unit	Cooling capacity of the AHU (sensible + latent)	W	Varying
Building zone	Return air flow of the zone	L/(s m²)	Varying
Building zone	Supply air flow of the zone	L/(s m²)	Varying
Building zone	Nominal power of the room unit	W	Varying
Building zone	Efficiency of the room unit using selected carrier, e.g stove 0.8, heat pump 3.0	-	Varying
DHW system	Hot water system constant thermal losses, circulation, storage tanks	kWh/(m²a)	Fixed
DHW system	Hot water system heat recovery efficiency	-	Varying
DHW system	Temperature of the cold domestic water	°C	Varying
DHW system	Supply temperature of the domestic hot water from the plant (hot water to showers and taps)	°C	Varying
DHW system	Overall efficiency of the domestic hot water heating system	-	Varying
DHW system	Capacity of the space DHW heating system	W	Varying
Space heating system	Overall efficiency of the space heating system	-	Varying
Space heating system	Capacity of the space heating system	W	Varying
Space cooling system	Overall efficiency of the cooling system	-	Varying
Space cooling system	Capacity of the cooling system	W	Varying
Photovoltaic system	The capacity of the battery system related to the RES electricity production	kWh	Varying
Photovoltaic system	PV capacity	kW	Varying
Photovoltaic system	Efficiency of the PV system	-	Varying
Photovoltaic system	Azimuth orientation (-90° is E, 0° is S, 90° is W)	°	Fixed

Parameter	Data variable	Unit	Nature
Photovoltaic system	Slope, the angle of the PV modules from the horizontal plane, 0 deg = horiz., 90 deg = Vertical	°	Fixed
Solar thermal system	Nominal zero loss efficiency with the temp diff zero, related to the reference area (0-1)	-	Varying
Solar thermal system	Azimuth orientation (-90° is E, 0° is S, 90° is W)	°	Fixed
Solar thermal system	Reference area of the collector	m²	Fixed
Solar thermal system	Slope, the angle of the PV modules from the horizontal plane, 0 deg = horiz., 90 deg = Vertical	°	Fixed
Distribution System	Supply temperature of the radiator, fan coils etc room systems in the design point	°C	Varying
Distribution System	Return temperature of the radiator, fan coils etc room systems in the design point	°C	Varying
Distribution System	Room Emission Type: Radiator, FanCoil, FloorHeating, FloorCooling, CeilingHeating, CeilingCooling	-	Fixed
Distribution System	Room Emission Control Type: Manual, ThermostaticValve, PIControl	-	Fixed
Distribution System	Pump efficiency of the hydronic distribution pumps (heating, cooling, radiators, AHU loop)	-	Varying

Table 3: Data variables regarding the HVAC systems

2.1.4. Energy Efficiency

The data variables regarding the energy efficiency, which can be measured and incorporated in the EPC, are summarized in Table 4. All these variables are varying in time, and are influenced by amongst others boundary conditions, building quality and occupant behaviour.

Parameter	Data variable	Unit	Nature
Energy use	Use of fossil fuels (for heating, cooling and hot water)	m3, litres, kWh	Varying
Energy use	Total Electricity use	kWh	Varying
Energy use	Electricity use for heating	kWh	Varying
Energy use	Electricity use for cooling	kWh	Varying
Energy use	Electricity use for EV	kWh	Varying

Parameter	Data variable	Unit	Nature
Energy use	Electricity use for lighting	kWh	Varying
Energy use	Electricity use for non-EPB uses	kWh	Varying
Energy use	Electricity use for DHW	kWh	Varying
On-site RES	On-site electricity production	kWh	Varying
On-site RES	Exported electricity	kWh	Varying

Table 4: Data variables regarding the energy efficiency

2.2. Data accessibility

Data gathered in buildings are often not accessible, because a lot of stakeholders are involved and privacy sensitivity of the data. The following paragraphs elaborate on data accessibility, and how it varies per data type. The link is made between measurements and the GDPR.

2.2.1. Ownership and privacy sensitivity

Different stakeholders are involved when a building is monitored, so often co-ownership between different parties occurs:

- **Inhabitants (either owners or tenants)** have co-ownership of all the data that are gathered.
- **Engineering companies, architectural firms, installers, contractors and manufacturers** have co-ownership of the data that are gathered regarding their product. For instance, a contractor has co-ownership of all data that is gathered on the rough construction (building envelope), while manufacturers have co-ownership of data regarding their HVAC systems of which the efficiency and performance are monitored.
- **Utility companies** have co-ownership of the energy use data that are gathered from their database or meters.
- **Operation & maintenance (O&M) companies** have co-ownership over all data regarding building automation and control systems that they service.
- **Energy auditors** have co-ownership of all data that is gathered with their equipment.
- **Research institutes** often perform more complex monitoring campaigns in their personal interest, with a large number of sensors (e.g. monitoring of the complete indoor environmental quality) or with a complex post-processing procedure (e.g. in-situ measured U-values of building components).

In addition to the different stakeholders that can be involved, data can be personal or non-personal, with different degrees of privacy sensitivity. The general data accessibility per data type is summarized in Table 5. Three levels of data accessibility can be identified. First, all data regarding the building envelope and boundary conditions is non-personal with a low privacy sensitivity because these data, such as building material characteristics and weather data, are often openly available. Second, all data variables of occupant behaviour and energy efficiency at personal/individual level are classified as personal data with high privacy sensitivity because private habits and preferences can easily be derived from these data. However, if the private data are aggregated (e.g. street level energy consumption) or anonymous (e.g. anonymous address), these are even publicly available, thus considered as low sensitivity. Some examples can be found in 2.2.2.3. Third, data variables that specify the HVAC systems are non-personal with a varying privacy sensitivity. For inhabitants, the efficiency of the HVAC is only of small interest, but for manufacturers, this can be confidential data that quantifies the performance of the system they developed. Also for O&M companies, this data has a high privacy sensitivity, as it can reveal operational deficiencies or shortcomings regarding the maintenance of the system.

Data type	Stakeholders involved	Personal or non-personal	Privacy sensitivity
Building envelope	Inhabitants, engineering companies, architectural firms, installers, contractors, energy auditors, (research institutes)	Non-personal	Low
Boundary conditions (outdoor climate)	Utility companies, (research institutes)	Non-personal	Low
Occupant behaviour	Inhabitants, O&M companies, (research institutes)	Personal	High
HVAC systems	Inhabitants, O&M companies, manufacturers, (research institutes)	Non-personal	Low/high
Energy efficiency	Inhabitants, utility companies, energy auditors, (research institutes)	Personal	Low/High

Table 5: Data accessibility: stakeholders and privacy sensitivity

2.2.2. Exploration of (energy) databases availability and their use in EPCs

The task team has carried out a mapping exercise to explore databases availability and their potential use in supplementing or replacing input parameters in EPC calculation.

2.2.2.1. Climate profiles:

In EPC calculation, a set of default climate profiles are often used. Additional climatic data sources are useful in updating or validating the default climate profile.

- JRC TMY data (https://ec.europa.eu/jrc/en/pvgis): the dataset with free and open access contains a Typical Meteorological Year (TMY) of data, which is produced by choosing for each month the most "typical" month out of 10 years of data. The variables used to select the typical month are global horizontal irradiance, air temperature, and relative humidity. The data can be incorporated as the climate profile into EPC calculation.
- EnergyPlus weather data (https://energyplus.net/weather): similar to the above data source, the climatic data can be used for refinement of the EPC inputs (temperature, solar radiation).
- Hourly data for temperature and irradiance per country (https://data.open-power-system-data.org/weather_data/2020-09-16): open and free access to population-weighted mean across all MERRA-2 grid cells within the given country
- Heating/Cooling degree days dataset (https://ec.europa.eu/eurostat/web/energy/data/database): the open Eurostat-dataset contains annual and monthly heating/cooling degree days in EU countries, which can be used for normalization of energy performance.

2.2.2.2. Building geometry:

- Building geometry database can potentially serve as a first step to retrieve geometrical parameters. Building geometry database: under the initiative of INSPIRE, various geometrical datasets are publicly available in different countries, which can be used as additional geometrical input of EPC calculation.
  https://data.opendataportal.at/dataset
  https://www.planlaufterrain.com/LiDAR-Data-and-FAQ/

- Building Typologies: TABULA project developed national building typologies representing the residential building stock of several countries, which provides an overview of the typical building characteristics (in combination with the construction period), such as U-value and infiltration rate.
  https://episcope.eu/building-typology/country/
  https://webtool.building-typology.eu/#bm

2.2.2.3. User profile (Actual energy consumption data):

User profile related energy consumption data can be directly used to correct/calibrate input parameters in the EPC calculations and reduce the energy performance gap which further increases the accuracy of EPC calculation results.

- The actual energy consumption (electricity and natural gas) profiles of Belgian households (https://www.fluvius.be/nl/thema/open-data): in combination with climate profiles, the dataset can be used to derive typical user profiles and building characteristics.
- Representative electrical load profiles of residential buildings in Germany (https://fs-cloud.f1.htw-berlin.de/s/wZZQKdupnJd8wmH) with a temporal resolution of one second
- Actual aggregated energy consumption data (https://www.fluvius.be/nl/thema/open-data): the aggregated energy consumption data can be used to derive the actual energy performance at building level, or to calculate the average energy performance of the building type for benchmarking purpose.
- Electricity consumption and PV generation for small business and residential households (https://data.open-power-system-data.org/household_data/2020-04-15)

2.2.2.4. Other relevant data

There are many other relevant data sources that can be used to supplement or replace EPC inputs. A few open data sources of solar energy are given as examples:

- PV data (https://ec.europa.eu/jrc/en/pvgis): the dataset contains monthly average/daily/hourly solar radiation.
- Solar map - 'Zonnekaart' (https://www.energiesparen.be/zonnekaart): the dataset gives an assessment of the potential for solar panels and solar collectors on all roofs in Flanders
- Solardachkataster Steiermark (https://www.data.gv.at/katalog/dataset/7c3cbfc9-b8fa-43e1-941e-2d93b65c2720): Potential surfaces for thermal solar systems on roofs in Austrian region Styria (basically available for all Austrian region, partly even more renewable potentials)

Besides, a research was performed on the projects part of EU H2020 funded calls DT-ICT-10-2018 and DT-ICT-11-2019, resulting in the following list of projects:

- Big Data for OPen innovation Energy Marketplace https://cordis.europa.eu/project/id/872525
- Digital PLAtform and analytic TOOls for eNergy https://cordis.europa.eu/project/id/872592
- Big Energy Data Value Creation within SYNergetic enERGY-as-a-service Applications through trusted multi-party data sharing over an AI big data analytics marketplace https://cordis.europa.eu/project/id/872734
- Interoperable Solutions Connecting Smart Homes, Buildings and Grids https://cordis.europa.eu/project/id/857237
- BD4NRG: Big Data for Next Generation Energy https://cordis.europa.eu/project/id/872613

However, no relevant links were found with the aim of this deliverable.

2.3. Identification and post-processing methods

To identify the previously discussed data variables, some acquisition and post-processing methods need to be applied. However, each method comes with a level of complexity and accuracy, as is discussed below.

2.3.1. Acquisition

Different levels of complexity can be defined for the acquisition of data.

- When the building is ready for measurements and no effort is required to access the data, the acquisition complexity is low. This is the case when data can be gathered without visiting the building e.g. from a database or the government. Only for new or recently-renovated buildings equipped with a building monitoring system (BMS), the acquisition complexity is low.
- When the building is ready for measurements, but extra effort is required to access the data, the acquisition complexity is of a medium level. This is the case for buildings that are equipped with a building automation and control system (BACS) which does not automatically store the measured data.
- When a building is not ready for measurements, and no sensors or BACS are available to extract the data from, the acquisition complexity is high. At the moment, the largest share of buildings have a high acquisition complexity, but this is expected to decrease in the next upcoming years, as the EU strongly encourages and imposes the installation of smart meters.

The acquisition complexity can strongly vary per data type. For instance, for a building that is only equipped with smart meters that monitor the energy use, the acquisition complexity of the energy use is low, while for other aspects the complexity is high. Furthermore, different acquisition techniques can be used to gather data. This is summarized in Table 6 per data type.

Data type	Acquisition method	Acquisition complexity	Accuracy
Building envelope	Estimations or advanced simulations based on plans, technical information and standards	Low	Low
	In-situ measurements (additional sensors)	High	High
Boundary conditions (outdoor climate)	Gathered from database	Low	High
	In-situ measurements (additional sensors)	High	High
Occupant behaviour	Schedules and habits derived from questionnaire	Medium	Low
	In-situ measurements (additional sensors)	High	High
	In-situ measurements (BMS)	Low	High
HVAC systems	In-situ measurements (additional sensors)	High	High
	In-situ measurements (BMS)	Low	High
Energy efficiency	Gathered from energy invoices	Low	Low
	In-situ measurements (additional sensors)	High	High
	In-situ measurements (smart meters)	Low	High

Table 6: Data acquisition: methods, complexity and accuracy

Two acquisition methods have a low acquisition complexity as well as accuracy: estimations/simulations and energy invoices. The advantage is that the building does not have to be visited, but the disadvantage is that these methods results in a low accuracy (or when advanced simulation techniques with high accuracy are applied, it is difficult to verify and calibrate them). Three methods have a low acquisition complexity, but a high accuracy: gathering the data from a database, a BMS or smart meters. However, as BMSs or smart meters are not yet the state of the art, these acquisition methods cannot be applied frequently. Finally, adding additional sensors to an existing building results in data of high accuracy, but the acquisition complexity is high, as it requires a lot of effort to install and maintain the sensors, and to log the data.

2.3.2. Post-processing measured data

2.3.2.1. Time-series data

Measured (or monitoring) data are often collected as a time-series with a certain interval or frequency. Four post-processing methods need to be applied to these time-series data before they can be used in an analysis:

1. **Check for missing values**: these values can be omitted, or the gaps can be filled by interpolation methods or predictions.
2. **Check for abnormal values:** often referred as outliers (mild or extreme ones) and errors (due to faults in devices), and can be omitted from the data.
3. **Resample to the desired frequency:** it is often necessary to resample the time-series data to a lower or higher frequency. Resampling to a lower frequency (down-sampling) often involves an aggregation operation - for example, computing daily energy consumption data from hourly data. Resampling to a higher frequency (up-sampling) often involves interpolation or other data filling methods - for example, interpolating hourly weather data to 15 minute intervals for input to a model.
4. **Harmonisation, i.e. making the data interoperable and consistent:** the measured data should be processed to the desired timeframe, and data from different sensors needs to be brought together.

2.3.2.2. Building envelope data

The **air infiltration rate** of a building can be identified by means of a fan pressurization test, following the national standard NBN EN 13829. To this end, an indoor-outdoor pressure difference of 50 Pascal is created across the building envelope by placing an air fan in an exterior doorway. The air flow rate that must be generated to maintain the pressure difference then represents the air leakage rate of the building at 50 Pa (V_{50} in m³/h). As a rule of thumb, the air leakage rate of the building at 50 Pa is divided by a value between 10 and 30 to obtain the air leakage rate of the building (G_{inf} in m³/s) in regular conditions, with an average pressure difference of 2 Pa. Besides the air leakage rate V_{50}, the air change rate n_{50} (1/h) and the air permeability q_{50} (m³/(h.m²)) at 50 Pa indoor-outdoor pressure difference are also often used to describe the air tightness of a building.

The **thermal resistance** R of a building component can be calculated following the European standard NBN EN ISO 6946:2007, but it can also be identified by means of the heat flow meter method, as described in the international standard ISO 9869. To this end, the heat flow through the building component (q in W/m²) is measured with a heat flow meter, which is placed on the interior surface of the building component. Additionally, the interior and exterior surface temperatures are measured (T_{si} and T_{se}). To deduce the thermal resistance from these three parameters, several methods can be applied such as the average method, simple linear regression or an ARX model (Deconinck 2016).

2.3.2.3. Normalization of energy use data

Before data regarding the energy use of a building can be used, it needs to be normalized for the indoor and outdoor climate of a building. Otherwise, the energy uses of different buildings cannot be mutually compared, since both occupant heating behaviour and climate conditions can have a significant impact on the energy use. For instance, it is unfair to compare the energy use of a building in the cold climate of Finland to that of a building in the warm climate in Spain without accounting for the strongly differing outdoor climate.

The heating degree method is the most frequently applied method to normalize the energy use for space heating and similarly, the cooling degree day method is used to normalize the energy use for space cooling. Heating or cooling degree days quantify the climate conditions as the sum of the indoor-outdoor temperature difference for the days that have a heating or a cooling demand respectively. However, several variations of the method exist, taking into account different temperatures, gains, thresholds to define heating and cooling days etc.

3. LITERATURE REVIEW: IMPACT OF INCORPORATING THE DATA IN THE EPC

A literature review was performed to gain insight in the impact that the incorporation of data can have on the EPC. The sensitivity of the EPC score, or more specifically the primary energy use of the building, is explored.

Hereto, we first explore the uncertainty of building performance analyses in general, and which types of data can have an impact on this uncertainty. Second, we zoom in on the impact of occupant behaviour, since it was found in literature that this is one of the most important factors that influences building energy performance analyses. Third, we make a short reflection, using the findings from literature, on how to incorporate measurement data in the EPC assessment and what the expected impact will be.

3.1. Uncertainty in building performance analyses

Tian et al. (Tian et al. 2018) explored the main sources of uncertainty in building performance analysis, stating the following conclusions regarding different types of data:

1. *Weather data*: In building energy simulation, a typical meteorological year is used. However, building performance is affected by future climate, not by historical weather conditions.

2. *Building envelope*: Parameters related to building envelope can be categorized into three types: thermal properties (i.e. density and specific heat capacity), surface properties (i.e. solar absorptance and emittance) and other parameters (such as infiltration rate, thermal bridges, convective heat transfer coefficient and thickness of materials).

3. *HVAC systems*: Building energy analysis usually assumes that HVAC systems operate in ideal conditions. However, the actual performance of HVAC system is affected by several factors, such as oversizing, ageing, maintenance, usual wear and tear.

4. *Occupant behaviour*: Occupant behaviour implies the major uncertainty source that can conduct up to 30% of variation in building energy performance according to Eguaras-Martínez et al (Eguaras-Martínez et al. 2014). Most building energy simulation programs use deterministic models for the variables associated to occupant behaviour (i.e. fixed schedules for occupancy, lighting use, plug loads, cooling/heating set-points, etc.). However, this approach, easy to implement, do not represent the complex stochastic nature of human behaviour or its interaction with the building.

To cope with these uncertainties, energy performance models can be calibrated. Measured calibration data, depending on objectives, may include:

- The total energy consumption of the building (kWh)
- Heating and cooling energy consumption (kWh)
- Electricity consumption (kWh)
- Zone temperature (ºC)
- Relative humidity (%)

High quality input data gathered from on-site measurements and/or monitoring data (e.g. BMS or sensor data) will allow high accurate calibrated models with lower computational costs due to lower uncertainty of input parameters, thus lower variations and then a less number of iterations required (i.e. number of simulations). Calibrated simulation in the context of EPCs implies then real-time measurements or monitoring when the modelling phase is in progress. According to Sözer (Sözer et al. 2019), based on short (approximately one month) data, the whole heating season data could be predicted with an acceptable level of accuracy.

Moreover, calibrated energy performance models facilitate a baseline representation of existing buildings performance patterns (Gucyeter 2018). Hence, further accuracy in diagnosis, operation and energy conservation measures (ECMs) become possible through the use of calibrated models. Including this approach in EPCs will allow an increase of market trust on EPCs and support renovation strategies for the current building stock.

3.2. Impact of occupant behaviour

Occupant behaviour is no doubt one of the major factors influencing building energy consumption and contributing to uncertainty in building energy use prediction and simulation. Occupant behaviour plays a crucial role in assessing the building energy performance and closing the gap between actual measured and theoretical values. Currently the understanding of occupant behaviour is insufficient both in building design, operation and retrofit (Tianzhen H. et al., 2016).

The impact of occupant behaviour is mostly quantified in more complex dynamic simulation models. One study (Kaiyu S., Tianzhen H., 2017) introduced a simulation approach to estimate the potential energy savings of occupant behaviour measures. The five behaviour measures include lighting, plug load, comfort criteria, HVAC control, and window control. The simulation results of an office building show the accurate occupant behaviour measures can achieve considerable energy savings as high as 22.9% for individual measures and up to 41.0% for the integrated measures. In addition, quantifying the savings from occupant behaviour remains a primary challenge. For behaviour-related energy savings an estimated savings of 10% to 20% for residential and 5% to 30% for commercial buildings (i.e. private offices) was achieved (Tianzhen H. et.al, 2016). Another study (Paliouras, P. et.al, 2015) states that occupant behaviour primarily contributes to the uncertainty of building energy simulations because the occupants interact in a highly stochastic manner with the building. Therefore, the authors suggest that probabilistic methods should be used instead of deterministic models for modelling the user behaviour to increase accuracy of results. Such probabilistic methods to model occupant behaviour were also elaborated by the work of Deurinck (Deurinck M. 2015).

Although multiple studies showed the importance of occupant behaviour, in (most of) the current EPC calculation methods, actual user behaviour related aspects and parameters are often not taken into account.

One study in Wallonia, Belgium (Monfils S., Hauglustaine J.-M., 2016), concludes that the gap between theoretical and real consumptions (margins decrease more than half) can be partially closed by introducing behavioural parameters (e.g. heating habits, DHW needs, ventilation habits, actual internal loads and consumption data) into the EPC steady-state calculation method. Hereto, the study replaces some standardized occupant-related inputs of the EPC-method by real-use values, obtained by a questionnaire. However, the number of questions in that questionnaire has to be limited to ensure sufficient understanding and attention of respondents, as well as the reliability in their answers.

It is concluded in the Swedish case study of QUALICHECK project (Pär J. et al.) that the variations on energy use caused by the occupants' behaviour is often underestimated in energy use calculations. In single-family houses, differences in the occupant behaviour can account for up to 50% of the building's energy use. In low energy houses the variation of the occupants' behaviour has a larger relative impact on the energy use than for buildings with higher energy use. It is assessed that hot water consumption, airing and indoor air temperature are three aspects that have the major impact on energy use. In single-family houses, the measured EPC is very much affected by the behaviour of the group/family living in the house. In multi-family buildings, the dispersion will be smaller since some apartments have lower energy use (e.g. use less hot water) and some have higher. It is important to use the correct heated floor area and attribute the energy use to its correct demand and supply in the calculations. Another Swedish study (Mikael M. et al.) further investigated the importance of the correct building heated floor area and normalization and attribution of the measured energy use.

A UK study (Jain N., et al) investigated the performance gap, using calibrated simulation and measurement data for four new different building types - office, school, hospital and apartment block. It is shown that the influence of the user behaviour on the performance gap increases with degree of operational control.

BIM4EEB project (Teemu V. et al.) concludes that the effect of the input data depends on the prevailing weather conditions and the archetypes of the buildings. The heating and cooling set-points and the air ventilation rates are the most influential parameters on the building's energy consumption. Besides, in cold weathers, main effects on the heating load come from the solar gains through the glazing, building envelope parameters of the window U-value, window g-value, wall conductivity and the heaviness of the building's structure. In hot weathers, the cooling load is mainly affected by the internal heat gains from the occupant's behaviour.

A sensitivity analysis, carried out in Dutch dwellings (Daša M. et.al, 2013), has clearly shown that the average indoor temperature has a major influence on the theoretical gas consumption together with the ventilation rate. The number of occupants together with internal heat load also have a limited impact on theoretical gas consumption. Another sensitivity analysis (Ioannou A., Itard L.C.M., 2015) also proves that the effect of behavioural parameters (such as thermostat use and ventilation flow rate) dominate over the effect of building related ones in energy performance, but also play an important role in thermal comfort.

3.3. Incorporating measurement data in the EPC assessment

Figure 2 illustrates three possible options to incorporate measurement data in the EPC methodology:

1. Theoretical inputs that are already included in the current method can be replaced by the average measured values,
2. New inputs can be added to the current EPC methodology, which requires a revision of the current method,
3. Or the EPC-score can be derived from measured energy uses, but then a new methodology needs to be developed.

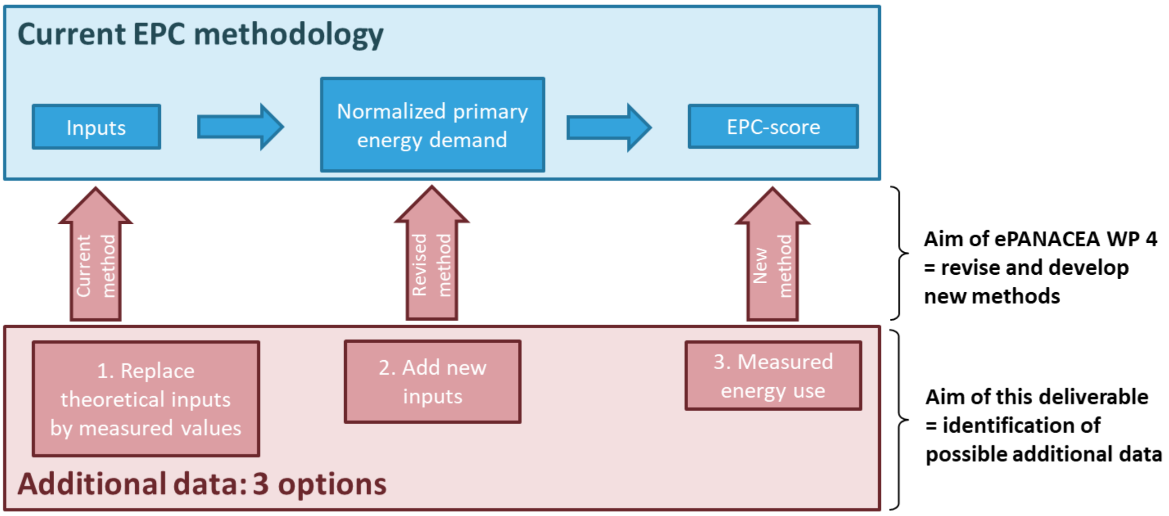

Figure 2: Three ways of incorporating data in the EPC methodology (Source: prepared by VITO)

As the figure shows, the aim of this deliverable is to explore the additional data that can be incorporated in three ways, while in ePANACEA work package 4 "*Method development*" the aim is to develop a holistic, accurate, flexible and modular methodology for EPCs, based on three assessment methods.

The first option mostly relates to measurement data regarding the building envelope, weather conditions and HVAC systems. Because the theoretical specifications of these aspects are already incorporated in the EPC methodology for the major part, it might be rather easy to replace these theoretical inputs by the measured values. This leads to a significant improvement and yields an EPC assessment that is a better representation of reality. However, it should be emphasized that the current EPC methodology remains unchanged, so most probably (quasi-)steady-state calculations are used (depending on the country).

Previous literature review (section 3.2) indicated that occupant behaviour is one of the major factors influencing building energy consumption. However, the EPC assessment in most countries only considers average occupant behaviour, often with a constant indoor temperature and a fixed heated volume. Therefore, measurement data that quantifies occupant behaviour should be incorporated by means of the second option shown on figure 2: new inputs need to be added to the current EPC methodology. Such new inputs can be average or dynamic inputs such as the measured indoor temperature per zone, schedules of the presence of the occupants, ventilation behaviour etc. Based on the literature review in section 3.2 we might expect that incorporating new inputs regarding the occupant behaviour into the EPC methodology might have a significant impact and lead to an EPC assessment that is again closer to reality. However, since occupant behaviour is very case-specific, it can be a fair approach to include a sensitivity analysis, or perform the EPC assessment for different scenarios of occupant behaviour.

The third option is to use the energy use in a new methodology to characterize the energy performance by means of a new indicator. This new indicator is expected to strongly differ from the EPC-score because of the energy performance gap (which is larger for energy-intensive dwellings) and can be used to supplement or replace the current EPC assessment. The normalization of the energy use, and other methods to identify the energy performance using measurement data are further elaborated in ePANACEA task T4.1 "*Smart & performance data-driven building energy performance assessment*".

4. CONCLUSIONS

Different data sources that can be relevant to an energy performance certificate (EPC) are explored with a scoping analysis. Hereto, we started from a large set of 175 data variables, summarized in a spreadsheet (see the Annex of this report), which are related to the building geometry, building envelope, boundary conditions, occupant behaviour, HVAC systems and energy performance. Next, we categorized all these variables into four types:

- Measurable, varying data variables to supplement or replace EPC inputs.
- Fixed data variables to supplement or replace EPC inputs.
- Data variables that cannot be used to improve the current EPC.
- Data variables that are considered to be out of scope or overlap with other variables.

Subsequently, we narrowed down the scope to the first two categories, since the aim of this deliverable is to explore various data sources that can supplement an energy performance certificate (EPC). The selected data variables are further analysed via their nature and accessibility, as well as their post-processing methods. In relation to the nature, the unit and related building parameter was defined per data variable and additionally, the nature was indicated as fixed (for constant or repetitive variables) or varying (for time-dependent variables). To evaluate the accessibility, the privacy sensitivity of the data variables was indicated, which strongly depends on the aggregation level and accuracy of the data. Moreover, (energy) data bases which contain relevant information that can be used as an input to EPC assessments were listed. Finally, some post-processing methods were defined, focussing on time-series data, characterization of the building envelope and the normalization of the measured energy use.

Furthermore, it can be concluded from the literature review that several types of data have an influence on the uncertainty of building performance analyses, which can be overcome by calibrating the performance assessment model. Occupant behaviour related inputs have one of the most important impacts on the energy performance calculation. Nevertheless, parameters regarding occupant behaviour are not incorporated in detail in current EPCs. There is a need for elaboration and improvement of these parameters in order to achieve in an improved EPC approach beyond the current state of the art.

To improve the occupant behaviour related inputs in EPC, its allocation and measured values, which are identified from the scoping analysis, remain extremely important. The quantification method and impact of an input varies with the type of parameters and measurements. The methodology of incorporating these key measured variables will be further explored and developed in WP4 “Methodology development” and validated in WP5 “Demonstration and validation”.

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6. ANNEX

A printout of the spreadsheet that contains 175 data variables is added below.

Nature of the data					Data accessibility			Building typology		Measurement & normalization methods			
Category	Parameters	Data variables	Data units	Data frequency	Ownership / Stakeholders involved	Personal / non-personal data	Privacy sensitivity	Building types	Building condition	Acquisition method & equipment	Acquisition complexity	post-processing required?	if yes, correction for which indicators?
boundary conditions - building geometry -							high - medium -	Multi-family building (MF)	new/renovated old, unrenovate	sensors - questionnaire -	high - medium - low		
MEASURABLE, VARYING DATA VARIABLES TO SUPPLEMENT OR REPLACE EPC INPUTS													
Energy efficiency	Energy need	heating energy need	kWh	yearly, seasonal, monthly	occupants, engineering firm	personal	Medium	MFB	new	meters, data base/	medium	yes	climate and use
Energy efficiency	Energy need	heating energy need	kWh	daily, hourly	occupants, engineering firm	personal	Medium	MFB	new	meters, data base/	medium	yes	climate and use
Energy efficiency	Energy need	cooling energy need	kWh	yearly, seasonal, monthly	occupants, engineering firm	personal	Medium	MFB	new	meters, data base/	medium	yes	climate and use
Energy efficiency	Energy need	cooling energy need	kWh	daily, hourly	occupants, engineering firm	personal	Medium	MFB	new	meters, data base/	medium	yes	climate and use
Energy efficiency	Energy need	DHW energy need	m3, kWh	yearly, monthly	occupants, engineering firm	personal	Medium	MF & SF & NR	new	meters, data base/	medium	yes	climate and use
Energy efficiency	Energy need	DHW energy need	m3, kWh	daily, hourly	occupants, engineering firm	personal	Medium	MF & SF & NR	new	meters, data base/	medium	yes	climate and use
Energy efficiency	Energy use	Use of fossil fuels	m3, litres, KV	yearly, seasonal, monthly	occupants, utilities	personal	Medium	MF & SF & NR	new & old	bills, data base/util	medium	yes	climate and use
Energy efficiency	Energy use	Total Electricity use	kWh	yearly, seasonal, monthly	occupants, utilities	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	Energy use	Total Electricity use	kWh	daily, hourly	occupants, utilities	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	Energy use	Electricity use for heating	kWh	yearly, seasonal, monthly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	Energy use	Electricity use for heating	kWh	daily, hourly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	Energy use	Electricity use for cooling	kWh	yearly, seasonal, monthly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	Energy use	Electricity use for cooling	kWh	daily, hourly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	Energy use	Electricity use for EV	kWh	yearly, monthly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	Energy use	Electricity use for EV	kWh	daily, hourly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	Energy use	Electricity use for DHW	kWh	yearly, monthly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	Energy use	Electricity use for DHW	kWh	daily, hourly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	Energy use	Electricity use for lighting	kWh	yearly, monthly	occupants, engineering firm, maintena	personal	Medium	NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	Energy use	Electricity use for lighting	kWh	daily, hourly	occupants, engineering firm, maintena	personal	Medium	NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	Energy use	Electricity use for non-EPB uses	kWh	yearly, monthly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	Energy use	Electricity use for non-EPB uses	kWh	daily, hourly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	on-site RES	on-site electricity production	kWh	yearly, monthly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate
Energy efficiency	on-site RES	on-site electricity production	kWh	daily, hourly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate
Energy efficiency	on-site RES	exported electricity	kWh	yearly, monthly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Energy efficiency	on-site RES	exported electricity	kWh	daily, hourly	occupants, engineering firm, maintena	personal	Medium	MF & SF & NR	new & old	smart meters, data	medium	yes	climate and use
Boundary conditions	outdoor climate	temperature, solar radiation, wind, rain	°C, W/m², °,	min. 1 hour	utilities	non-personal	low	MF & SF & NR	new & old	sensors	low	no	-
Occupant behaviour	occupants	activity level per occupant	met	per hour	inhabitant (owner/tenant)	personal	high	MF & SF & NR	new & old	questionnaire	low	no	-
Occupant behaviour	occupants	number of occupants	-	per hour	inhabitant (owner/tenant)	personal	medium	MF & SF & NR	new	sensors	medium	no	-
Occupant behaviour	heating behaviour	heating schedule	°C	per hour	inhabitant (owner/tenant)	personal	high	MF & SF & NR	new	sensors	medium	no	-
Boundary conditions	indoor climate	indoor comfort: Indoor Temp	°C	per day	inhabitant (owner/tenant)	can be both	high	MF & SF & NR	new & old	sensors	high	no	-
Boundary conditions	indoor climate	temperature in neighboring zones	°C	per day	inhabitant (owner/tenant)	can be both	medium	MF & SF & NR	new & old	sensors	high	no	-
HVAC systems	Air Handling unit	Specific power consumption in kW/(m3/s)	kW/(m3/s)	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Air Handling unit	Exhaust air heat recovery efficiency (0-1), dimless	dimless	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Air Handling unit	Heating capacity of the AHU, W	W	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
HVAC systems	Air Handling unit	Cooling capacity of the AHU, W (sensible + latent)	W	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
HVAC systems	Building or zone	Return air flow of the zone in L/(s m2)	L/(s m2)	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	high	yes	harmonisation, making the data in
HVAC systems	Building or zone	Supply air flow of the zone in L/(s m2)	L/(s m2)	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	high	yes	harmonisation, making the data in
HVAC systems	Building or zone	Natural ventilation air change of the building, 1/h, e.g. 0.5 1/h	1/h	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	high	yes	harmonisation, making the data in
HVAC systems	Room unit	Nominal power of the room unit, in W	W	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant	Domestic hot water demand of the building l/floor-m2,a	l/floor-m2,a	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant	Hot water system constant thermal losses, kWh/m²,a, circulation, storage tanks	kWh/m²,a,	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant	Hot water system heat recovery efficiency, dimless	dimless	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant	The capacity of the battery system related to ther RES electricity production (kWh)	kWh	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant system details	Overall efficiency of the space heating system, dimless	dimless	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant system details	Overall efficiency of the domestic hot water heating system, dimless	dimless	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant system details	Overall efficiency of the cooling system, dimless	dimless	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant system details	Capacity of the space heating system, W	W	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant system details	Capacity of the space DHW heating system, W	W	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant system details	Capacity of the cooling system, W	W	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Photovoltaic	PV capacity in kW (commercial unit, not SI),	kW	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Photovoltaic	Efficiency of the PV system, dimless, like 0,15	dimless	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Photovoltaic	Azimuth the orientation, is the angle of the PV modules relative to the direction. -90° is E, 0° is S and 90° is W.	deg	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Solar thermal	Nominal zero loss efficiency with the temp diff zero, dimless (0-1), related to the reference area	dimless	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Solar thermal	Azimuth the orientation, is the angle of the PV modules relative to the direction. -90° is E, 0° is S and 90° is W.	deg	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Building automation	Lighting - Occupancy & light level control	Enumeration	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Blind control	Enumeration	once	designer, O&M personnel, logboog	can be both	low	MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
FIXED DATA VARIABLES TO SUPPLEMENT OR REPLACE EPC INPUTS													
Occupant behaviour	occupants	type of occupants	-	-	inhabitant (owner/tenant)	personal	medium	MF & SF	new & old	questionnaire	low	no	-
Occupant behaviour	occupants	number of occupants	-	per hour	inhabitant (owner/tenant)	personal	medium	MF & SF & NR	old	questionnaire	low	no	-
Occupant behaviour	heating behaviour	gross heated/cooled volume	-	-	inhabitant (owner/tenant)	personal	high	MF & SF & NR	new & old	questionnaire	low	no	-
Occupant behaviour	domestic hot water use	number of showers & baths	-	per day	inhabitant (owner/tenant)	personal	high	MF & SF	new & old	questionnaire	low	no	-
Occupant behaviour	domestic energy use	cooking time	h	per day	inhabitant (owner/tenant)	personal	high	MF & SF	new & old	questionnaire	low	no	-
Occupant behaviour	domestic energy use	big energy consumers (pool, hot tub, sauna, EV)	-	-	inhabitant (owner/tenant)	personal	medium	MF & SF & NR	new & old	questionnaire	low	no	-

Nature of the data					Data accessibility			Building typology		Measurement & normalization methods			
Category	Parameters	Data variables	Data units	Data frequency	Ownership / Stakeholders involved	Personal / non-personal data	Privacy sensitivity	Building types	Building condition	Acquisition method & equipment	Acquisition complexity	post-processing required?	if yes, correction for which indicators?
boundary conditions - building geometry -							high - medium -	Multi-family building (MF)	new/renovated old, unrenovate	sensors - questionnaire -	high - medium - low		
Occupant behaviour	domestic energy use	number of dishwashers, washing machines and dryers	-	per day	inhabitant (owner/tenant)	personal	high	MF & SF	new & old	questionnaire	low	no	-
HVAC systems	Air Handling unit	Supply air setpoint in oC (the air that is delivered to the zones)	descriptive	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Air Handling unit	Schedule of the air handling unit	schedule	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	high	yes	harmonisation, making the data in
HVAC systems	Setpoints for a zone or buildin	Heating set point in oC	oC	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Setpoints for a zone or buildin	Cooling set point in oC	oC	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Setpoints for a zone or buildin	Maximum CO2-lev of the zone when CO2-controlled ventilation, in ppm	ppm	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Setpoints for a zone or buildin	Maximum RH of the zone when RH-controlled ventilation, in %	%	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Setpoints for a zone or buildin	Schedule of the indoor air heating setpoint temperature	schedule	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	high	yes	harmonisation, making the data in
HVAC systems	Setpoints for a zone or buildin	Schedule of the indoor air cooling setpoint temperature	schedule	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	high	yes	harmonisation, making the data in
HVAC systems	Building or zone	CAV, VAV CO2, VAV RH, VAV temperature control (constant or variable air volume control)		once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Room unit	Efficiency of the room unit using selected carrier, dimless, e.g stove 0.8, heat pump 3.0	dimless	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Room unit	Schedule of the room unit, e.g. fireplace 2 h in the evenings	schedule	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	high	yes	harmonisation, making the data in
HVAC systems	HVAC plant	Temperature of the cold domestic water (cold water from the city systems)	degC	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
HVAC systems	HVAC plant	Supply temperature of the domestic hot water from the plant (hot water to showers and taps)	degC	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Photovoltaic	Slope, the angle of the PV modules from the horizontal plane, 0 deg = horiz., 90 deg = Vertical	deg	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Solar thermal	Reference area of the collector	m2	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Solar thermal	Slope, the angle of the PV modules from the horizontal plane, 0 deg = horiz., 90 deg = Vertical	deg	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Distribution System Details	Supply temperature of the radiator, fan coils etc room systems in the design point, e.g 70 degC or 15 degC	degC	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Distribution System Details	Return temperature of the radiator, fan coils etc room systems in the design point, e.g 40 degC or 20 degC	degC	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Distribution System Details	RoomEmissionType: Radiator, FanCoil, FloorHeating, FloorCooling, CeilingHeating, CeilingCooling	enumeration	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
HVAC systems	Distribution System Details	Room Emission Control Type Manual, ThermostaticValve, PIControl	enumeration	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Distribution System Details	Pump efficiency of the hydronic distribution pumps (heating, cooling, radiators, AHU loop), dimless, like 0,35	dimless	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
Building envelope	opaque building components	thermal transmittance, U-value	W/(m2*K)	when relevant energy ren	owner, building manager, energy audit	non personal	low	MF & SF & NR	new & old	technical guideline	low/medium	no	-
Building envelope	opaque building components	Coefficient of total linear thermal transmittance, Ψ	W/K	when installation of therm	owner, building manager, energy audit	non personal	low	MF & SF & NR	new & old	calculations based	medium	no	-
Building envelope	Air tightness	Infiltration air change of the building, 1/h, e.g. 0.2 1/h	1/h	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
Building envelope	transparent building compone	thermal transmittance, U-value	W/(m2*K)	when relevant energy ren	owner, building manager, energy audit	non personal	low	MF & SF & NR	new & old	technical guideline	low/medium	no	-
Building envelope	transparent building compone	g-value	-	when relevant energy ren	owner, building manager, energy audit	non personal	low	MF & SF & NR	new & old	technical guideline	low/medium	no	-
CAN NOT BE USED TO IMPROVE THE CURRENT EPC													
Building geometry	floor area	net area	m2	when installation of therm	owner, building manager, energy audit	personal/non-pers	low	MF & SF & NR	new & old	questionnaire, plan	low/medium	no	-
Building geometry	floor area	gross area	m2	when installation of therm	owner, building manager, energy audit	personal/non-pers	low	MF & SF & NR	new & old	questionnaire, plan	low/medium	no	-
Building geometry	space volume	net volume	m3	when installation of therm	owner, building manager, energy audit	personal/non-pers	low	MF & SF & NR	new & old	questionnaire, plan	low/medium	no	-
Building geometry	space volume	gross volume	m3	when installation of therm	owner, building manager, energy audit	personal/non-pers	low	MF & SF & NR	new & old	questionnaire, plan	low/medium	no	-
Building geometry	opaque building components	orientation	o	-	owner, building manager, energy audit	non-personal	low	MF & SF & NR	new & old	map, plans	low	no	-
Building geometry	opaque building components	Area	m2	-	owner, building manager, energy audit	non-personal	low	MF & SF & NR	new & old	map, plans	low	no	-
Building envelope	transparent building compone	Area	m2	when relevant energy ren	owner, building manager, energy audit	non personal	low	MF & SF & NR	new & old	technical guideline	low/medium	no	-
Building geometry	transparent building compone	orientation	o	-	owner, building manager, energy audit	non-personal	low	MF & SF & NR	new & old	map, plans	low	no	-
Boundary conditions	construction & renovation yea	year	-	-	owner	non-personal	low	MF & SF & NR	new & old	questionnaire	low	ne	-
Boundary conditions	location	address, coordinates	-	-	owner	non-personal	low	MF & SF & NR	new & old	questionnaire, data	low	no	-
Boundary conditions	indoor climate	indoor comfort: humidity	% or g/m³	per day	inhabitant (owner/tenant)	can be both	high	MF & SF & NR	new & old	sensors	high	no	-
Boundary conditions	indoor climate	indoor air quality: CO2	ppm	per day	inhabitant (owner/tenant)	can be both	medium	MF & SF & NR	new & old	sensors	high	no	-
HVAC systems	Air Handling unit	Name of the air handling unit	descriptive	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
HVAC systems	Building or zone	Name of the Zone (Zone1, bedroom, etc..)	descriptive	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
HVAC systems	Building or zone	Controller serving the zone, in the list zoneControllerSetPointSet (1:N)		once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Building or zone	Heating and cooling devices		once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
HVAC systems	Building or zone	Air handling unit serving the zone,		once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Room unit	Energy carrier for the unit Gas, Oil, District, Electricity, Solar, Biomass, Wind	enumeration	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
HVAC systems	HVAC plant	The volume of the heating energy storage m³ (water)	m³	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant	The volume of the cooling energy storage m³ (water)	m³	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in

Nature of the data					Data accessibility			Building typology		Measurement & normalization methods			
Category	Parameters	Data variables	Data units	Data frequency	Ownership / Stakeholders involved	Personal / non-personal data	Privacy sensitivity	Building types	Building condition	Acquisition method & equipment	Acquisition complexity	post-processing required?	if yes, correction for which indicators?
boundary conditions - building geometry -							high - medium -	Multi-family building (MF)	new/renovated old, unrenovate	sensors - questionnaire -	high - medium - low		
HVAC systems	HVAC plant system details	System description either main or aux., like gas boiler with DHW preparation, no centralized cooling	enumeration	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant system details	EnergyCarrierForSpaceHeating	enumeration	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
HVAC systems	HVAC plant system details	EnergyCarrierForDHWHeating	enumeration	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
HVAC systems	HVAC plant system details	EnergyCarrierForCooling	enumeration	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
HVAC systems	Photovoltaic	System description		once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
HVAC systems	Solar thermal	System description		once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
Building envelope	building materials	type		when relevant energy ren	owner, building manager, energy audit	personal	low	MF & SF & NR	new & old	manufacturer's dat	low/medium	no	-
Building envelope	building materials	thermal conductivity, λ	W/mK	when relevant energy ren	owner, building manager, energy audit	non personal	low	MF & SF & NR	new & old	manufacturer's dat	low/medium	no	-
Building envelope	building materials	thickness	m	when relevant energy ren	owner, building manager, energy audit	non personal	low	MF & SF & NR	new & old	calculations based	low/medium	no	-
Building envelope	opaque building components	composition (layers)		when relevant energy ren	owner, building manager, energy audit	non personal	low	MF & SF & NR	new & old	calculations based	low/medium	no	-
CONSIDERED TO BE OUT OF SCOPE OR OVERLAP WITH OTHER VARIABLES													
HVAC systems	Building automation	Heat flow towards emission system	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Cooling - (Intermittent) control of emission and/or distribution	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
Building envelope	transparent building compone	shading	-	when relevant energy ren	owner, building manager, energy audit	non personal	low	MF & SF & NR	new & old	manufacturer's dat	low/medium	no	-
HVAC systems	Room unit	MainHeating, AuxHeating, MainCooling, AuxCooling	enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logboo	low	yes	harmonisation, making the data in
HVAC systems	Building automation	Ventilation - Humidity control	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Lighting - Light level/Daylight control	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Technical Management - Setpoint management	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Technical Management - Runtime management	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Technical Management - Detecting faults of technical building systems and providing support to the diagnosis of these faults	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Technical Management - Reporting information regarding energy consumption, indoor conditions	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Technical Management - Local energy production and renewable energies	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Technical Management - Waste heat recovery and heat shifting	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Technical Management - Smart Grid integration	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	EN15232-1:2017 efficiency class	A, B, C, D	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Heating - Emission control	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Heating - Emission control for TABS (heating mode)	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Heating - Control of distribution network hot water temperature (supply or return)	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Heating - Control of distribution pumps in networks	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Heating - Heat generator control (combustion and district heating)	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Heating - Heat generator control (heat pump)	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Heating - Heat generator control (outdoor unit)	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Heating - Sequencing of different heat generators	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Heating - Control of Thermal Energy Storage (TES) operation	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	DHW - Control of DHW storage charging with direct electric heating or integrated electric heat pump	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	DHW - Control of DHW storage charging using hot water generation	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	DHW - Control of DHW storage charging with solar collector and supplementary heat generation	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	DHW - Control of DHW circulation pump	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Cooling - Emission control	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Cooling - Emission control for TABS (cooling mode)	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Cooling - Control of distribution network chilled water temperature (supply or return)	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Cooling - Control of distribution pumps in networks	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Cooling - Interlock between heating and cooling control of emission and/or distribution	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Cooling - Generator control for cooling	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Cooling - Sequencing of generators for chilled water	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Cooling - Control of Thermal Energy Storage (TES) operation	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Ventilation - Supply air flow control at the room level	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Ventilation - Room air temp. control (all-air systems)	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Ventilation - Room air temp. control (Combined air-water systems)	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Ventilation - Outside air (OA) flow control	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Ventilation - Air flow or pressure control at the air handler level	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Ventilation - Heat recovery control: icing protection	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in

Nature of the data					Data accessibility			Building typology		Measurement & normalization methods			
Category	Parameters	Data variables	Data units	Data frequency	Ownership / Stakeholders involved	Personal / non-personal data	Privacy sensitivity	Building types	Building condition	Acquisition method & equipment	Acquisition complexity	post-processing required?	if yes, correction for which indicators?
boundary conditions - building geometry -							high - medium -	Multi-family building (MF)	new/renovated old, unrenovate	sensors - questionnaire -	high - medium - low		
HVAC systems	Building automation	Ventilation - Heat recovery control: prevention of overheating	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Ventilation - Free mechanical cooling	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Building automation	Ventilation - Supply air control (temperature and air flow)	Enumeration	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logbook or product info		yes	harmonisation, making the data in
HVAC systems	Distribution System Details	SpaceSupplyIsConstant, False= is proportional to the outside temperature, otherwise constant, heating proportional/cooling usually constant	boolean	once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Distribution System Details	Outside Air Design Point Temperature, Outside air temp where the design supply temp at max.value	degC	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Distribution System Details	Supply fluid temperature of the AHU heat exchanger, always constant like 50 or 7 degC	degC	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Distribution System Details	Return fluid temperature of the AHU heat exchanger, always constant like 30 or 12 degC	degC	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Solar thermal	First order solar themal collector performance factor, related to the reference area		once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Solar thermal	Second order solar themal collector performance factor, related to the reference area		once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	Solar thermal	Incidence angle modifier 50 degrees, dimless (0-1)	dimless	once	designer, O&M personnel, logboog	non-personal	low	MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant	Details of the main system like boiler, GSHP		once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant	Details of the auxiliary system like back-up electricity in case of GSHP		once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant	Solar PV system details		once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant	Solar thermal system details		once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant	Heating hydronics system details		once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in
HVAC systems	HVAC plant	Cooling hydronics system details		once	designer, O&M personnel, logboog	non-personal		MF & SF & NR	new & old	plans, BMS, logboo	medium	yes	harmonisation, making the data in