X-tendo

# TOOLS AND IT-COMPONENTS OF THE PROPOSED CALCULATION AND DATA HANDLING PROCEDURES TESTED IN X-TENDO

## ENHANCED RECOMMENDATIONS

JUNE 2022

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X-tendo

eXTENDing the energy performance assessment and certification schemes via a mOdular approach

# D4.6

# Tools, IT-components and related documentation of the proposed calculation and data handling procedures to be tested in WP5

*June 2022*

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| Author(s) | Iná Maia, Péter Gyamarti, Richard Dominik Paul and Lukas Kranzl (TUW), Cláudia Monteiro and Rui Fragoso (ADENE), Kalle Virkus (TREA), George Koras (CRES), and Jonathan Volt and Zsolt Toth (BPIE) |
| Co-author(s) | |
| Reviewed by | Borragán Pedraz Guillermo and Maarten De Groote (VITO) |
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https://x-tendo.eu/wp-content/uploads/2022/08/X-tendo-D4.6_rev_RDA_with-cover.pdf

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# EXECUTIVE SUMMARY

The X-tendo project is developing a framework of ten "next-generation EPC features", aiming to improve compliance, usability and reliability of the EPC. These features are divided in two categories, respectively, innovative indicators and innovative data handling.

This report describes the tools and IT-components of the proposed calculation and data handling procedures to be tested in WP5. For the feature **EPC databases** this document provides a summary of the quality control methodology for EPCs in the Database, an explanation of the programming algorithm in Python language, that implements this methodology and the explanation to the repository link. For the feature **enhanced recommendations** this document provides the explanation to the calculation spread sheets and guidelines. For the feature **building logbook** this document provides the technical specifications for linking the national logbook with the EPC data (or even EPC database). In the **building logbook** chapter, country specific solutions for Portugal, Estonia and Greece are presented.

This report builds on past project's activities. Moreover, upcoming project activities include the testing of these tools and data-handling concepts in the implementing partners (foreseen in the project phase for "**testing and developing guidelines**"). Below, the series of previous project reports are listed that present complementary information to the present report:

1. Introductory reports of the 10 innovative EPC features (Deliverable 2.3)
2. Development of assessment methods of next-generation EPC – features 1-5 (Deliverable (3.2)
3. Beta version of algorithms and calculation tools for assessment of next-generation EPC – features 1-5 (Deliverable 3.3)
4. Description of implementing partners' user needs and detailed technical specifications regarding features on handling and user of EPC data – features 6 to 10 (Deliverable 4.2)
5. Summary of implementing partners' user needs and detailed technical specifications – features 6 to 10 (Deliverable 4.3)
6. Description of methodologies and concepts for the technical implementation of each feature regarding improved handling and use of EPC data in selected implementing countries– features 6 to 10 (Toolbox – area per each feature)
7. Tools, concepts and guidelines for features: building logbook, enhanced recommendations and EPC databases (Toolbox – area per each feature)
8. Recommendations and replicability potential (Toolbox – area per each feature)

The complete material is online accessible in the X-tendo Toolbox (https://x-tendo.eu/toolbox/ ).

This document is the revised version of the report completed in April 2021.

# INTRODUCTION

EPCs are the most widely available information documents on building energy performance across Europe. They have the potential to be used as more than just an informative document for example through providing relevant information to assess, benchmark and improve the building's energy performance. Besides the information included in each document, the usage of these information and data handling are becoming more and more important. The recent Renovation Wave Communication published by the European Commission in October 2020 reinforced the importance of the existing EPC frameworks to improve the data gathering, storage and overall quality of EPCs. Besides that, the EPDB review is an activity going on recently and could an important opportunity to include insights and learning outputs from the X-tendo project.

In this context, the five X-tendo EPC features **EPC databases, building logbooks, enhanced recommendations, financing options and one-stop shops** play a relevant role, targeting to improve the way EPC data is being handled and used for different objectives and targeted stakeholders. For the features **EPC databases, building logbooks and enhanced recommendations**, the X-tendo project deep dived on the technical aspects of the implementation of feature, getting closer to the praxis. This was done by developing tools and technical concepts based on lessons learned from the current practice in the X-tendo expert countries (Table 1). For the features **financing options and one-stop shops** embracing concepts were explored. The complete material will be online accessible in the X-tendo Toolbox (https://x-tendo.eu/toolbox/ ).

The Figure 1 below summarizes the main objectives of each feature. Because of the focus on the technical components, the present document covers the features EPC databases, logbook and enhanced recommendations.

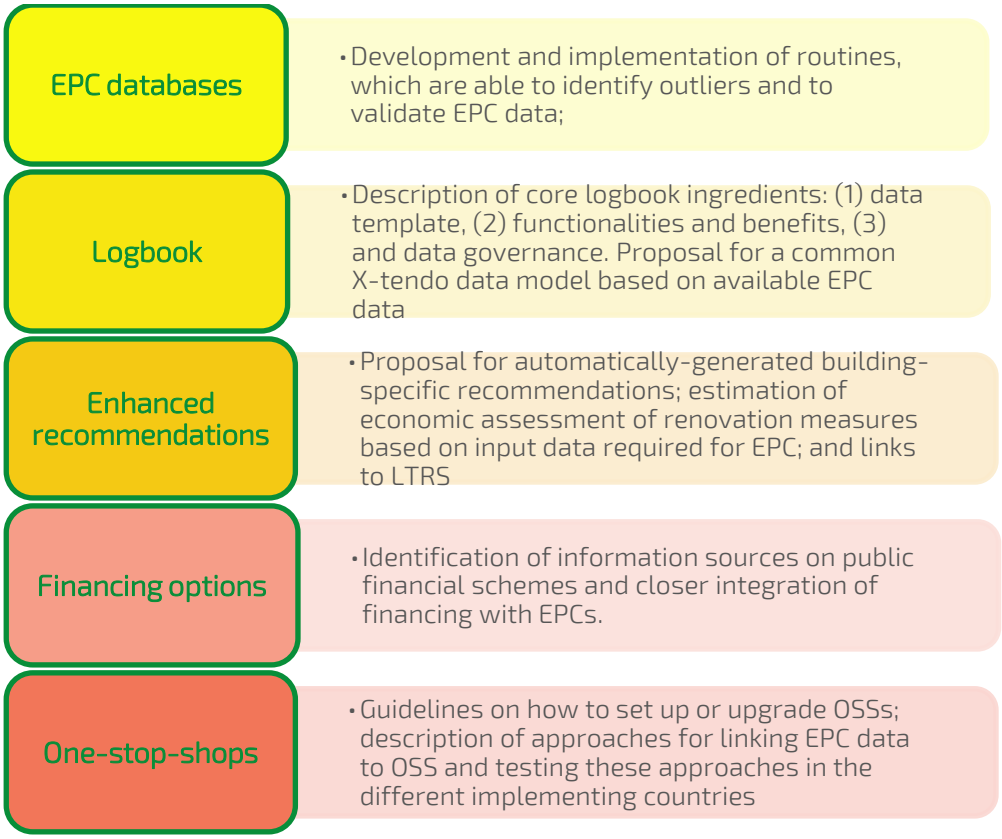



Figure 1: X-tendo methodology for features EPC Databases, Logbook, Enhanced recommendations, Financing options and One-stop-shops

The feature methodologies will be tested in different X-tendo target countries, as showed in the table below:

| |  EPC databases |  Building Logbooks |  Enhanced Recommend ations |  Financing Options |  One Stop Shops |
|---|---|---|---|---|---|
| *Feature lead* | *TU Wien* | *BPIE* | *TU Wien* | *ADENE* | *ADENE* |
| Austria, EAST | | | | | |
| Denmark, DEA | System-test | | In-building test | User and system test | User and system test |
| Estonia, TREA | | User and system test | | | |
| Greece, CRES | System-test | User and system test | | | |
| Italy, ENEA | System-test | | | | |
| Poland, NAPE | | | In-building and system test | | |
| Portugal, ADENE | | User and system test | | User and system test | |
| Romania, AAECR | | | | User and system test | User and system test |
| UK, EST | | | In-building test | | User and system test |

Table 1: Implementing and expert countries per feature

# FEATURE: ENHANCED RECOMMENDATIONS

## X-tendo methodology

The main objective of the X-tendo methodology is to support public authorities in increasing the usefulness and accuracy of EPC recommendations. In the context of the X-tendo project, this feature will be tested in the following countries of Denmark, Poland and Scotland.

The proposed method builds on three pillars:

1) Enhancing actual recommendations, by automatically-generated additional building-specific recommendations: in addition to techno-economic considerations, this will comprise a discussion about how co-benefits resulting from these recommended measures can be included in the EPC recommendations.
2) Showing how the costs of recommended measures can be included in the EPC provision process, enabling calculation of the cost-effectiveness of the recommended measures.
3) Setting targeted values for recommendations in order to guarantee that they are in line with national long-term and climate strategies for the building stock. In addition to the calculation methods, guidelines will also be provided on how to perform the calculations and assess the values, as a support handbook for energy auditors.

Figure 2 below presents the overview of the method. In general, this method can be divided into three parts: providing measure-by-measure recommendations, defining the whole building impact of all recommendations, and providing an economic assessment. The third part – the economic assessment – is optional, as it will depend on the availability and link to external databases, as cost databases.

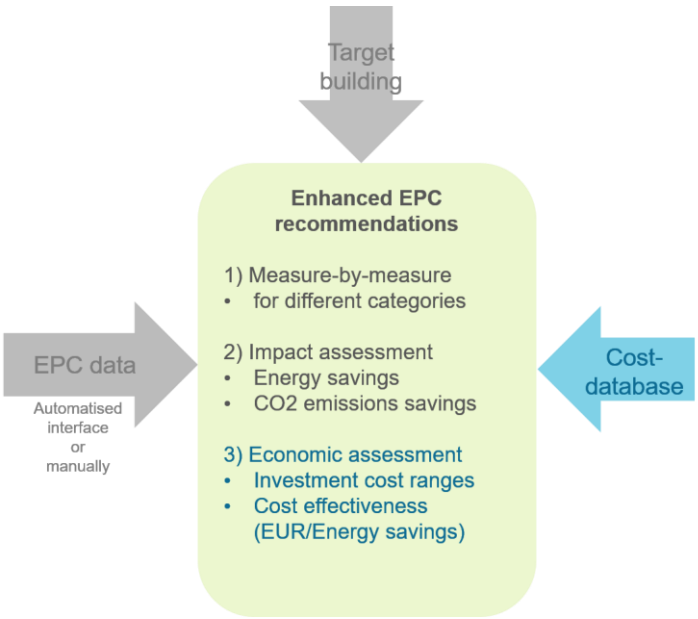



Figure 2: Overview of the Enhanced EPC recommendations

The recommendations will be delivered for different categories: measures for improving the building envelope (for example: insulation thickness), technical building systems (for example: dimension size of heating system) and integration of renewable energy systems (for example: recommended area of PV systems to be installed). The impact of the provided recommendations will be assessed by using indicators as energy savings and CO2 emission reductions. The economic assessment is based on the results generated in the previous steps. Therefore, a link with external databases (i.e. measures' costs and energy prices) is necessary, and a database structure will be proposed. The impact of the provided recommendations will be assessed by using indicators as cost-effectiveness (EUR/energy savings) and energy cost savings.[1]

Another aspect covered by the methodology refers to the definition of the target building. The target building can be set based on: 1) actual building standards regulations or other standards (passive house, nearly zero energy building etc.), or 2) energy auditors expertise or, 3) according to national long-term renovation strategies or other climate plans.

The present document presents the guidelines to handle with the calculation spread sheet **(Beta Version 1)**. With the spread sheet user can deliver the measure-by-measure recommendations, enter the target building standards (based on which the enhanced recommendations will be calculated) and set the database information, especially cost database. Therefore, the spread sheet provides an example of a possible cost database structure and required information.

## X-tendo calculation spread sheet

This document aims to guide the tool user through the spread sheets and calculations exclusively for the X-tendo F8 "**Enhanced recommendations**". The main software required is Excel. Additionally, other tools can be used to automatically extract the EPC data from the XML file.

### Spread sheet overview

Content of files and explanation of the terms, can be found in the tabs:

1. Title
2. File Content

Building relevant information, as well required input data for the calculation and targeted energy standards in the sheet:

[1] This document is complementary to the project report that explains the methodology in detail: D4.4 Description of methodologies and concepts for the technical implementation of each feature regarding improved handling and use of EPC data in selected implementing countries.

3. Building input data (current building information)
4. Targeted standards (for recommendations)

Required databases:

5. Insulation material database
6. Window and door database
7. Heating system database
8. Solar radiation information (average monthly radiation)

Calculation tabs:

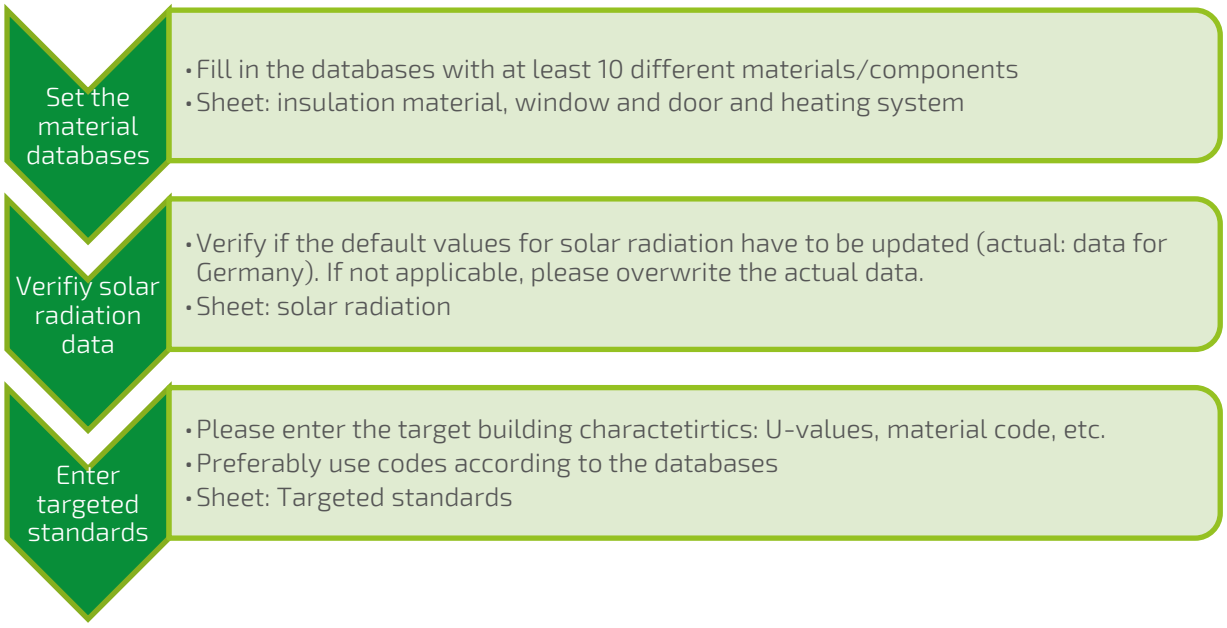
9. External wall
10. Floor (or cellar ceiling)
11. Roof (or upper ground ceiling)
12. PV production

Results tabs:

13. Recommendations (building category, criteria check, parameters, co-benefits and explanation of benefits)
14. Costs (recommendations cost ranges estimation)

## Preparation of the background information and databases (for all buildings)

Setting the background information and databases can be done one time, before the calculation per building. Few materials and equipment are suggested as default values, however the user encouraged to update it. Following activities should be performed:




### Set the databases and solar radiation information

The spread tabs (in grey) provide the structure for different databases: insulation material, window and door and heating system. Also, weather information regarding solar radiation

can be entered. These tabs should be filled in by the tool user before the calculation procedures start. And, can be used to all testing cases.


Figure 3: Spread tabs for databases

## Definition of targeted building standards

In this spread sheet the building user has to input the specifications of the targeted building, which is aimed to be achieved due to the recommendations. These "targeted building standards" should be derived either from national building codes or long-term building renovation targets as well as from decarbonisation targets.

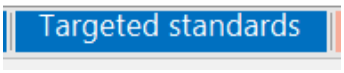



Figure 4: Spread sheet for target buildings

In this sheet, the tool user can enter U-values, efficiency rates, etc (required data in showed in Figure 5 below). The material code is the information that links the chosen recommended material (according to the databases in Figure 3) with the calculated recommendations (in the calculation spread tabs. Therefore, it is important to enter this information in the beginning.

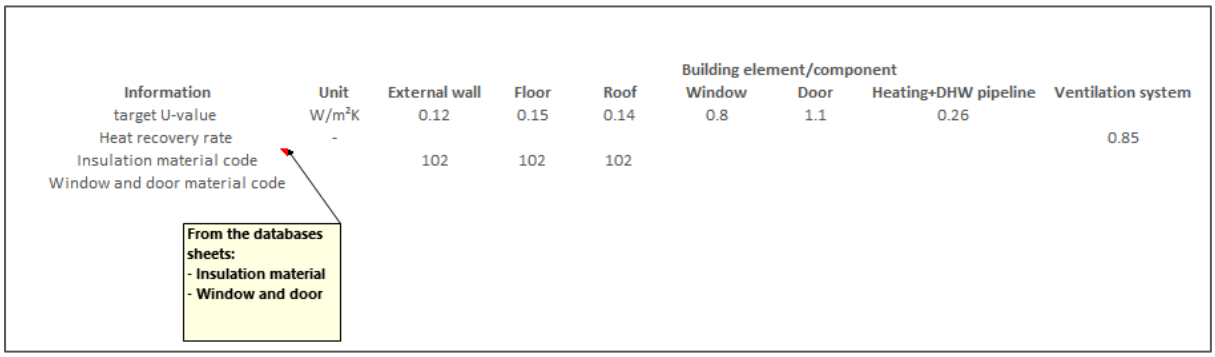



Figure 5: Required target building information

## Calculation steps (per building)


## Building input data

This spread sheet contains all the input data required by the calculation procedure. Here, it is possible to provide an interface with EPC xml file. For example, extracting the EPC data from the xml file automatically. For that, a Pyhton script (or other software code) is necessary as additional tool to extract automatically EPC data. In the context of the project, a code was written for the Danish EPC scheme and the automatised data extraction will be tested during the testing phase.

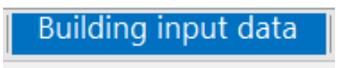



Figure 6: Spread sheet for building input data

The number of the parameters (column A) follows the same structure as the X-tendo internal file for documenting EPC data.[2] The columns on the right should be filled by the

[2] https://tuwienacat.sharepoint.com/sites/X-tendo2/_layouts/15/Doc.aspx?OR=teams&action=edit&sourcedoc={142D3119-9435-4C28-9A70-0034D36CA7D7}

implementing partner as well. It indicates if the parameter is in the current EPC or if the data should be gathered through other sources, as for example, during the on-site visit.

Building input data necessary in the calculation, and its availability in the country specific EPCs

according to EPC data file

| No | Input data (Level 1) | Input data (Level 2) | Input data (Level 3) | Unit | Value | availability in the EPC -> per country | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | DK | PL | UK |
| 68 | Envelope | External wall | Layer thickness | m | 0.015 | | x | |
| 68 | Envelope | External wall | Layer thickness | m | 0.18 | | x | |
| 68 | Envelope | External wall | Layer thickness | m | 0.0019 | | x | |
| 68 | Envelope | External wall | Layer thickness | m | | | x | |
| 68 | Envelope | External wall | Layer thickness | m | | | x | |
| 68 | Envelope | External wall | Layer thickness | m | | | x | |
| 68 | Envelope | External wall | Layer thickness | m | | | x | |
| 71 | Envelope | External wall | Layer thermal conductivity | W/mK | 0.81 | | x | |
| 71 | Envelope | External wall | Layer thermal conductivity | W/mK | 2.3 | | x | |
| 71 | Envelope | External wall | Layer thermal conductivity | W/mK | 0.8 | | x | |
| 71 | Envelope | External wall | Layer thermal conductivity | W/mK | | | x | |
| 71 | Envelope | External wall | Layer thermal conductivity | W/mK | | | x | |
| 71 | Envelope | External wall | Layer thermal conductivity | W/mK | | | x | |
| 71 | Envelope | External wall | Layer thermal conductivity | W/mK | | | x | |
| | Envelope | Floor | Layer thickness | m | 0.012 | | | |
| | Envelope | Floor | Layer thickness | m | 0.001 | | | |
| | Envelope | Floor | Layer thickness | m | 0.05 | | | |
| | Envelope | Floor | Layer thickness | m | 0.0002 | | | |
| | Envelope | Floor | Layer thickness | m | 0.036 | | | |
| | Envelope | Floor | Layer thickness | m | 0.2 | | | |
| | Envelope | Floor | Layer thickness | m | | | | |
| | Envelope | Floor | Layer thermal conductivity | W/mK | 0.16 | | | |
| | Envelope | Floor | Layer thermal conductivity | W/mK | 0.9 | | | |
| | Envelope | Floor | Layer thermal conductivity | W/mK | 1.1 | | | |
| | Envelope | Floor | Layer thermal conductivity | W/mK | 0.5 | | | |
| | Envelope | Floor | Layer thermal conductivity | W/mK | 0.046 | | | |
| | Envelope | Floor | Layer thermal conductivity | W/mK | 2.3 | | | |

Figure 7: Spread sheet for building input data

## Calculation procedures

The calculation procedures are carried out in the following tabs:

External wall | Floor_Cellar ceiling | Roof_Upper ground ceiling | PV production

Figure 8: Spread tabs with the calculations

Each calculation spread sheet contains the legend below (Figure 9). This legend should help the user understanding the type of input data requested. And, which are the output values.

**Legend**

From input data: sheet building input

To input: user should input

From targeted values: From sheet targeted building

Calculated values

Default or suggested values

Figure 9: Spread sheet data input legend

In general all fields can be modified by the user. Some are automatically linked with other tabs or default values are suggested.

The Figure 10 below shows the spread sheet for external walls insulation thickness calculation. The same structure is followed in the other tabs roof (or upper ceiling) and floor (or cellar ceiling). However, the input data (building element layers, thermal resistance, and material thermal conductivity) should be specific for each building element.

This method calculates the insulation thickness according to a targeted U-value

Legend
From input data
To input
From targeted value
Calculted values
Default or suggested values

1

External wall layers description

Please verify the layers of the actual wall construction (imported from **Summary building inout data sheet**) OR enter them

| | Material | Thickness (m) | Lambda (W/mK) | R ($m^2$/KW) |
|---|---|---|---|---|
| Layer 1 | Finery | 0.015 | 0.81 | 0.019 |
| Layer 2 | Cement | 0.18 | 2.3 | 0.078 |
| Layer 3 | Finery | 0.0019 | 0.8 | 0.002 |
| Layer 4 | | | | |
| Layer 5 | | | | |
| Layer 6 | | | | |
| Layer 7 | | | | |
| | | | | 0.10 |

2

External wall additonal information

Enter the required information

| Parameter | Unit | Value | Description |
|---|---|---|---|
| Rsi_external wall | $m^2K/W$ | 0.13 | inner coefficient of thermal resistance |
| Rse_external wall | $m^2K/W$ | 0.04 | external coefficient of thermal resistance |
| external wall insulation material code | | 102 | please enter the code according to sheet "insulation material database",if information from database is required |
| λ external wall insulation | W/mK | 0.038 | lambda value: automatically calculated from the chosen material (cell F29) or entered by the user |

3

Additonal information for cost-optimal calculation (method 2)

Enter the required information

| Parameter | Unit | Value | Description |
|---|---|---|---|
| heating system (recommendations) | | Boilers gas | according to sheet input data |
| HDD | Kd/a | 3247 | heat degree days, according to sheet input data or entered by the user |
| EPuse | EUR/kWh | 0.07684 | price energy use can be linked to the heating system database or directly entered by the user |
| η | - | 0.73 | annual efficiency , according to sheet input data or entered by the user |
| fret | - | 0.01 | rate of return, default value or entered by the user |
| IVP | $EUR/m^3$ | 26.34 | insulation volume price can be linked to the insulation material database or directly entered by the user |
| EPneeds | EUR/kWh | 0.11 | price energy needs |

Figure 10: Calculation spread sheet "external wall" – input data

The results are provided for two different calculation methods: method 1 is a reversed U-value calculation, and method 2 a cost optimal calculation (according to the Austrian Standard ÖNORM B 8110-4[3]), as specified in the report D4.4. The results of method 1 are automatically linked to the spread sheet with the final recommendations. But, the user can change the link, according to their preference and choice. That is the reason, why both calculation methods are presented.

[3] ("ÖNORM B 8110-4:2011 07 15 - Lesesaal - Austrian Standards," 2011)

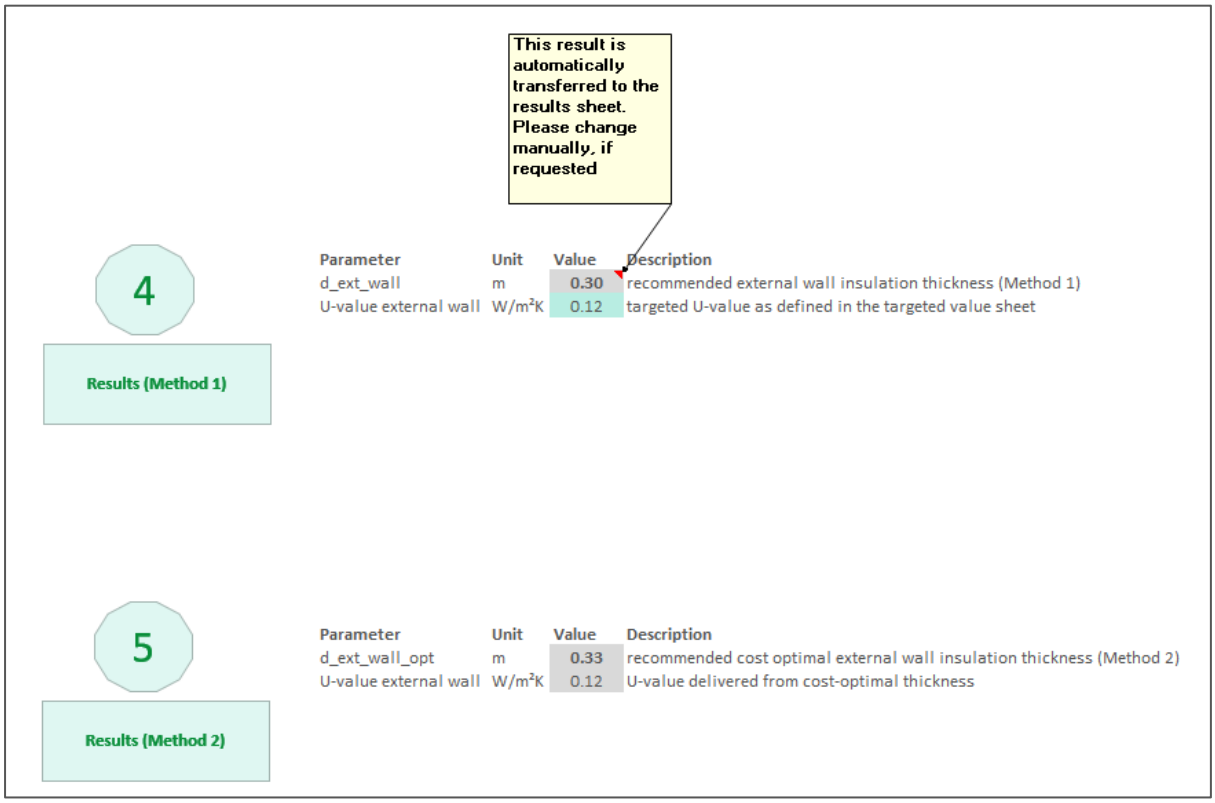



Figure 11: Calculation spread sheet "external wall" – results data

The Figure 12 below shows the spread sheet for estimating the solar energy production with PV cells. The calculation is based on the German Standard DIN 18599-9[4] .

| Parameter | Unit | Value | Description |
|---|---|---|---|
| PV surface area | m2 | 50 | By default 50% of roof area |
| Esol | kWh/m2yr | 1217 | annual irradiation energy |
| PV cell orientation | | South | |
| PV cell inclination | degree | 35 | |
| PV cell type | | monocrystalline silicon | |
| PV installation type | | moderated ventilation | |
| fperf | - | 0.75 | system performance factor (also from table B1) |
| Iref | kW/m2 | 1 | reference solar irradiation intensity |
| KpK | kW/m2 | 0.135 | peak capacity (area specific) - (also from Table B2) |
| Ppk | kW | 6.75 | peak capacity (PV Standard Test) |
| **Energy_production_PV** | **kWh** | **6161** | yearly netto PV electric energy production |

Figure 12: Calculation spread sheet "PV production"

## Results: enhanced recommendations

The results are presented in the following tabs:

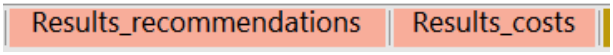



Figure 13: Spread sheet for building input data

The "sheet results recommendations" contain measure-by-measure recommendations:

1) Building category

[4] (DIN Norm, 2018)

2) Building element/component
3) Criteria check
4) Need of recommendation
5) Short explanation
6) In some cases, also quantitative recommendations are provided, including energy savings
7) Co-benefits (non-energetic benefits for the measures)
8) Short explanation about the benefits of each measure

It is also suggested to perform a new calculation of the energy performance (taking into account all measures) by making use of the national EPC software used by the EPC assessor. Then document the savings in the field:

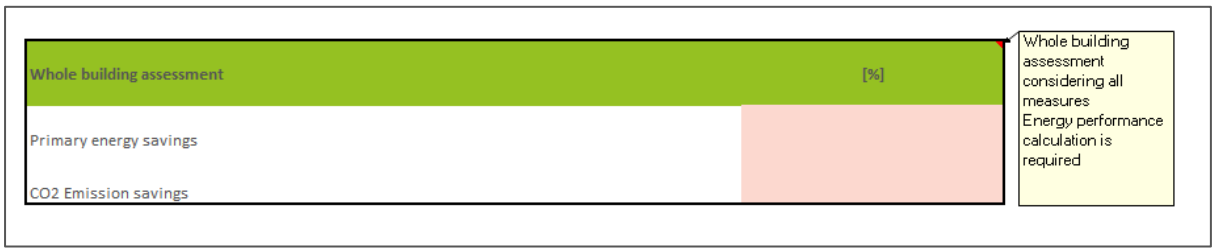



Figure 14: Whole building assessment

The "sheet results costs" contains measure-by-measure costs estimation – material, labor, business profit and general expenditure) and VAT fees.

Here, the user can enter the values or use the suggested defaults one.

| Building category | Building element/component | Recommendation (Yes/No) | Unit | Material costs [Euro] | Labor costs [%] | Business profit and general expenditure [%] | Total costs | VAT Fees (%) | Total |
|---|---|---|---|---|---|---|---|---|---|
| Building envelope | External wall | Yes | m | 26,691.20 | 0.15 | 0.10 | 29,360.48 | 0.19 | 34,938.98 |
| Building envelope | Floor or cellar ceiling | Yes | m | 8,900.07 | 0.15 | 0.10 | 9,790.25 | 0.19 | 11,650.39 |
| Building envelope | Roof or upper ground ceiling | Yes | m | 8,641.24 | 0.15 | 0.10 | 9,505.52 | 0.19 | 11,311.57 |

Figure 15: Measure-by-measure cost assessment

## Automatized XML file data extraction

### Introduction

This tool serves to analyse the structure of XML files representing building EPC data as well as to extract data from it and export the extracted details into the calculation spreadsheet. This exercise is performed specifically for the XML EPC scheme of the Danish partner. Any other different XML file (for example, from other country or that has a different tree structure) would require an adaptation of the programming code.

### Programme code information

The main idea of this tool is to allow the user to define custom queries and query options that the program will consider during the XML processing. The content of the XML tags matching the specified queries will be extracted and exported into spreadsheet.

### What computations are performed?

Stemming from the nature of the tool, the main objective of the software is purely to extract data from existing XML files. However, aggregate operations are supported in the export phase of the processing. This means the script can aggregate the extracted data to facilitate the interpretation of the generated spreadsheets without modifying the XML file.

### How to run the code?

The code can be run using Python 3.8 and a command-line interface. The available arguments are specified on the homepage of the repository. Please proceed to the next section to locate the project and its documentation.

### Where is the code hosted?

The permanent repository for the code presented here may be found at:

https://eeg.tuwien.ac.at/gitlab/gyarmati/x-tendo-f8-xml-processing

Detailed description of the tool's usage can be found at:

https://eeg.tuwien.ac.at/gitlab/gyarmati/x-tendo-f8-xml-processing/-/blob/master/README.md

## Possible Q&A during the testing

Question 1:

If the same building element (for example: external wall) has different U-values. Which one should be used?

A: Here you can 1) use the U-value of material with the highest share or 2) provide a weighted U-value (representative for the whole building element).

Question 2:

If the same building element has different U-values and respective surface area. Which surface area should be used?

A: The surface area of this building element should be the sum of all areas.

Question 3:

If the building elements layers cannot not be specified in the EPC scheme. Is it really necessary to provide each building element layer?

A: Use standardised constructions. Please verify if there are building construction databases. The project EPISCOPE provides exemplary building typologies. https://episcope.eu/welcome/

# REFERENCES

DIN Norm, 2018. DIN V 18599-9 | 2018-09 Energetische Bewertung von Gebäuden - Berechnung des Nutz-, End- und Primärenergiebedarfs für Heizung, Kühlung, Lüftung, Trinkwarmwasser und Beleuchtung - Teil 9: End- und Primärenergiebedarf von stromproduzierenden Anlagen [WWW Document]. Baunormenlexikon.de. URL https://www.baunormenlexikon.de/ (accessed 4.19.21).

ÖNORM B 8110-4:2011 07 15 - Lesesaal - Austrian Standards [WWW Document], 2011. URL https://lesesaal.austrian-standards.at/action/de/private/details/396775/OENORM_B_8110-4_2011_07_15 (accessed 4.6.21).

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