
DELIVERABLE D6.3:

APPLICATION OF THE METHODOLOGY AND TOOL

DELIVERABLE VERSION:	D6.3, v.1.0
DOCUMENT IDENTIFIER:	NewTREND_WP6_D6.3_Application_of_the_Methodology_and_Tool_V0830_MASTE R (1).docx
PREPARATION DATE:	August 30, 2018
NATURE OF DOCUMENT:	Report
DOCUMENT STATUS:	Final
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DISSEMINATION LEVEL:	CO - Confidential, only for members of the consortium (including the Commission Services)



DELIVERABLE SUMMARY SHEET

DELIVERABLE DETAILS

TYPE OF DOCUMENT:	Deliverable
DOCUMENT REFERENCE #:	D6.3
TITLE:	Application of the Methodology and Tool
VERSION NUMBER:	1.0
PREPARATION DATE:	August 30, 2018
DELIVERY DATE:	August 31, 2018
AUTHOR(S):	Tobias Maile, Melinda Orova, Dimitrios Ntimos, Davor Stjelja, Rosemarie MacSweeney, Marco Barbagelata, Pau Asens and Elena Bazzan
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DOCUMENT IDENTIFIER:	NewTREND_WP6_D6.3_Application_of_the_Methodology_and_Tool_V0830_MASTER (1).docx
DOCUMENT STATUS:	Final
DISSEMINATION LEVEL:	CO - Confidential, only for members of the consortium (including the Commission Services)
NATURE OF DOCUMENT:	Report

PROJECT DETAILS

PROJECT ACRONYM:	NewTREND
PROJECT TITLE:	NEW integrated methodology and Tools for Retrofit design towards a next generation of ENergy efficient and sustainable buildings and Districts
PROJECT NUMBER:	680474
CALL THEME:	EeB-05-2015: Innovative design tools for refurbishing of buildings at district level
PROJECT COORDINATOR:	01. IES – Integrated Environmental Solutions Limited – United Kingdom
PARTICIPATING PARTNERS:	01. IES – Integrated Environmental Solutions Limited – United Kingdom 02. ABUD – ABUD Mernokiroda KFT – Hungary 03. JER – Uli Jakob – Germany 04. iiSBE IT R&D – International Initiative for a Sustainable Built Environment Italia Research and Development srl – Italy 05. REGENERA – Regenera Levante SL – Spain 06. GO – Granlund Oy – Finland 07. UCC – University College Cork, National University of Ireland, Cork – Ireland 08. NUID UCD – University College Dublin, National University of Ireland, Dublin – Ireland 09. MUAS – Hochschule fur angewandte Wissenschaften Munchen – Germany 10. LBS – London Business School – United Kingdom 11. STAM – Stam srl – Italy

	12. Sant Cugat – Ajuntament de Sant Cugat del Valles – Spain
	13. UNIVPM – Università Politecnica delle Marche – Italy
FUNDING SCHEME:	Innovation Action
CONTRACT START DATE:	September 1, 2015
DURATION:	36 Months
PROJECT WEBSITE	www.NewTREND-project.eu
ADDRESS:	

DELIVERABLE D6.3: SHORT DESCRIPTION

This deliverable presents the results of Task 6.3 “Application of the methodology and tool”, Task 6.4 “Evaluation and upgrade of the methodology and tools”, and Task 6.5 “Monitoring and follow-up”. This deliverable first describes the application of the methodology and tools on three demo sites. Based on this application, it details the evaluation of the methodology and tools and reports on performed upgrades of the tools as well as discusses possible future enhancements. Finally, the report entails monitoring results and follow-up of the demo sites as possible given the demo site schedules and the project timeframe.

Keywords: Testing, Application, BIM, DIM, CDP, Data Manager, Testing Templates

DELIVERABLE D6.3: REVISION HISTORY

VERSION:	DATE:	STATUS:	AUTHOR:	COMMENTS:
0.2	23/01/2018	Initial Outline	ABUD	
0.5	8/8/2018	Initial Draft	UCD	Chapters 1-5
0.7	8/20/2018	Next draft	UCD	Chapters 1-5 & 7

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ABBREVIATIONS AND ACRONYMS

ACRONYM	DEFINITION
BIM	Building Information Model
CDP	Collaborative Design Platform; NewTREND web tool with user interface
DIM	District Information Model
DM	Data Manager
EeB	Energy-efficient buildings
GA	Grant Agreement
GUI	Graphical User Interface
LAT	Local Advisory Team
NewTREND	NEW integrated methodology and Tools for Retrofit design towards a next generation of ENergy efficient and sustainable buildings and Districts
WP	Work Package

EXECUTIVE SUMMARY

This deliverable presents the results of Task 6.3 “Application of the methodology and tool”, Task 6.4 “Evaluation and upgrade of the methodology and tools”, and Task 6.5 “Monitoring and follow-up”. We first describe the application of the NewTREND methodology and tools for three demo sites. Based on these applications, we detail the evaluation of the methodology, tools and reports on upgrades of the tools as well as discussing possible future enhancements. Finally, the report reviews monitoring results and follow-up for each of the demo sites, accounting for site schedules and respective project timeframes.

This deliverable is based on the methodology developed in WP2 “Development of the NewTREND design methodology”, the software platform developed in WP3 “Life-cycle collaborative design platform” in combination with the Simulation & Design Hub developed in WP4 “Simulation & Design Hub” as well as the financial instruments developed in WP5 “Innovative financial instruments and business models”.

Applying the NewTREND methodology at the demonstration sites provides many advantages and benefits for the project. Demonstration sites help validate the methodology and tools and give valuable feedback to previous tasks and deliverables, provide integrated project delivery methodology and help market dissemination. The NewTrend project as a whole generated a number of key findings with respect to retrofitting in general and retrofitting using the NewTREND methodology, platform and toolset. While most feedback focused on the GUI of the various tools, feedback also indicated that the main concept and core features of the methodology and tools were well received by users and were useful when applied at the demo sites. Testing of the NewTREND methodology and tools revealed a number of key outcomes:

- The project made important steps toward defining how BIM and CityGML models should be made to be suitable for dynamic energy simulation software. The modular nature of the DIM server and API facilitated a range of stakeholder interactions through standardised and cloud-based data management;
- The data manager is a worthwhile interface for creation and manipulation of simulation information at the district scale. Future functionality that automates data upload (e.g.: excel upload) would further enhance usability of the tool;
- The section of the methodology that focuses decision making for retrofitting interventions is intuitive and the design of NewTREND platform aligns with the steps outlined.

The demo projects were delayed so only a subset of post retrofit activities were realized. However, a number of lessons were distilled from suitable NewTREND retrofit activities:

- Early involvement of key stakeholders, especially occupants, is important for the project process and dramatically fosters acceptance of retrofit projects. This also pre-empts later occupant complaints and possible project delays due to occupant resistance or a range of other stakeholder issues;
- Further and deeper interaction with users is necessary so as to ensure that users better understand the new technologies in their building throughout operation. It is also incumbent on methodology and software systems designers to consider the usability and accessibility of features to the end user;
- A large variety of monitoring tools are available in the demo buildings and if they are used purposefully they can be used to keep up the increased building efficiency and comfort. Both methodologies and software systems should be flexible enough to access and include this diverse range of present and future tools;

1. INTRODUCTION

This report presents the results of Task 6.3 “Application of the methodology and tool”, Task 6.4 “Evaluation and upgrade of the methodology and tools”, and Task 6.5 “Monitoring and follow-up”. Within the context of the developed new collaborative design methodology and tools, this report summarizes the application of methodology and tools based on three demo sites. The integrated design methodology detailed in deliverable D2.6 (Paul Mittermeier, Ahmed Khoja 2017) describes a project workflow given different scenarios such as level of detail and design phases. In addition, the three different modes: basic, advanced and premium mode cover typical use cases. The characteristics of the three demo sites are outlined in deliverable D6.1 (ABUD, STAM, UNIVPM, Regenera, Sant Cugat, GO, UCD 2018) which includes further background on the demo site projects. A key aspect of the new collaborative design methodology is the engagement with stakeholders, specifically the occupants, which we elaborate specifically in section 7.3, but more detail can be found in deliverable D6.2 (Mac Sweeney et al 2018).

To evaluate, verify and upgrade the methodology and tools, we developed a set of feedback templates to collect input of stakeholders using the methodology and tools. The development of the feedback templates was done looking at fundamental aspects of each facet of the methodology and the related platform tools. We identified and defined process indicators that could provide relevant information for each step of the process. For this purpose, we designed the “Testing Feedback Templates (TFT)” to collect qualitative and graphic feedback about all relevant tools of the platform: the Data Manager (DM) and the Collaborative Design Platform (CDP). The DIM server as the data container and was tested through standard internal software testing and through the systematic tests of the DM and CDP. Furthermore, the TFTs collect feedback on aspects of the platform processes such as user interface design, functional aspects of the tools as well as possible improvements.

These Feedback Templates were developed by iiSBE Italia, the project partner selected for this task due to their “impartial” role in this field. iiSBE acts as an independent evaluator since it is neither involved in a demo site nor in the implementation and development of the NewTREND software. This guarantees objectivity for the assessment of the platform as well as to the results and outcomes of the project. Consequently, this approach fosters the independence of the evaluation and ensures that the tool platform is widely applicable beyond the specifics of the three demo site projects.

The results of the TFTs have been analyzed in depth and they have facilitated improvements to the NewTREND Platform both from a technical and practical point of view.

Since WP6 “Demonstration and validation” includes not only the evaluation of the tool platform, but also the evaluation of the “Integrated Retrofit Design Methodology” (developed in Task 2.6), we also developed “Feedback Tables for the IDM Process (FTIP)”. These include all related aspects within each phase of the methodology and how those functions as implemented within the NewTREND Platform.

The main objective is to evaluate whether the procedure developed for the IDM in WP2 was followed by the three case studies and if the logical sequence of the actions was correct or if some aspects were missing. Understanding the direct connection between the IDM Process and the NewTREND Platform through the implemented features was particularly important. To assess this objective, we used the FTIP to collect feedback from project partners about the integration of features within the platform compared to their specific phases in the IDM.

Within this deliverable, a short section has been devoted to the Detailed Surveys, created to support the developer team when upgrading the NewTREND tools to address specific actions at the design stage.

These surveys have been distributed during the LAT meetings to get feedback from the stakeholders about the operation of the NewTREND platform.

These testing templates were used in the context of all three demo sites, to evaluate and assess the NewTREND platform within the NewTREND project timeframe as well as the demo site project timelines. Due to typical time delays on the three demo sites and unforeseen events, it was not possible to apply the methodology and tools for all three demo sites through a full retrofit project cycle. Particularly, post-retrofit monitoring was only available at the Hungarian demo site in terms of acoustic measurements.

This report first describes the application of the methodology and tools on three demo sites (chapter 1 – 6). Based on this application, it details the evaluation of the methodology and tools and reports on performed upgrades of the tools as well as discusses possible future enhancements (chapter 7 and 8). Finally, the report describes monitoring results and follow-up of the demo sites where possible; given the demo site schedules and the project timeframe (chapter 9), this was not completed across all sites. In chapter 10 we conclude with a discussion on the findings of the application of the methodology and tools based on the experience of the three demo sites.

This deliverable comprises 9 chapters, which start with a brief introduction as well as an overview of the demo sites. In chapter 2, data gathering and model creation of all three demo sites are described and different workflows for generating a BIM and district model are detailed. Chapter 3 describes the backbone of the software toolkit provided by Newtrend, the District Information Model (DIM) server and its testing. Chapter 4 provides details on the testing of the Data Manager including a discussion of user feedback. Chapter 5 summarizes the Collaborative Design Platform (CDP) testing including a discussion of user feedback. Chapter 6 details the Integrated Design Methodology (IDM) testing in detail for each of the three demo sites. Chapter 7 reports on the testing and evaluation of the IDM application detailed in chapter 6. Chapter 7 also discusses upgrades that emerged from the user feedback and highlights which upgrades have already been performed in context of the project as well as provides an overview of possible future upgrades to the NewTREND platform. Chapter 8 describes the monitoring and follow-up for each of the three demo sites. Chapter 9 concludes with the findings from the use of the methodology and tools based on the experience of the three demo sites.

2. DEMO SITE MODEL GENERATION

In this chapter we provide an overview of the demo sites and describe the workflows of the demo sites to generate building (BIM) and district level models that are the basis of the NewTREND platform.

2.1. DEMO SITES OVERVIEW

The demonstration sites were tangible demonstration projects that benefit from participating in the NewTREND project. Access to the online interface helped each demonstration site to optimize design and facilitate stakeholder involvement. Through the NewTREND toolset, “as-is” simulations help to evaluate the districts’ and buildings’ current state. Design variations allowed for analysis of different retrofitting options and helped facilitate decision-making processes.

Demonstration sites also had to undertake some tasks for the validation of the methodology and providing feedback. Demonstration site owners had to collect all the relevant information on the existing districts and buildings to be renovated by applying the new approach and support tools proposed, BIM and CityGML models for the simulations had to be prepared. Installation of measuring and monitoring instruments had to be ensured. Demonstration site owners had to engage with all the relevant stakeholders involved in each pilot project, including occupants and decision-makers to promote participative project management. The new design methodology, platform and tools had to be applied in the real project design phases. The impacts of the new design approach had to be evaluated according to the indicators. After completion of each retrofitting exercise, post-retrofitting control had to be undertaken through monitoring the occupants’ behavior and performance of retrofitted buildings, by providing post-retrofit measurements or audits based on the behavior of building users and the observation of performance indicators.

The detailed descriptions of the NewTREND demonstration sites can be found in the Deliverable 6.1. Characterization of the Buildings Involved in the Pilot (Evaluation and Data Collection). This section provides an overview and update of what has been reported in Deliverable 6.1 (ABUD, STAM, UNIVPM, Regenera, Sant Cugat, GO, UCD 2018).

NewTREND project has altogether six demonstration sites, in three different countries.

- Old hospital area in Seinäjoki, Finland – as district and building level case studies
- 35 rented apartments in Sant Cugat, Spain – as building level case study
- Pins del Valles School in Sant Cugat, Spain – as district and building level case studies
- 2 private houses in Les Planes, Spain – as building level case studies
- Bókay Garden in Budapest, Hungary – as district level case study
- Bókay School in Budapest, Hungary – as building level case study

2.1.1. OLD HOSPITAL AREA IN SEINÄJOKI

The old hospital area was originally constructed to be the provincial hospital at 1931. The hospital moved to the new central hospital at halfway of 1980’s. The area consists of four buildings as shown in Figure 1: Main building (Figure 2), Dental clinic & office building, Heat Distribution building and Kivirikko House. Nowadays, the buildings are occupied by three main tenants: Seinäjoki University of Applied Sciences (SeAMK), Music School of Southern Ostrobothnia and Dental Clinic.



FIGURE 1: DISTRICT LEVEL DEMONSTRATION SITE – OLD HOSPITAL AREA IN SEINÄJOKI, FINLAND



FIGURE 2: BUILDING LEVEL DEMONSTRATION SITE – MAIN BUILDING IN SEINÄJOKI, FINLAND

2.1.2. 35 RENTED APARTMENTS IN SANT CUGAT

The first demo building in Spain is an apartment building with 35 apartments for youth people (Figure 3).. This demo site is located in the Can Trabal neighbourhood, nearby the Golf Club and Collserola Natural Park. This demo site consists of three connected buildings by two stairways. Each block has a ground floor and two additional floors. Parking is located in the basement of one of the blocks. To overcome unevenness of the street, every block has a different ground level. The structure of the building has been built with the system Tecon (light metall structure with insulation) and wrought plate working. The building incorporates water recycling systems and solar thermal energy. It also incorporates centralized production energy for heating and hot water (DHW) with individual metering.



FIGURE 3: BUILDING LEVEL DEMONSTRATION SITE – 35 RENTED APARTMENTS IN SANT CUGAT, SPAIN

2.1.3. PINS DEL VALLES SCHOOL IN SANT CUGAT

The second demo site in Spain is the Pins del Vallès School (State School) is shown in Figure 4. The school is in an isolated and opened area of the city. The school's buildings are in a secluded sector, surrounded by green areas and sports facilities. The area where the school is located is very airy and sunny. Pins del Vallès school consists of four buildings (Primary School Building, Administration Building, Sport Pavilion, Kindergarten Building).



FIGURE 4: DISTRICT AND BUILDING LEVEL DEMONSTRATION SITE – PINS DEL VALLES SCHOOL IN SANT CUGAT, SPAIN

2.1.4. 2 PRIVATE HOUSES IN LES PLANES

The third demo site in Spain consists of 2 private houses in the Les Planes neighborhood as illustrated in Figure 5. This neighborhood is located in the south of Sant Cugat municipality, surrounded by Collserola Natural Park, in a forest area. Most of the houses are single-family houses. This neighborhood has a low social and economic level.



FIGURE 5: BUILDING LEVEL DEMONSTRATION SITE – 2 PRIVATE HOUSES IN LES PLANES, SPAIN

2.1.5. BÓKAY GARDEN IN BUDAPEST

The Bókay Garden, one of the district's public parks, is one of the largest and most significant green areas in the district (Figure 6). The garden is used as a multifunctional public park, it is a recreational / leisure centre. The 16-hectare garden serves as a community venue and provides many different sports facilities for residents. There is a "four-season" ski slope, a beach and indoor swimming pool, garden cinema, gym, football, basketball and tennis courts, as well as the Bókay Adventure Park in the park.



FIGURE 6: DISTRICT LEVEL DEMONSTRATION SITE – BÓKAY GARDEN IN BUDAPEST, HUNGARY

2.1.6. BÓKAY SCHOOL IN BUDAPEST

The school building (Figure 7) can be found in the 18th district of Budapest, a few blocks away from Bókay Garden. Originally the building of the primary school building was a two-story building, in the 1980s a 3rd floor was built on top with a steeper pitched roof structure. The building has brick walls. The original exterior wall structure (ground floor + 1st floor walls) is a 70 cm thick traditional solid wall structure with small-sized brick wall. The extension (2nd floor) has narrower exterior walls: 30 cm (towards inner courtyard) and 45 cm thick (street facade).



FIGURE 7: BUILDING LEVEL DEMONSTRATION SITE – BÓKAY SCHOOL IN BUDAPEST, HUNGARY

The detailed description of the demonstration sites' retrofitting activities can be found in Section 8.1.5.

For the demo sites application of the NewTREND methodology, BIM models are necessary. Building information modelling (BIM) is a process involving the generation and management of digital representations of physical and functional characteristics of buildings. Since BIM is becoming widespread in architectural design and in the construction industry, it was expected that the demonstration site owners would generate an appropriate BIM to provide sufficient data to IES VE simulations. The following sections describe the various workflows including the workflow from laser scanning through creating a BIM to exporting the building data in IFC format. An overview of these workflows can be found in Figure 8.

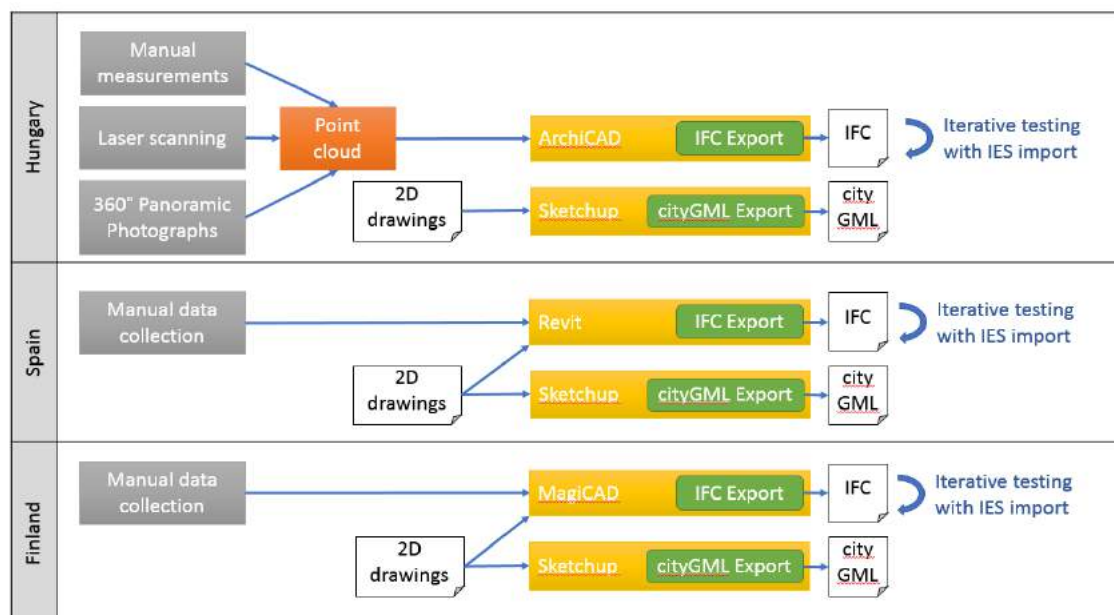


FIGURE 8: OVERVIEW OF WORKFLOW OF THE THREE DEMO SITES

2.2. CREATING BIM THROUGH LASER SCANNING

The Hungarian demo site used laser scanning to generate a BIM. The process is detailed in the following sections.

2.2.1. LASER SCANNING AND POINT CLOUDS - INTRODUCTION

THREE-DIMENSIONAL RECORDING

Several techniques are available to collect three-dimensional survey information. The most common method is manual measurement, which is used to gather data of smaller and simple buildings. For large and complex buildings or districts, photogrammetry and laser scanning are more suitable since they can collect large amounts of data quickly. Both processes might be undertaken on the ground or in the air, depending on the requirements and the size of the covered area. Usually, these techniques are supplemented and controlled with geodetic measurements to position the measured object in the global coordinate system. Each of the methods has its own advantages and disadvantages, therefore in most of the cases, different combinations of these survey methodologies are used.

LASER SCANNING

Laser scanner is “any device that collects 3D co-ordinates of a given region of an object’s surface automatically and in a systematic pattern at a high rate achieving the results in near real-time” (W. Böhler and A. Marbs 2002). The laser scanning process can be deployed from a static position or from a moving platform on the ground or in the air. Laser scanning is still regarded as a high-cost technique, however given its high accuracy and quick application, it can provide high value to buildings where the required information may not be available through other means or would involve a high manual and/or time intensive data collection.

POINT CLOUDS

The result of the laser scanning process is the point cloud, which is a collection of XYZ co-ordinates in a common co-ordinate system. The point cloud can include additional semantic information, such as color values or thermal data. An example of a point cloud view from the courtyard is shown in Figure 9.



FIGURE 9: BÓKAY SCHOOL POINT CLOUD - VIEW FROM THE COURTYARD

2.2.2. BUDAPEST DEMO SITE LASER SCANNING

The demo building – Bókay Árpád Primary School – is located in Budapest's 18th district. The neighbourhood is a suburban area, mostly with one- and two-storey detached houses. The building is a three-storey-building, with attic and partial basement, a total of 2200 m².

The primary aim of the laser scanning was to generate a 3D model for the NewTREND simulation. Laser scanning was selected because it was considered as the most effective method for documenting the building. It enabled fast data collection and comprehensive coverage while providing the required accuracy and resolution.

INSTRUMENTS AND SOFTWARE:

- Leica C10 laser scanner: time-of-flight laser scanner, to provide 3D record of the building and its surroundings
- Geomax Zenith 20: complete and fully integrated GNSS receiver, to provide reliable positioning
- Canon EOS 1200D camera: to produce 360-degree panoramic images for each scan position to color the point cloud data
- Leica Cyclone: to process the laser scan data and to assemble the point clouds
- CloudCompare: to reduce the size of the point cloud file
- ArchiCAD: CAD software, to create the BIM.

ON-SITE LASER SCANNING

The contractor surveyed the building internally and externally including its surroundings using a time-of-flight, Leica C10 laser scanner.

The laser scanning went smoothly at the primary school, since it was performed during the autumn holiday when the building was empty and occupants did not cause any disruption.



FIGURE 10: BÓKAY SCHOOL POINT CLOUD - VIEW FROM THE STREET

Externally, the whole façade was recorded. The building is placed on a corner lot, bounded by urban roads from two sides and by a courtyard from the other two. The building was relatively easy to capture from a series of scan set-ups on all sides since the streets and courtyard are wide enough to have appropriate measuring angles and distances from the walls. The individual scanner set-ups were decided after an initial site inspection, to ensure complete coverage and a high degree of overlap of each scan. All scan positions were tied into control points to provide reliable alignment of the separate point clouds in a common co-ordinate system. Figure 10 shows the point cloud view from the street.

The school building is surrounded by trees, but the laser scanning was carried out in November, therefore the tree canopy was not blocking the view. Laser scanners can measure through leaves, but dense vegetation is an obstacle; it is recommended to collect data when trees are bare, and the canopy is not hindering the sight (English Heritage 2011).

The building was constructed in 1903, so typically for the period, some ornaments can be found on the façade, but these details were not important to record in high resolution, since the point cloud is not used for heritage protection purposes, but rather, only for the BIM and energy simulations.



FIGURE 11: BÓKAY SCHOOL POINT CLOUD - INTERIOR VIEW

Internally, the entire ground floor was recorded. During the interior laser scanning furniture and small objects were not moved away from the walls, and curtains were not removed from the windows, which caused many difficulties during the modelling as the exact measurements were difficult to calculate. These scanned objects significantly increased the number of points in the model, which was already critical during the architectural modelling process. It would be recommended for future projects, when using laser scanning, to remove distributed elements where possible. For illustration purposes, Figure 11 shows an interior view from the point cloud.

GEODESY

It is necessary to couple laser scanning with GNSS to measure the exact positions. Geomax Zenith 20, a complete and fully integrated GNSS receiver was used to provide reliable positioning. The established survey control network was tied to the EOVS (Egységes Országos Vetület – Hungarian Unified National

Projection System). All data was registered to this co-ordinate system to bring together the various metric survey datasets.

360-DEGREE PANORAMIC PHOTOGRAPHS

The laser scan survey was supported by a photographic survey. At each scanner set-up, 360-degree color photographs were taken with an external Canon EOS 1200D camera, to color the point cloud data later. This was done by extracting the RGB color codes from the photograph and matching them with the appropriate point in the point cloud (i.e. the XYZ coordinates are supplemented with RGB color codes). This helps later in the modelling of the building, as elements and details are much easier recognizable on a colored point cloud, thus facilitating the modelling work.

For precise vertical alignment, the camera was positioned directly above the scanner head, on purpose-built mounts. The process required that photographs were taken in the best lighting conditions so as to avoid shadows on the data. Similarly, the 'leaf off' condition is preferable when taking the 360-degree panoramic photographs. Additional high-resolution images were taken to aid ArchiCAD drafting from the point clouds in the office.



FIGURE 12: BÓKAY SCHOOL – EXAMPLE OF A 360-DEGREE PANORAMIC PHOTOGRAPH

The panorama photos (like in Figure 12) can be used for a virtual walk-through tour. Information can be assigned to each panorama photo, so the building might be explored on the web interface.

OTHER MEASURING METHODS USED ON THE DEMO SITE

Due to financial considerations, only the ground floor was recorded by the laser scanner. Additional measurements were necessary to survey the first and second floors and the basement. Tape measure and manual laser distance meter were used to supplement the laser scanning data.

2.2.3. FROM POINT CLOUD TO BIM

POINT CLOUD REGISTRATION

The point cloud registration was undertaken by the same contractor that conducted the laser scanning since it requires dedicated software and experience. Leica Cyclone software was used to import and process the laser scan data. Noise, outliers and irrelevant points were cleaned off the point cloud. To

assemble the point clouds recorded from the external set-ups, the control points were co-ordinated. The internal scans were aligned visually without any reference points. RGB codes from the 360-degree panoramic photos were attached to the 3D co-ordinates. In total, more than 300 million data points were collected. The result was a complete, fully registered colored point cloud of the building and its surroundings, delivered in PTS Leica format.

IMPORTING THE POINT CLOUD TO CAD SOFTWARE

Difficulties were encountered in the smooth transition of large volumes of data between different platforms and different formats. Mainstream software tools for 3D modelling are not originally designed to handle the large datasets generated by laser scanning. In our case, a 3D point cloud processing software, CloudCompare was used to convert the point cloud from PTS to E57 format, which is a supported file format in the architectural modelling software, ArchiCAD. Still, the size of the laser-scan dataset caused some difficulties. By using CloudCompare to handle this dataset, the file size could be reduced: the external environment of the school was cut down, and the point density was reduced. Using this approach, the point cloud could be imported into the CAD software as shown in Figure 13.



FIGURE 13: BÓKAY SCHOOL - POINT CLOUD IN THE CAD SOFTWARE

PREPARING BIM

The general process required to convert the collected point cloud information into a more useful product for modelling is now encountered. The BIM was generated using the architectural modelling software, ArchiCAD 20, as this tool can handle point clouds, is a widely known architectural modelling software and our team was experienced in its use. Figure 14 shows a section through the completed BIM model.



FIGURE 14: BÓKAY SCHOOL - BIM SECTION

After importing the point cloud, preparation of the design documentation and modelling did not pose any major problems. The laser scanning not only facilitated on-site data collection, but also enabled office data processing. Longitudinal and angular inaccuracies were reduced so allowing precise technical drawings to be made more quickly. The point cloud clearly indicated the different wall structures, windows and doors. For hard-to-reach places (e.g. ceiling, roof structure), it also provided accurate information and helped to draft structures that cannot be measured in conventional ways. Another advantage of the point cloud was that it stored all the spatial data of the objects, so without any follow-up on-site measurements, it was still a good basis for a subsequent reconstruction or further design.

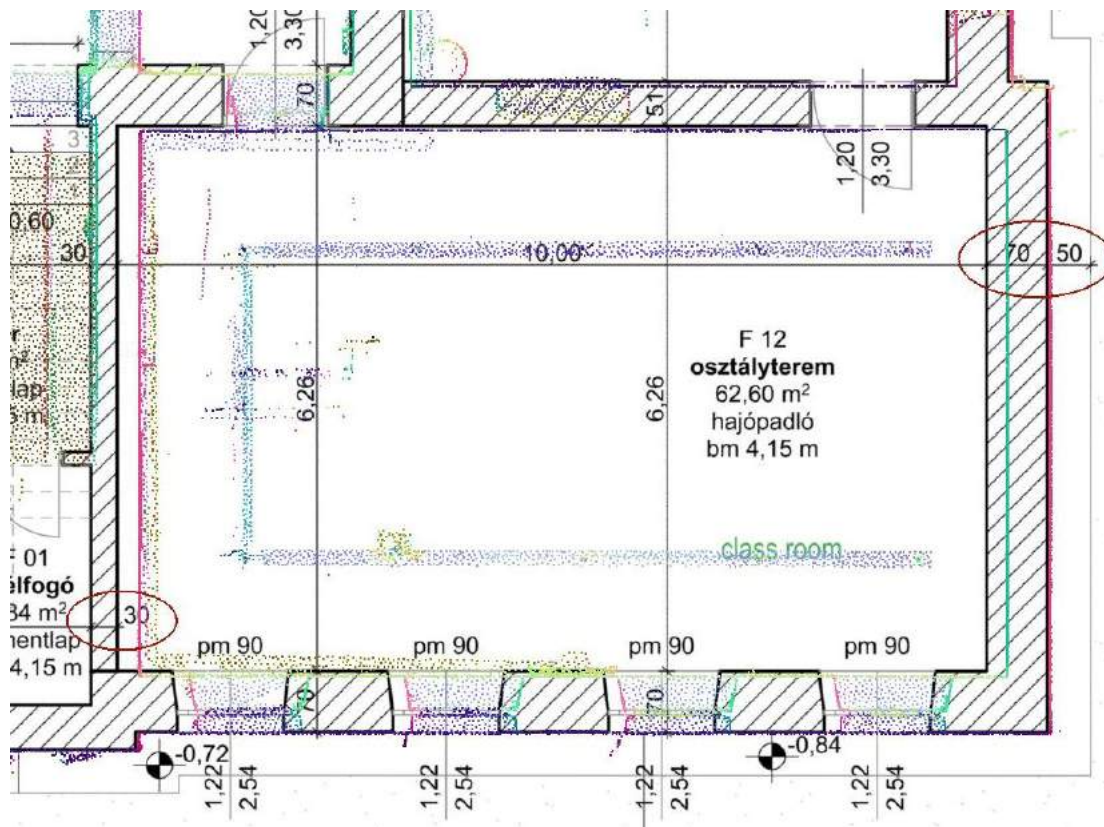


FIGURE 15: BÓKAY SCHOOL - COMPARISION OF MANUAL MEASUREMENT AND LASER SCANNING

Using ready-made design documentation, which was based on a traditional manual survey, a comparison could be made with the point cloud. This revealed significant differences. In some cases, the sections and details resulting from the two techniques were completely different, with inaccuracy in the manual measurements of up to 20-30 cm. Figure 15 shows some of these inaccuracies between the two different methods.

Apart from the many benefits of the technology, we faced some difficulties during the drafting. The inside of the building was not completely scanned, so manual measurements were needed to determine the missing dimensions. In some cases, certain architectural details were difficult to determine from the scan, particularly in areas where scan density was reduced. In these cases, we used high-resolution digital images to aid drafting of features. As mentioned earlier, during interior laser scanning furniture was not moved away from the walls, and curtains were not removed from the windows, so the exact measurements were more difficult to define. Further disadvantages of the laser scanning technology included the additional cost compare to traditional processes. This is due to the purchase / rental of the laser scanner, as well as the specialised hardware and special software requirements. Finally, the workflow of the survey required more complex professional skills and thorough preparation (e.g. the visibility of the tie points must be planned in advance), time and resources are needed to train and gain experiences in the new technology.

During the recording of the building, the laser scanner provided the expected result: the time span was reduced, and the precision and accuracy improved considerably. Based on the acquired knowledge and experience, we believe that this methodology can be applied more cost-effectively in further retrofitting projects. The final BIM model external courtyard view is shown in Figure 16.



FIGURE 16: BÓKAY SCHOOL - FINAL BIM

2.3. CREATING BIM THROUGH 2D DRAWINGS

A more traditional process to create BIMs for existing buildings is to import existing 2D drawings into CAD software and add a third dimension as well as object related data to it. The demo sites in Spain and in Finland used this process to generate the BIMs using Revit and MagiCAD.

2.3.1. FINLAND DEMO SITE BIM CREATION

The 4 BIMs (1 in advanced model and 3 in basic mode) for the buildings at the Finnish pilot site were created with the MagiCAD Room software. With this software tool one can create technical 3D models of buildings by referencing an architectural drawing file and drawing walls on top of the drawing. The construction materials and their thermal properties are defined later in the simulation software; thus, it was not necessary to consider all the thermal properties while creating the models. However, the thickness of building elements were an important factor for creating a consistent building model in 3D. In addition to modelling of external walls and slabs, windows and doors were added according to the drawings. These have been complemented with balconies and shelters.

In addition to adding components of the exterior envelope, interior walls were modelled to enable definitions of rooms. This was done by referencing the architectural drawings and creating walls on top of the reference. As none of the floors in this building are identical and the building has interior walls of multiple different thicknesses, this was a time-consuming task. The interior of the third floor is presented in Figure 17.

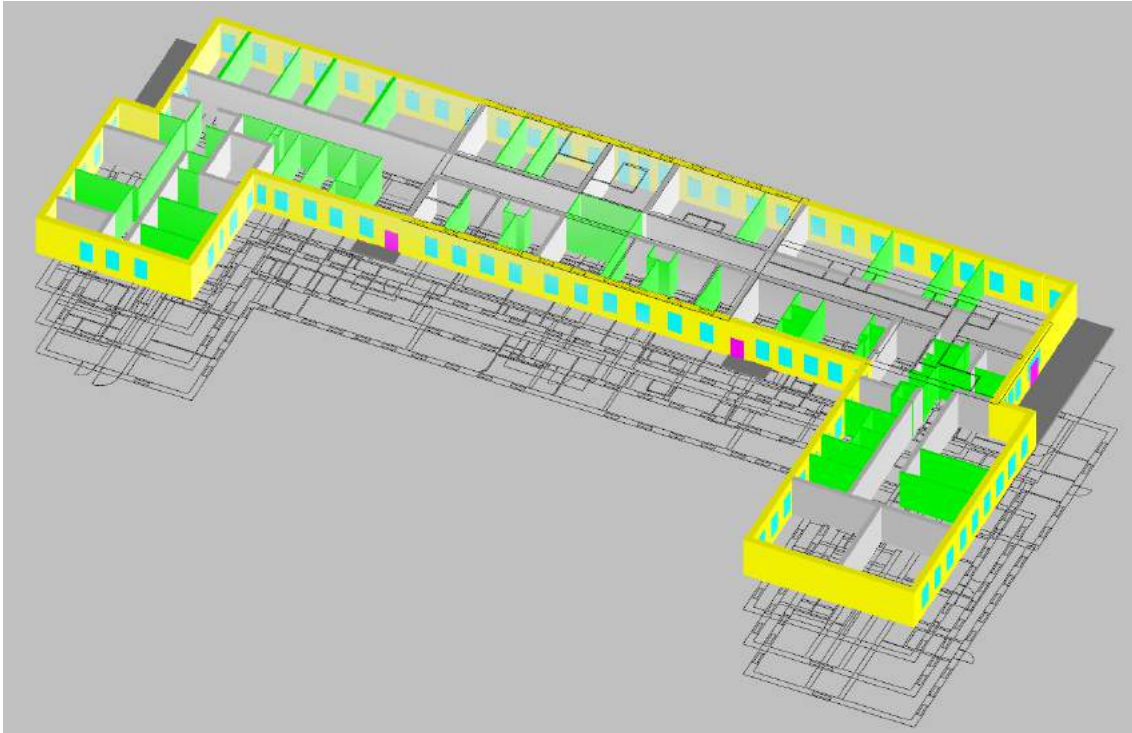


FIGURE 17: THE INTERIOR OF THE FINNISH PILOT MAIN BUILDING THIRD FLOOR IN MAGICAD ROOM 3D PREVIEW

2.3.2. SPAIN DEMO SITE BIM CREATION

The BIMs for the buildings at the Spanish pilot site were created using Revit. This Revit tool contains a parametric engine with a relational database that manages and coordinates the information necessary for the modelling of the architectural design, construction, and engineering of a building, including many disciplines. For this demo site, this mode was used within the architectural, structural and MEP disciplines. Revit allows creation of CAD-designs based on intelligent and three-dimensional objects. Through the parametric functionality of the Revit tool, changes can automatically propagate through the model based on parametric relationships.

Phase I: Previous work

- Data collection and analysis of the renovation project: In this phase, all the related information for the renovation project was collected and studied to acquire a better understanding of the building by the technical team specialized in BIM technology. In this context, missing information necessary for the creation of the BIM was identified. Parallel to this analysis, relevant information was compiled for the later creation of the different modules of BIM technology: Architecture Module, Structures Module, MEP Module.

Phase II: Uprising and parameterization of existing information in BIM

- Introduction and management of the data was collected to obtain a level of detail of LOD 300 (for the envelope) and of LOD 100 (for the interior): In this phase, we proceeded to introduce data using the different BIM modules. The level of detail was LOD 300 for exteriors and LOD 100 for the interior of the buildings: It was based on a two-dimensional model previously generated with a CAD system and evolved towards a single parameterized model of each project. To achieve this transition, each object was defined by its necessary parameters that make up the geometric

definition: Thus geometry, positioning and characteristics of the materials according to the definition level LOD 100/300 were defined. To achieve the single model, parameterization was developed by generating the models for each of the 3 disciplines (architectural, structural and MEP). Figure 18 shows the interior view of the main building in context of the site.

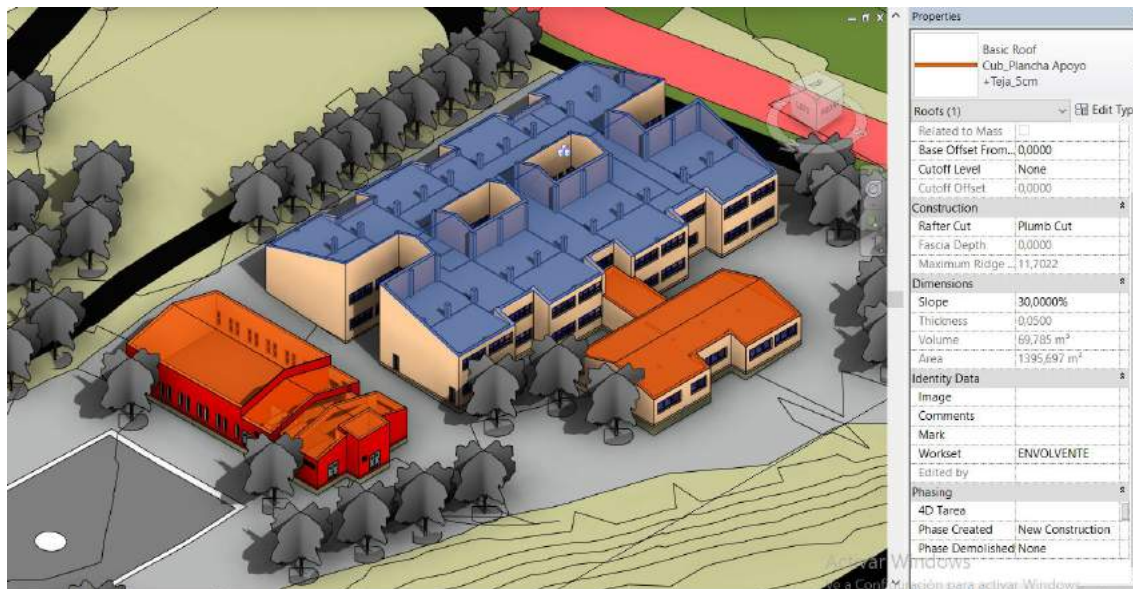


FIGURE 18: THE INTERIOR OF THE SPANISH PILOT MAIN BUILDING IN REVIT

2.4. BIM – IFC EXPORT

The data stored in the BIM is transferred to the IES VE simulation tool via IFC file format, which is a widely used format for Building Information Modeling. The BIMs of the three case studies have been prepared with three different CAD software: MagiCAD, Revit and ArchiCAD. Based on initial difficulties with BIM models, we encouraged project partners to build upon existing BIM modelling guidelines (Maile et al. 2013). The following sections describe the workflow and how the IFC files compatible for IES VE were generated.

MAGICAD (GO)

The generated BIM in MagicCAD was exported to IFC and iteratively tested by importing it into IES VE. The IFC export in MagicCAD is straight forward and one just needs to ensure that both options to export structures and spaces are checked. When the model with wall thicknesses was exported to IES-VE using built-in IFC export of MagicCAD, a problem with gaps between the rooms arose. An internal IES-VE feature called “Adjacency separation distance” was not enough to resolve these issues. Walls had a thickness of 600 mm and even after adjacency separation distance was adjusted, the issue still persistent that internal wall surface pairs could not be established. Thus, internal wall surfaces were incorrectly tagged as external since their opposite pair could not be determined. This issue can potentially create a source of inaccuracy in the simulation. A workaround to set all interior walls in MagicCAD be 1 mm thick resolved this problem. However, it introduced an inaccuracy of slightly increased interior volumes of the spaces. For floor objects this workaround was not necessary, since the adjacency problem could be resolved by using the “Adjacency separation distance” feature. The original model included balconies and shelters, which due to incompatibility with IES’ software, were excluded from the IFC-file. These balconies and shelter were

later manually re-added into IES VE. An example of the results showing the main building of the Finnish pilot site in IES-VE model viewer is shown in the Figure 19.

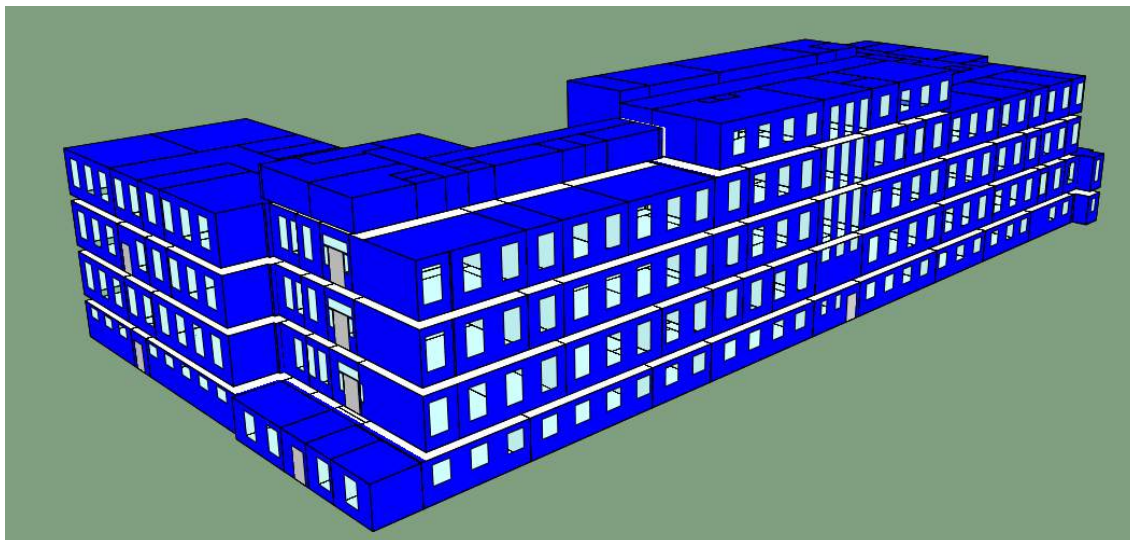


FIGURE 19: MAIN BUILDING OF FINNISH PILOT SITE IN IES-VE MODEL VIEWER

REVIT (SANT CUGAT)

The generated Revit model was exported to IFC using the GSA Concept Design BIM 2010 set up and imported into the IES VE software tool to test the data transfer. The main problem was that some rooms were missing from the initial model. Not all of the actual spaces were detected as Revit “zones” and thus were not imported into the IES VE model. The resulting model was incomplete. Adding the missing zones in IES failed due to an apparent permission problem, that arose when trying to edit the zones. It was not clear why the zones in IES were locked for editing. However, it was possible to correct the problem in Revit and reimport the IFC file as follows: Since it was easy to visualize the zones in Revit, one could see that not all the rooms were defined as zones. Therefore, this issue could be easily corrected in the next iteration of the IFC model, by defining the remaining zones and reexporting.

We found that IES VE did not import all the relevant data. In addition to the missing rooms of the buildings almost all the windows were missing. The reason for all the missing windows were a consequence of the missing rooms. Hence IES VE only imports windows that are connected to Revit zones and are described through a relationship between window and zone. IES VE imports only the boundaries of spaces (rooms and spaces), instead of geometry. Like the missing rooms, the missing windows could also be resolved by adding the remaining zones in Revit and re-exporting the model to a new IFC.

The main building of the Spanish pilot site in IES-VE model viewer is shown in the Figure 20.

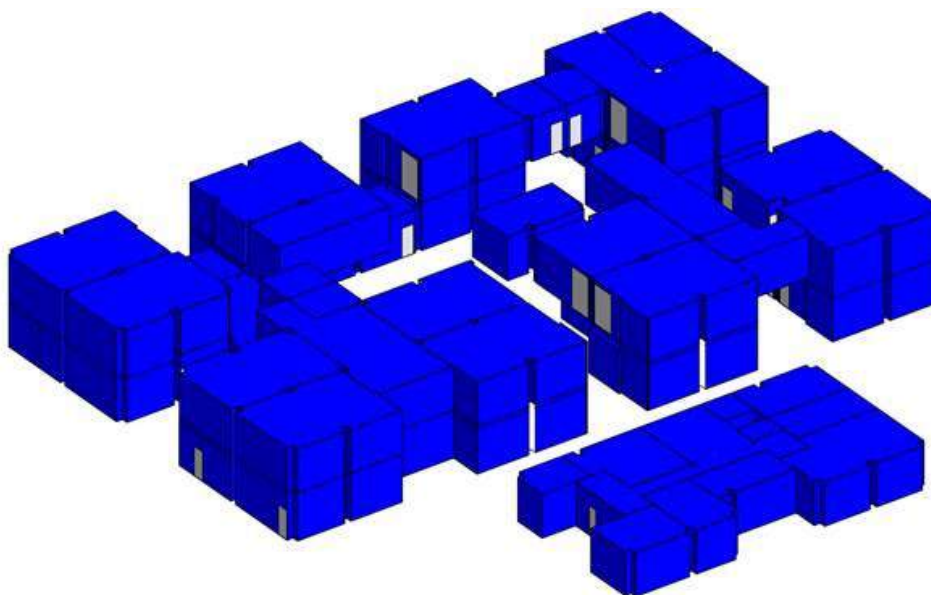


FIGURE 20: MAIN BUILDING OF SPANISH PILOT SITE IN IES-VE MODEL VIEWER

ARCHICAD (ABUD)

The BIM was prepared using ArchiCAD 20 software, in accordance with our architecture office's general workflow, level of detail, and file- and model structure. Fortunately, ArchiCAD has several default IFC translators that can export the IFC format depending on the data requirements of the other software. Furthermore, in addition to these default IFC translators, it is possible to create customized IFC translators as well. Since IES VE performs simulations on room level, it was crucial to export the individual spaces and their boundaries correctly. We have created a customized IFC translator by using the main settings of 'General Translator', with additional space boundary export, to make it compatible with IES VE's IFC import. The translator settings are shown in the Figure 21 and Figure 22.

EXPORT OPTIONS	
Elements to export:	Visible elements (on all stories) ▼
IFC Schema:	IFC2x3 ▼
IFC Model View Definition:	Coordination View Version 2.0 ▼
Name of custom extended view:	
Properties to export:	All IFC properties ▼
Geometry conversion	Conversion Options...
Building Information data to export	Data Settings...
IFC model units	Units Settings...
IFC Global Unique Identifier attribute (GlobalId):	Keep ARCHICAD IFC ID (recommended) ▼

FIGURE 21: IFC EXPORT SETTINGS IN ARCHICAD 20

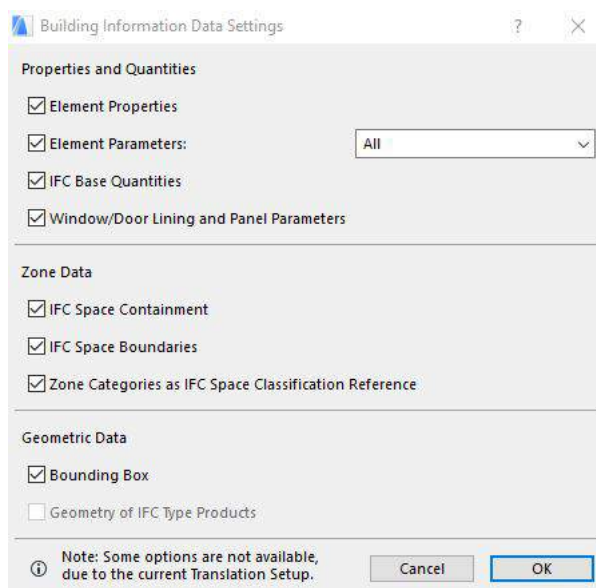


FIGURE 22: BUILDING INFORMATION DATA SETTINGS WITH IFC SPACE BOUNDARIES IN ARCHICAD 20

However, finding the right data transfer method between the modelling software and IES VE was only the first step. To test the data transfer compliance for later NewTREND simulations, we checked the exported IFC files in the desktop software IES VE 2016. During the testing, we encountered some difficulties in importing the IFC file correctly using IES VE. These were mostly caused by the complexity of the BIM and the geometry of the spaces, and IES VE was not able to retrieve and heal all the spaces. That is why the BIM had to be simplified. The following list contains the simplifications made to the model:

- the complex roof structure had to be simplified to a hipped roof;
- structures irrelevant for energy simulations had to be removed (such as chimneys and gutters);
- composite walls and slabs with multiple layers had to be converted to single layer structures;
- long corridors had to be divided into several smaller rooms;
- since the building is more than one hundred years old, many rooms are covered with vaulted ceilings, these ceilings had to be converted into flat slabs;
- importing spaces under staircases or cut by inclined planes was problematic, these spaces had to be simplified to prisms;
- spaces drawn manually in ArchiCAD were not always correctly imported to IES VE, therefore spaces had to be generated automatically from areas enclosed by walls.

After these simplifications were carried out in the BIM, an IFC file was re-generated, and successfully imported into IES VE. The imported model in IES is shown in Figure 23.

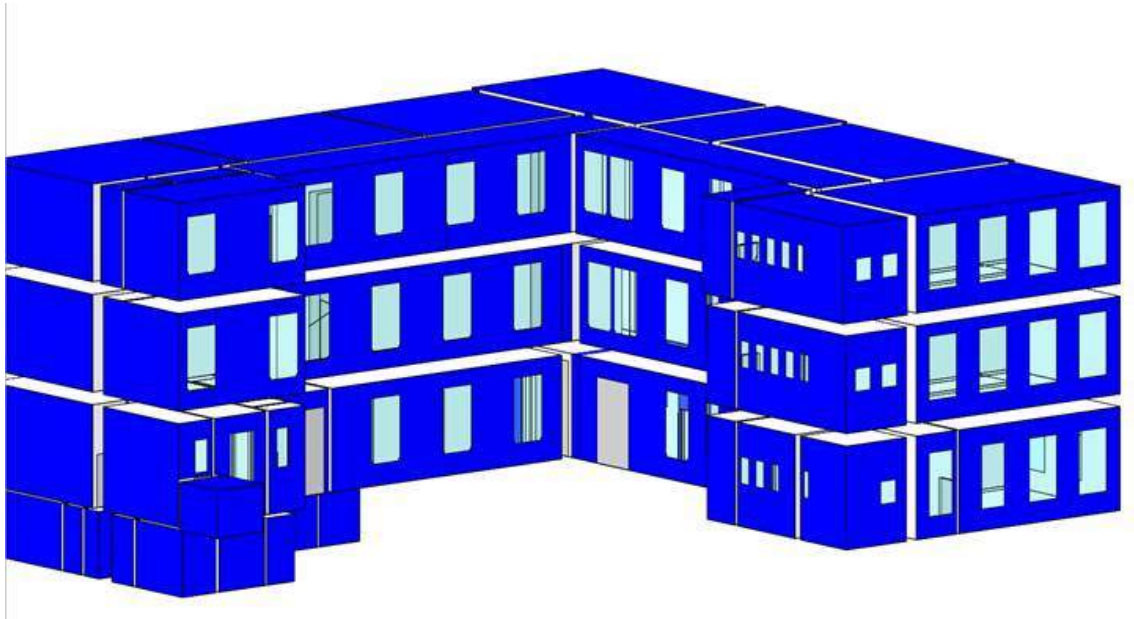


FIGURE 23: BÓKAY SCHOOL'S BIM IMPORTED INTO IES VE

2.5. CREATING CITYGML

CityGML is an open standard data model and exchange format for storing digital 3D models of districts. In NewTREND, demonstration site owners are required to provide CityGML files for the district level analysis and simulation. Current trends indicate that cities and municipalities in the future will have a CityGML-format database. Unfortunately, this is not the case at present, only a few municipalities have prepared the CityGML databases. The implication of this for demonstration site owners was that they had to prepare CityGML files on their own. The following sections describe, how the CityGML files were prepared for the three case studies in the NewTREND project.

2.5.1. FINNISH PILOT SITE CITYGML MODEL CREATION

The remaining three buildings of the Finnish pilot site were modelled corresponding to the NewTREND Basic mode. Thus, only their footprint and height were modelled in a 3D box. A CityGML file was created with SketchUp Pro 2015 and SketchUp extension "SU_CityGML_ExportPlugin". The 4 IFC models were imported into SketchUp and were placed on the satellite image from Google Maps to ease the right placement and orientation of IFC models, as seen in Figure 24. Using the CityGML Export Plugin and providing the Spatial Reference System (SRS) ETRS89 / UTM zone 35N of Finnish pilot site the models could be placed in the correct context.



FIGURE 24 FINNISH PILOT SITE CITYGML MODEL CREATION IN SKETCHUP 2015

2.5.2. SPANISH PILOT SITE CityGML MODEL CREATION

At the Spanish demo site the following process was used to generate the CityGML file. The IFC building model was transferred into semantically and geometrically valid representations for CityGML with the IFC Explorer tool. The IFC Explorer is a tool for creating and processing IFC models. The IFC Explorer offers the ability to export IFC files to CityGML files as well as to make changes to object attributes in CityGML files. For this demo site a transformation algorithm was developed to convert the IFC model into the CityGML format that includes the following steps using the IFC Explorer application:

- derivation of LOD1 building models
- formal mapping rules allowing for a fully automated model transformation

The resulting model is shown in Figure 25.

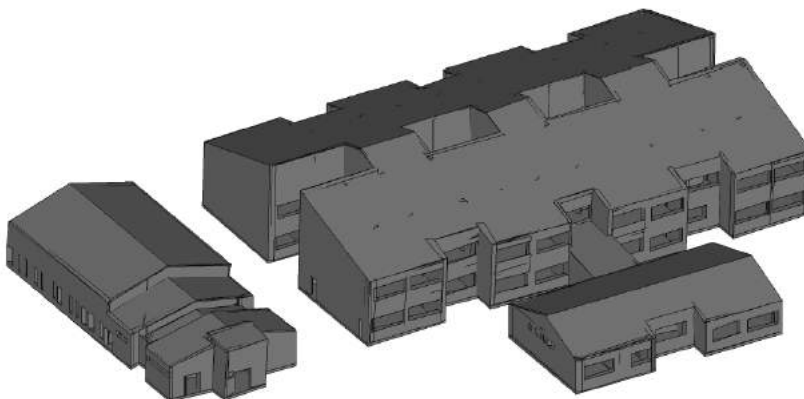


FIGURE 25: SPANISH PILOT SITE CITYGML MODEL

Beside commercial software packages there are also several free tools and services that support CityGML, like IFC Explorer or citygml4j. Citygml4j, is an open-source Java class library and API for the processing of 3D city models encoded in CityGML. Another example of useful tools is VirtualcitySYSTEMS—BuildingReconstruction: that can automatically derive extensive 3D city models from digital elevation data in CityGML and ESRI-Shape formats as shown in Figure 26.

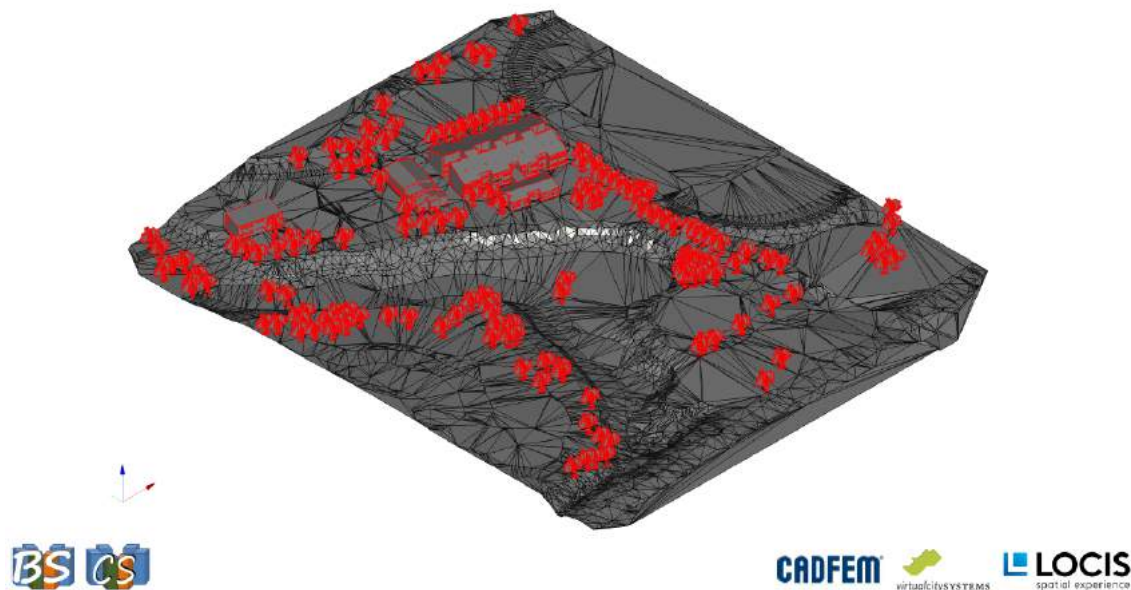


FIGURE 26: SPANISH PILOT SITE CITYGML MODEL WITH SURROUNDING CONTEXT

2.5.3. HUNGARIAN PILOT SITE CITYGML MODEL CREATION

CityGML data format was not available neither for Bókay Garden nor for Bókay School and its surroundings, therefore the required file format with the sufficient content had to be generated manually from already existing data and additional measurements.

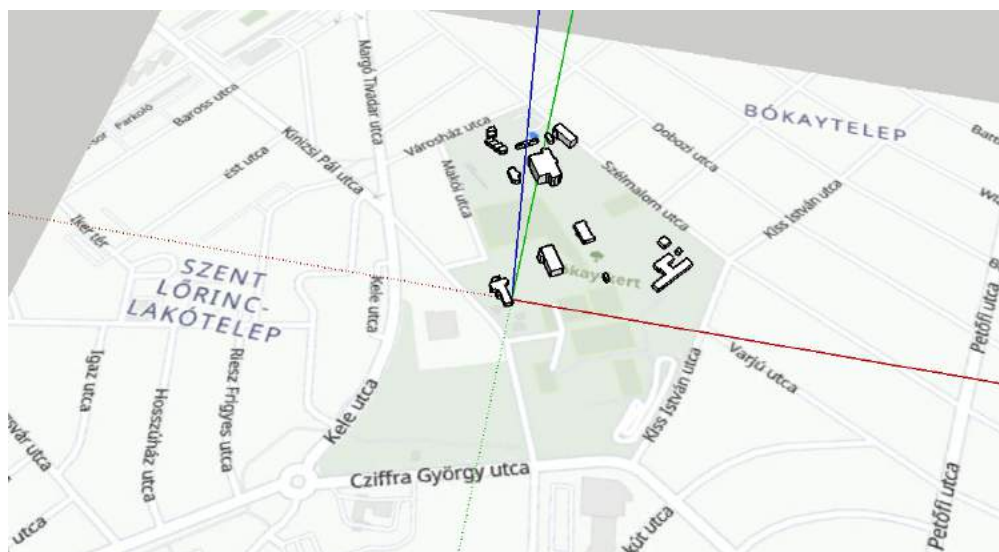


FIGURE 27: BUDAPEST DISTRICT LEVEL DEMONSTRATION SITE, BÓKAY GARDEN LAYOUT – BASIS OF THE CITYGML

2D site plans in DWG format was provided by the Local Municipality of Pestszentlőrinc – Pestszentimre, XVIII. district of the capital city of Budapest. This provided an adequate basis for further data collection, as it included the buildings' footprint, orientation and relative positions. Missing data were the buildings' height and the exact coordinates. The former was provided by existing plans and on-site measurements, while the latter was supported by Google Earth.

However, the data collection was only the first step, which was followed by converting the data into the appropriate CityGML format. For this, SketchUp 2016 software was used, with SU_CityGML_ExportPlugin (SU 2018). The workflow was done as follows:

- DWG file containing relevant district data was imported to SketchUp 2016;
- 2D surfaces of the buildings' footprints were generated automatically from DWG;
- using building height data, surfaces were extruded into blocks (this step is optional since NewTREND simulations require LOD0.1);
- with the help of SU_CityGML_ExportPlugin, data was exported to CityGML file format. Additionally, the applicable coordinate system had to be added, which is EPSG:25833 - ETRS89 / UTM Zone 33N for Budapest.
- to check exported file format and content, we used FZK Viewer developed by Karlsruhe Institute of Technology (Karlsruhe Institute of Technology 2018).

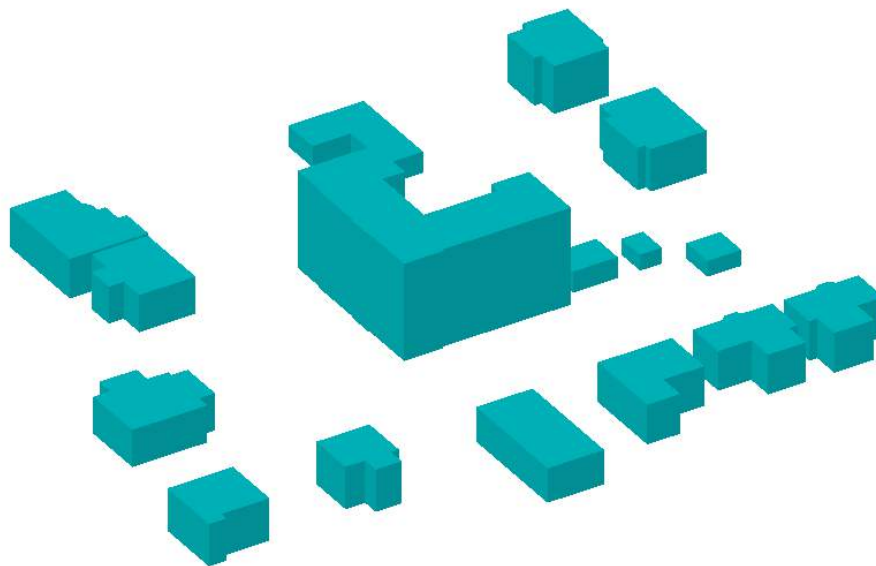


FIGURE 28: CITYGML REPRESENTING BÓKAY SCHOOL AND ITS SURROUNDINGS IN FZK VIEWER

3. DIM SERVER TESTING PROCESS

The following section describes testing of the DIM server. As a 'back end' component - one that serves parts of the NewTREND architecture that are utilised by end-users, and given the evolutionary nature of front-end components, DIM server testing has largely concentrated on ensuring:

1. That it serves correct results (both in content and format);
2. That it remains compatible with components that connect to it, and due to its deployment model, remained affordable;
3. That the services it provides are secure, ensuring data security and privacy of user information;
4. That it evolves without issue, supporting new requirements and older ones;
5. That each new DIM server is deployed correctly;

This section includes a description of the DIM server and the services it supports. The testing hierarchy, along with techniques and technologies used are then described. This process includes unit, functional, integration and deployment testing. There is also an overview of regression testing carried out when a new feature is deployed, or significant bug fixes are rolled out. A standalone feature of the DIM server is its role in data collection for and invocation of acoustic comfort simulations, this is treated separately. Specifically, unique features of the communications process used between the acoustic and DIM server are described, and results of testing these components are also presented. A usability test for the acoustic data collection component is also presented.

In general, the DIM server is implemented using the principles of 'continuous development'. As a result, this section does not present a definitive set of test results as these were run frequently to facilitate the development process. Rather, it describes the process used to test the server and gives samples of these tests' results.

3.1. THE DIM SERVER

DIM Server grew out of the NewTREND project where it served as a central, semantically enabled data-store to unify an assortment of information formats including IFC, CityGML, custom databases and other files. The NewTREND project sought to develop an integrated retrofit design methodology that focuses on participatory design in support of neighborhood to district scale retrofit. This methodology was implemented as a series of interdependent software services that included: 1) a Data Manager for crowd-sourced data collection, 2) a Simulation and Design Hub to provide decision support, and 3) a Collaborative Design Platform that provides a user-friendly interface both for project setup, data collection and result visualization. DIM Server supported these tools by providing an interoperable, distributed, multi-model data exchange server to store information on energy efficient design and integration with neighbourhood energy systems, linking existing data model formats at building and district levels. The DIM Server offers the following services:

- Acts as a core data provider that provides interoperable data exchange for the construction sector, acting as either a central database to which other services can connect, or as a central data aggregator and translator in a set of loosely bound services that manage their own data in proprietary formats;
- Provides a federated model that admits horizontal and vertical traversal through the data-set arising from the combined set of represented formats. This model is extensible, with the ability to define custom data-store accessed through industry standard **application programming interfaces (APIs)** serving several data formats including JSON;

- Acts as an enabling service by providing core functionality such as user management and access control;

The DIM server is based on Django, which is a popular Python based web-development framework. Django, in turn is as a high-level framework that encourages rapid, organized code development on top of a secure and scalable set of frameworks. A Django project is modular in design, allowing easy integration of bundles of independent functionality called *apps* to produce a new service. This is augmented with several add-on packages, including Django Rest Framework to provide industry standard API access to the server and its data. For the purposes of NewTREND, the DIM Server exposes JSON APIs both for its core functionality and for add on apps to manage NewTREND specific content. These allow other software components to connect and use the functionality offered by DIM server.

The server is normally run as a cloud service using Bitnami's Django server image. This provides a pre-configured, secure installation of all the components required, including databases (PostGIS), webserver (Apache and Apache Tomcat) and programming tools (Python and Java). It is planned that the DIM Server itself will soon be published through Github as a downloadable release. An installation script automates customization and deployment; as a result, a base DIM Server can be deployed and configured in minutes.

In addition to the DIM Server, several other components are installed. These include Open BIMServer to manage IFC based resources. This can be queried and managed by the DIM Server through its web-services component. CityGML is managed by deploying the 3dCityDB to PostGIS and using the associated importer/exporter tool to marshal data to and from the database. Queries of this database are executed using Django's object model framework. Other types of data artifact, such as files, are also handled using Django frameworks. The architecture of the NewTREND DIM Server is shown in Figure 29.

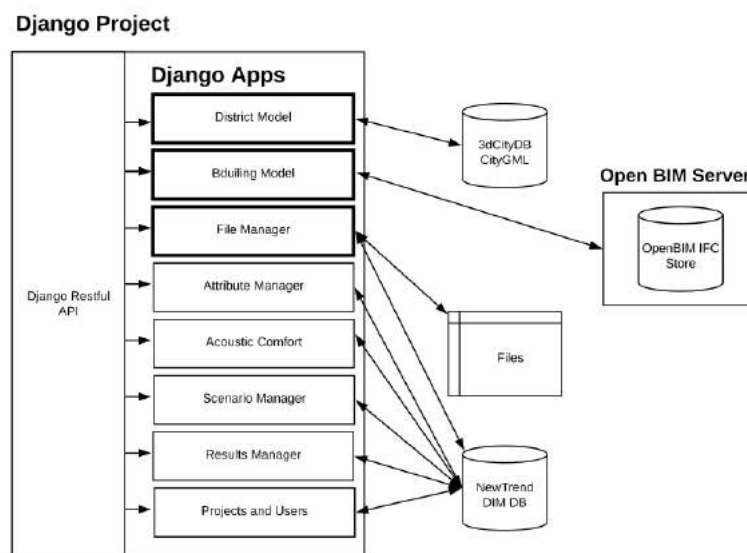


FIGURE 29: DIM SERVER ARCHITECTURE AND SUBSYSTEMS

3.2. PROCESS OVERVIEW AND TECHNOLOGIES USED FOR DIM SERVER TESTING

Several tools were used for testing. The Django framework (and its derived API framework, Django RESTful Framework (DRF)) provide unit testing support. This allows a development team to develop their tests in parallel with functionality. A library of these tests is developed and becomes part of the code base. These

tests can be configured to test outlier cases. It also means that these tests can be run frequently and at low cost to the development process.

The development team conducted functional testing using the Postman application. This tool can be used to build suites of functional tests with pass/fail criteria. Every API call had an associated test suite to test both correct and incorrect configurations. The tool was also used to test third party software such as the OpenBIM server used to manage IFC content. This was required as these third-party tools released incremental improvements, whose compatibility with the DIM server had to be monitored.

In both unit and functional testing, API calls and their parameters, as well as their returned values can be validated. Error handling can also be tested. Their use in the context of the DIM server will be described in more detail in the following sections. This testing also extended to performance testing (memory and temporal cost of execution).

Other forms of testing were also conducted. Since new versions of the DIM server were deployed frequently, regression testing and configuration verification was frequently a consideration. Cloud based deployments also required profiling of the DIM server across various model complexity to determine both the specifications of cloud host required and to understand the involved financial costs. These were accomplished using standard linux profiling tools and tools provided by the cloud host services Amazon Web Services (AWS) and Bitnami.

The DIM server was implemented using an agile continuous development model. As a result, testing is conducted frequently. The applied testing types and their frequency of application are described in Table 1.

Type of Testing	Frequency	Tools used
Unit Testing	Many times during each software development and bug fixing cycle	Django/Python Unit Test Frameworks
Functional Testing	At the completion of development/bug-fixing of an API Endpoint	Postman test suites
Regression Testing	Formally, at the end of a bug fix, but informally throughout the bug fixing cycle as unit tests and integration tests are also used to provide debug information.	Unit/Functional Tests and Integration Tests
Deployment (Sanity) Test	Composite Functionality Test to test major functional components of a newly deployed server.	Sanity Test Form
System Integration Testing	During integration of the CDP, DM and DIM Server components. Repeated for each iteration.	IES Test Functionality Test Form and feedback from
Component Integration Testing	At each upgrade of some third-party component, including server software (Apache, Tomcat), and delegate software (CityGML, Open BIM Server).	Integration test suites that tested the functionality.

TABLE 1: SUMMARY OF TESTING CONDUCTED

3.3. UNIT TESTING

The goal of unit testing is to isolate each part of the program and show that the individual parts are correct. A unit test provides a strict, written contract (Wikipedia 2018) that the piece of code must satisfy. The technique allows bugs to be found early, allowing a code base to develop on the basis that its constituent parts are correct. Unit tests usually operate on a specific method or functional component of the code. Test suites are developed to confirm correct operation based on valid inputs and confirm correct error handling when inputs are invalid. Unit tests are developed as code components and run frequently (often as part of the development cycle itself). The unit tests are, like the codebase, a continuously evolving component, and develop in parallel to the codebase. They are also used extensively during bug fixing as a low-level regression test to confirm that changes made are correct, and to confirm that changes made have had no impact on the rest of the codebase's functionality.

Django, the framework used to develop the DIM server, provides a unit test framework. This is an adaptation of Python's own unit test functionality. Each server developed using the framework is made up of several 'apps' and along with a Django project (see Figure 29). These interact with project level resources, such as media content and databases. Each app is divided into three broad Python modules, though these can be further subdivided and structured. These are:

- Model files: Python classes that together define the project's data stores. These are usually sets of small classes made up of sets of attributes, and a small number of helper functions;
- URL files: a list of definitions that together define the server's API;
- View file: the business logic of the app. URL definitions are associated with a method in this file. The method will then manipulate resources retrieved from the database models, or otherwise carry out some task;

Testing within a Django server will apply unit tests to methods within views (and their helper methods) and functional tests to verify the functionality of the App through its API.

3.3.1. WRITING UNIT TESTS

Unit Tests are implemented through writing test classes of code and defining pass/fail conditions in these. These classes subclass the Django.TestCase class. This allows their integration with Djangos test execution and reporting functionality. A typical unit test is shown in Figure 30. In this case, the parameters that are setup at instantiation of a BimHelper class (helper class that encapsulates querying of BIM Server and synthesis of this information into packages served to other NewTREND components). Unit Tests were written for each App added to the server. As can be seen in Figure 30, unit tests had a setup component, along with an actual set of test conditions. In the case of the NewTREND project, a standard database/3rd party software setup containing a fixed set of buildings, parameters, etc, was used. A separate database,

as is typically used, could not be used because the database schema in the project contained non-managed components related to the 3DCityDB that was managed using external tools.

```
from django.test import TestCase

from bim import BimHelper

class BIMHelper_Instantiation_TestSuite(TestCase):

    def setUp(self):

        self.bh = bimhelper()

    def test_instantiation(self):

        self.assertEqual(self.bh.getServerIP(), getattr(settings, "SERVER_IP",
"192.168.1.1"))
```

FIGURE 30: A TYPICAL UNIT TEST IMPLEMENTATION

3.3.2. RUNNING UNIT TESTS

Unit tests were run through the Django Framework's testing component. This could be run at an app level or for the entire server. The framework would report numbers of tests passed or failed, and where tests failed, indicate the assert clause that failed.

Since these tests were run frequently, and the last set was most relevant, there was no need to maintain a record of test results.

STANDARDS REQUIRED

Development standards required that all tests pass when a new version was deployed. Issues occurred in later development cycles, particularly in fixing bugs arising from integration testing with other NewTREND components. These were:

1. The development cycle shortened significantly, as fixes were urgently required by other partners. This often meant that unit tests were written post deployment (in time for future regression tests). In these cases, integration testing and visual inspection of outputs were used to confirm the fix.
2. Requirements were often fluid, making it difficult to write unit and other tests.

Coverage of unit testing was found on occasion to not be complete. Error conditions were discovered at integration time. This required rewriting of some unit tests.

3.4. FUNCTIONAL TESTING

Functional testing is a form of black box testing of a whole vertical slice of functionality. The internal structure of the code is considered tested using unit tests. The purpose of the code is to ensure that all components required for some functionality are working together correctly, and that the system is fault tolerant. The interface used to access the functionality can also be considered in the form of unit testing, though in this case, the interface was programmatic.

Functional testing was conducted at an API Endpoint level. Test suites were developed using the Postman tool (Figure 31) to test ideal and erroneous test cases. This allowed testing of the full stack, including third party components (Apache, and CityGML/OpenBIM), along with the full Django Stack including database, to confirm the correct operation of each endpoint. Each endpoint had its own test suite that was run both during development and as a regression test.

Testing was conducted primarily using the Postman API Development tool. This tool comprehensively supports the testing of RESTful APIs. Fundamentally, the tool allows developers to configure and submit requests to the server as if they were being produced by client software. Both correct and incorrect configurations can be submitted, and the results of these can be analyzed for correctness. Suites of related calls are gathered in 'collections', and these can be reused to produce consistent testing that can be run quickly when new software versions are released.

Most calls to the API produced a JSON response. These were tested in two ways. The first used a LINT test to ensure that the response had a correct form. The second form of test consisted of JSON unit tests - in the form of Python assert tests - that ensured that requests to a particular server configuration returned known values consistently.

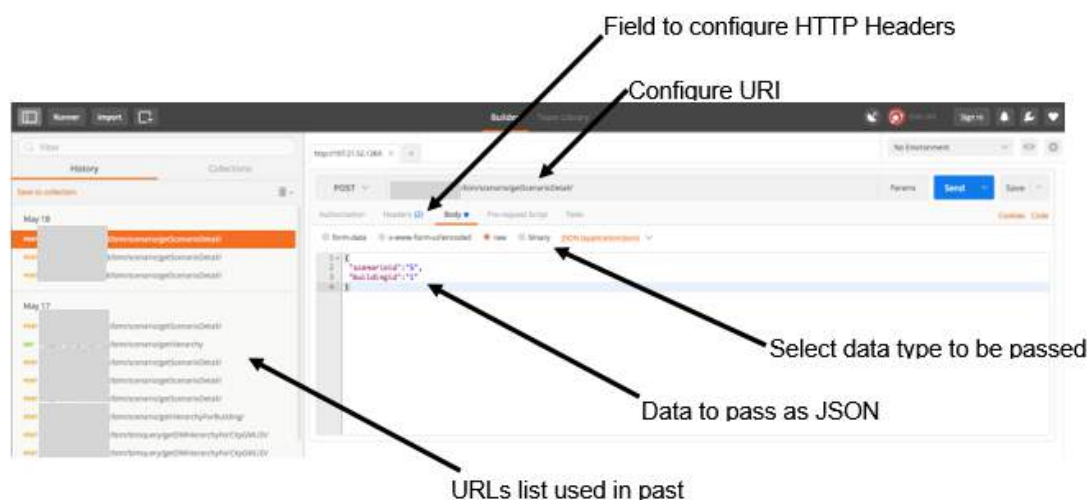


FIGURE 31: POSTMAN API DEVELOPMENT TOOL

To support functional testing, a DIM Server had to be provisioned and running on a virtual machine instance. Data required to support the task would have had to have been provided; for instance, a database could be empty if uploading CityGML files was being tested, while a full set of CityGML, IFC would be required if calls to support the data manager were being tested. A matrix of these requirements was maintained, and for frequent test conditions, the configuration of this data was automated. A series of SQL scripts were also written to allow for configuration of the databases to test for outlier cases. In these, specific error conditions were inserted into the databases. Several instances of the database were

maintained, each testing different error conditions. A similar Python script was used to introduce errors to the BIM server. These were integrated with Django, and by setting a flag in the project's settings, the appropriate database/BIM server would be used when the server was restarted.

A series of SQL scripts were also written to allow for configuration of the databases to test for outlier cases. In these, specific error conditions were inserted into the databases. Several instances of the database were maintained, each testing different error conditions. A similar Python script was used to introduce errors to the BIM server. These were integrated with Django, and by setting a flag in the project's settings file to determine which database would be connected to.

A series of tests were designed on paper. These were composite tests that checked several Endpoints used to achieve some functional goal. These tests were then converted to test suites on Postman. An example is shown in Figure 32.

```
Title: Log In Test

Purpose: Confirm that a login can be achieved for user using a specific username and password.

Outcome: Receipt of a valid Authorization Token.

Step 1. Use a HTTP Post to rest-auth/login passing a JSON fragment containing the username and password for a user on the server.

Step 2. Confirm receipt of an authorisation token by Postman as a result of step 1.

Step 3. Use the token to call a restricted method (/bim/getDMHierarchy).
```

FIGURE 32: EXAMPLE TEST FUNCTIONAL TEST PROCEDURE

Because of the multi-component nature of the DIM server, both unit and functional tests were run frequently. Given this frequency, test results were not maintained. As part of each development cycle, both unit and functional tests would be modified and extended to cater for new capabilities or changes made to the server.

ISSUES THAT AROSE

Given the closeness of the tests, similar issues to those reported in the Unit Testing section arose.

3.5. DIM SERVER INTEGRATION TESTING

DIM Server integration testing takes two forms:

- Integration testing of third-party components used in the DIM Server over the course of the project's lifetime.
- Data Integration testing. A requirement for this testing arose as various file formats - for example, IFC or CityGML - generated using various tool chains, proved sensitive to minor settings changes.
- Integration testing of the DIM Server as a component in the NewTREND project. This testing occurred primarily in the tertiary phase of development of components.

This section discusses how both types of testing were conducted in the context of the DIM Server.

INTEGRATION TESTING OF THIRD-PARTY COMPONENTS

As has been mentioned, DIM Server uses several third-party components. These include various changes to virtual machine images used for cloud hosting of DIM Server, Python libraries such as GDAL, the OpenBIM Server and 3dCityDB for managing CityGML content.

The OpenBIM Server proved challenging. Utilizing an agile development model, the developers of this open source project delivered two major releases and over one hundred point releases over the course of the NewTREND project. While some releases delivered minor bug fixes, others added large sets of new functionalities and deprecated and removed redundant code. This code also used a plugin structure, where each of the plugins are released on an independent development cycle; releases associated with these components also had to be considered in integration testing. The plugin issue was further complicated by interdependencies between plugins and automatic installation of latest version at install time; even if an older compatible version of BIM was installed, later incompatible versions of plugins would be installed also, thus forcing integration with new releases.

Here, integration testing was handled by developing an understanding of what was required by the DIM server from these features. These features were tested, looking at performance, correctness, and compatibility with previous versions. While the CityGML 3dCityDB feature barely changed, the OpenBIM server frequently released new versions, and several dozen releases were tested. Early adoption of a new release was required but did cause many issues as the initial release was not stable. This caused frequent refactoring of BIM related functionality on the DIM server, with the consequent knock on effects to the development schedule.

INTEGRATION TESTING OF DATA

Various techniques and tool chains were used to produce initial District (CityGML) and building geometry (IFC) information. These resulted in issues with data compatibility. While issues around IFC (OpenBIM) were quickly resolved, CityGML, because of the standard's relative immaturity were initially significant. While tools were available to export, for instance, from Sketchup, to CityGML, these tools were found to have bugs, or obscure, undocumented features. Extensive testing was required to arrive at a reliable tool chain and production specification. These problems were somewhat exacerbated by the need to further convert some of these formats to other formats such as KML and Well Known Text - both standards that were not well understood initially. However, with the co-operation of partners on the project, reliable processes were defined for this task, too.

INTEGRATION TESTING WITH OTHER COMPONENTS OF NEWTREND

DIM Server is a central component of the NewTREND implementation. Most components interact with the server's APIs. While careful design and regular communications mitigates the complexity of integrating many complex components, issues still arise. A series of conference calls between developers from all teams were held. During these, testing, and where possible, minor adjustments to the code base and configurations was conducted; on occasion, a more complex fix was required, and the conference call was adjourned until this was completed. Tests were co-ordinated according to an agreed testing framework provided by the project management team.

Initially, testing was conducted using 'dummy data' - that is, data that would not produce realistic results. This facilitated the following:

- Develop for the ideal case: in this circumstance, integration with all components was achieved under ideal circumstances. This was the best understood configuration, and so easiest to debug;

- Outlier cases were then tested to ensure correct functionality and performance. These ensured that cases that might not arise during testing of real code was tested;
- Finally, integration was tested using real data collected from the test sites. In addition to integration testing, this phase also served to produce results that could be used for testing of the CDP results visualization interface.

3.6. DEBUGGING PROCESS

Invariably, bugs arose during testing of DIM Server. These were tracked using the Asana platform. This service had been used by the development team previously, and so was a natural choice to manage bug reports and deployment of their solutions. During initial development of DIM Server, bugs arose and were reported internally; these tended to arise from coding errors and were frequently captured during unit testing. However, as the platform was integrated into the NewTREND project, and was used by the demonstration sites, issues became more complex, and often required input from several of the teams to resolve. In the later stages of the project, few bugs were directly reported to the DIM server development team as it was not 'customer facing' software. Rather, an issue would arise in another component, and after the issue was understood and debugged there, would result in a bug reported to the DIM Server development team. The bug would be logged, and the issue investigated.

Generally, these bugs fell into one of three categories:

1. A non-code error arising from data submitted to the DIM Server. Initially, these often arose due to incomplete error checking of parameters submitted to the DIM Server. There were also issues around various toolchains being used to generate input that was incompatible with the third-party tools used in the DIM Server. These arose during integration testing and again when the service was tested by the demo sites;
2. A non-code error arising from non-aligned requirements where expected functionality was not present or behaved in an unexpected way. These arose particularly during initial integration testing;
3. Configuration errors arose as some sites required specialisations of server functionality. These specialisations, while extensively tested on occasion did throw errors when unexpected conditions arose. While a small number of these were fixed through code fixes, most required reconfiguration of data or system configuration information;
4. Logic errors and code errors did occur, though generally when unexpected conditions were encountered. These tended to arise particularly when errors of type 1 or 2 arose. While they often obfuscated the original problem, and cost time understanding an issue, they were generally quickly resolved once identified;
5. Bugs also arose due to failures in regression testing;

Bugs were reported through IES to the relevant party. Often, some joint debugging was required to identify where the issue arose. If the issue arose on the DIM server, the chain of calls made, and parameters passed to the DIM was identified by the reporting party (STAM/IES). Then Postman was used to recreate these calls. Log and debug information was then examined.

In many instances, errors arose because of configuration errors (user permissions etc). In these cases, the configuration fix was made, and the Postman tests rerun to confirm the fix and ensure other components hadn't been affected by the change.

Where a code fix was required, the fix was made and tested. The code was released onto the code repository with a label, and this fix was rolled out to all servers. Regression tests were run, both on the development server and on the deployment servers. This latter step was taken as some servers had bespoke configurations that could impact or be impacted by the fix.

Once the fix was complete, the reporting body (normally, IES) was informed, and further integration tests were conducted to confirm the fix when operating with other NewTREND components. Once the fix was confirmed, the demo sites were informed.

ISSUES THAT AROSE DURING TESTING

In general, few issues arose during testing/deployment after the initial setup was achieved. Initial setup was on occasion, difficult as some sites, for reasons beyond their control, didn't conform to the DIM server's information organisation. For instance, some buildings didn't have IFC descriptions. In these cases, only basic mode results could be produced. A series of configuration and code changes were required to support this. In general, however, frequent 'open mic' testing sessions quickly identified issues, and these were resolved through the continuous test and integration software methodology.

4. DATA MANAGER TESTING

Data manager testing was split in two phases: In house testing, and external testing. The process started with in-house testing with the purpose to deliver a functional user interface and robust communication with the DIM server, that will allow the demo site partners and participants in the LATs proceed with their testing in the next phase, without facing any critical issues. In-house testing was accompanied by reporting the issues to the developers in IES and UCD and the issues identified to be blocking the external testing were addressed. In-house testing was focused on end-to-end communications between the user and the software and between the software components. Some examples of tests conducted during in house testing are listed below:

- Make sure that all buttons and functionalities in the Data Manager front end work as expected
- Ensure that user entered inputs in the Data Manager User Interface (UI) are stored in the DIM server, and can be accessed by the Simulation and Design Hub for simulation purposes via the web API.
- Ensure that there is no missing content on the Data Manager UI according to the requirements

External testing on the other hand involved the use of the software in real world cases by people not involved in the development. This testing phase was coordinated by iiSBE and involved testing of the Data Manager via the data collection for the three NewTREND demo site locations. External Testing of the Data Manager required a Feedback template to gather feedback from users of the tool. To develop the structure of the “Data Manager Testing Feedback Templates (DM-TFT)”, they analyzed the “User manual for NewTREND: support tool for data collection (data manager)” (IES 2017). This manual was created by IES to guide the users through the online prototype Data Manager, developed under Task 3.3 of the NewTREND project. It contains *background information* about the NewTREND web tool kit, the Data Manager’s (DM) requirements, and the initial research and investigation conducted prior to the prototype implementation as well as some *general information* on key features and functionalities of the DM. It includes general information about the DM architecture, its context and key features. It also contains a *detailed section that describes all aspects of the tool*. This detailed section was crucial for the creation of the DM-TFT because it showcases the Graphical User Interface of the Data Manager, outlining all the functionalities and capabilities of the tool.

The structure of the DM-TFT follows the same workflow the Data Manager Tool, spanning from the registration to the configuration status for the District Information Model. For the testing template to be successful it needs to cover all aspects of the data manager tool. This way the user can relate the data manager features and UI-Elements such as buttons directly to the feedback template. This alignment enables users to give valid and useful feedback within the correct context. Thus, while browsing the platform of NewTREND, all the fields and functionalities of the platform can be identified within the spreadsheet. Another important aspect of the testing of the data manager is the consideration of the different NewTREND modes:

- **BASIC mode:** Since Basic mode is designed for occasions where the data availability is limited, most of the inputs are pre-defined and shown in the form of dropdown lists. Only few properties are required and do not have a default value. The number of outputs in this mode is limited to energy and life cycle cost related outputs excluding user comfort related aspects;

- **ADVANCED mode:** The advanced mode allows the user to display and edit properties of a building in more detail at a room level. This relies heavily on user inputs to operate with acceptable accuracy, thus

this mode imposes a high demand for data and for a detailed 3D BIM. Advanced mode can perform comprehensive, detailed analysis from a single room to the building level. The results include environmental, user comfort, user behavior and thermostat location analyzes;

- PREMIUM mode: used when real monitored performance data of the building is available. The user can obtain the most detailed representation of their building using this mode. The Data Manager allows entering monthly energy consumption and performance data, which can be extracted from utility bills or energy metering systems. These include electrical energy consumption and production, used fuels and energy consumed for heating and cooling.

The feedback collected through the DM-TFT is divided into two main sections: Usability and Functionality. The former focuses on the perceptions of users regarding the graphical quality and functionality of the platform elements while the latter evaluates the functionality of the platform. Therefore, the following sections will provide detail of the Usability and Functionality testing.

4.1. USABILITY TESTING OF THE DATA MANAGER

4.1.1. FEEDBACK TEMPLATE FOR USABILITY TESTING

The Feedback Template for usability testing of the Data Manager followed the workflow of the NewTREND Platform. It starts with user access to the Data Manager website which is hosted on IES servers, it can be accessed at the following URL:

URL address: <http://uat7.iesve.com>

User name: <User Name>

Password: <Password>

Besides the user access to the Data Manager the remaining feedback template is divided into the following five Sections:

1. SECTION 1: My Account (displays user details);
2. SECTION 2: Logout (logs user out of the system);
3. SECTION 3: Attribute View (displays district and building information);
4. SECTION 4: File View (upload files from District to Room Level);
5. SECTION 5: DIM Status (to check the data availability status for all modes).

Specific to the usability testing, the information to be obtained mainly focuses on users' perceptions of the graphical quality and functionality of the platform elements. We attain feedback from users of the Data Manager Platform on the comprehensibility of the buttons and of the drop-down menus; in the case of incorrect and/or unclear operation. Additionally, considerations about the ease of use and potential improvements are also of interest here.

Based on the discussed aspects, the following questions have been asked:

- How does the user interface look?
- How easy is it to navigate?
- Are interface elements setup in a meaningful manner?
- Do all interface elements work correctly?
- Do you have any ideas about improving the usage of the tool?

Another important aspect to add to the template in “Section 3: Attribute View” is the navigation features from individual stories and rooms within buildings. This navigation feature is closely connected to the selected NewTREND Modes described above.

In

Figure 33 we illustrate a subset of the “Usability Aspects” of the Data Manager in form of the Testing Feedback template. The complete feedback template can be found in Annex 1.1:.

USABILITY ASPECTS
WP6 - T6.4_TESTING FEEDBACK TEMPLATE (Data Manager)
User gets access and logs in the Data Manager
<i>How the user interface looks?</i>
<i>How easy is to navigate?</i>
<i>Are buttons name and menu options comprehensible?</i>
<i>Buttons work correctly?</i>
<i>Any ideas about helping ease the usage of the tool?</i>
NewTREND Data Manager_ Button Functionality
SECTION 1 _My Account (displays user details)
<i>How the user interface looks?</i>
<i>How easy is to navigate?</i>
<i>Are buttons name and menu options comprehensible?</i>
<i>Buttons work correctly?</i>
<i>Any ideas about helping ease the usage of the tool?</i>

FIGURE 33: SUBSET OF THE DATA MANAGER TESTING FEEDBACK TEMPLATE CONCERNING THE USABILITY ASPECTS

4.1.2. EVALUATION OF FEEDBACK FROM TEMPLATES

The completed feedback templates were collected and evaluated by IES. After merging the feedback templates, a comprehensive list of issues and suggested enhancements was compiled and prioritized by IES. The most important issues and enhancements were fixed and implemented respectively, while the least important ones are kept in a list as suggested future enhancement before releasing the commercial version of the tool to the public.

In general, the feedback of the testers was positive, highlighting the ease of use and minimalistic user-friendly design.

Regarding the usability and appearance of the DM, we received the following answers:

In general, for most of the reviewers, the interface appearance was found nice and clear. Some suggestions in sections 1,2,3 included:

- Improve the icon of the file view
- Include more user information in the my account screen
- Introduce a “keep me logged in” button
- Align the tooltip buttons

Furthermore, while testing the navigation throughout the various pages within the website, all the reviewers found it easy, apart from some confusion with advanced mode navigation, where sometimes was not easy to select specific rooms.

Regarding section 4 the feedback received was about providing a security question before someone tries to delete a file and displaying the actual note instead of the file name.

4.2. FUNCTIONALITY TESTING OF THE DATA MANAGER

4.2.1. FEEDBACK TEMPLATE FOR FUNCTIONAL TESTING

The Functionality section of the Data Manager Testing Feedback Template is aligned with features of the NewTREND software tools but differs from the usability template because it focuses the functionality of the platform. Contrary to the usability aspects of the DM-TFT, each of the five Sections correspond to one or main feature areas. They aim is to identify problems have been encountered in their implementation.

This feedback template uses the same five sections as identified in the feedback template of Usability Testing. The questions focus on features in terms of Expected and Obtained Outcomes. The user can report related observations with Notes or Screenshots.

The focus of content testing lies in "SECTION 3_Attribute View". It is divided into two parts: the first of which is "Test District" where the user can navigate through all buildings in the district. Each district element is characterized by a list of data attributes which describe the district. The second part focuses on "Test the Building aspects", which is split into the three NewTREND modes. Starting with the Basic mode the user enters some general information about the construction year, building height, building primary use, glazed area, space conditioning type. More detailed information is needed in Advanced mode, for example the transmittance values of the different components or the lighting and heating operation profiles. In Premium mode even, real monitored values of the buildings can be defined.

At the end of the session, in "SECTION 5_DIM Status" the user can check the data availability status for all modes and restore data from a previous session. The Data Manager records all projects that each user participates in and can fetch information already defined (buildings, floors, rooms, etc.) from the DIM server.

Figure 34 shows an example of the "Functionality Aspects" of the Data Manager Testing Feedback Template. The complete feedback template is given in Annex 1.1

FUNCTIONALITY ASPECTS
WP6 - T6.4_TESTING FEEDBACK TEMPLATE (Data Manager)
Action 1: User gets access and logs in the Data Manager
URL address: http://uat7.iesve.com
User name: xx
Password: xx
Any problems encountered in Action 1? Insert here your comments
Action 2: Selection of the typology of User
Non-Expert: Y/N
Expert: Y/N
Admin: Y/N
Any problems encountered in Action 2? Insert here your comments
NewTREND Data Manager_ Button Functionality
SECTION 1 _My Account (displays user details)
Action 3: User enters in section "My Account"
Any problems encountered in Action 3? Insert here your comments
SECTION 2 _Logout (logs user out of the system)
Action 4: User enters in section "Logout"
Any problems encountered in Action 4? Insert here your comments

FIGURE 34: SUBSET OF THE FEEDBACK TEMPLATE FOR THE DATA MANAGER CONCERNING THE FUNCTIONALITY ASPECTS

4.2.2. EVALUATION OF FEEDBACK FROM TEMPLATES

The completed feedback templates were collected and evaluated by IES. After merging the feedback templates, a comprehensive list of issues and suggested enhancements was compiled and prioritised by IES. The most important issues and enhancements were fixed and implemented respectively, while the least important ones are kept in a list of suggested future enhancements before releasing the commercial version of the tool to the public. All these are described in detail in the following Section.

Some examples of feedback we received are:

- “In case the PV panels Installation category 'None' is selected, the fields 'Azimuth' and 'Inclination' could turn to non-editable.”
- “After clicking 'Update Attributes', an error message comes up (see screenshot on the right). However, changes are saved.”
- “After clicking 'Update Attributes', an error message comes up (see screenshot on the right). However, changes are saved.”
- “Default value - we recommend to actually show the default value (as a benchmark).”
- “Advanced mode doesnt take into account previously entered values in Basic mode + cant enter decimal values”
- “Data given in Basic mode - units are missing (e.g. Heating/Hot water fuel cost, Electricity cost) - see Screenshot attached.”

- “Additional information could be added, what the different options (heavy, medium, light) actually mean.
External walls U-value:
- I recommend adding more fields if there are several different external wall types.
- Ideally, this information could be retrieved from the BIM.”
- “There is no option for District Heating in Premium mode fuels”

4.3. PERFORMED AND FUTURE ENHANCEMENTS

The following enhancements have been implemented in the current version of the Data Manager tool, based on the feedback received by users.

4.3.1. PERFORMED ENHANCEMENTS

PERFORMED ENHANCEMENT - TOOLTIPS TO INFORM THE USER ABOUT THE ATTRIBUTES REQUIRED TO BE COLLECTED.

In the Attributes screen, on the right hand side of each attribute an “i” button has been added to provide help to the user with information about the attribute. In the screenshot shown in Figure 35, the information about the roof type is displayed when the tooltip button next to this attribute is selected.

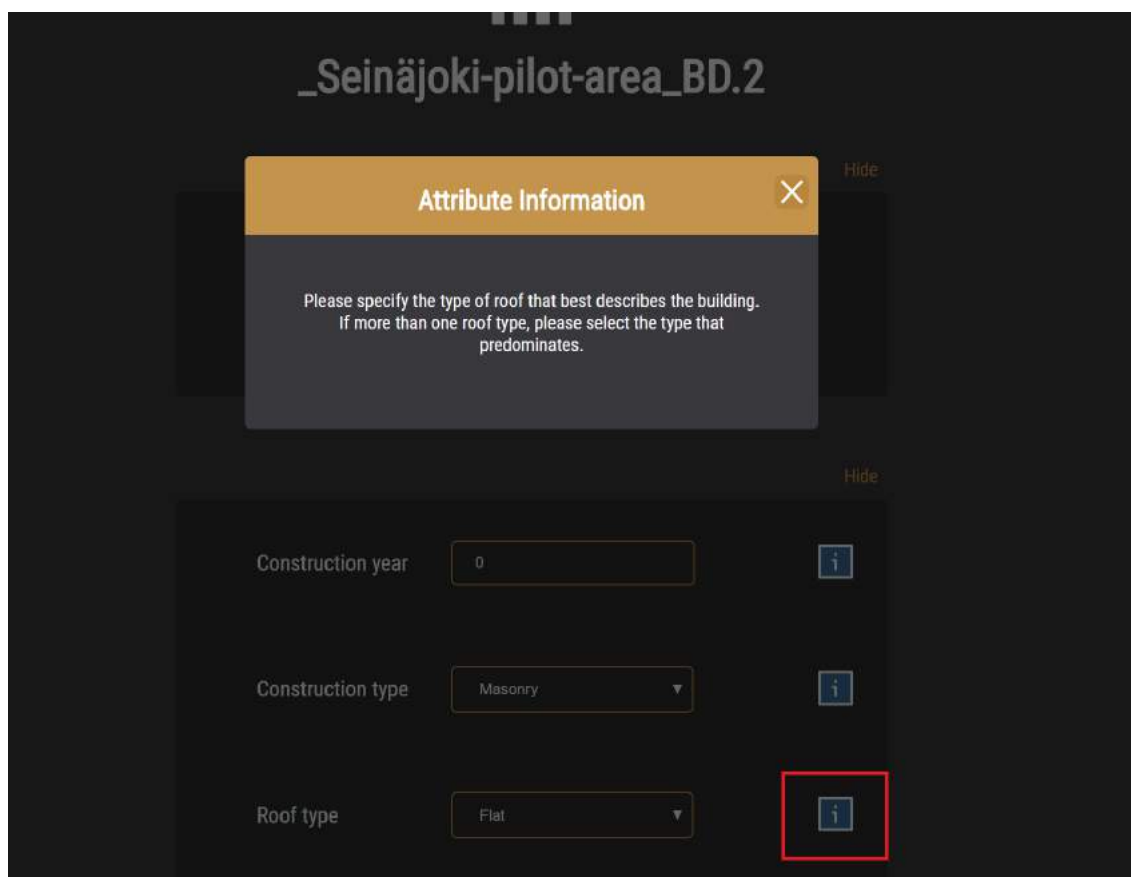


FIGURE 35: PERFORMED ENHANCEMENT - TOOLTIPS IN DATA MANAGER

PERFORMED ENHANCEMENT – STABILITY

The error message shown in the screenshot in Figure 36, was a very common issue during the data collection. It occurred quite often when a user was selecting “Update attributes” button. This was mainly due to software process issue involving communications of the Data Manager with the DIM server. This issue was fixed by UCD and now the Data Manager is successfully storing the updated attributes.

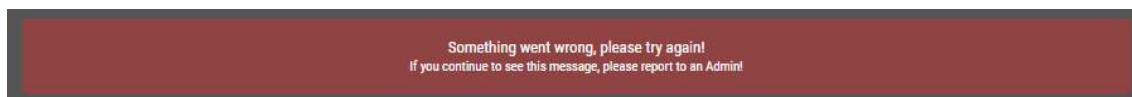


FIGURE 36: SOMETHING WENT WRONG ISSUE FIXED

PERFORMED ENHANCEMENT – BUILDING CONFIGURATION STATUS

A notification is added for every building in the district to inform the user on the status of the data collection for each building. In the initial version, the configuration status was only shown for the whole district. As seen in the screenshot from the Data Manager in Figure 37, the green button indicates that the building is ready to be simulated, while the red means that more data attributes are needed to be configured by the user.

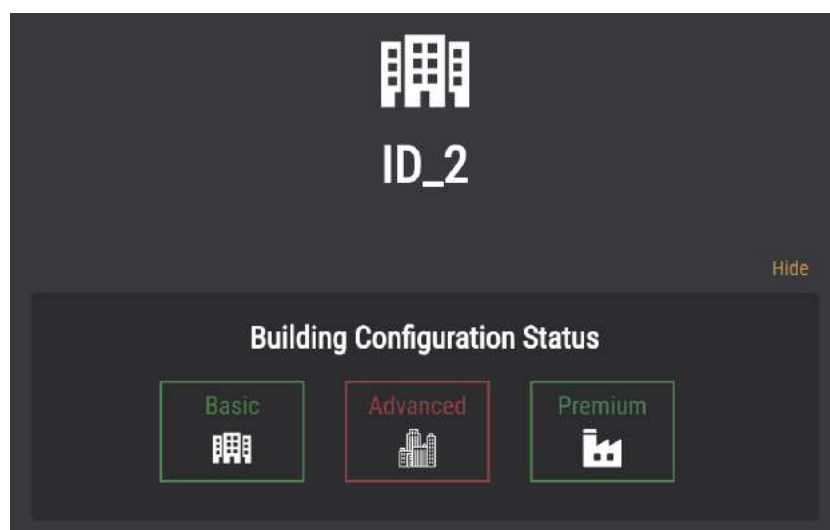


FIGURE 37: BUILDING CONFIGURATION STATUS

PERFORMED ENHANCEMENT – IMPROVED DISPLAY FOR SMALLER SCREENS

The display for smaller screens has been improved to avoid items on the screen collapsing. The view of the reported issue before the enhancement is on the left of Figure 38, while the improved display is on the right-hand side.

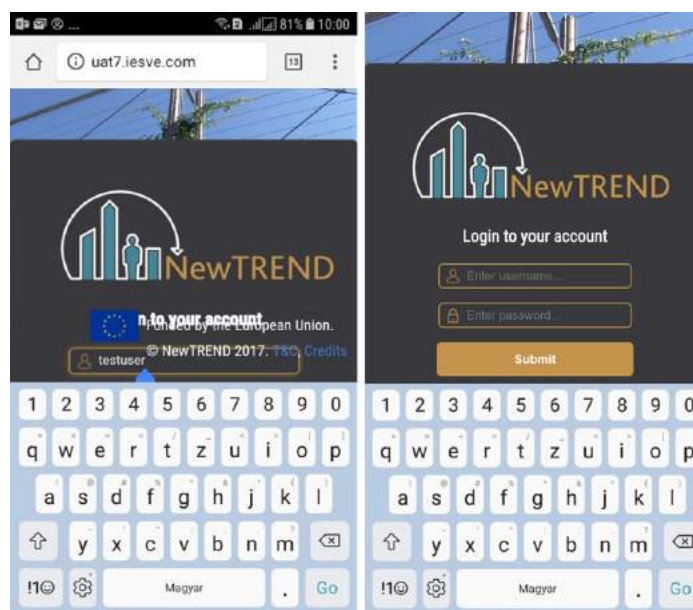


FIGURE 38: IMPROVED THE DISPLAY FOR SMALLER SCREENS

4.3.2. SUGGESTED FUTURE ENHANCEMENTS

The following list of future enhancements were suggested by the Data Manager Usability and Functionality testers and will be implemented before the release of the commercial version, after the NewTREND project finishes.

- Usability enhancements
 - a. Addition of the NewTREND logo in the top left corner to link the project website
 - b. Move the “log out” button below the DIM status button as it is usually the last step of a work session.
 - c. Load attributes automatically when selecting the mode. At the moment, the user needs to press “Get attributes”
 - d. Resolve the issue where the DM gets stuck and the user needs to clear the cookies and empty cache memory on their browser before logging in
- Functionality enhancements
 - a. Keep me logged in' checkbox.
 - b. Allow users to create an account
 - c. Show more information about the users e.g. show role in the project
 - d. In case some essential values for the simulation are missing, those missing values should be flagged. At the moment, the only feedback for the user is that the particular mode is shown as not configured for their building
 - e. Default value - show the default value (as a benchmark if possible).
 - f. Separate fields for domestic hot water and heating systems, as the source of hot water and heating can be different (like in our case: gas is used for heating, however, hot water is produced by electric heaters)
 - g. Include district heating as a fuel option for single buildings.
 - h. Advanced mode to consider previously entered values in Basic mode
 - i. Improve tooltips

5. CDP TESTING

Similar to the development of Feedback Templates for testing of the Data Manager, the first draft the Feedback Templates for testing of the Collaborative Design Platform (CDP) has been developed by following the user manual of the CDP (STAM 2017). This “User Manual for NewTREND: Collaborative Design Platform (CDP)” was written by STAM and guides the user through the processes of the Collaborative Design Platform. This manual was developed under Task 3.4 of the NewTREND project. The CDP is based on the Integrated Retrofit Methodology developed in WP2. The manual forms the basis for evaluating the software as well for creating training materials. In particular, the fourth Section of the manual contains step-by-step instructions about the complete functionality of the tool. The manual also includes the creation of different scenarios with different interventions at both the district and building level.

As for the feedback template of the Data Manager, the feedback templates for the CDP are divided into two main sections: Usability and Functionality. The template for usability testing is described in the next section, including the feedback received through the template. The next section contains a description of the templates for functional testing as well as the collected feedback. This Section then concludes with an outline of performed and future upgrades that are based on user feedback.

The comfort models integrated into the CDP were tested in a standalone fashion first, see Deliverable 4.3 (Aarnes et al. 2017) for more details. In addition to the standalone tests, the comfort models were part of CDP and thus also tested via the feedback templates.

5.1.1. INTERNAL TESTING

Prior to any of the testing activities performed by project partners, the development team (intended as the organization involved in software development: STAM, UCD, and IES) went through a set of internal tests that can be broken down into:

- Unit testing: each new functionality, or portion of code was tested by the developer to assure its correct logic and proper integration with the rest of the code;
- Integration testing: each of the functionalities of the CDP requires the communication with other NewTREND software tools (mainly the DIM server and the SDH). This required each communication interface (REST APIs), to be tested individually before testing the software functionalities;
- Validation testing: after verifying each piece of software and its communication interface, the user workflow was simulated to see if any additional bug or error would come up. Only after this activity the tool would be given to project partners to test.

5.2. USABILITY TESTING OF THE CDP

5.2.1. FEEDBACK TEMPLATE FOR USABILITY TESTING

The Feedback Template for usability testing of the Collaborative Design Platform follows the workflow of the NewTREND Platform. It starts with user login and continues with the following three major areas:

- AREA 1_Administration (manage workgroups and members);
- AREA 2_E-collaboration (manage social tools to encourage the exchange of information between members and to conduct surveys);

- AREA 3_Projects (manage projects related to the management of a DIM model that contains a representation of a district).

This chapter reports on evaluating the "Usability Aspects of the Collaborative Design Platform, reporting on the clarity of interface elements. The aim is to gather feedback from the user on the workflow in order to improve it and make it more intuitive.

In this context, the questions for users are as follows:

- How does the user interface look?
- How easy is it to navigate?
- Are interface elements setup in a meaningful manner?
- Do all interface elements work correctly?
- Do you have any opinions about improving the functionality of the tool?

These questions also apply to the simulation part of the CDP, particularly for scenario creation, simulation configuration, simulation execution and for results visualization. The aim here is to collect feedback about the appearance of the interface - ease of navigation, correct operation of buttons on the menu, etc. Direct user feedback in this area is crucial to help improve the usage of the software tool.

USABILITY ASPECTS
WP6 - T6.4_TESTING FEEDBACK TEMPLATE (Collaborative Design Platform)
User gets access and logs into the Collaborative Design Platform
<i>How does the user interface look?</i>
<i>How easy is it to navigate?</i>
<i>Are interface elements setup in a meaningful manner?</i>
<i>Do all interface elements work correctly?</i>
<i>Do you have any ideas about improving the functionality of the tool?</i>
NewTREND Collaborative Design Platform_ Button Functionality
AREA 1_Administration (manage workgroups and members)
Workgroups
<i>How does the user interface look?</i>
<i>How easy is it to navigate?</i>
<i>Are interface elements setup in a meaningful manner?</i>
<i>Do all interface elements work correctly?</i>
<i>Do you have any ideas about improving the functionality of the tool?</i>
Members (physical person that has access to the various functionalities of CDP)
<i>How does the user interface look?</i>
<i>How easy is it to navigate?</i>
<i>Are interface elements setup in a meaningful manner?</i>
<i>Do all interface elements work correctly?</i>
<i>Do you have any ideas about improving the functionality of the tool?</i>

FIGURE 39: EXAMPLE OF THE COLLABORATIVE DESIGN PLATFORM TESTING FEEDBACK TEMPLATE - USABILITY ASPECTS

Figure 39 illustrates an example of the Feedback Template to test “Usability Aspects” of the of the Collaborative Design Platform Testing. The complete feedback template is show in Annex 1.3.

An example of user feedback from all three demo sites related to user login and access is given in Figure 40. A more detailed review of the feedback is given in the following Section.

WP6 - T6.4_TESTING FEEDBACK TEMPLATE (Collaborative Design Platform)		
User gets access and logs in the Collaborative Design Platform		
<i>Are buttons name and menu options comprehensible?</i>		
BUDAPEST DEMO SITE	SEINAJOKI DEMO SITE	SANT CUGAT DEMO SITE
The top tab is hardly visible, since it's written in white letters on a light background. Maybe make it similar to the Tech library top tab. Also, when scrolling down this top tab remains in place, but because its background is transparent, the text on the page could became jumbled up (see print screen on the right)	The color of top links is a bit too close to background color	Yes
AREA 2_E-collaboration <i>(manage social tools to encourage the exchange of information between members and to conduct surveys)</i> Poll/Doodle <i>is used to ask one simple question. (http://doodle.com/)</i>		
<i>How the user interface looks?</i>		
BUDAPEST DEMO SITE	SEINAJOKI DEMO SITE	SANT CUGAT DEMO SITE
Nice and clear	Preview of the poll and survey not visible, until I click on the part of website where it should be. Same problem as with Gantt chart	Clear and simple

FIGURE 40: ANSWERS OF THE TESTING FEEDBACK TEMPLATE FOR CDP

5.2.2. EVALUATION OF FEEDBACK FROM TEMPLATES

The collection of feedback from testing partners was done in an iterative fashion, allowing developing partners to continuously feed this valuable information into the development process. For this reason, user feedback was collected and analyzed by STAM both during and after the testing activities. This user input drove further developments, corrective actions and improvements to the CDP. Moreover, STAM has led the software training activities, allowing testing not only for internal stakeholders, but also by professionals, students, decision makers, municipalities and others from outside the project consortium. This resulted in a rich set of information from a broad spectrum of users to develop an extensive list of enhancements to the Collaborative Design Platform front-end.

The overall usability feedback was positive, and the enhancements requested could be solved either with small graphic improvements, additions to the training material, or enhancements to the CDP portability (e.g. different web browsers, devices and operating systems).

For this the feedback templates from different partners were merged into a single document to create a matrix of issues and issue creators. Based on this matrix, STAM developed possible issue solutions as shown in Figure 41. Further details of major performed enhancements are reported in section 5.4.

Members (Person that accesses the CDP functionalities)	ABUD	JER	SANT CUGAT	GRANLUND	STAM SOLUTION
How does the user interface look	Nice and clear. Members deleting: it is not necessary to make the text of deletion confirmation request red.	Clear and simple	Clear and simple	I would hide the password somehow, not make it visible straight away	Text color changed to black (bold letters) Users' password hidden
How easy is it to navigate	Very Easy	Easy	Easy	Easy	
Any ideas about helping ease the usage of the tool?	Members Deleting – I recommend adding a 'Cancel' button. One member can only be part of one workgroup? Right now it looks like it. I recommend giving option to include one member in multiple Workgroups		I would hide members' password		Added a 'GO BACK' button on member creation. Inserted User-workgroup association in the manual.

FIGURE 41: FEEDBACK FROM PROJECT PARTNERS ON CDP

5.3. FUNCTIONALITY TESTING OF THE CDP

5.3.1. FEEDBACK TEMPLATE FOR FUNCTIONAL TESTING

The Functionality section of the Feedback Template to test the Collaborative Design Platform is aligned with features of the NewTREND software tools. This Section focuses on the functionality and operability of the platform. The aim is to highlight problems in the implementation of the platform features. It contains three main areas each entails one or more actions. These areas are the same as identified for the usability testing, but the questions asked to the users are different. These questions focus on the action, the expected and obtained outcome. The answers to these questions are reported in notes and where relevant, accompanying screenshots.

Within the first area "AREA 1 _Administration" supported actions are to create, delete or edit a workgroup. Furthermore, this area includes workgroup member management and a review of members within a group. Consequently, the feature set includes the creation, edit and deletion of a member that belongs to a workgroup.

Within "AREA 2_ E-collaboration" the user can select a social tool type he or she wants to use in a particular project. The available social tools are:

- Pool/Doodle, used to ask one simple question;
- Surveys/Surveymonkey, used to ask a wide range of questions;
- Quiz/Online quiz creator.

Users can create, manage, edit and delete each social tool and report on any problems encountered while using them.

In the last Area of feedback template “AREA 3_Projects”, the user can create a new, edit or delete an existing project as well as insert project details. Editable project details include a description, a start date, a target date, a closing date, the name of the creator, a creation date and any information about the status of the project. In addition to manage the project, the user can also create, edit and delete phases in a project. In context of the project phases the user can create, edit or delete a Task. The feature set of tasks also includes related tasks, tasks members and a Gantt Chart. The Gantt Chart is used to show duration and percent completion of tasks.

Besides these three areas, the CDP also contains a feature set on analyzing the district and building including the comparisons of different design options. This is a key component of the CDP and allows simulation of different design scenarios as well as their assessment for different design scenarios at the building and district level. This allows the user to evaluate different design options for the building in question considering the surrounding neighborhood. The simulations can be performed as either “as-is” or “what-if” simulations. The “as-is” simulation allows calculation of and retrieval of parameters that describe the actual and real conditions of the district. The “what-if” simulations allows users to verify the behavior and the performance of the district given a set of user-defined interventions.

When the user creates a simulation, it is possible to enter a name and description of the scenario as well as the target of this simulation: the whole district or one of the buildings. In addition, the user needs to select the mode (basic, advanced or premium) and select a range of the interventions to analyze. Once a scenario is created, it can be simulated and KPIs and results can be analyzed.

Figure 42 contains a short section of the graphical interface of the Feedback Template to test the functionality of the Collaborative Design Platform. A more complete version of this feedback template is shown in Annex 1.3.

NewTREND Collaborative Design Platform_ Button Functionality	
AREA 1 _Administration (manage workgroups and members)	
Workgroups	
Action 2: User enters in the list of the workgroups	
<i>Any problems encountered in Action 2? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Action 3: User creates a Workgroup	
<i>Any problems encountered in Action 3? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Action 4: User edits a Workgroup	
<i>Any problems encountered in Action 4? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Action 5: User deletes a Workgroup	
<i>Any problems encountered in Action 5? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Members (physical person that can access to the various functionalities of CDP)	
Action 6: User checks Members included and not included of a Workgroup (name, password, workgroup, role, actions)	
<i>Any problems encountered in Action 6? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Action 7: User creates a new Member	
<i>Any problems encountered in Action 7? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Action 8: User edits a Member	
<i>Any problems encountered in Action 8? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Action 9: User deletes a Member who currently belong to the workgroup	
<i>Any problems encountered in Action 9? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	

FIGURE 42: EXTRACT FROM THE COLLABORATIVE DESIGN PLATFORM TESTING FEEDBACK TEMPLATE CONCERNING THE FUNCTIONALITY ASPECTS.

5.3.2. EVALUATION OF FEEDBACK FROM TEMPLATES

Similar to the usability feedback, functionality testing allowed the development team to collect relevant information about system malfunctioning, bugs, and potential inconsistencies. The key difference between usability and functionality testing lies in the fact that functional testing aims at answering the

question ‘does the software produce the expected output?’. For this reason, each error or bug reported produced an in-depth analysis of the causes. Due to the integrative nature of the tool set it was important to understand the root cause of an issue. Is the issue originating in one of the software tools of the platform or is it caused by external factors (network configuration, communication issues, etc.).

WP6 - T6.4_TESTING FEEDBACK TEMPLATE (Collaborative Design Platform)		
User gets access and logs in the Collaborative Design Platform		
AREA 2_E-collaboration <i>(manage social tools to encourage the exchange of information between members and to conduct surveys)</i>		
Poll/Doodle <i>is used to ask one simple question. (http://doodle.com/)</i>		
Action 10: User creates a new poll		
Expected Outcome of action:		
BUDAPEST DEMO SITE	SEINAJOKI DEMO SITE	SANT CUGAT DEMO SITE
-	User creates a new poll	User creates a new poll
Obtained Outcome:		
BUDAPEST DEMO SITE	SEINAJOKI DEMO SITE	SANT CUGAT DEMO SITE
-	New poll created through a different service	Done. New poll created through external service

FIGURE 43: FUNCTIONAL TESTING FEEDBACK TEMPLATE FOR THE CDP

The first testing phase revealed several errors in the user administration and project management functionalities. This phase (started on January 2018 and lasted until February 2018) revealed some initial shortcuts and workarounds in the initial CDP implementation. These issues could be resolved through a better and more reliable software integration of CDP with the other NewTREND tools.

Details of performed and future enhancements on the CDP are reported in section 5.4.

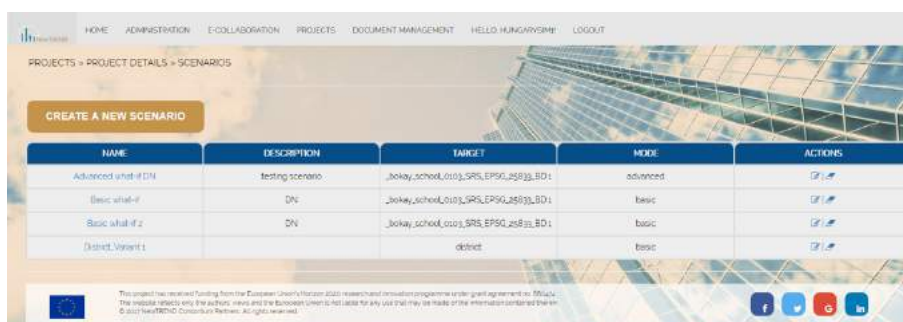
5.4. COMPLETED AND FUTURE ENHANCEMENTS

Both feedback templates described in the two previous sections contributed to a list of enhancements to CDP. In this section we provide a list of performed enhancements as well as a list of potential future enhancements.

5.4.1. COMPLETED ENHANCEMENTS

In the following we list the most relevant performed enhancements:

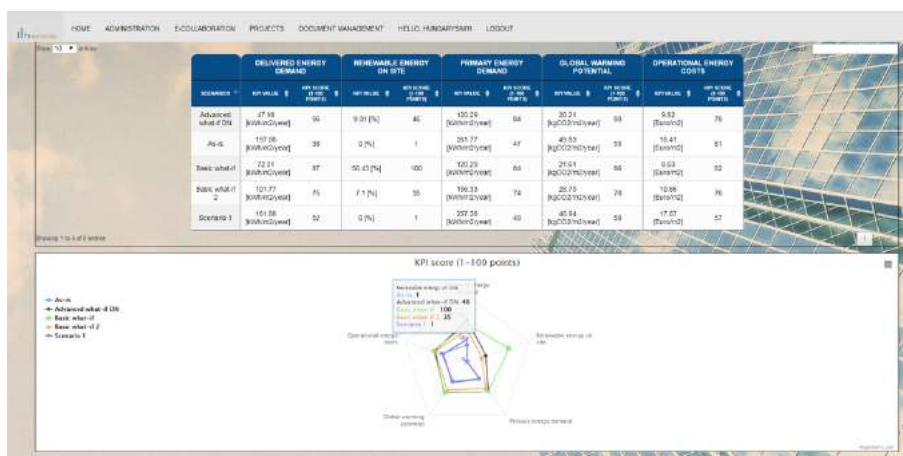
- **Introduction of breadcrumbs:** Some of the initial feedback was the complexity of the CDP to non-expert users in particular the large number of pages and features. To guide the users within the complex CDP web application, the notion of *breadcrumbs* was introduced. Breadcrumbs are a block of links under the main navigation tab, which show the user the current path of links he/she followed. These breadcrumbs do not only show the path, but also allow navigation to previous pages (Figure 44).


FIGURE 44: ENHANCED NAVIGATION: BREADCRUMPS

- **3D District visualization:** Based on user feedback, the initial view of footprints of buildings was replaced by their respective 3D volumes (Figure 45).


FIGURE 45: ENHANCED DISTRICT VISUALIZATION

- **Combined visualization of KPIs:** The display of KPI was improved to increase their readability. The calculated KPIs are now displayed both in a graphic form and in a table (Figure 46). In addition, both the actual KPI values as well as the physical value generating the KPI are shown in the table.


FIGURE 46: ENHANCED KPI DISPLAY

- Zoomable Graphics:** Based on a suggestion coming from testing activities zoomable graphics were realized. Since several simulation results are presented as annual time series that are great to get a quick overview of the annual performance (Figure 47). However, without the zoom it was not possible to get into more detail. STAM enhanced the graphing functionality to allow zooming, so the user can view data as detailed as at an hourly frequency.



FIGURE 47: ENHANCED ZOOM IN GRAPHICS

6. IDM DESIGN PROCESS TESTING (SEPARATELY PER DEMO SITE)

The Integrated Design Methodology is translated to the different functions of the NewTREND tool especially the CDP. In the CDP, the following phases and steps of the methodology can be tested:

- **Preparation phase** - Freezing model for Diagnosis
- **Diagnosis phase** - Current State Analysis
- **Strategic Definition phase** - Targets
- **Concept phase** - Variant Creation
- **Concept phase** - Checking Variants Against Targets
- **Concept phase** - Decision Making

6.1. BUDAPEST DEMO SITE

6.1.1. FREEZING MODEL FOR DIAGNOSIS

The final models, which have been uploaded to the DIM server, contain geometrical information. All additional data is created via the Data Manager and stored in the DIM server.

The data for the school building is stored as IFC, CityGML and project data and contains the following information:

- A detailed IFC model for advanced mode simulations of the school
- A CityGML file with the school building and its surroundings
- Basic, advanced and premium mode data is collected and uploaded to the Data Manager. In cases where no information was available, the default values were used, or assumptions based on previous refurbishment project experiences were applied.

The district CityGML file and project data contain the following information:

- The CityGML file contains the buildings located in the Bókay garden
- There is no IFC file for any building in the district, as no building is analyzed in advanced mode
- Only basic level data is collected and uploaded via the Data Manager to the DIM server

For the Budapest Demo Site, the analysis is separated into two parts, the basic mode district analysis and the advanced school building analysis.

6.1.2. SCHOOL BUILDING CURRENT STATE ANALYSIS

The following sections describe the evaluation of the case study building, the Bókay school in Budapest, using the analysis tools available in the NewTREND platform. The advanced mode was chosen for the analysis as a detailed model and data are available about the building.

KEY PERFORMANCE INDICATORS

Investigating the state of the building KPIs can reveal strengths and weaknesses, that can be considered during decision making. Figure 48 is a screenshot from the NewTREND platform displaying the KPIs for the current sustainability state of the case study in advanced mode. The scores for the indicators in the current state allowed identification of domains where the building was poorly performing. These aspects are easily visualized on the NewTREND tool using the scoring system for district indicators and the meaningful radar chart (Figure 49).

	Delivered energy demand (kWh/m ² ,year)	Renewable energy on site (%)	Primary energy demand (kWh/m ² ,year)	Global warming potential (kgCO ₂ /m ² ,year)	Operational energy costs (EUR/m ²)
Advanced as_is	169,6	0	218,78	41,91	13,49
	Indoor air quality	Summer comfort without cooling	Thermal comfort in the heating season	Thermal comfort in the cooling season	
Advanced as_is	1	100	100	100	

FIGURE 48: THE RESULTS OF THE BUILDING KPI AS-IS ANALYSIS

The KPI analysis shows 9 indicators in 3 categories: Environmental, Economic and Social indicators.

In the Environmental category the Delivered Energy Demand scores just below average with an actual value of 169,6 kWh/m²,year (KPI score = 49) so there is room for improvement (especially since there is no cooling and ventilation system so the main part of the energy demand comes from heating). The primary energy demand of the building is just above average with an actual value of 218,78 kWh/m²*year. The closely related GWP indicator shows similar result (value: 41,91 kgCO₂/m²*year). Also, the building has no renewables installed which is reflected also by the 0 score of the Share of Renewable Energy on Site indicator.

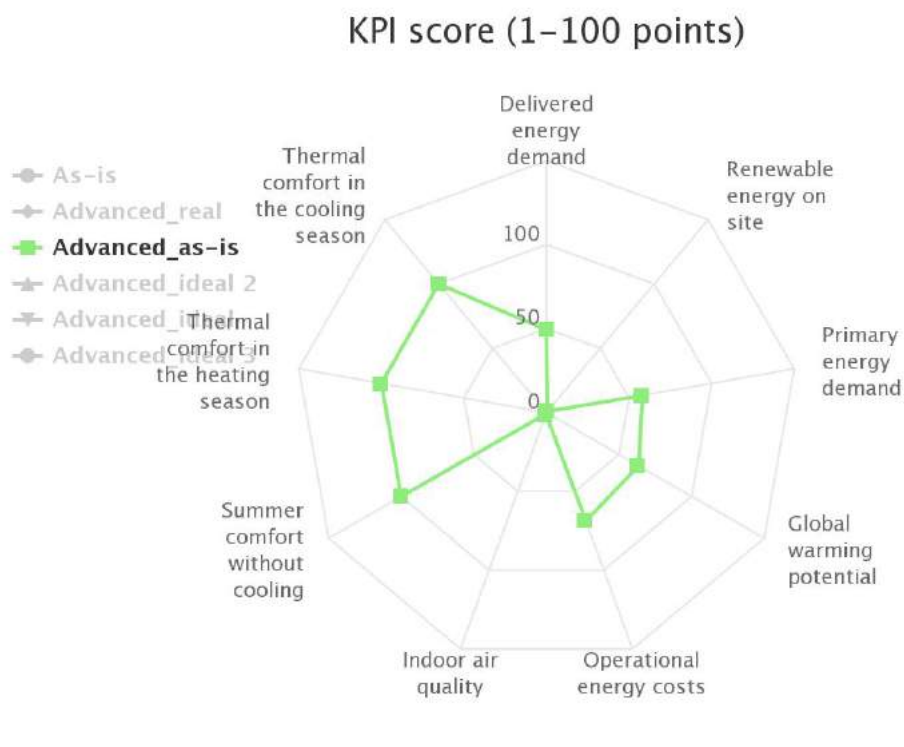


FIGURE 49: THE RESULTS OF THE BUILDING KPI AS-IS ANALYSIS ON A RADAR CHART

In the Economy category the only available indicator is the Operational energy cost indicator. Here the building scores well above average with an actual value of 13,49 EUR/m² by profiting from the below EU average energy prices in Hungary^{1,2}.

In the Social category the KPIs are showing the following results:

- Indoor air quality = 1 - according to the KPI calculation method the result means that more than 5% of the operating hours are out of the comfort range (determined according to EN15251)
- Summer comfort without cooling, Thermal comfort in the heating season, Thermal comfort in the cooling season = 100, based on the KPI calculation method the results mean that 0% of occupied hours are out of the comfort range

During validation of the results showed by the CDP the following issues has emerged:

- The calculation of thermal comfort has been applied to all buildings zones (including boiler room, storage, corridors, bathrooms etc.), so the resulting comfort KPI result is lowered because "service" rooms are not heated and should be excluded from the calculation.
- In some cases, it is not clear how the simulation output data is interpreted on the CDP interface

Due to the above issues the results of the comfort analysis are regarded as unreliable and were therefore not considered during the analysis.

In summary there is a need to act on the reduction of the energy demand of the building, which will cause further reduction of the operational energy cost. This means that there is a need to further investigate the as-is state of this building using the rest of the analysis tools.

DELIVERED ENERGY DEMAND

The energy tab of the simulation results section of the NewTREND tool shows the results of the delivered energy demand breakdown.

¹ Source: EUROSTAT Electricity prices for non-household consumers, second half 2017

² Source: EUROSTAT gas prices for non-household consumers, second half 2017

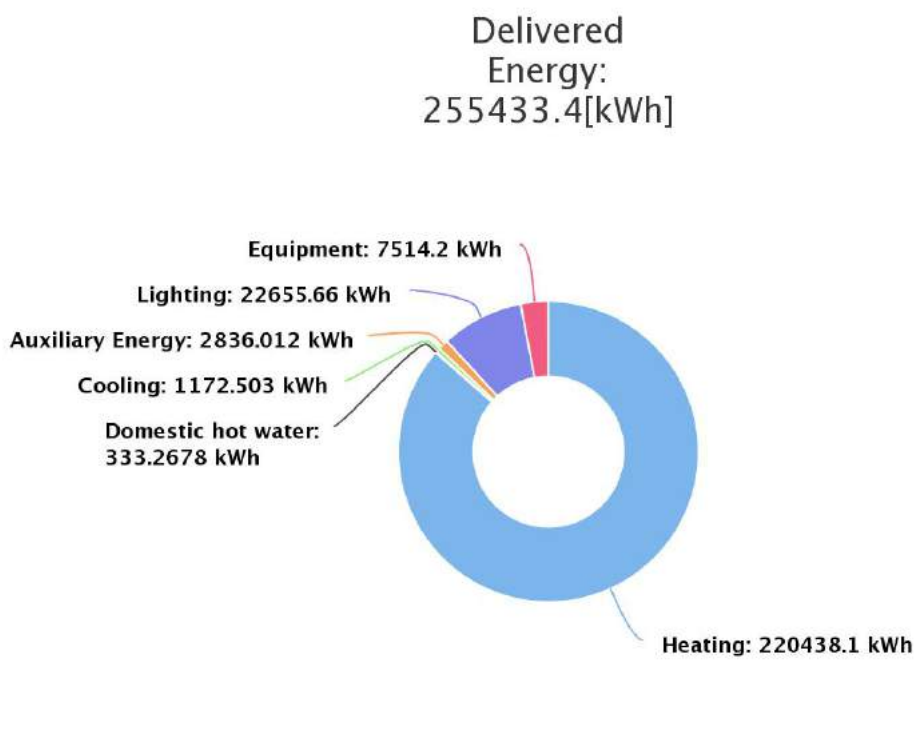


FIGURE 50: DELIVERED ENERGY BREAKDOWN OF THE BÓKAY SCHOOL

According to Figure 50 the main consumer of the delivered energy is the heating system using 86% of the total delivered energy. The second highest consumer is the lighting system with 9% share of the total energy. The remaining 5% of the energy is used by the domestic hot water system, the cooling system (as there is only one split unit for the IT classroom), the equipment and other auxiliary energy. Therefore, it is highly recommended to reduce the heating needs of the building and then improve the heating system as well. Possible improvements on the lighting system can also reduce the energy consumption with a much lesser effect.

Therefore, further analysis is needed to investigate the reasons behind the high consumption of the heating system with the thermal based weak points analysis function of the NewTREND tool.

THERMAL BASED WEAK POINTS

The Thermal based weak points analysis is the other analysis available on the Energy tab. Here two diagrams are available representing the heat losses in winter (Figure 51) and the heat gains in summer (Figure 52) of the building.

HEAT LOSSES

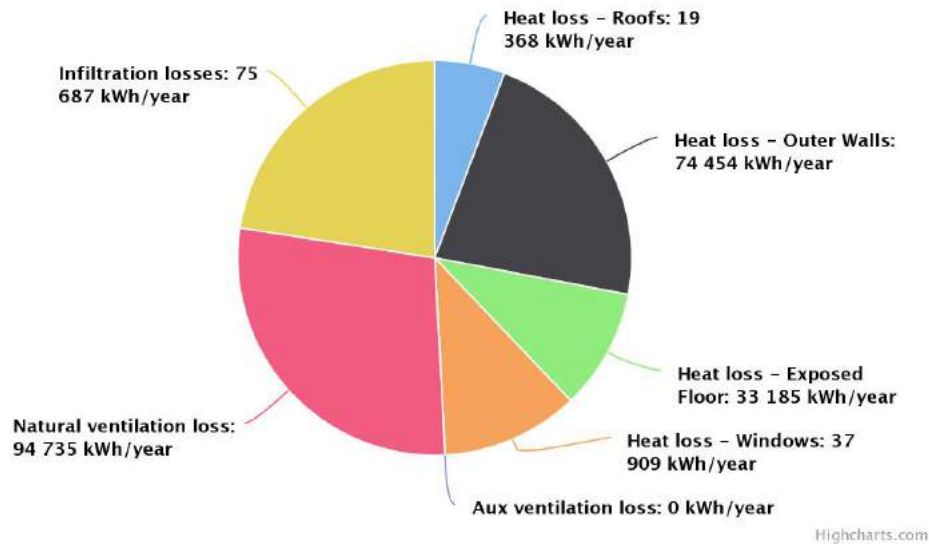


FIGURE 51: HEAT LOSSES OF THE BÓKAY SCHOOL

The heat loss diagram indicates that the main heat losses are through the thermal envelope with 49,18% of the total heat losses. Natural ventilation causes other significant losses (28.25% of the total) as well as the infiltration losses (22,57% of the total). The losses through the thermal envelope can also be broken down: the outer walls cause the highest losses, then the windows and through the exposed floor and less so by the roof.

Therefore, it is recommended to update the existing thermal envelope and assess the feasibility of installing a mechanical ventilation system to reduce natural ventilation losses.

HEAT GAINS

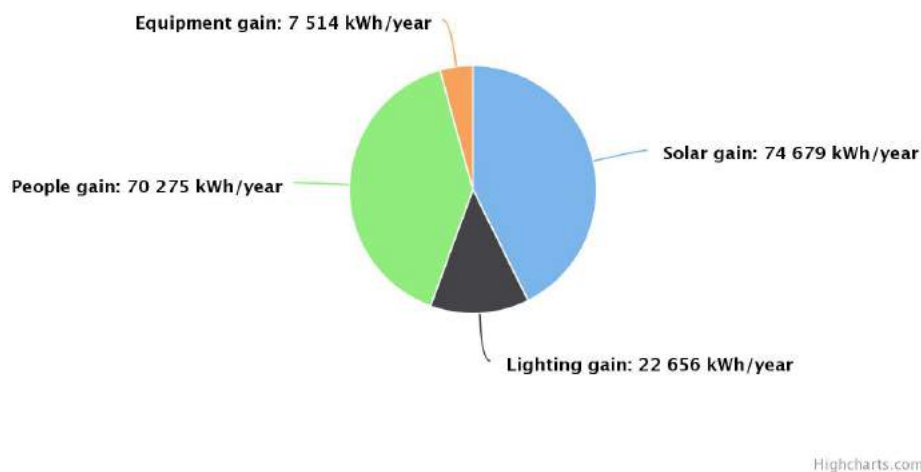


FIGURE 52: HEAT GAINS IN THE BÓKAY SCHOOL

The heat gains diagram shows that the solar gains are the main contributor with 42,64% of the total gains. These are closely followed by the people gains. Lighting and equipment have some minor heat gains in the building.

As heating system improvements are concerned, heat gains are positive factors, but they would affect negatively the summer cooling energy consumption (if there would be a cooling system) and causes discomfort in summertime. Therefore, it is not recommended to further improve heat gains.

ELECTRICAL LOAD PROFILE

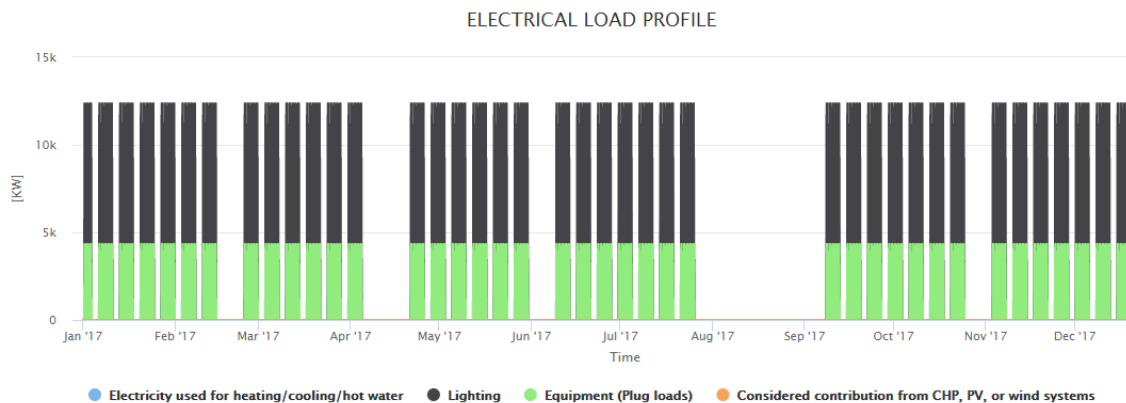


FIGURE 53: LIGHTING AND EQUIPMENT LOAD PROFILE OF THE BÓKAY SCHOOL

The electrical load profile of the building (Figure 53) shows a weekly constant load for lighting and equipment loads for weekdays. Only the electricity used for cooling of one room (Figure 54) is varying, as it is getting high in parallel with the summer hot months. On weekends and during the summer holiday the electricity load of the building is zero.

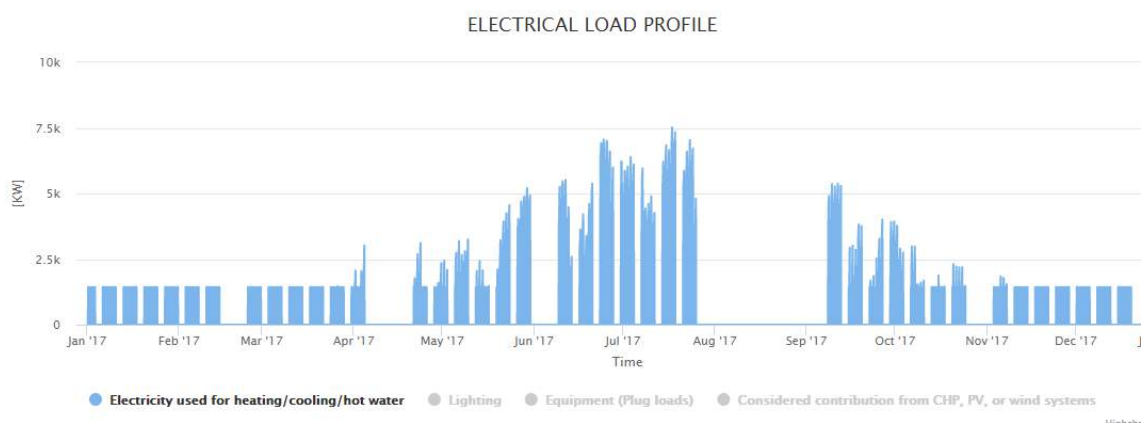


FIGURE 54: COOLING LOAD PROFILE OF THE BÓKAY SCHOOL

Looking at a daily profile it can be seen that the electricity loads are present during the daytime, mostly between 6:00-19:00 (Figure 55).

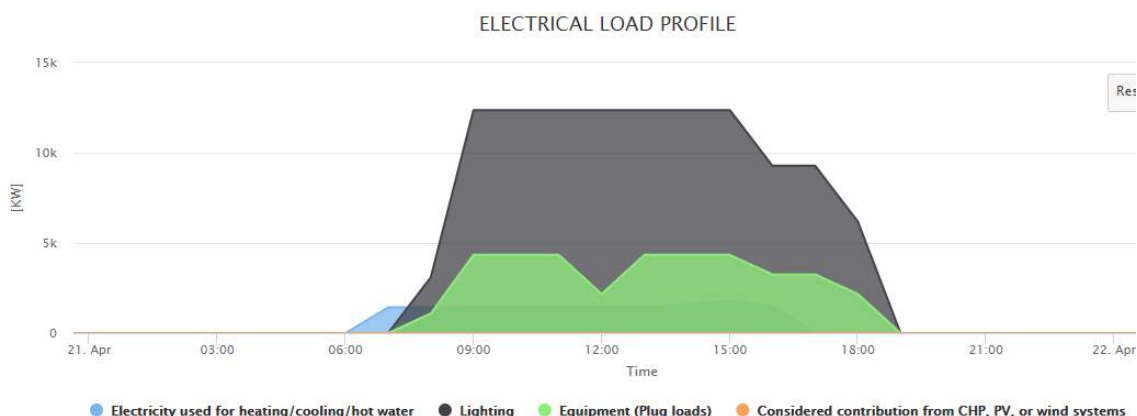


FIGURE 55: ELECTRICAL LOAD PRIFLE OF THE BÓKAY SCHOOL FOR ONE SUMMER DAY

ENERGY BALANCE

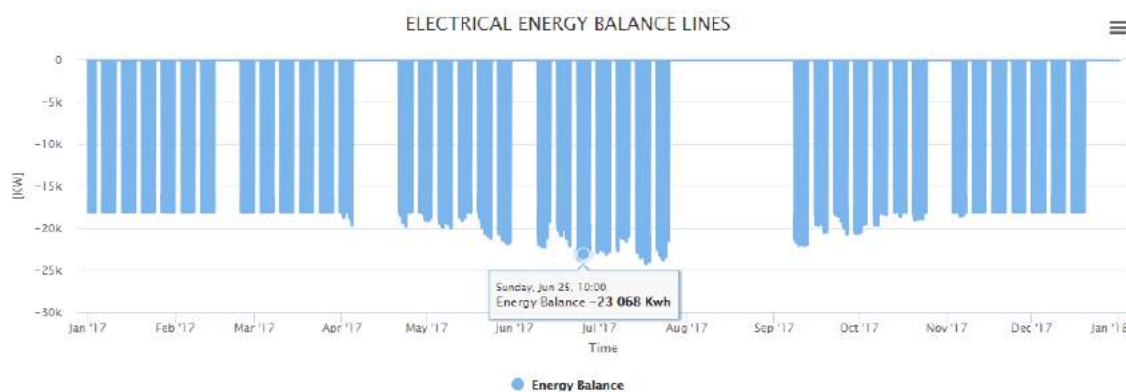


FIGURE 56: ELECTRICAL ENERGY BALACE LINES OF THE BÓKAY SCHOOL

The NewTREND tool also has a function that shows the yearly electrical energy balance lines of the building. As Figure 56 shows the sum of the electrical energy loads in the Bókay school balanced with the produced electrical energy. Since there is no energy production on site the balance line only shows the energy demand of the building.

HEAT DURATION CURVE

The NewTREND tool is capable to analyze the heating energy consumption of the building as well. The main result of the analysis is the heat duration curve for the building (Figure 57). The heat duration curve is showing the number of hours on which a specific load demand occurs. Typically, the peak load in the building occurs only for a few hours a year. The heat duration curve also shows that the heating demand in the building occurs less than 20% of the year, therefore it is not feasible to design interventions that generate heat constantly, for example CHP or solar thermal collectors.

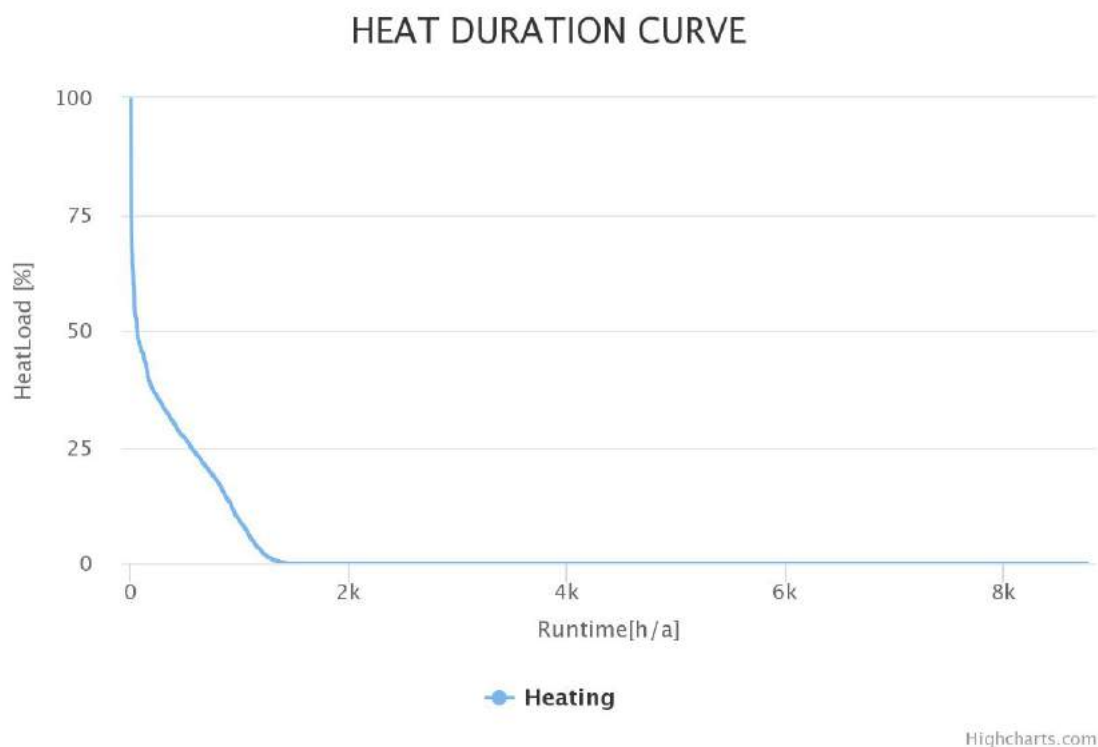


FIGURE 57: HEAT DURATION CURVE OF THE BÓKAY SCHOOL

THERMAL COMFORT

The NewTREND tool has a function to investigate, in detail, the thermal comfort of rooms using advanced mode. However, the comfort calculation validation showed that some result are unreliable and the diagrams are not showing if the room conditions are inside or outside of the comfort ranges. Therefore, the result are not analyzed.

6.1.3. TARGETS

In the Strategic Definition phase the main tasks are to set meaningful targets for the retrofitting project and to identify main constraints and restrictions which may limit the retrofitting design. The possible interventions that can improve the current state of the building should be filtered by the constraints of the building and prioritized by the main targets of the refurbishment project.

Five main types of constraints can be identified in retrofitting projects, and the following issues should be considered for the Bókay school:

- Legal constraints – the main legal restriction is the local historical protected state of the building. This means that the building façade should be maintained in its original condition, and on the roof above the main façade no PV can be installed (but can be installed on other roof areas of the building)
- Technical constraints
- Financial constraints – the project was financed by EU regional cohesion funds, which had budget limitations and it prescribed the possible interventions that can be financed
- Environmental condition constraints

- Stakeholder based restrictions – the building is owned by the municipality, but the surrounding buildings are private residences

Based on these constraints, no outer wall insulation is designed as an intervention for the building and the full PV capacities of the roof is not used. Furthermore, no district synergies are assessed because of the complex stakeholder structure of the neighborhood. As the building retrofitting has already been financed, the financial constraints are not taken into account, the analysis was more focused on how the realized design could have been improved.

According to the NewTREND IDM, S.M.A.R.T.(specific, measurable, attainable, relevant and time-bound) targets should be set for each KPI of the building. As the refurbishment project has already been realized for the building, the targets that the project owners intended can be deduced: maximize the energy use reduction and renewable energy generation for a fixed investment cost. The comfort criteria of the building occupants were not considered. From the viewpoint of the actual building users the main priority would be to maximize building comfort and minimize the operational costs for a fixed investment amount.

	CATEGORY PRIORITY LEVEL	BUILDING CORE KEY PERFORMANCE INDICATOR	BUILDING KPIS PRIORITY LEVEL	KPI PRIORITY SCORE	KPI WEIGHTING
ENVIRONMENT	HIGH ▼	1 Energy			
		1.1 Operational Primary Energy Demand	MEDIUM ▼	6	11.11 %
		1.2 Delivered Energy Demand	HIGH ▼	9	16.67 %
		1.3 Renewable Energy on site	MEDIUM ▼	6	11.11 %
		2 Impacts			
SOCIETY	LOW ▼	2.1 Global Warming Potential	MEDIUM ▼	6	11.11 %
		3 Air Quality			
		3.1 Indoor air quality	HIGH ▼	9	4.17 %
		4 Thermal Comfort			
		4.1 Summer comfort without cooling	HIGH ▼	9	4.17 %
		4.2 Thermal comfort in the heating season	HIGH ▼	9	4.17 %
		4.3 Thermal comfort in the cooling season	HIGH ▼	9	4.17 %
ECONOMY	MEDIUM ▼	5 Operational Costs			
		5.1 Operational Energy Costs	HIGH ▼	9	33.33 %

FIGURE 58: KPI WEIGHTING FROM THE BUILDING OWNER POINT OF VIEW FOR THE BÓKAY SCHOOL

The main targets of the building owners were defined as KPI weights in the assessment (Figure 58). As the delivered energy demand reduction is the main goal, the environment category gets the highest priority. Within this category the Delivered energy demand indicator is the top priority, the others are medium priority. The Economy category gets medium priority and the comfort indicators in the Society category get the lowest priority. Based on this, the only indicator in the Economy category has the highest weight (33.33%) followed by the Delivered Energy Demand indicator with 16,67% weight. The Society indicators only have 4,17% weight if the owners priorities are taken into account.

6.1.4. VARIANT CREATION

In an ideal refurbishment project using the NewTREND IDM, the concept phase would evaluate the analysis of the current state based on the targets developed and then, determine the interventions to be used during the design phase. Since the Bókay school demonstration project is not ideal in a sense that the refurbishment plan has already been determined, a modified method was used for the concept phase.

First, the real refurbishment was created as a variant to be assessed, then ideal variants were determined to see if the original design could have been improved from energy efficiency and comfort point of view.

Summing up the current state analysis, the following areas for improvement were identified:

- Areas for energy efficiency improvement:
 - Consumption reduction (passive technologies): wall insulation, window insulation, floor insulation, LED lighting
 - Supply improvement: heating system improvement, change of ventilation system to mechanical ventilation
 - Renewables: inclusion of renewables
- Areas for comfort improvement:
 - Indoor air quality – improve the ventilation systems

	Advanced_real	Advanced_ideal	Advanced_ideal 2
Boiler Plant Improvements			
Chiller Plant Improvements			
Terminal controls			
Plant controls			
Fans			
Ventilation			Ventilation heat recovery 90%
Distribution Pipes Insulation			
Lighting source		LED best (120 lm/W)	
Lighting controls			
Roof insulation	20 cm	20 cm	20 cm
Loft insulation			
Exposed floor insulation	15 cm	15 cm	15 cm
External wall inner insulation		10 cm	
external wall cavity insulation			
external wall timber frame insulation			
external wall outer insulation			
Fabric opaque doors			
Glazing type	triple glazed window	triple glazed window	triple glazed window
Shading glazing			
Distributions systems insulation			
Electric motors and drives			
Heat Pump (heating)			Air source heat pump (CoP 3,5)
Solar water heater			
Heat pump (cooling)			
PV panels	20 kW (medium commercial)	20 kW (medium commercial)	20 kW (medium commercial)
Wind Turbine			

TABLE 2: VARIANTS CREATED FOR THE BÓKAY SCHOOL ADVANCED MODE ANALYSIS

Based on the available interventions and the identified areas for improvement, three variants were identified (Table 2). The first variant (Advanced_real) is the one that closely resembles the implemented design. Table 3 shows the interventions that the real design includes. This implemented real design could represent the actual retrofit through 3 or 4 interventions. In the fourth case, the 'PV panels', there was no option to choose 40kW PV panels, so the closest option was chosen (installation of 20kW PV panel).

	Reality
Boiler Plant Improvements	
Chiller Plant Improvements	
Terminal controls	
Plant controls	
Fans	
Ventilation	
Distribution Pipes Insulation	
Lighting source	
Lighting controls	
Roof insulation	20 cm
Loft insulation	
Exposed floor insulation	15 cm
External wall inner insulation	
external wall cavity insulation	
external wall timber frame insulation	
external wall outer insulation	
Fabric opaque doors	
Glazing type	Triple glazed 7 chamber PVC window $U_g=0,8W/m^2K$; $U_w<1,15 W/m^2K$.
Shading glazing	
Distributions systems insulation	
Electric motors and drives	
Heat Pump (heating)	
Solar water heater	
Heat pump (cooling)	
PV panels	176 PV module (250 W / piece) = 40kW
Wind Turbine	

TABLE 3: THE IMPROVEMENTS USED IN THE REAL DESIGN IN THE BÓKAY SHOOL

6.1.5. CHECKING VARIANTS AGAINST TARGETS

The variants created were simulated and the results are summarized in the following paragraphs.

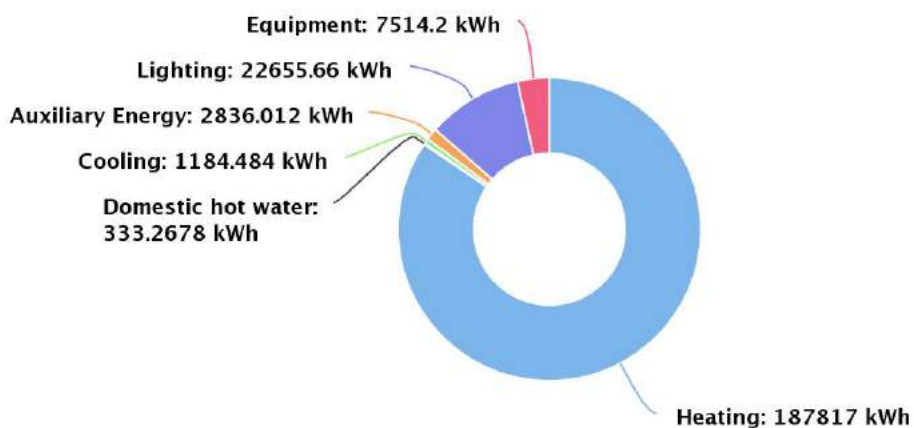
ADVANCED_REAL

The Advanced_real variant only contains interventions that reduce the Heating demand and increase the renewable energy on site.

The main conclusions from the results of this variant:

- Delivered energy demand – only the heating energy has been reduced by ~15% (Figure 59)
- The renewable share has been increased to 6% from zero.
- Thermal based weak points – heat loss through windows and exposed floors has been reduced, so the dominant heat losses are via natural ventilation and infiltration
- Electrical energy loads – the PV energy production is now contributing to the energy use of the building (Figure 61)
- Electrical energy balance – the energy balance of the building has improved with the PV production, but the building is not capable of using the produced electricity on full capacity as there is no storage system. Therefore, on weekends and in the summer period the surplus electricity is sold to the grid (Figure 62)

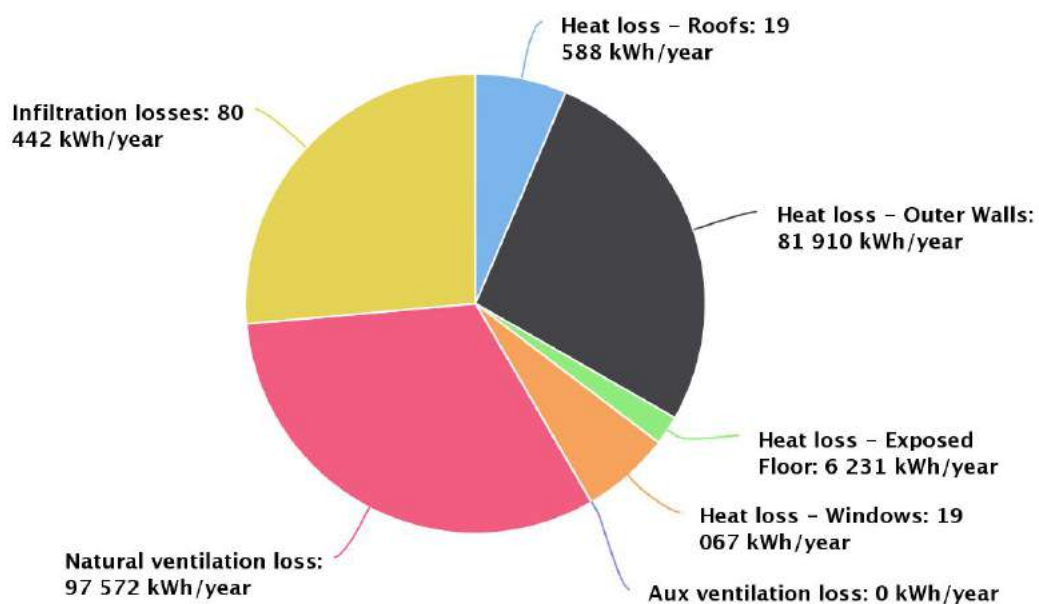
Delivered
Energy:
222347.6[kWh]



Highcharts.com

FIGURE 59: DELIVERED ENERGY BREAKDOWN OF THE ADVANCED_REAL VARIANT OF THE BÓKAY SCHOOL

HEAT LOSSES



Highcharts.com

FIGURE 60: HEAT LOSS BREAKDOWN OF THE ADVANCED_REAL VARIANT OF THE BÓKAY SCHOOL

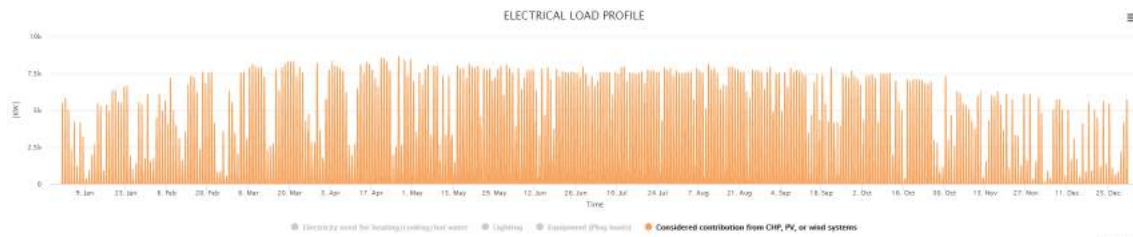


FIGURE 61: PV LOAD PROFILE OF THE BÓKAY SCHOOL IN THE DAVANCED_REAL VARIANT

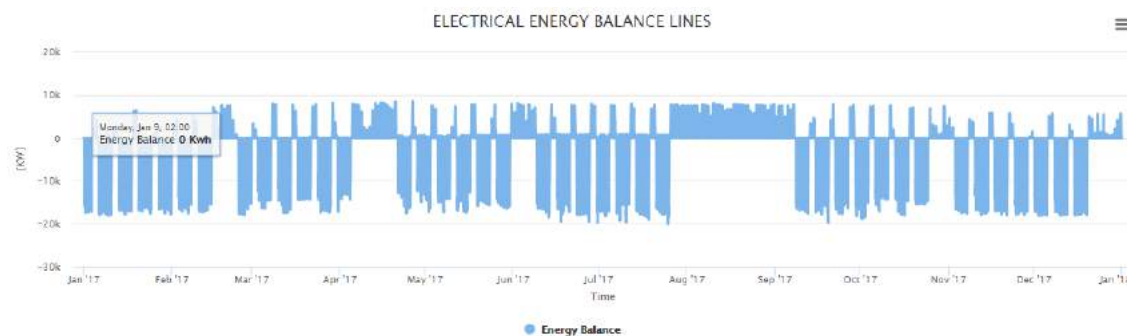


FIGURE 62: ELECTRICAL ENERGY BALANCE OF THE BÓKAY SCHOOL IN THE ADVANCED_REAL VARIANT

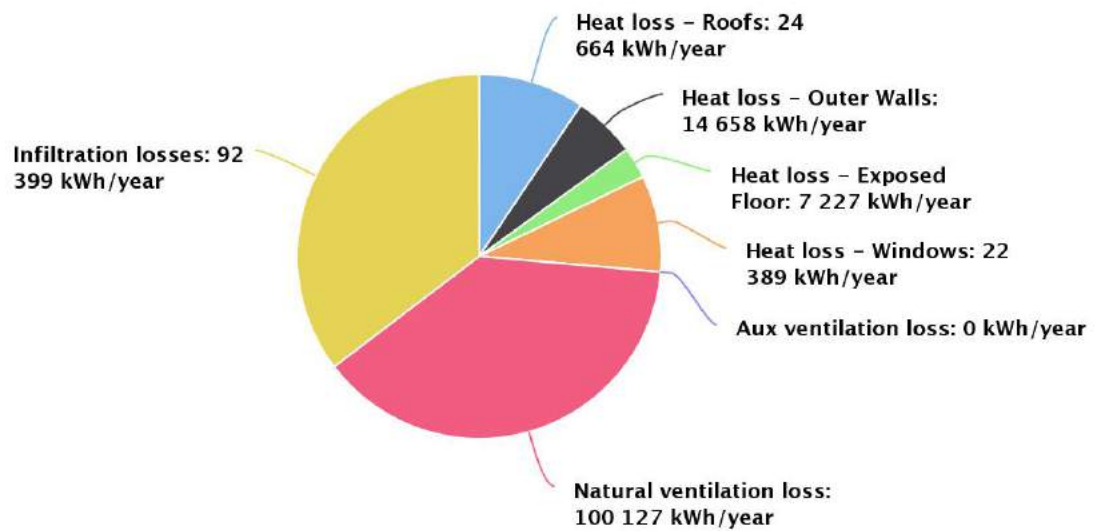
ADVANCED_IDEAL

The main conclusions from the results of this variant:

- The delivered energy demand has been reduced by 33%, the main contributor is the improvement of the thermal envelope.
- The lighting energy demand has decreased by 62% due to switching the lighting system from T5 fluorescent to LED lighting (Figure 63)

- The renewable energy share has been increased from the Advanced_real scenario, as the delivered energy demand has been decreased (

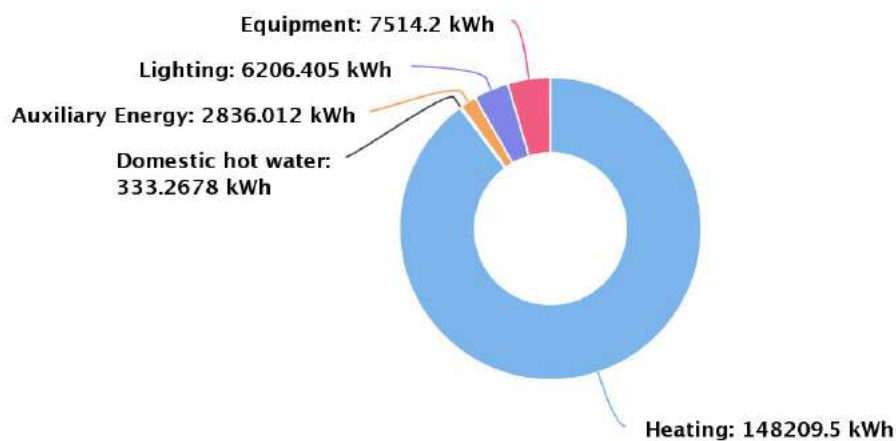
HEAT LOSSES



Highcharts.com

- Figure 64)
- The electrical energy breakdown shows the lighting energy demand decrease. This means that the electrical balance lines became more balanced.
- The heat losses through walls has further decreased (Figure 60 versus Figure 64)

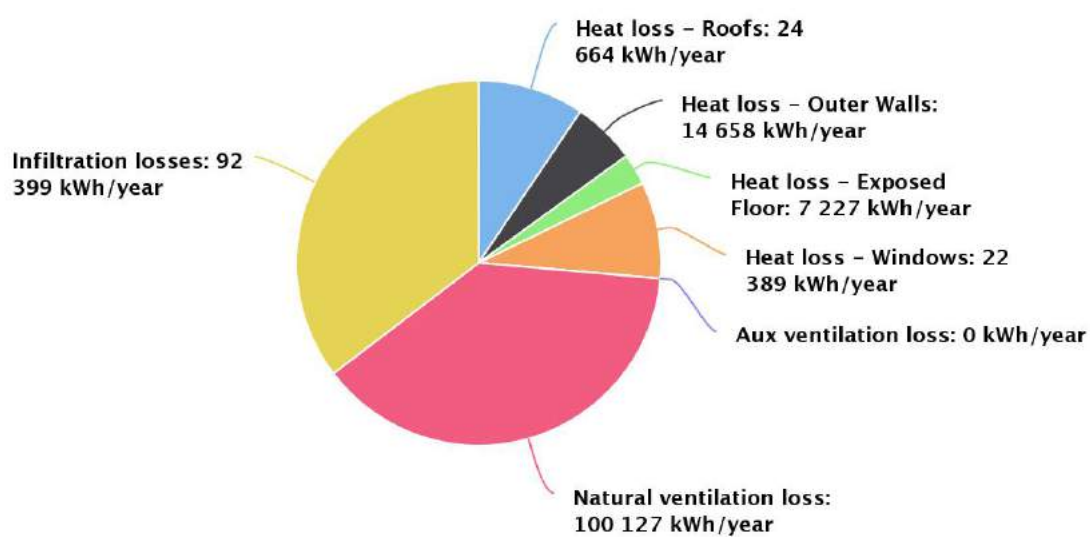
Delivered
Energy:
164661.6[kWh]



Highcharts.com

FIGURE 63: DELIVERED ENERGY BREAKDOWN OF THE ADVANCED_IDEAL VARIANT OF THE BÓKAY SCHOOL

HEAT LOSSES



Highcharts.com

FIGURE 64: HEAT LOSS BREAKDOWN OF THE ADVANCED_IDEAL VARIANT OF THE BÓKAY SCHOOL

ADVANCED_IDEAL 2

The main conclusions from the results of this variant:

- The delivered energy demand has been reduced by ~63%, the main contributor is the improvement of the thermal envelope and the improvement of the heating system. However, the auxiliary energy has been increased due to the new heating system electricity use (Figure 65)
- The operational energy costs are higher than the previous variants, but lower than the current state as the heating system was switched to electricity use from gas and the Hungarian gas prices are around half of the electricity prices. The KPI is not counting the income from selling the surplus electricity to the grid.
- The renewable energy share has been increased from the Advanced_real scenario, as the delivered energy demand has been decreased
- The electrical energy breakdown now includes the electricity use of the heating system (Figure 66). However, the energy balance lines (Figure 67) still show imbalances due to the low energy use in the summer months and on weekends.

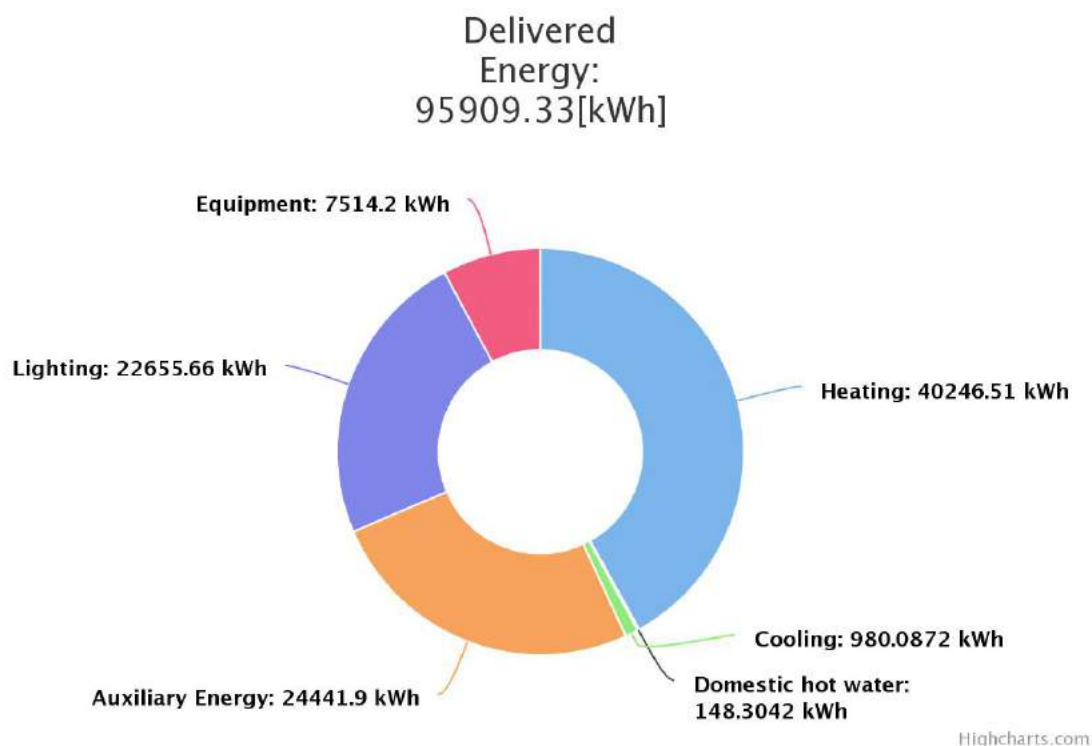


FIGURE 65: DELIVERED ENERGY BREAKDOWN OF THE ADVANCED_IDEAL2 VARIANT OF THE BÓKAY SCHOOL

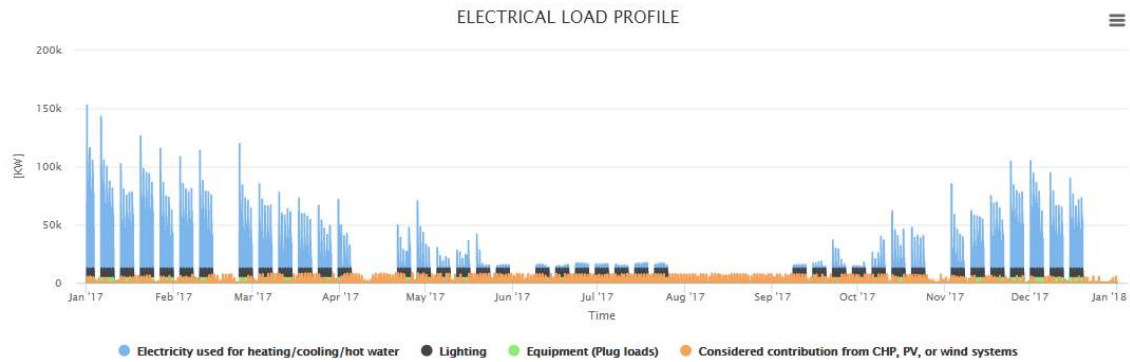


FIGURE 66: ELECTRICAL LOAD PROFILE OF THE BÓKAY SCHOOL IN THE DAVANCED_IDEAL2 VARIANT

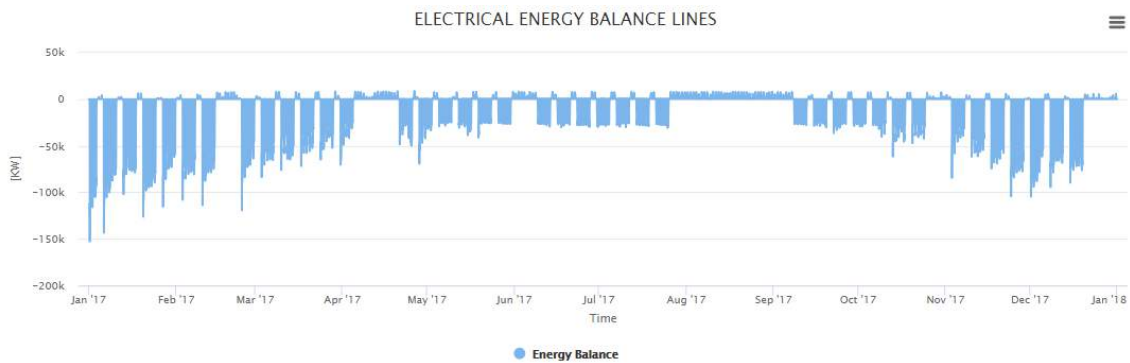


FIGURE 67: ELECTRICAL BALANCE LINES OF THE BÓKAY SCHOOL IN THE DAVANCED_REAL VARIANT

6.1.6. DECISION MAKING

The NewTREND tool helps the users in the decision making with its KPI weighting tool. In Chapter 6.1.3 the targets of the building owners were determined. In the following the variants are weighted based on their preferences and a list of preference is determined by the NewTREND tool (Figure 68).

The diagram shows that the Advanced_ideal2 variant is the highest scoring as it has the highest energy use reduction. However, this has lower score in the Economy category than the Advanced_ideal version. The Advanced_ideal version has overall good scores, but a technical constraint can deter the owners from choosing this option (the reduction of usable floor area with the internal insulation).

	CATEGORY PRIORITY LEVEL	BUILDING CORE KEY PERFORMANCE INDICATOR	BUILDING KPIS PRIORITY LEVEL	KPI PRIORITY SCORE	KPI WEIGHTING	AS-IS BENCHMARK (1- 100)	ADVANCED, REA L BENCHMARK (1-100)	ADVANCED, AS- IS BENCHMARK (1-100)	ADVANCED, IDEA L 2 BENCHMARK (1-100)	ADVANCED, IDEA L BENCHMARK (1-100)
ENVIRONMENT	HIGH	1 Energy								
		1.1 Operational Primary Energy Demand	MEDIUM	6	11.11 %	51	59	49	90	72
		1.2 Delivered Energy Demand	HIGH	9	16.67 %	1	30	1	69	40
		1.3 Renewable Energy on site	MEDIUM	6	11.11 %	64	70	58	73	80
		2 Impacts								
SOCIETY	MEDIUM	2.1 Global Warming Potential	MEDIUM	6	11.11 %	67	73	64	80	81
		3 Air Quality								
		3.1 Indoor air quality	HIGH	9	8.33 %	0	100	1	100	100
		4 Thermal Comfort								
		4.1 Summer comfort without cooling	HIGH	9	8.33 %	0	100	100	100	100
ECONOMY	LOW	4.2 Thermal comfort in the heating season	HIGH	9	8.33 %	0	100	100	1	1
		4.3 Thermal comfort in the cooling season	HIGH	9	8.33 %	0	1	100	100	100
		5 Operational Costs								
		5.1 Operational Energy Costs	HIGH	9	16.67 %	74	77	69	70	83
		CostsOverall Variant Score of Value Assessment				33	65	56	75	71

FIGURE 68: THE KPI WEIGHTING TABLE OF THE BÓKAY SCHOOL

In summary, the realized energy refurbishment increased the energy efficiency of the building, but there is still high potential for further improvements, from which the update of the heating system can cause the highest increase in efficiency.

6.1.7. COMPARISON OF BUILDING CURRENT STATE RESULTS IN THE THREE MODES

Since all needed data was collected from the demonstration building to test all three modes of the NewTREND tool, these could be compared. As the premium mode offers only as-is analysis, the comparison was made using the 'current state' results.

The premium mode assessment is based on measured data, reflecting actual behavior of the building. It is worth comparing the results from the other 2 modes to see their relationship to the measurements.

TABLE 4: BASIC, ADVANCED AND PREMIUM MODE KPI CURRENT STATE RESULTS OF THE BÓKAY SCHOOL

	Delivered energy demand (kWh/m ² *year)	Renewable energy on site (%)	Primary energy demand (kWh/m ² *year)	Global warming potential (kgCO ₂ /m ² *year)	Operational energy costs (EUR/m ²)
Basic as_is	197,88	0	261,77	49,83	16,41
Advanced as_is	169,6	0	218,78	41,91	13,49
Premium	198,2	0	263,8	50,14	16,47

Table 4 shows the results of the current state analysis from all three modes. According to the table, basic mode has ~1% difference from the Premium mode results and the Advanced mode has ~15% difference.

The difference between the measured and the simulated results can be caused by the accumulation of several effects, where the main factors are:

- The input data for the basic mode is a rough approximation of the building geometry, systems and operations conditions. Advanced mode gives a more realistic representation of the building geometry and its systems.
- The measured data imported to the Premium mode is related to a specific year with distinct weather conditions, meanwhile the dynamic simulation uses climate data averaged from several years.
- The building occupants use the buildings different from the ideal, as the individual comfort levels can hugely differ from the average values used by the dynamic simulation.

Considering the above factors, the 1% and 15% differences of the Basic and Advanced modes can be considered good results. In general, the advanced mode should deliver a more accurate result as it uses more realistic geometric and systems input data. Thus, in this case the exceptionally close results of the basic mode to the real results can be considered an anomaly. The validation of the simulation results is explained in more detail in NewTREND D4.5.

6.1.8. NEIGHBORHOOD CURRENT STATE ANALYSIS

The following chapters describe the evaluation of the case study district, the Bókay garden in Budapest, using the analysis tools available in the NewTREND tool.

KEY PERFORMANCE INDICATORS

The KPIs of the Bókay garden can be shown on Neighborhood scale and also on building scale, separately for the 14 buildings. Table 5 shows the Neighborhood KPIs of the Bókay garden. As the whole district is assessed in Basic mode, only the indicators representing the Environmental and Economic categories are available, the Comfort KPIs from the Social category are not present. The assessment shows poor results for the Delivered energy demand aggregated for the whole district. The Operational Energy Costs are high as well, showing 37,52 EUR/m² value.

TABLE 5: NEIGHBOURHOOD AS-IS KPIS OF THE BÓKAY GARDEN

	Delivered energy demand (kWh/m ² ,year)	Renewable energy on site (%)	Primary energy demand (kWh/m ² ,year)	Global warming potential (kgCO ₂ /m ² ,year)	Operational energy costs (EUR/m ²)
Basic as_is	401,45	0	572,21	102,31	37,52

DISTRICT KPI's score (1–100 points)

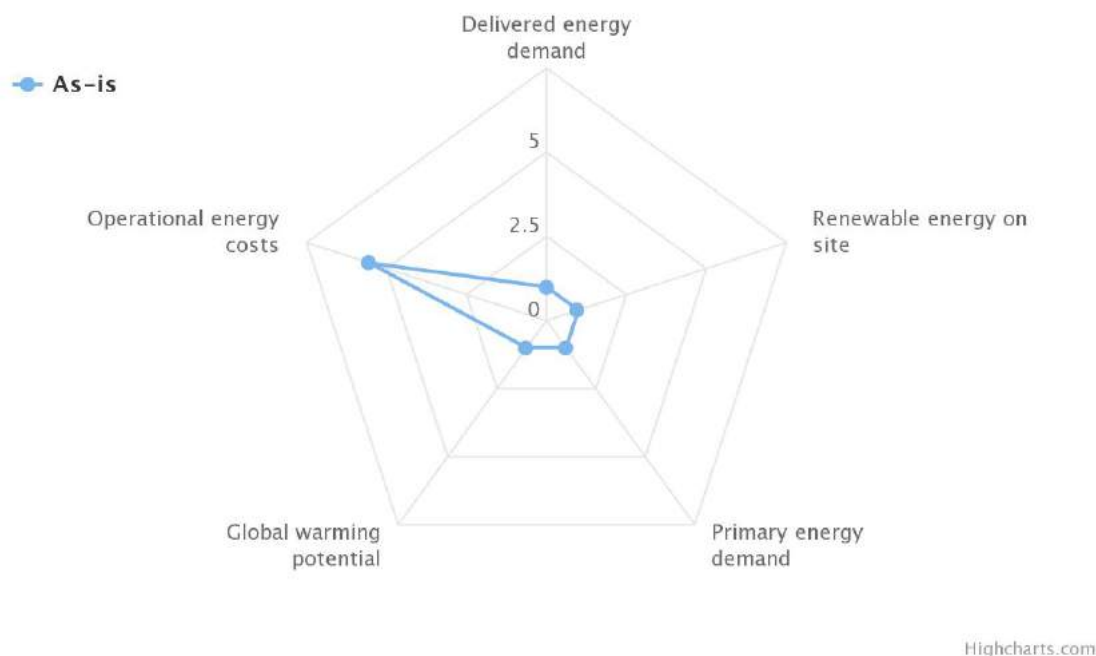


FIGURE 69: KPI RESULTS FOR THE DISTRICT CURRENT STATE ARE DISPLAYED ON A RADAR CHART

The KPIs are also available for each building separately (Table 6). The results of the Delivered Energy Demand KPI for the buildings show big differences between the buildings, which is due to the fact that 7 of the 14 buildings on site are heated (park main, info pavilion, primary school, cafeteria, swimming pool, kindergarten main and the Herrich-Kiss villa), but the others are not tempered in the model. In every case, the buildings are in poor condition, they need improvements to reach better KPI scores.

TABLE 6: DELIVERED ENERGY DEMAND KPI FOR EACH BUILDING IN THE BÓKAY GARDEN

ID (building name in CDP)	Building name	Delivered energy (kWh/m ² *Year) Building KPI)
_bokay_garden_july4_BD.08v7WZTyH3QZeqlMjWIT	park_main	527,84
_bokay_garden_july4_BD.8uvUQyB7A5HDELM5hfHD	info_pavilion	756,88
_bokay_garden_july4_BD.JVX1HmRpBmkHMKCYJY1	primary school	249,61
_bokay_garden_july4_BD.sGMfkhXJpt4YXcYyaWwh	cafeteria	826,53
_bokay_garden_july4_BD.jSmFAi2pPBvTi5pEqAKU	swimming_pool	606,91
_bokay_garden_july4_BD.wPgRoOejasYE8EBoOT54	stage	68,32
_bokay_garden_july4_BD.db4M46yxmNtOY3lcIJ5L	gym_01	74,15
_bokay_garden_july4_BD.AvhWR6Ly4PvJnTb9ldrp	gym_02	74,15
_bokay_garden_july4_BD.p4n1XFGzvULUIKYff1jv	changing_rooms	74,15
_bokay_garden_july4_BD.Hi65cjMg8c9UV1sRXv0D	kindergarten_annex	46,79
_bokay_garden_july4_BD.Grb2wwmcYhWIWuN2lcOc	kindergarten_main	221,23
_bokay_garden_july4_BD.rVC8fZ3osQWgD8P9QTPF	vip_pavilion	70,26

_bokay_garden_july4_BD.r42enj6HMXxZYHfjmOXw	herrich_kiss_villa	384,24
_bokay_garden_july4_BD.0K0klQZLYpEjTx08S4Da	boiler_house	96,67

DELIVERED ENERGY DEMAND

The results in the Energy page of the CDP are only available at the building scale. For the analysis, one of the three main types of the 14 buildings were chosen for further analysis: heated – primary school; heated and ventilated – swimming pool and not tempered – changing rooms.

The delivered energy demand for the primary school shows that 75% of the delivered energy is used by the heating system. In case of the swimming pool still the heating system the largest contributor to the energy usage, but the auxiliary energy use increases due to the ventilation system electricity usage. The results for the changing rooms show that only the lighting and equipment use energy.



Highcharts.com

FIGURE 70: DELIVERED ENERGY DEMAND OF THE PRIMARY SCHOOL IN THE BÓKAY GARDEN

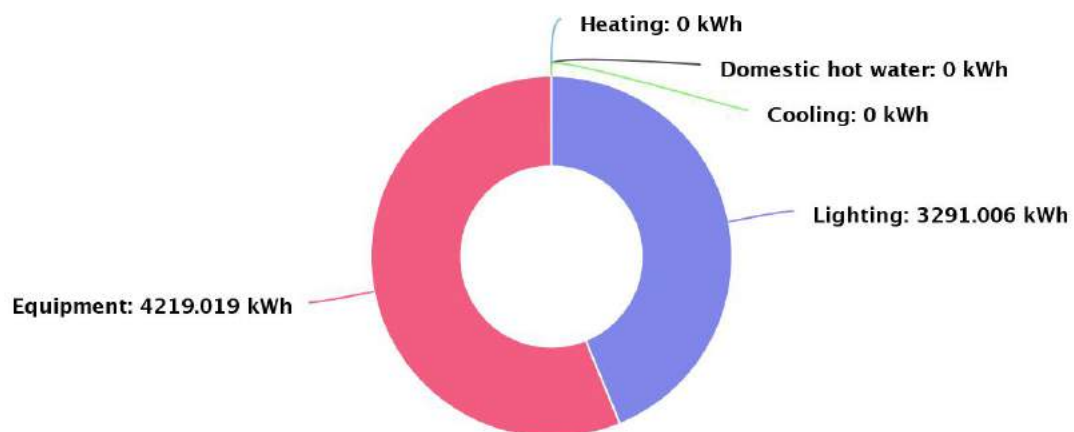
Delivered
Energy:
688844.4[kWh]



Highcharts.com

FIGURE 71: DELIVERED ENERGY DEMAND OF THE SWIMMING POOL IN THE BÓKAY GARDEN

Delivered
Energy:
7510.025[kWh]



Highcharts.com

FIGURE 72: DELIVERED ENERGY DEMAND OF THE CHANGING ROOMS IN THE BÓKAY GARDEN

THERMAL BASED WEAK POINTS

The Thermal based weak points analysis is also only available at the Building scale, where the same 3 buildings are assessed.

The results for the primary school show that 83% of the heat losses are caused by the thermal envelope (mainly the windows and the roof). Solar gain through windows is also high (78%).

The results for the swimming pool show that 60% of the heat losses occur through the thermal envelope, especially through windows and outer walls. The auxiliary ventilation losses are present here because of the mechanical ventilation system. The heat gains diagram shows that 72% of the gains is through windows, due to the large window glazed areas on the facades.

For the buildings that are modelled as not controlled, the thermal based weak points analysis is not relevant.

ELECTRICAL LOAD PROFILE

The district electrical load profiles show the aggregation of the individual building load profiles. It shows that there is a constant load due to lighting and equipment electricity usage. The summer time peak loads are caused by the ventilation electricity usage of the swimming pool. Figure 73 and Figure 74 show that the total consumption is covered by external supply. Therefore, it is recommended to install an onsite constant electricity generation technology using renewable source.

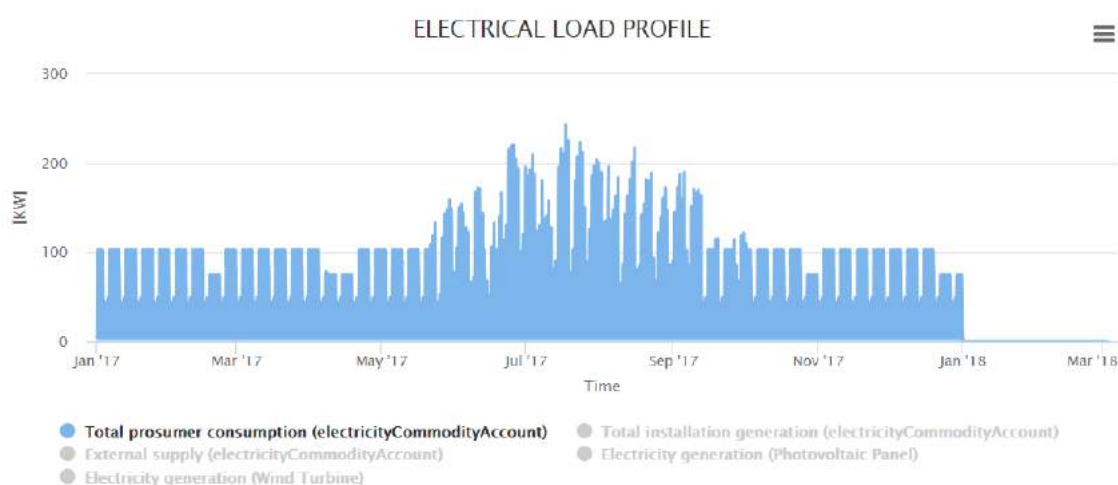


FIGURE 73: ELECTRICITY CONSUMPTION PROFILE OF THE BÓKAY GARDEN

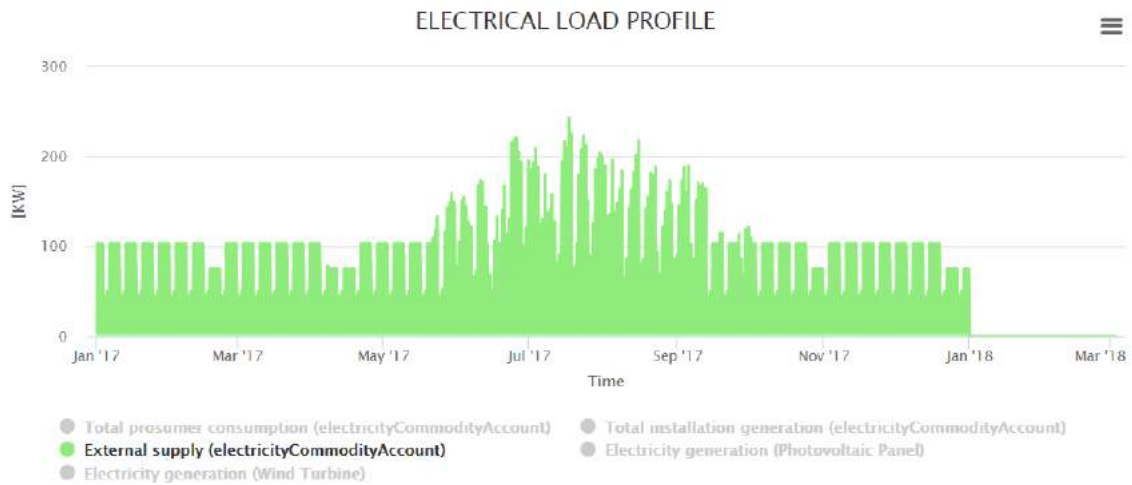


FIGURE 74: ELECTRICITY SUPPLY PROFILE OF THE BÓKAY GARDEN

The NewTREND CDP is also capable of showing building scale load profiles. Most of the building has close to constant consumption (when the buildings are occupied) as only lighting and equipment usage consumes electricity which are not depending on the climate. Only the swimming pool shows a varied load profile that was caused by the ventilation system energy use

ENERGY BALANCE

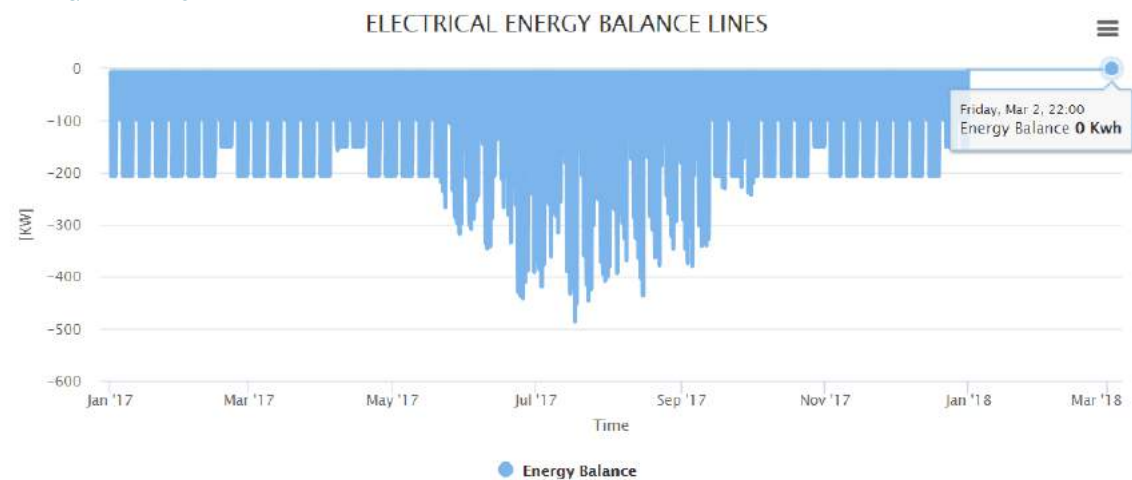


FIGURE 75: ELECTRICAL ENERGY BALANCE OF THE BÓKAY GARDEN DISTRICT

There are no energy generation systems on site. The electricity balance diagram (Figure 75) of the district is showing the same profile as the district load profile.

6.1.9. DISTRICT TARGETS

The Bókay garden refurbishment project is in early design phase, so there is no information about the owner's preferences regarding sustainability. As the owner of the district is the same as the school (the Budapest 18th district municipality), it is reasonable to assume that their preferences will be similar. Therefore, the Energy indicators have a high ranking and the Economic indicator has a medium priority ranking.

	CATEGORY PRIORITY LEVEL	BUILDING CORE KEY PERFORMANCE INDICATOR	BUILDING KPIS PRIORITY LEVEL	KPI PRIORITY SCORE	KPI WEIGHTING
ENVIROMENT	HIGH ▼	1 Energy			
		1.1 Operational Primary Energy Demand	MEDIUM ▼	6	11.11 %
		1.2 Delivered Energy Demand	MEDIUM ▼	6	11.11 %
		1.3 Renewable Energy on site	HIGH ▼	9	16.67 %
		2 Impacts			
ECONOMY	MEDIUM ▼	2.1 Global Warming Potential	MEDIUM ▼	6	11.11 %
		3 Operational Costs			
		3.1 Operational Energy Costs	HIGH ▼	9	33.33 %

FIGURE 76: KPI WEIGHTING FROM THE BUILDING OWNER POINT OF VIEW FOR THE BÓKAY GARDEN

6.1.10. VARIANT CREATION, AND RANKING FOR THE DISTRICT

It is possible to create refurbishment scenarios for the district scale with the NewTREND tool. The district scale interventions consist of small to large scale energy generation systems that can lower the dependency of the Bókay garden from the energy grid and city scale supply systems. The potential interventions are: installation of power station, heat generator, CHP plant, PV panel, wind turbine, electricity storage and heating storage.

From the available options the following variants were created in basic mode:

- District_basic_1: 100 kW Photovoltaics + 20kW electricity storage
- District_basic_2: 100 kW CHP + 20kW heat storage

TABLE 7: COMPARISON OF THE KPIS OF THE CURRENT STATE AND VARIANTS OF THE BÓKAY GARDEN

KPIs		As-is	district_basic_1	district_basic_2	units
Delivered Demand	Energy	401.45	123.61	290.6	kWh/m ² /year
Renewable on site	energy	0	18.85	0	%
Primary demand	energy	572.21	234.68	356.96	kWh/m ² /year
Global warming potential	warming	102.31	34.09	73.55	kgCO ₂ /m ² /year
Operational costs	energy	37.52	15.19	22.15	Euro/m ²

FIGURE 77:

Table 7 shows the results of the two variants created. From the displayed results it can be concluded that the PV installation is a more suitable technology for the district than the CHP plant as there is a supply-demand match for the produced electricity, but the heating need is present for a too short a time when compared to the high number of running hours which is needed for an efficient CHP plant.

Regarding the building scale, the same interventions are available in the basic mode as in advanced mode (list of possible interventions can be found in Table 2). For the heated buildings the current state results showed that the energy needs can be reduced by improving the building envelope. For example, applying a what-if scenario with external wall insulation as an intervention for the heated park_main building reduces the energy demand (Table 8). For buildings modelled as not tempered, it is recommended to reduce the lighting needs by replacing the current lights to LEDs.

TABLE 8: RESULTS OF AS-IS AND WHAT-IF SCENARIOS FOR THE BÓKAY GARDEN PARK_MAIN BUILDING

KPIs		As-is	What-if	units
Delivered Demand	Energy	527,84	319,53	kWh/m ² /year
Renewable on site	energy	0	0	%
Primary demand	energy	690,65	461,51	kWh/m ² /year
Global warming potential	warming	131,84	86,1	kgCO ₂ /m ² /year
Operational costs	energy	42,99	30,49	Euro/m ²

In summary, the district scale basic mode analysis can help the project by showing what type of larger scale energy production system is suitable and in the meantime individual building performances can also be improved.

6.1.11. ASSESSMENT OF THE APPLICABLE FINANCING AND BUSINESS MODELS

In case of the Bókay school and the Bókay garden the CDP provides the following options for the Financial analysis:

- Financial Planning Template for Consolidated Project
- Financial Planning Template for Energy Production Replacement PreTax
- Financial Planning Template for Energy Demand Reduction PreTax
- Financial Planning Template for Renewable Energy Facility Pre Tax
- Financial Planning Template for Renewable Energy Facility Post Tax
- Financial Planning Template for ESCO Service Contract

The purpose of the templates is:

- To demonstrate the type of financial model and detail that funding institutions and project partners would normally wish to see in order to progress deliberations leading to support.
- To promptly act in order to consider alternative elements in the project assessment
- To understand how other stakeholders, eg ESCOs, will evaluate engagement.
- To provide a starting point for users' own Excel spreadsheets.

In case of the Bókay school and garden demonstration projects, the above listed financial planning templates are not applicable due to the project phase they are in. The Bókay school has already received funding and the Bókay garden is still in the early planning stage where no intervention is selected yet. Therefore, the Financial analysis isn't applicable in this case.

6.2. SANT CUGAT DEMO SITE

6.2.1. FREEZING MODEL FOR DIAGNOSIS

The final models that have been uploaded to the DIM server contain information about the geometry. All supplementary information is stored via the Data Manager in the DIM server.

The school buildings IFC, CityGML file and project data contain the following information:

- IFC model detailed for advanced mode simulations.
- CityGML file contains the school buildings and its surroundings.
- Basic, advanced and premium mode data is collected and uploaded to the Data Manager. Where no information was available, the default values were used, or assumptions based on previous refurbishment project experiences were applied.

The district CityGML file and project data contain the following information:

- The CityGML file contains the buildings located in the Pins del Vallès School area.
- There is an IFC file for the ID-3 school building and this building is analyzed in advanced mode
- Only basic level data is collected and uploaded via the Data Manager to the DIM server

For the Sant Cugat Demo Site the analysis is separated into two parts, the basic mode district analysis and the advanced mode ID-3 school building analysis (Primary School Building + Administrative Building). The Kindergarten and Sport Pavilion buildings (ID-1 and ID-2 buildings) are only available in basic mode.

6.2.2. BUILDING CURRENT STATE ANALYSIS

The following chapters describe the evaluation of the case study building, the ID-3 building (main building) of the Pins del Vallès School in Sant Cugat, using the analysis tools available in the NewTREND platform. Advanced mode was chosen for the analysis as a detailed model and data are available about the building.

KEY PERFORMANCE INDICATORS

Investigating the state of the building KPIs can reveal strengths and weaknesses that can be considered in decision making. Table 9 represents a screenshot from the NewTREND platform displaying the KPIs for the current sustainability state of the case study in advanced mode. The scores for the indicators in the current state allow identifying domains where the building was poorly performing. These aspects are easily visualised on the NewTREND tool thanks to the scoring system for district indicators and the meaningful radar chart (Figure 78).

TABLE 9: THE RESULTS OF THE ID-3 SCHOOL BUILDING KPI AS-IS ANALYSIS

	Delivered energy demand (kWh/m ² ,year)	Renewable energy on site (%)	Primary energy demand (kWh/m ² ,year)	Global warming potential (kgCO ₂ /m ² ,year)	Operational energy costs (EUR/m ²)
Advanced as_is	287,52	0	394,11	74,37	25,26
	Indoor air quality	Summer comfort, no cooling	Thermal comfort in the heating season	Thermal comfort in the cooling season	
Advanced as_is	0	0	0	0	

The KPI analysis shows 9 indicators in 3 categories: Environmental, Economic and Social indicators.

In the Environmental category the Delivered Energy Demand scores just below average with an actual value of 287,52 kWh/m²*year (KPI score = 4) so there is room for improvement (especially since there is no cooling and ventilation system so the main part of the energy demand comes from heating). The primary energy demand of the building is just above average with an actual value of 394,11 kWh/m²*year. The closely related GWP indicator shows similar result (value: 74,37 kgCO₂/m²*year). Also, the building has no renewables installed which is reflected also by the 0 score of the Share of Renewable Energy on Site indicator.

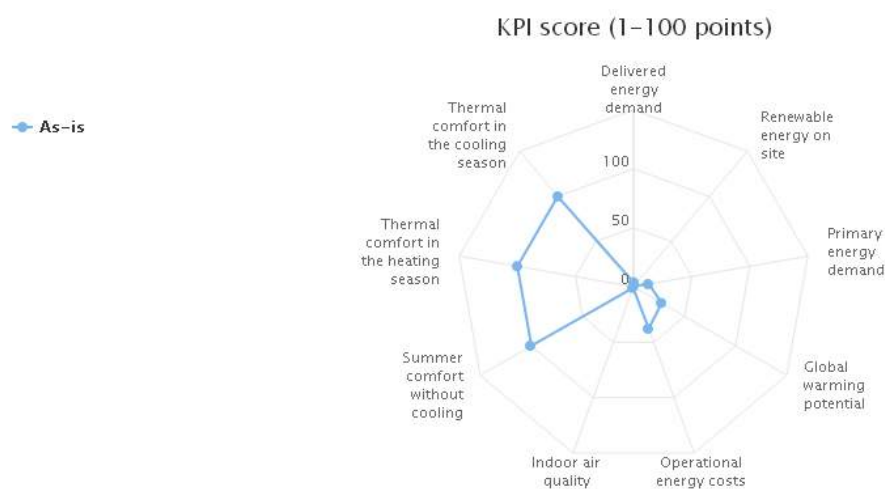


FIGURE 78: THE RESULTS OF THE ID-3 SCHOOL BUILDING KPI AS-IS ANALYSIS ON A RADAR CHART

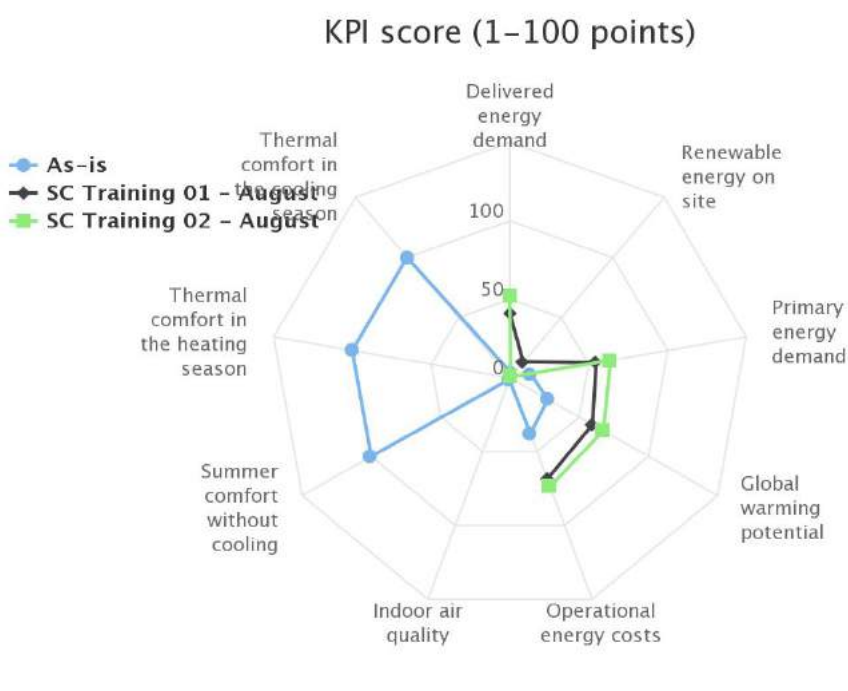


FIGURE 79: THE RESULTS OF THE ID-3 SCHOOL BUILDING KPI AS-IS ANALYSIS ON A RADAR CHART WITH ADDITIONAL TEST VARIATIONS

In the Economy category the only available indicator is the Operational energy cost indicator. Here the building scores well above average with an actual value of 25,26 EUR/m² by profiting from the below EU average energy prices in Spain^{3,4}.

In the Social category the KPIs are showing 0 as score so this category is not evaluated in this case.

In summary there is a need to act on the reduction of the energy demand of the building, which will cause further reduction of the operational energy cost. This means that there is a need to further investigate the as-is state of this building using the rest of the analysis tools.

DELIVERED ENERGY DEMAND

The energy tab of the simulation results section of the NewTREND tool shows the results of the delivered energy demand breakdown.

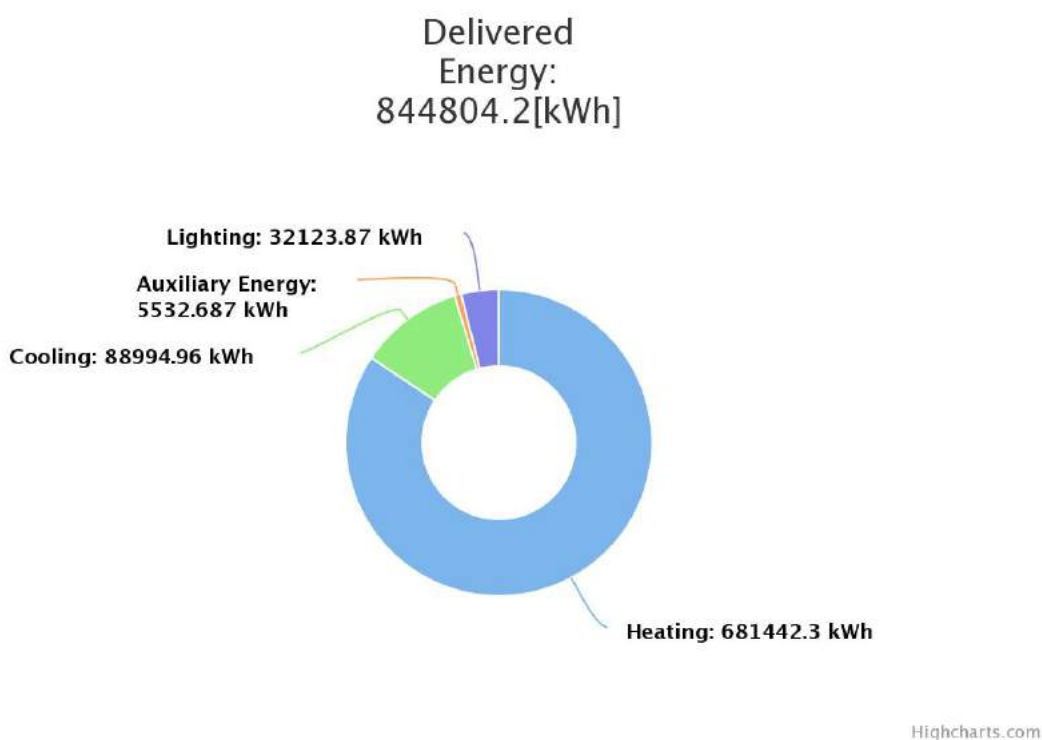


FIGURE 80: DELIVERED ENERGY BREAKDOWN OF THE ID-3 BUILDING OF PINS DEL VALLES SCHOOL

According to Figure 80, the main consumer of the delivered energy is the heating system using 81% of the total delivered energy. The second highest consumer is the cooling system with 11% share of the total energy (two split units for the two IT classrooms). The third highest consumer is the lighting system with 4% share of the total energy. The remaining 4% of the energy is used by the domestic hot water system and the equipment and other auxiliary energy. Therefore, it is highly recommended to reduce the heating

³Source: EUROSTAT Electricity prices for non-household consumers, second half 2017

⁴Source: EUROSTAT gas prices for non-household consumers, second half 2017

needs of the building and then improve the heating system as well. Possible improvements on the lighting system can also reduce the energy consumption with a much lesser effect.

Therefore, further analysis is needed to investigate the reasons behind the high consumption of the heating system with the thermal based weak points analysis function of the NewTREND tool.

THERMAL BASED WEAK POINTS

The Thermal based weak points analysis is the other analysis available on the Energy tab. Here two diagrams are available representing the heat losses in winter (Figure 81) and the heat gains in summer (Figure 82) of the building.

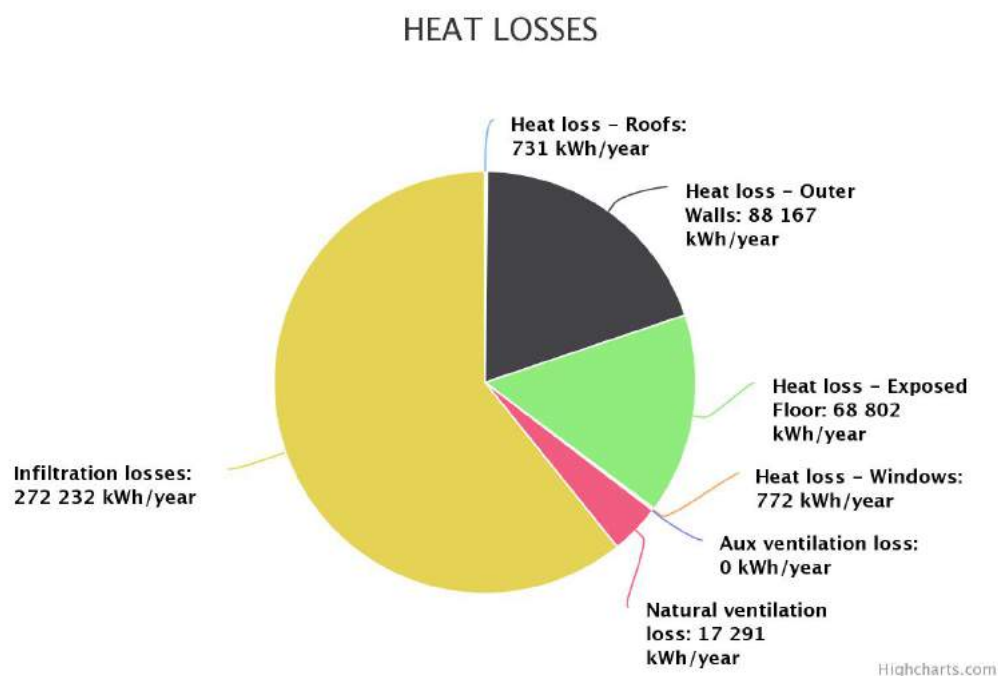


FIGURE 81: HEAT LOSSES OF THE ID-3 BUILDING OF PINS DEL VALLES SCHOOL

The heat loss diagram indicates that the main heat losses are through the infiltration with the 60,77% of the total heat losses. The thermal envelope causes other significant losses (35,37% of the total). The losses through the thermal envelope can be broken down as well: the outer walls cause the highest losses, then through the exposed floor and less so by the roof and windows.

Therefore, it is recommended to update the existing thermal envelope.

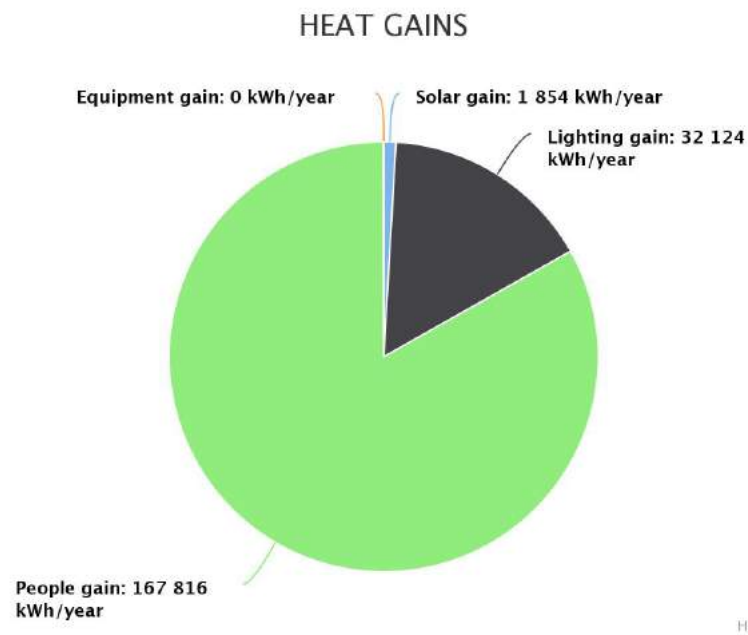


FIGURE 82: HEAT GAINS IN THE ID-3 BUILDING OF PINS DEL VALLES SCHOOL

The heat gains diagram shows that the people gains are the main contributor with 82,3% of the total gains. These are followed by the lighting gains with 15,9% of the total gains. The Solar gains have some minor heat gains in the building.

Therefore, it is recommended to further improve the solar gains.

ELECTRICAL LOAD PROFILE



FIGURE 83: LIGHTING PROFILE OF THE ID-3 BUILDING OF PINS DEL VALLÈS SCHOOL

The electrical load profile of the building (Figure 83) shows a weekly constant load for lighting and equipment loads for weekdays. Only the electricity used for cooling of two rooms (Figure 84) varies, as it increases in parallel with the hot summer months. On weekends and during the summer holiday the electricity load of the building is zero.

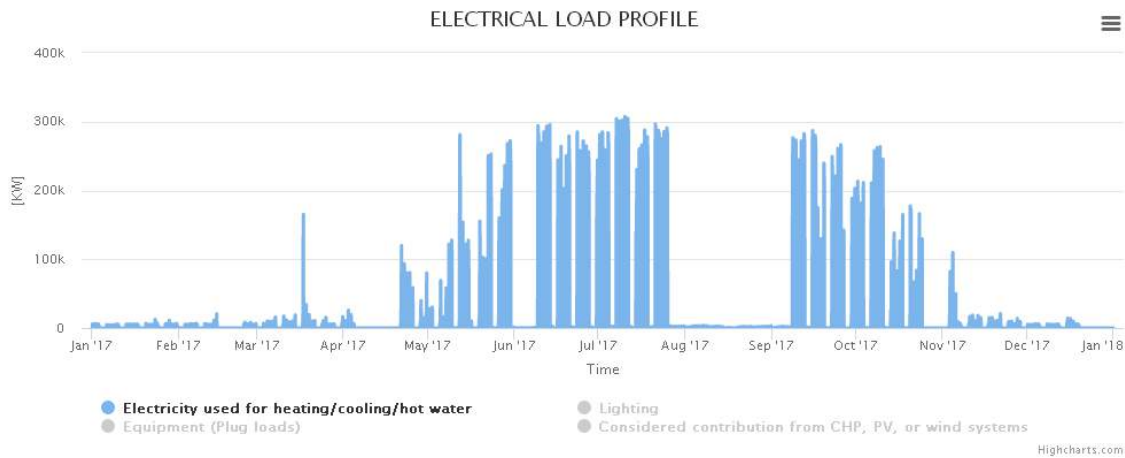


FIGURE 84: COOLING LOAD PROFILE OF THE ID-3 BUILDING OF PINS DEL VALLÈS SCHOOL

ENERGY BALANCE

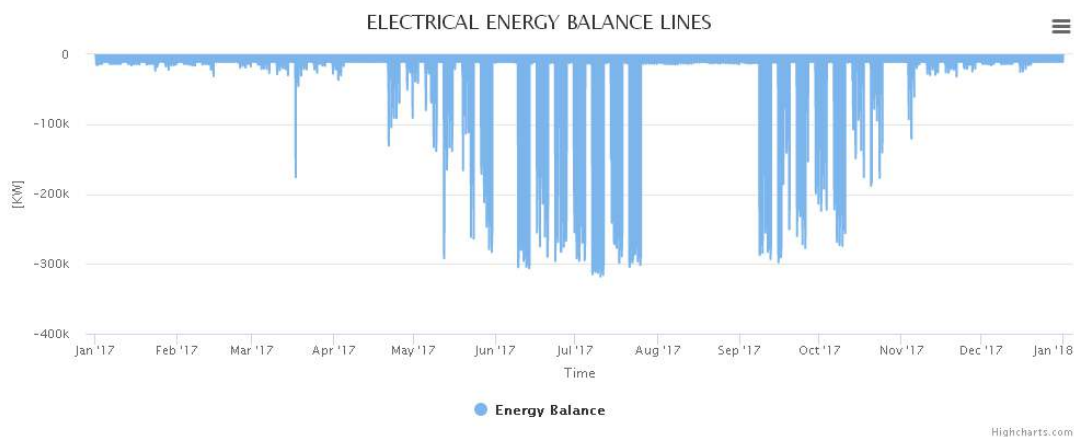


FIGURE 85: ELECTRICAL ENERGY BALANCE LINES OF THE ID-3 BUILDING OF PINS DEL VALLÈS SCHOOL

The NewTREND tool also has a function that shows the yearly electrical energy balance lines of the building. As Figure 85 shows the sum of the electrical energy loads in the ID-3 building of Pins del Vallès school balanced with the produced electrical energy. Since there is no energy production on site the balance line only shows the energy demand of the building.

HEAT DURATION CURVE

The NewTREND tool is capable to analyze the heating energy consumption of the building as well. The main result of the analysis is the heat duration curve for the building (Figure 86). The heat duration curve is showing the number of hours on which a specific load demand occurs. As typical, the peak load in the building occurs only for a few hours a year. The heat duration curve also shows that the heating demand in the building occurs approximately a 30% of the year, therefore it is not feasible to design interventions that generate heat constantly, for example CHP or solar thermal collectors.

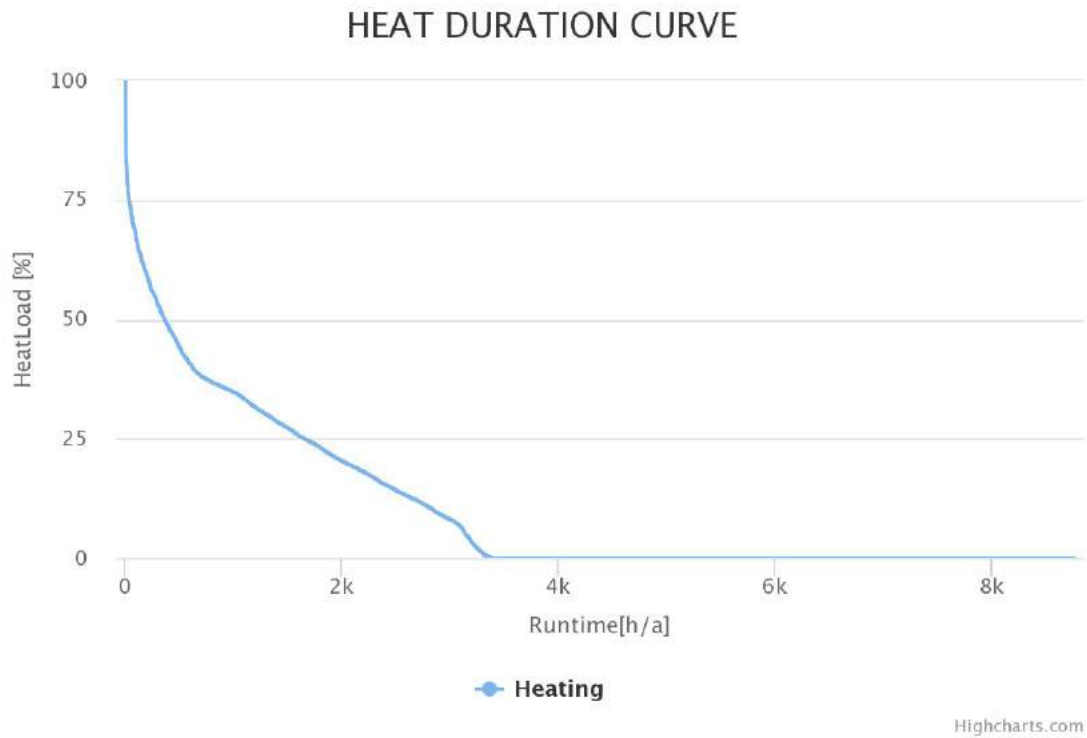


FIGURE 86: HEAT DURATION CURVE OF THE ID-3 BUILDING OF PINS DEL VALLES SCHOOL

THERMAL COMFORT

Hereunder, there are screenshots of Thermal Comfort as-is simulations of ID-3 building of Pins del Vallès School (Figure 87 - Figure 94 inclusive). Note that the building is outside of the desired thermal comfort range for all methods:

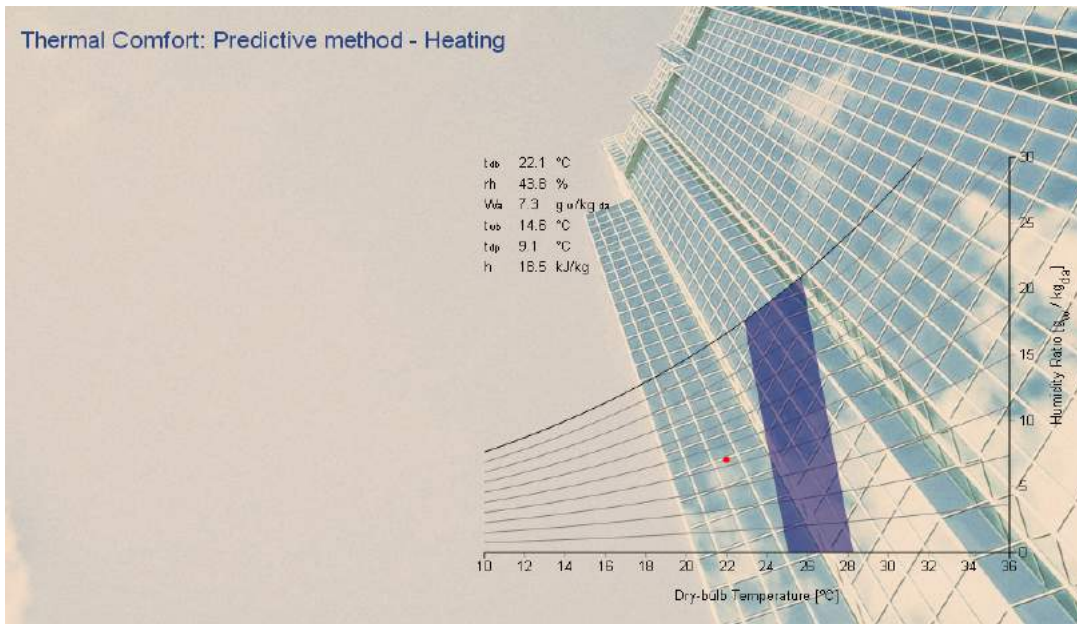


FIGURE 87: AS-IS THERMAL COMFORT FOR ID-3 SCHOOL DURING HEATING SEASON

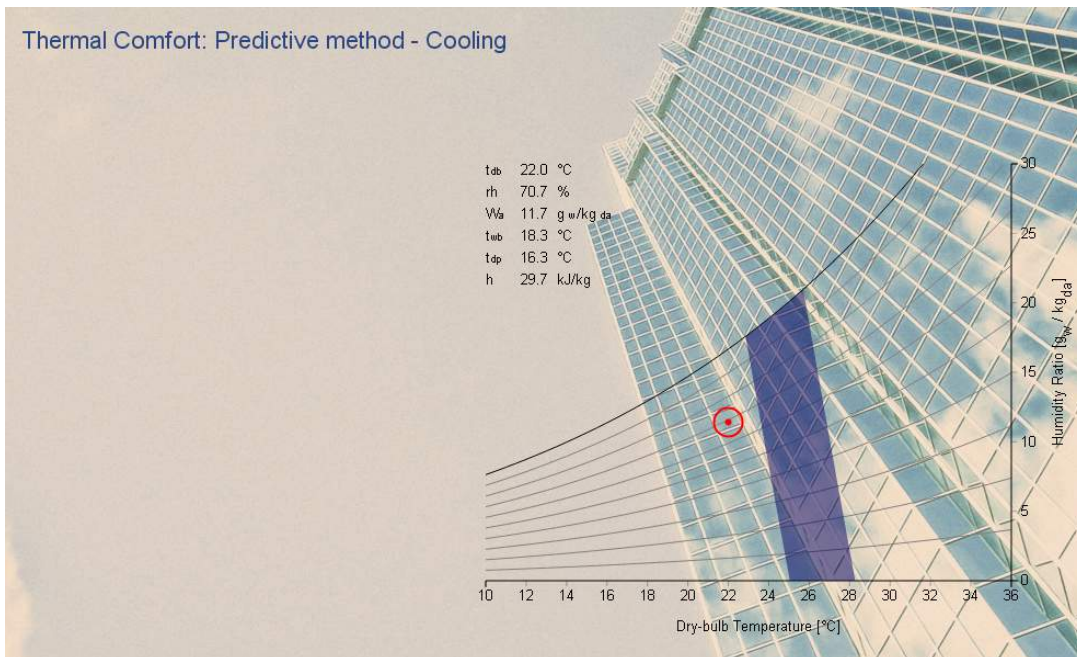


FIGURE 88: AS-IS THERMAL COMFORT FOR ID-3 SCHOOL DURING COOLING SEASON

Thermal Comfort: Adaptive method - EN-15251 - Heating

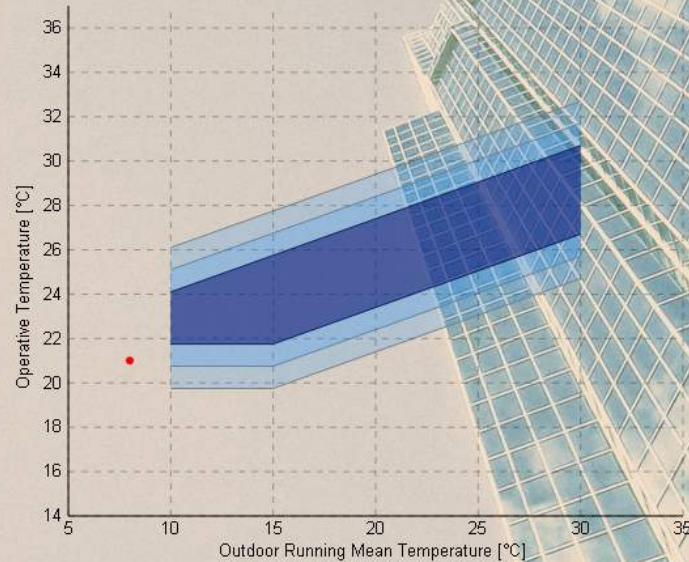


FIGURE 89: AS-IS THERMAL COMFORT FOR ID-3 SCHOOL DURING USING THE HEATING SEASON (EN ADAPTIVE METHOD)

Thermal Comfort: Adaptive method - EN-15251 - Cooling

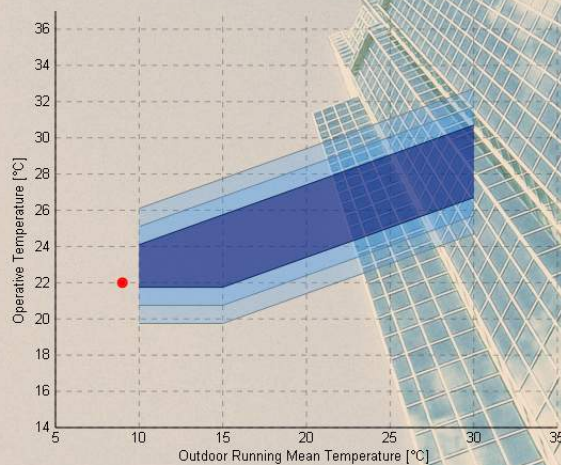


FIGURE 90: AS-IS THERMAL COMFORT FOR ID-3 SCHOOL DURING USING THE COOLING SEASON (EN ADAPTIVE METHOD)

Thermal Comfort: Adaptive method - ASHRAE55 NMC - Heating

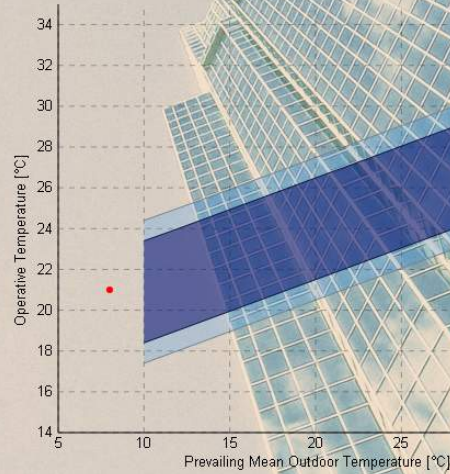


FIGURE 91: AS-IS THERMAL COMFORT FOR ID-3 SCHOOL DURING USING THE HEATING SEASON (ASHRAE ADAPTIVE METHOD)

Thermal Comfort: Adaptive method - ASHRAE55 NMC - Cooling

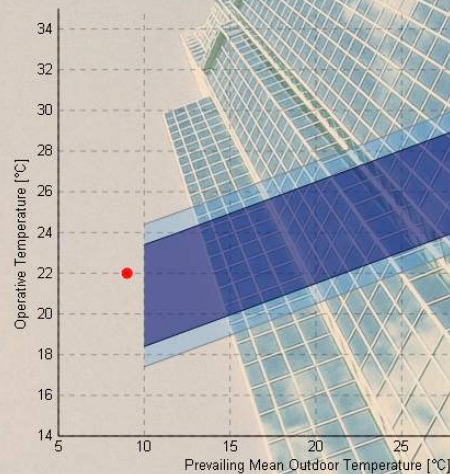


FIGURE 92: AS-IS THERMAL COMFORT FOR ID-3 SCHOOL DURING USING THE HEATING SEASON (ASHRAE ADAPTIVE METHOD)

Thermal Comfort: Adaptive method - ASHRAE55 FMC - Heating

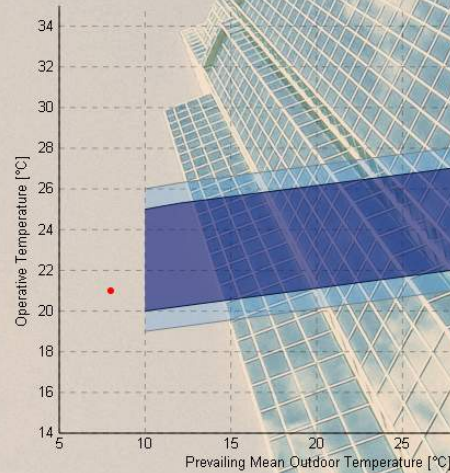


FIGURE 93: AS-IS THERMAL COMFORT FOR ID-3 SCHOOL DURING USING THE HEATING SEASON (ASHRAE FORCED ADAPTIVE METHOD)

Thermal Comfort: Adaptive method - ASHRAE55 FMC - Cooling

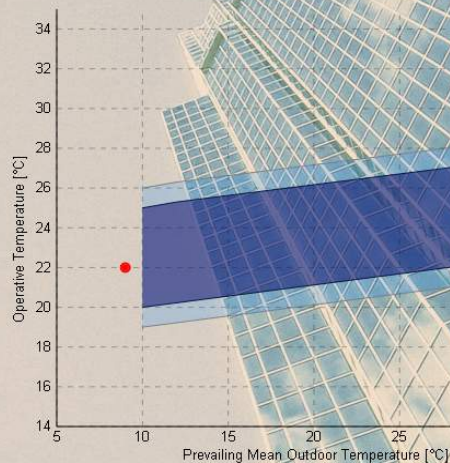


FIGURE 94: AS-IS THERMAL COMFORT FOR ID-3 SCHOOL DURING USING THE COOLING SEASON (ASHRAE FORCED ADAPTIVE METHOD)

6.2.3. TARGETS

In the Strategic Definition phase, the main tasks are to set meaningful targets for the retrofitting project and to identify the main constraints and restrictions which may limit the retrofit design. The possible interventions that can improve the current state of the building should be filtered by the constraints of the building and prioritized by the main targets of the refurbishment project.

Five main types of constraints can be identified in retrofitting projects, and the following issues should be considered for the Pins del Vallès school:

- Legal constraints – the main legal constraint is the average period of the tenders with the new law of public recruitment. The great majority of delays in the project development came from the problems in the execution of the actions planned in this demo sites of Sant Cugat. The average period of the tenders has been extended with the law of public recruitment which became effective a few months ago.
- Technical constraints
- Financial constraints – the project was financed by EU regional cohesion funds, which had budget limitations and it prescribed the possible interventions that can be financed
- Environmental condition constraints
- Stakeholder based restrictions – the building is owned by the municipality, but currently is in use. This is the main restriction with the development of retrofitting works in this building of Pins del Vallès School.

As the building retrofitting has already been financed, the financial constraints are not considered, the analysis focused on how the realized design could have been improved.

According to the NewTREND IDM, S.M.A.R.T. (specific, measurable, attainable, relevant and time-bound) targets should be set for each KPI of the building. As the refurbishment project has already been realized for the building, the targets that the project owners intended can be deduced: maximize the energy use reduction and renewable energy generation for a fixed investment cost. The comfort criteria of the building occupants were not considered. From the viewpoint of the actual building users the main priority is to maximize building comfort and minimize the operational costs for a fixed investment cost.

	CATEGORY PRIORITY LEVEL	BUILDING CORE KEY PERFORMANCE INDICATOR	BUILDING KPIS PRIORITY LEVEL	KPI PRIORITY SCORE	KPI WEIGHTING
ENVIROMENT	HIGH ▼	1 Energy			
		1.1 Operational Primary Energy Demand	HIGH ▼	9	12.5 %
		1.2 Delivered Energy Demand	HIGH ▼	9	12.5 %
		1.3 Renewable Energy on site	HIGH ▼	9	12.5 %
		2 Impacts			
SOCIETY	MEDIUM ▼	2.1 Global Warming Potential	HIGH ▼	9	12.5 %
		3 Air Quality			
		3.1 Indoor air quality	HIGH ▼	9	33.33 %
		4 Thermal Comfort			
		4.1 Summer comfort without cooling	HIGH ▼	9	16.67 %
ECONOMY	LOW ▼	4.2 Thermal comfort in the heating season	HIGH ▼	9	16.67 %
		4.3 Thermal comfort in the cooling season	HIGH ▼	9	16.67 %
		5 Operational Costs			
		5.1 Operational Energy Costs	HIGH ▼	9	16.67 %

FIGURE 95: GENERIC KPI WEIGHTING TABLE

The main targets of the building owner were defined with KPI weightings in the assessment (Figure 95). The society category gets the highest priority. Within this category the Indoor air quality indicator is the top priority, the others are medium priority. The Economy category and the Environment Category gets medium priority. Based on this, the Indoor air quality in the Society category has the highest weight (33.33%) followed by the rest of Society indicators and the Economy Category with 16,67% weight. The Environmental indicators have 12,5% weight if the owner's priorities are considered.

6.2.4. VARIANT CREATION

In an ideal refurbishment project using the NewTREND IDM, the concept phase would comprise of evaluating the current state analysis results based on the targets developed and then determining the interventions to be used to help the design phase.

Summing up the current state analysis, the following areas for improvement were identified:

- Areas for energy efficiency improvement:
 - Consumption reduction (passive technologies): new thermal envelope
 - Renewables: inclusion of renewables

TABLE 10: VARIANTS CREATED FOR THE ID-3 BUILDING OF PINS DEL VALLÈS SCHOOL ADVANCED MODE ANALYSIS

	Advanced_real (as-is)	Advanced_variant 1	Advanced_variant 2
Boiler Plant Improvements			
Chiller Plant Improvements			
Terminal controls			
Plant controls			
Fans			
Ventilation			
Distribution Pipes Insulation			
Lighting source	LED (120 lm/W)	LED (120 lm/W)	LED (120 lm/W)
Lighting controls			
Roof insulation			
Loft insulation			
Exposed floor insulation			
External wall inner insulation			
external wall cavity insulation	5 cm	5 cm	5 cm
external wall timber frame insulation			
external wall outer insulation			8 cm
Fabric opaque doors			
Glazing type	triple glazed window	triple glazed window	triple glazed window
Shading glazing			
Distributions systems insulation			
Electric motors and drives			
Heat Pump (heating)			

Solar water heater			
Heat pump (cooling)			
PV panels		20 kW (medium commercial)	
Wind Turbine			

Based on the available interventions and the identified areas for improvement, two variants were identified (Table 10). The first variant (Advanced_variant1) proposes to implement new PV system on the roof of this building. Concerning the 'PV panels' type, there was no option to choose 27kW PV panels (real planned retrofitting), so the closest option was chosen (installation of 20kW PV panel). This variant (Advanced_variant1) proposes to implement a new PV system on the roof of this building.

Advanced_variant2 proposes to implement new external wall insulation (80 mm of new external insulation using ETICS: External Thermal Insulation Composite Systems) in addition to the 50mm of External Wall Cavity Insulation.

6.2.5. CHECKING VARIANTS AGAINST TARGETS

The variants created were simulated and the results are summarized in the following paragraphs.

ADVANCED_VARIANT 1

The Advanced_real variant only contains interventions that reduce the Heating demand and increase the renewable energy on site.

The main conclusions from the results of this variant:

- Delivered energy demand has been reduced by ~20% (Figure 96). Heat demand has been reduced and cooling demand has been eliminated.
- The renewable share has increased.
- Thermal based weak points – heat losses have been reduced.
- Electrical energy loads – the PV energy production is now contributing to the energy use of the building (Figure 98)
- Electrical energy balance – the energy balance of the building has improved with the PV production, but the building is not capable of using the produced electricity on full capacity as there is no storage system. Therefore, on weekends and in the summer period the surplus electricity is sold to the grid (Figure 99).



FIGURE 96: DELIVERED ENERGY BREAKDOWN OF THE ADVANCED_VARIANT 1 OF THE ID-3 BUILDING OF PINS DEL VALLÈS SCHOOL

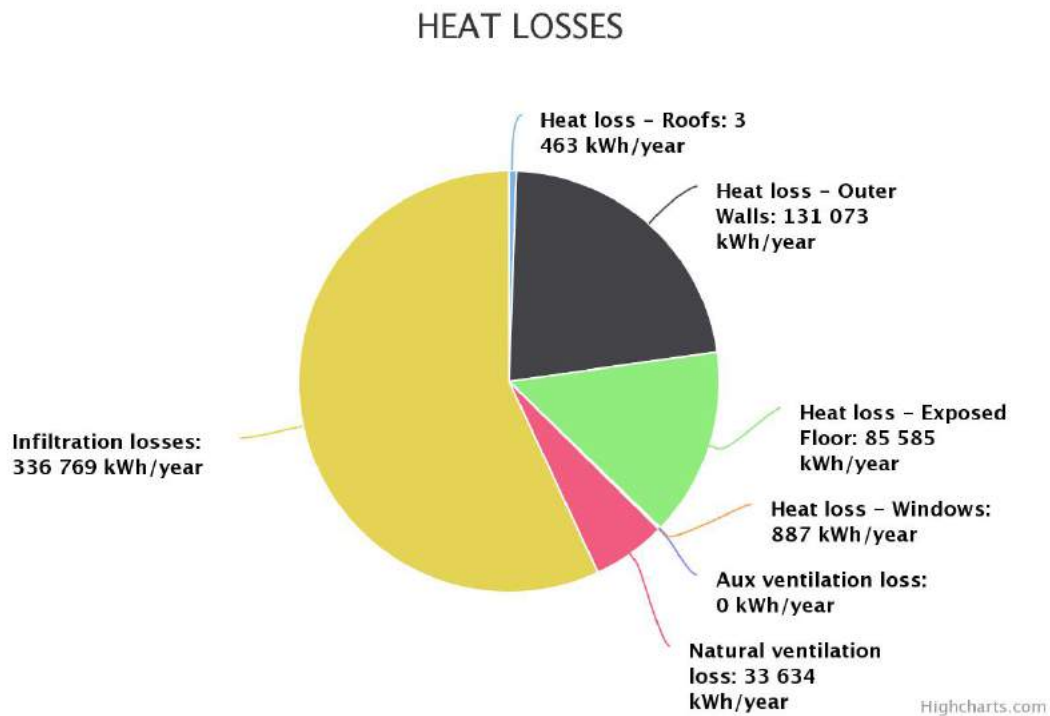


FIGURE 97: HEAT LOSS BREAKDOWN OF THE ADVANCED_VARIANT 1 OF THE ID-3 BUILDING OF PINS DEL VALLÈS SCHOOL

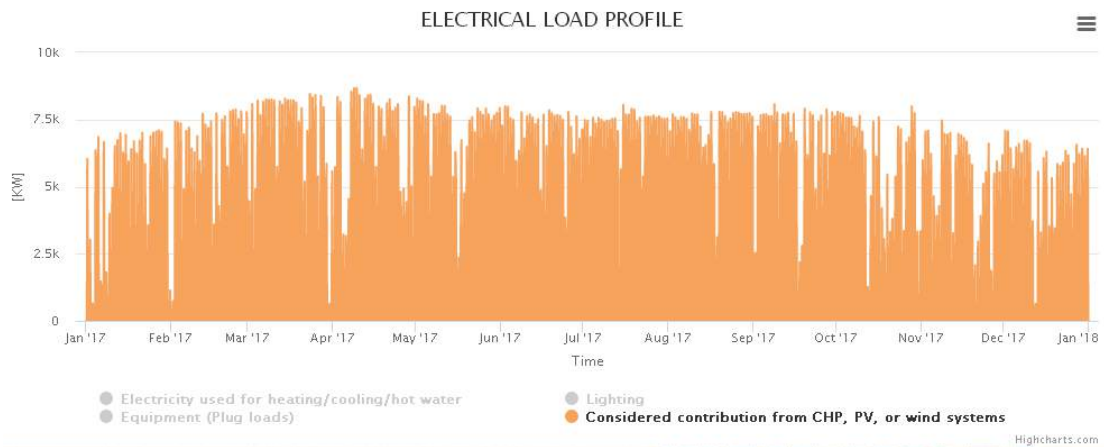


FIGURE 98: PV LOAD PROFILE OF THE ID-3 BUILDING OF PINS DEL VALLÈS SCHOOL IN THE ADVANCED_VARIANT 1

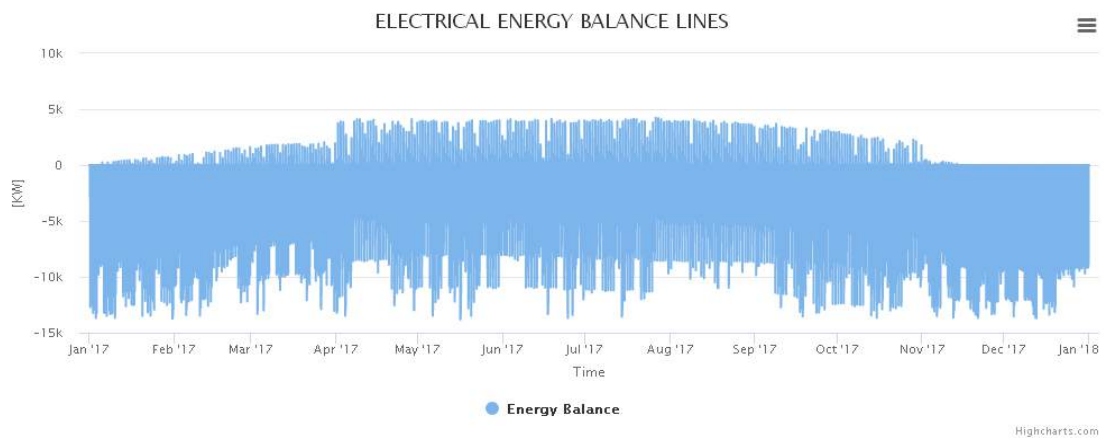


FIGURE 99: ELECTRICAL ENERGY BALANCE OF THE ID-3 BUILDING OF PINS DEL VALLÈS SCHOOL IN THE ADVANCED_VARIANT 1

ADVANCED_VARIANT 2

The main conclusions from the results of this variant:

- The delivered energy demand has been reduced by ~44%, the main contributor is the improvement of the thermal envelope (Figure 100).

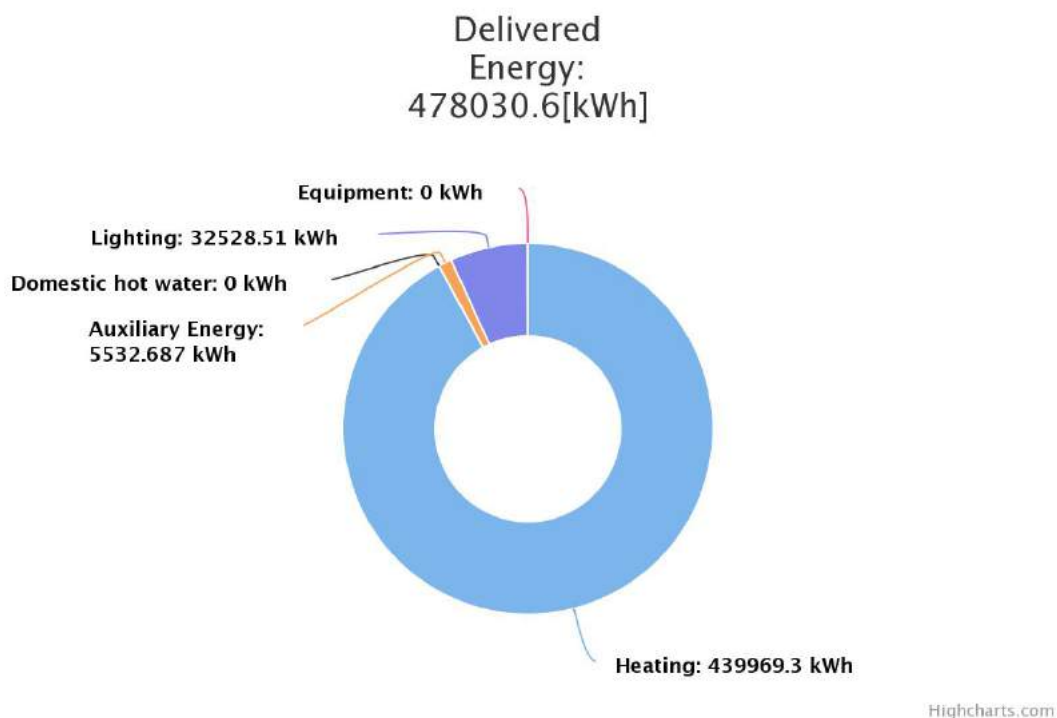


FIGURE 100: DELIVERED ENERGY BREAKDOWN OF THE ADVANCED_IDEAL2 VARIANT OF THE PINS DEL VALLÈS SCHOOL

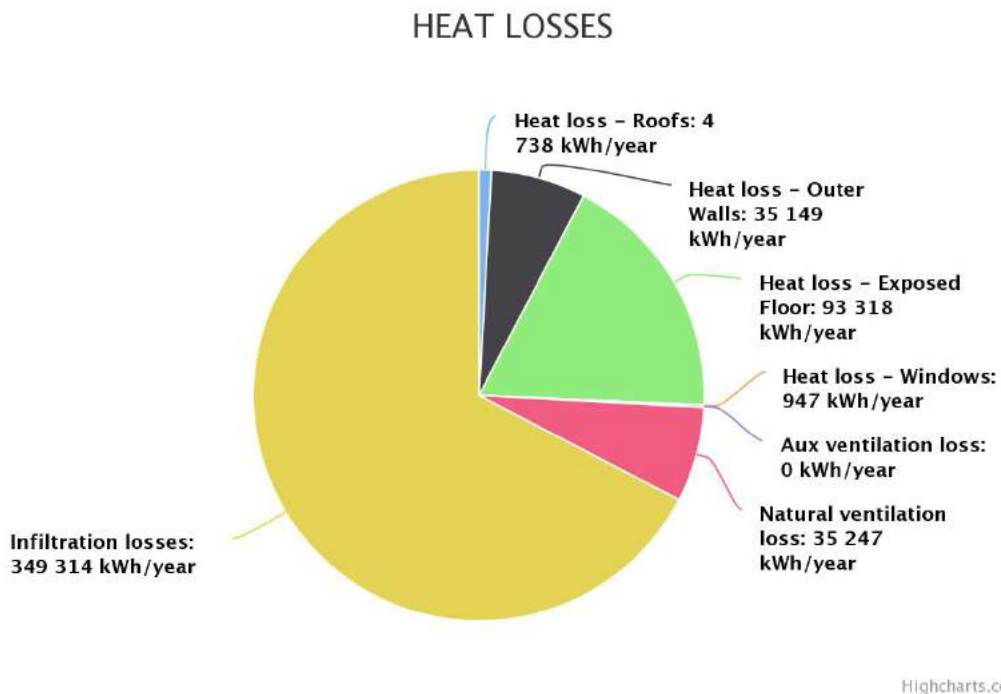


FIGURE 101: HEAT LOSS BREAKDOWN OF THE ADVANCED_VARIANT 1 OF THE ID-3 BUILDING OF PINS DEL VALLÈS SCHOOL

- Heat losses through thermal envelope has been reduced by ~10%, the main contributor is the improvement of the thermal envelope. (Figure 101)

6.2.6. DECISION MAKING

The NewTREND tool helps the users in the decision making with its KPI weighting tool. In Chapter 6.1.3 the targets of the building owners were determined. In the following the variants are weighted based on their preferences and a list of preference is determined by the NewTREND tool (Figure 102).

TABLE WITH KPIS FOR: ID_3								
	CATEGORY PRIORITY LEVEL	BUILDING CORE KEY PERFORMANCE INDICATOR	BUILDING KPIS PRIORITY LEVEL	KPI PRIORITY SCORE	KPI WEIGHTING	AS-IS BENCHMARK (1-100)	SC TRAINING 01 - AUGUST BENCHMARK (1-100)	SC TRAINING 02 - AUGUST BENCHMARK (1-100)
ENVIROMENT	HIGH ▾	1 Energy						
		1.1 Operational Primary Energy Demand	HIGH ▾	9	12.5 %	4	41	52
		1.2 Delivered Energy Demand	HIGH ▾	9	12.5 %	1	13	1
		1.3 Renewable Energy on site	HIGH ▾	9	12.5 %	13	55	64
		2 Impacts						
		2.1 Global Warming Potential	HIGH ▾	9	12.5 %	27	60	67
SOCIETY	MEDIUM ▾	3 Air Quality						
		3.1 Indoor air quality	HIGH ▾	9	8.33 %	1	0	0
		4 Thermal Comfort						
		4.1 Summer comfort without cooling	HIGH ▾	9	8.33 %	100	0	0
		4.2 Thermal comfort in the heating season	HIGH ▾	9	8.33 %	100	0	0
		4.3 Thermal comfort in the cooling season	HIGH ▾	9	8.33 %	100	0	0
ECONOMY	LOW ▾	5 Operational Costs						
		5.1 Operational Energy Costs	HIGH ▾	9	16.67 %	38	69	74
CostsOverall Variant Score of Value Assessment:					37	33	35	
Achievend rank of Variant in Value Assessment					-	1	2	

FIGURE 102: THE KPI WEIGHTING TABLE OF THE ID-3 BUILDING OF PINS DELS VALLÈS SCHOOL

Advanced_2 variant is the highest scoring as it has the highest energy use reduction (Figure 102). However, this has lower score in the Delivered Energy Demand category than the Advanced_1 version.

In summary, the proposed energy refurbishments increased the energy efficiency of the building, but there is still high potential for further improvements, especially in the field of renewable energies.

6.2.7. COMPARISON OF BUILDING CURRENT STATE RESULTS IN THE THREE MODES

Since all needed data was collected from the demonstration building to test all three modes of the NewTREND tool, these could be compared. As the premium mode offers only as-is analysis, the comparison was made on the current state results.

The premium mode assessment is based on measured data, reflecting actual behaviour of the building. It is worth to compare the results from the other 2 modes to see their relation to measurements.

TABLE 11: BASIC, ADVANCED AND PREMIUM MODE KPI CURRENT STATE RESULTS OF THE ID-3 BUILDING OF PINS DEL VALLÈS SCHOOL

	Delivered energy demand (kWh/m ² *year)	Renewable energy on site (%)	Primary energy demand (kWh/m ² *year)	Global warming potential (kgCO ₂ /m ² *year)	Operational energy costs (EUR/m ²)
Basic as_is	114,94	0,64	174,38	32,14	11,83
Advanced as_is	287,52	0	394,11	74,37	25,26
Premium	124,75	0	192,26	35,31	12,99

Table 11 shows the results of the current state analysis from all three modes. According to the table, basic mode has ~8% difference from the Premium mode results and the Advanced mode has ~60% difference.

The difference between the measured and the simulated results can be caused by the cumulation of several effects, where the main factors are:

- The input data for the basic mode is a rough approximation of the building geometry, systems and operations conditions. The advanced mode gives a more realistic representation of the building geometry and its systems.
- The measured data imported to the Premium mode is related to a specific year with distinct climate conditions, meanwhile the dynamic simulation uses weather data averaged from several years.
- The building occupants use the buildings differently from the ideal, as the individual comfort levels can hugely differ from the averages used by the dynamic simulation.

In general, the advanced mode should deliver a more accurate result as it uses more realistic geometric and systems input data. Thus, in this case the different results of the basic mode to the real results can be considered normal.

6.2.8. NEIGHBOURHOOD CURRENT STATE ANALYSIS

The following sections describe the evaluation of the case study district, the Pins del vallès School area in Sant Cugat (ID-1 + ID-2 + ID-3 buildings), using the analysis tools available in the NewTREND tool.

KEY PERFORMANCE INDICATORS

Investigating the state of the district KPIs can reveal strengths and weaknesses, that can be considered when making decisions. Table 12 represents a screenshot from the NewTREND platform displaying the KPIs for the current sustainability state of the case study in district mode. The scores for the indicators in the current state allow identification of areas where the district was performing poorly. These aspects are easily visualised on the NewTREND tool thanks to the scoring system for district indicators and the meaningful radar chart (Figure 103).

TABLE 12: THE RESULTS OF THE BUILDING KPI AS-IS DISTRICT ANALYSIS

	Delivered energy demand (kWh/m ² *year)	Renewable energy on site (%)	Primary energy demand (kWh/m ² *year)	Global warming potential (kgCO ₂ /m ² *year)	Operational energy costs (EUR/m ²)
District as_is	225	0	324,45	57,74	21,42

The KPI analysis shows 5 indicators in 2 categories: Environmental and Economic indicators.

In the Environmental category the Delivered Energy Demand scores just below average with an actual value of 225 kWh/m²*year (KPI score = 28). The primary energy demand of the district is just above average with an actual value of 324,45 kWh/m²*year. The closely related GWP indicator shows similar result (value: 57,74 kgCO₂/m²*year). The district is devoid of installed renewables which is reflected by the 0 score of the Share of Renewable Energy on Site indicator.

In the Economy category the only available indicator is the Operational energy cost indicator. Here the building scores well above average with an actual value of 21,42 EUR/m² by profiting from the below EU average energy prices in Spain^{5,6}.

DISTRICT KPI's score (1–100 points)

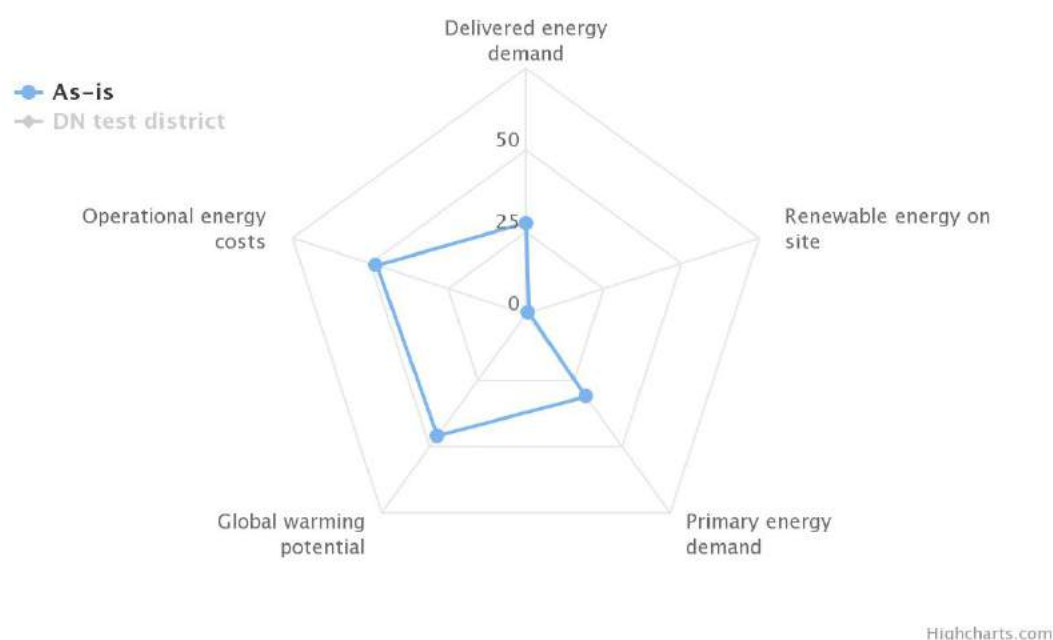


FIGURE 103: THE RESULTS OF THE DISTRICT KPI AS-IS ANALYSIS ON A RADAR CHART

⁵Source: EUROSTAT Electricity prices for non-household consumers, second half 2017

⁶Source: EUROSTAT gas prices for non-household consumers, second half 2017

In summary there is a need to act on the reduction of the energy demand of the district, which will positively result in a further reduction of operational energy cost. Consequently, there is a need to further investigate the as-is state of this district using the rest of the analysis tools.

ELECTRICAL LOAD PROFILE

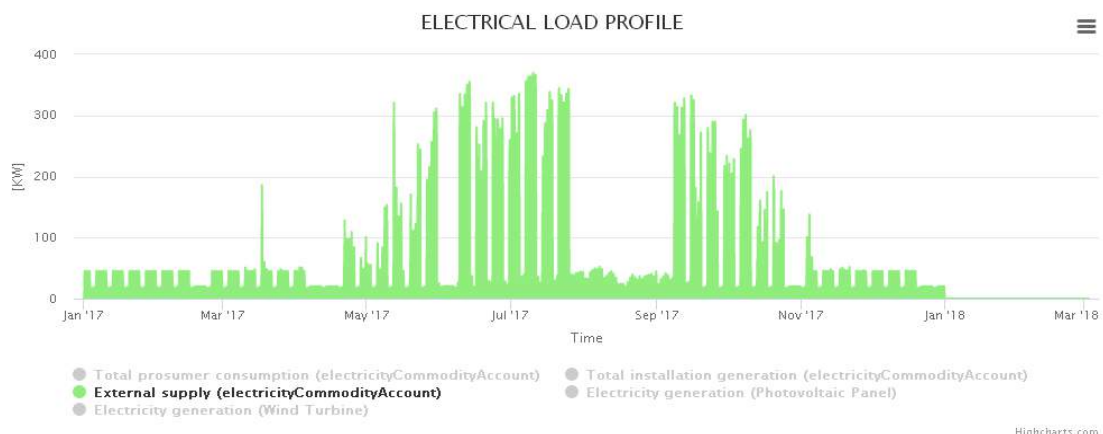


FIGURE 104: LIGHTING PROFILE OF THE ID-3 BUILDING OF PINS DEL VALLÈS SCHOOL

The electrical load profile of the district shows a weekly constant load for lighting and equipment loads for weekdays (Figure 104). The only observed variation is due to electricity used for cooling of two IT rooms in the ID-3 building (Figure 105). These variations reflect an increase in cooling during warmer summer months. On weekends and during the summer holiday the electricity load of the district is closest to zero.

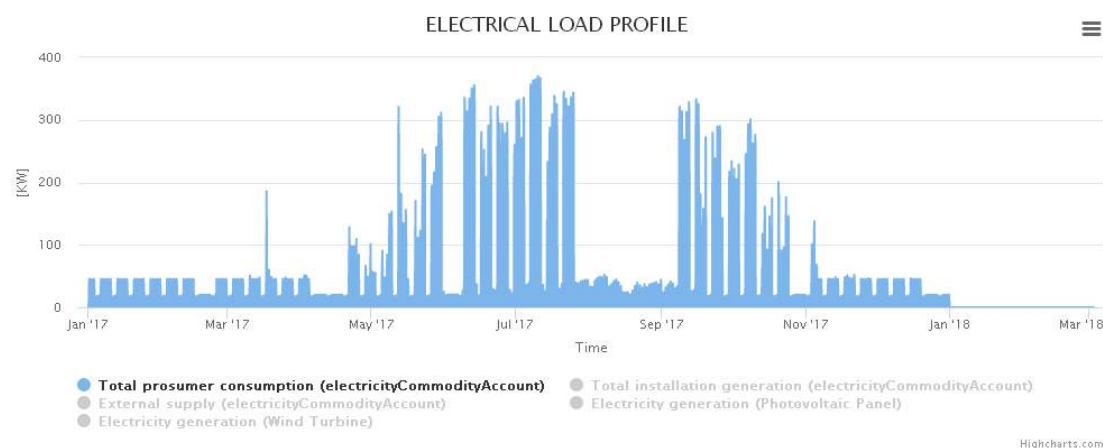


FIGURE 105: COOLING LOAD PROFILE OF PINS DEL VALLÈS SCHOOL DISTRICT

ENERGY BALANCE

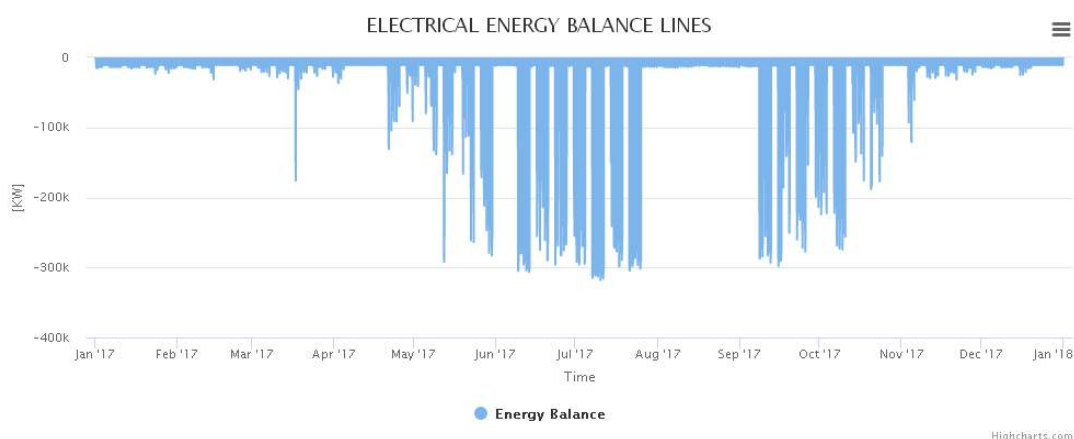


FIGURE 106: ELECTRICAL ENERGY BALANCE LINES OF PINS DEL VALLÈS SCHOOL DISTRICT

The NewTREND tool also has a function that shows the yearly electrical energy balance lines of the district. As Figure 106 shows, the sum of the electrical energy loads in the district of Pins del Vallès school balanced with the produced electrical energy. Since there is no energy production on site the balance line only shows the energy demand of the district

6.3. SEINAJOKI DEMO SITE

6.3.1. FREEZING MODEL FOR DIAGNOSIS

The final CityGML base model of the Seinäjoki pilot area contains 4 buildings. This file was uploaded to DIM server and rest of the associated information was stored via the Data Manager in the DIM server.

The main building of the pilot site has been modelled in advanced mode and exported as an IFC file, while the data for the building was entered in the Data Manager for basic, advanced and premium mode.

6.3.2. NEIGHBOURHOOD CURRENT STATE ANALYSIS

A district as-is simulation was run via CDP tool with 4 buildings modelled in basic mode. Table 13 lists the calculated KPIs for existing buildings.

TABLE 13 RESULTS FROM DISTRICT AS-IS SIMULATION IN BASIC MODE FOR FINNISH PILOT SITE

	Delivered energy demand (kWh/m ² *year)	Renewable energy on site (%)	Primary energy demand (kWh/m ² *year)	Global warming potential (kgCO ₂ /m ² *year)	Operational energy costs (EUR/m ²)
Kivirikko house	251,73	0	367,86	29,3	16,36
Main building	344,05	0	502,77	40,04	22,36
Boiler room	273,18	0	401,9	32,58	18,11
Office building	430,95	0	727,03	78,59	41,02

TABLE 14 COMPARISON OF DISTRICT BASIC AS-IS SIMULATION WITH MEASURED RESULTS FOR FINNISH PILOT SITE

	Delivered energy demand (kWh/ m ² *year)		Difference
	Simulated	Measured	
Kivirikko house	251,73	263,1	-5 %
Main building	344,05	221,7	36 %
Boiler room	273,18	297,5	-9 %
Office building	430,95	204	53 %

ON ITS OWN THIS DOESN'T TELL US MUCH, SO

Table 14 contains district results for the basic mode as-is case., predicted results are compared with the measured values. From the table we can see that two smaller buildings of the pilot site even in the basic mode are relatively close to the measured values, while main and office building have quite a difference. As this is all in basic mode, using simple geometry and information from templates, which translates to inputs with many assumptions, results are expected to differ significantly.

6.3.3. MAIN BUILDING ADVANCED CURRENT STATE ANALYSIS

The advanced as-is simulation for the Main Building was done using an IFC building model, data entered in Data Manager and the CDP. Results can be seen in Table 15 together with the desktop study comparison.

TABLE 15 KPIS FOR MAIN BUILDING OF FINNISH PILOT SITE IN ADVANCED MODE

	Delivered energy demand (kWh/ m ² *year)	Renewable energy on site (%)	Primary energy demand (kWh/ m ² *year)	Global warming potential (kgCO ₂ / m ² *year)	Operational energy costs (EUR/m ²)
Main building - advanced	267,94	0	435,29	43,97	23,26
Main building – desktop study	221,55	0	208,19	47.8	13.2

Advanced simulation using the NewTREND tool gave better results for the main building than in the basic mode, still some differences persisted with the KPI values compared to calibrated desktop simulation study. Digging deeper in the results, we found that the reason might be difference in occupancy and equipment schedules and that there are different conversion factors for primary energy demand. The pilot case building is a part of Seinäjoki city district heating network, while in the Data Manager doesn't yet have the ability to select district heating.

DELIVERED ENERGY DEMAND

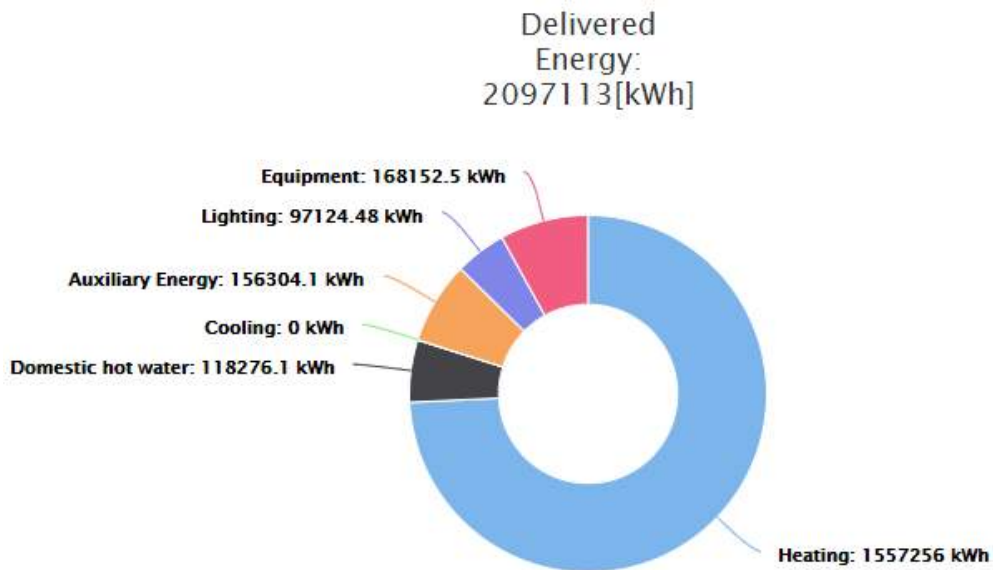


FIGURE 107 DELIVERED ENERGY BREAKDOWN OF THE MAIN BUILDING IN FINNISH PILOT SITE

According to Figure 107, heating is the main driver of annual energy consumption, which is expected because of the Finnish climate and the fact that building is quite old. However, this result suggests that decreasing heating need in the building will have the highest impact on the building performance.

THERMAL BASED WEAK POINTS

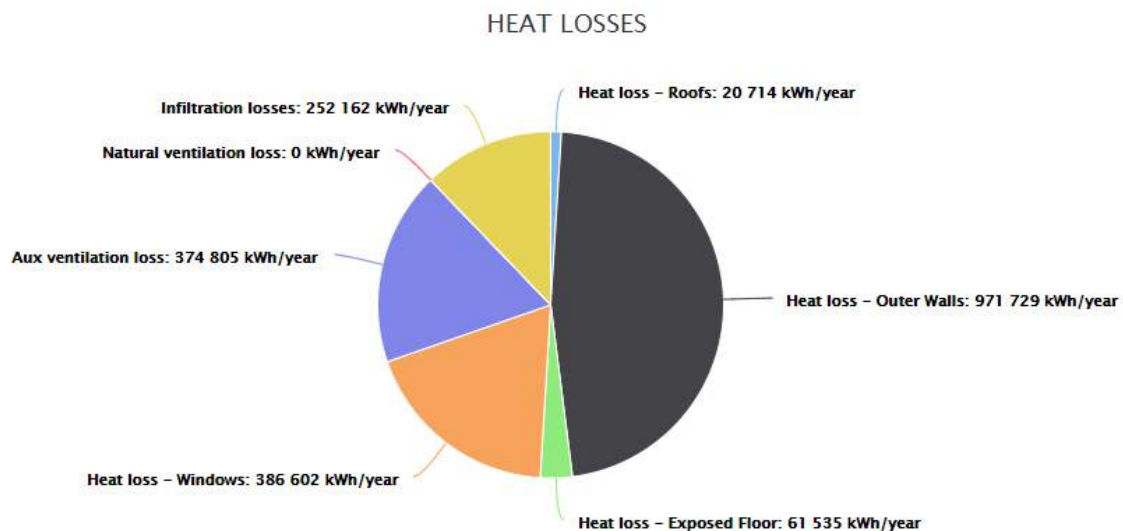


FIGURE 108 HEAT LOSSES OF THE MAIN BUILDING IN THE FINNISH PILOT SITE

With the analysis of the diagram in Figure 108 it is possible to figure out main sources of heat loss in the building. Heat loss through the outer walls accounts for nearly half of the heat losses in the building, followed by losses through windows and ventilation. Since the roof has recently been retrofitted, its impact on heat loss is minimal. Retrofitting the outer walls would have the highest impact, but since the

building is historically protected, this is not possible. Therefore, the retrofit should focus on windows and the ventilation system.

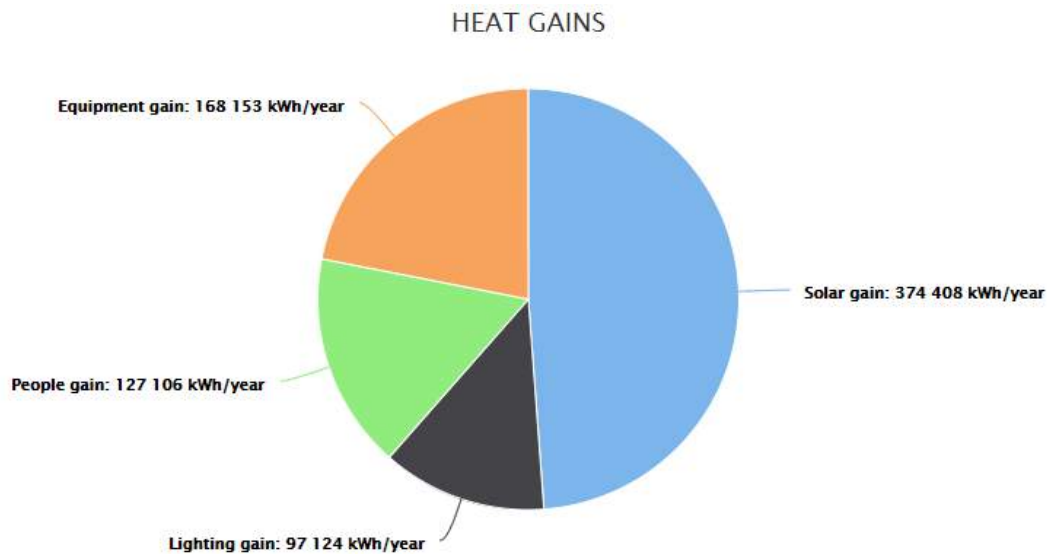


FIGURE 109 HEAT GAINS IN THE MAIN BUILDING OF THE FINNISH PILOT SITE

Solar gains have a strong influence on total heat gains (Figure 109). Even though it initially appears high, further decomposition of the annual total reveals that solar gains are beneficial in the colder part of the year, while in summer, when the gains would have negative impact on comfort, the school is not operating.

HEAT DURATION CURVE

A very interesting feature of the tool is heat duration curve, where one can analyze how is the heat load distributed over the year. A key observation is that the highest 50 % of the load is achieved in less than 5% of the year and that heat load above 80% happens in less than 8 hours per year (Figure 110). This means that peak power can be (and should be) curbed in the retrofit, which can be done with very low cost as it can be avoided with reprogramming building automation system. In this case saving would come mostly with paying lower peak power reserve fee to the district heating operator.

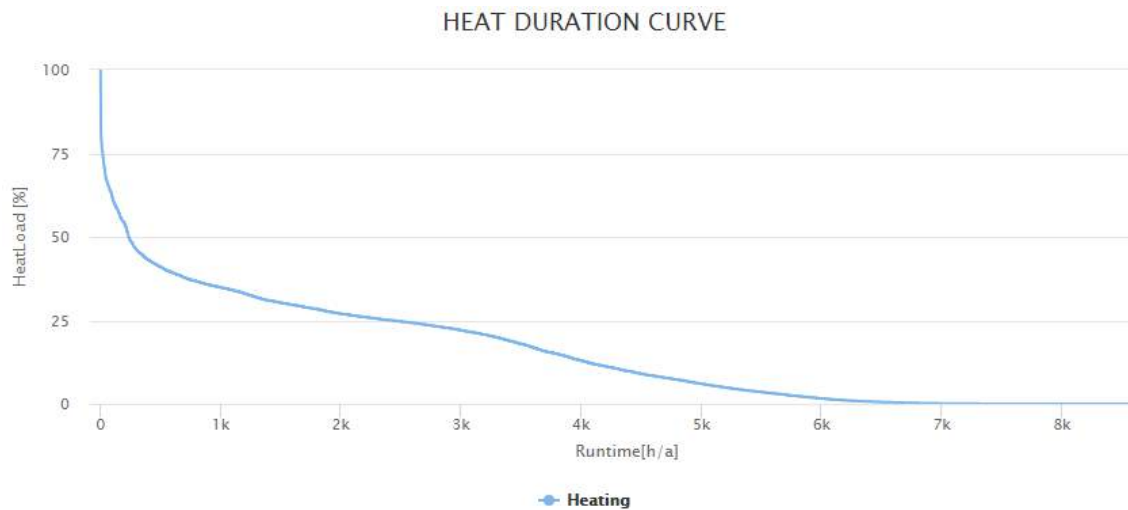


FIGURE 110 HEAT DURATION CURVE OF THE MAIN BUILDING IN THE FINNISH PILOT SITE

6.3.4. TARGETS

The targets of the retrofit in Seinäjoki are to lower energy consumption of the buildings but to simultaneously increase the indoor comfort of the occupants. The historical significance of the façade limits interventions. There is also a conflict between the need for the increase of ventilation airflows and the decrease of energy consumption.

	CATEGORY PRIORITY LEVEL	BUILDING CORE KEY PERFORMANCE INDICATOR	BUILDING KPIS PRIORITY LEVEL	KPI PRIORITY SCORE	KPI WEIGHTING
ENVIROMENT	HIGH ▼	1 Energy			
		1.1 Operational Primary Energy Demand	HIGH ▼	9	12.86 %
		1.2 Delivered Energy Demand	HIGH ▼	9	12.86 %
		1.3 Renewable Energy on site	LOW ▼	3	4.29 %
		2 Impacts			
SOCIETY	MEDIUM ▼	2.1 Global Warming Potential	HIGH ▼	9	12.86 %
		3 Air Quality			
		3.1 Indoor air quality	HIGH ▼	9	10.71 %
		4 Thermal Comfort			
		4.1 Summer comfort without cooling	LOW ▼	3	3.57 %
		4.2 Thermal comfort in the heating season	HIGH ▼	9	10.71 %
ECONOMY	MEDIUM ▼	4.3 Thermal comfort in the cooling season	LOW ▼	3	3.57 %
		5 Operational Costs			
		5.1 Operational Energy Costs	HIGH ▼	9	28.57 %

FIGURE 111 KPI WEIGHTING FOR THE FINNISH PILOT SITE

In Figure 111, the KPI weighting is shown, the Environmental category KPI has highest priority level but inside the Renewable energy category, on site production has lowest priority level. This is because of interest of the owner to keep the building on the district heating network (as it has the same owner) and because solar PV panels are not highly considered in Finnish environment. The Societal category has a medium level, where the highest KPI level has indoor air quality and thermal comfort in heating season, during most of the summer school is not in operation so comfort in summer is not of much interest.

6.3.5. VARIANT CREATION

For the purpose of retrofit, three variants were created in advanced mode for the Finnish pilot site. Analyzing the current state of the building has aided the creation of potential variants (Table 16). Since it was discovered that heating pipe insulation had significantly deteriorated, it was decided to put it in all three variants, same as with the thermostatic valves and the retrofit of the heating recovery unit. Two other variants are combination of the first one, plus changes in windows, floor insulation and lighting type. Furthermore, a third variant explores the potential of demand-controlled ventilation and solar PV.

TABLE 16: DESIGN VARIANTS FOR THE FINNISH SITE

	Advanced_variant 1	Advanced_variant 2	Advanced_variant 3
Boiler Plant Improvements			
Chiller Plant Improvements			
Terminal controls	Thermostatic radiator valves	Thermostatic radiator valves	Thermostatic radiator valves
Plant controls			
Fans			Speed control (CO ₂ based)
Ventilation	Ventilation heat recovery 90%	Ventilation heat recovery 90%	Ventilation heat recovery 90%
Distribution Pipes Insulation	Insulate heating pipes	Insulate heating pipes	Insulate heating pipes
Lighting source		LED (120 lm/W)	LED (120 lm/W)
Lighting controls			Standalone occupancy switching
Roof insulation			
Loft insulation			
Exposed floor insulation		100 mm	150 mm
External wall inner insulation			
external wall cavity insulation			
external wall timber frame insulation			
external wall outer insulation			
Fabric opaque doors			
Glazing type		Windows double glazed U=1,6 W/m ² K	Windows triple glazed U=0,8 W/m ² K
Shading glazing			
Distributions systems insulation			
Electric motors and drives			
Heat Pump (heating)			
Solar water heater			
Heat pump (cooling)			
PV panels			20 kW (medium commercial)
Wind Turbine			

Unfortunately due to certain problems with what-if simulation in the tool before the deliverable submit date, it was not possible to simulate the variants and compare them to as-is solution.

7. IDM PROCESS TESTING EVALUATION

This paragraph describes the relationships between the application of the methodology and tools (WP6) and the Integrated Retrofit Design Methodology (WP2 – T2.6). The Integrated Retrofit Design Methodology seeks to guide all involved stakeholders in finding an effective energy retrofitting solution within a neighborhood. The criteria considered for an effective retrofit project are energy, cost and overall sustainability.

Evaluation of the methodology focuses on testing the support it provides to the stakeholders involved on the three demo sites. The testing activities described earlier in this report aim to assess communication and participation mechanisms at every phase of the project in a structured and systematic manner. The goal is to assess whether the procedure of the IDM was closely followed in the three demo site projects. This early application of the IDM on three different projects was an opportunity to learn about the strengths and weaknesses of this methodology. The testing process evaluated completeness, correctness and possible redundancies, as well as general feedback.

TABLE 17: FEEDBACK ON THE IDM PROCESS FROM THE PROJECT PARTNERS

PHASE	ACTION/PURPOSES	Platform functions	PP FEEDBACK
Initiation	Develop Project Charter	<ul style="list-style-type: none"> DM- Setting up NewTREND Project Platform CDP- Define the project physical boundaries and stakeholders 	Feedback to contain demo project definition (input from D6.1) and description of NewTREND platform launch
	Define Project Boundaries		
	Soft launch of NewTREND Project website		
	Choosing NewTREND mode		
Preparation	Launching of NewTREND Platform	<ul style="list-style-type: none"> DM- Minimum data entry for building and neighbourhood level data and data from occupants DM- Freeze the model for the diagnosis phase CDP- Setting up users account for stakeholders CDP- Poll, ask for the availability of different stakeholders to schedule the Kick-Off meeting 	Summary of data collection methods (referencing D6.1) and data entry to the DM
	Collection of neighbourhood data		
	Collection of building data		
	Collection of occupant data		
	Freeze model for diagnosis		
	Neighbourhood current state analysis		
Diagnosis	Building current state analysis	<ul style="list-style-type: none"> DM- Accessing the information on the DIM server DM- Creation of a Diagnosis Phase Summary Report 	Description of results of the current state analysis
	Non-simulated aspects		
	Diagnosis phase summary report		
	Apply continuous post occupancy measures to avoid sub-optimal use		
	Update and maintain the project BIM/DIM model and documents		

In addition to the methodology itself, it is important to evaluate the NewTREND platform and its relationship to the IDM. This assessment focuses on the completeness of the implementation of the platform when compared to the defined IDM. To collect relevant feedback from users, we developed a simple but effective Feedback Table for the IDM process.

The structure of this table is based on the 10 phases of the IDM: initiation, preparation, diagnosis, strategic definition, concept, decision-making, design development and tendering, construction, handover and close-out, and in-use. For each phase, the table provides the relevant processes. These processes are placed in the context of the features of the NewTREND platform, in particular the Data Manager and the Collaborative Design Platform. Thus, the processes are also linked to the different phases of IDM. The development of the table also considered the use cases defined in the T1.3. Through this configuration of the table, the user can easily find NewTREND platform features that are relevant for each of the different phases of the IDM. With this arrangement in place, only relevant features for a given IDM phase were examined. Finally, the table provides a column to collect feedback from the Partners involved in the testing activity of the demo sites.

Of special interest was feedback concerning the alignment of the NewTREND platform with the IDM. Hereby, the focus was on missing features as well as redundant features and general user feedback. Table 17 shows the first three phases of the table sent out to users. It contains a complete table including all phases of the IDM.

7.1. SUMMARIZING THE EXPERIENCES BY STAKEHOLDERS

One of the key aspects of the IDM is that actively participating stakeholders receive important feedback about all relevant aspects of the project. This feedback places the stakeholders in the context of the project and ensures that it is successful and well described by the stakeholders. It is important to include the perspective of various stakeholders; however, such selections are essential to finding the key actors that are affected by the outputs of NewTREND and participants that can enrich the final results of the project. This selection of users for the NewTREND platform led to the identification of four target groups:

1. technical organizations and professionals
2. financial organizations
3. administration and policy makers
4. occupants.

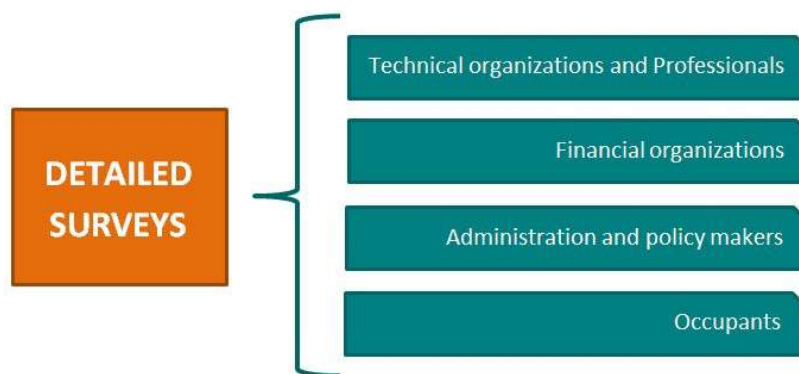


FIGURE 112: FOUR TARGET GROUPS INVOLVED IN THE DETAILED SURVEYS

There are key motives for the involvement of each of the defined target groups. Professional stakeholders can provide valuable suggestions from performing the more technical functions of the NewTREND platform. Financial organizations help evaluate the effectiveness of financial investments in the context of energy efficiency and refurbishment. These organisations can also provide important feedback to the components of the platform that relate to their professional activity. Administration and policy makers evaluate the components of the platform related to their professional and business needs. The occupant perspective on the use of NewTREND platform is fundamental for a more integrated approach to design. Involving end users at the different stages of the project improves the acceptance of the project from stakeholders throughout and after the project. This feedback from all stakeholders was collected through the following different modes:

- LAT Meetings (questionnaires, interviews, etc.);
- Events and focus groups related to the project;
- Active participation on the Platform through the E-collaboration section (forum, doodle, surveys, etc.);
- Training courses (testing feedback templates, etc.).

The CDP offered the ability to use social tools to encourage the exchange of information between stakeholders and to conduct surveys. The social tools (poll, survey and quiz) are integrated into CDP by linking existing external tools. The online forum, user notification and messenger options are not implemented in the current version of CDP due to limited project resources, but could be added as future enhancements.

The most important reason for the collection of stakeholder feedback is to understand the real interaction of users with the platform when considering the upcoming exploitation and the future application of the platform.

During this project, feedback from testing templates by stakeholders was considerable and many comments and issues were raised. The compilation of feedback highlighted technical problems and potential enhancements, with the aim of making the platform easier to understand and stable (see sections 4.3 and 5.4 for more details). Similarly, the comments provided through the detailed surveys and the questionnaires illustrated specific issues and potential future enhancements of the tool (see section 7.2). Furthermore, the social tools integrated in CDP were received as intuitive and useful for their purposes (see section 7.3).

7.2. DETAILED SURVEYS

Within Task 6.4, the evaluation and upgrade of the methodology and tools, the Detailed Surveys have been created to support the developer team in gathering feedback. This feedback forms the basis for tool enhancements to address identified issues at different stages. The goal of these interviews is to improve the tools through the feedback from stakeholders' experience using the NewTREND platform. The stakeholder groups involved in this activity are similar to the participants of the LATs. They are knowledgeable about the project; its goals and the tools being developed through their participation in the different demo site projects. These detailed surveys also form a connection between WP6 and WP7 in context of the activities of the LATs. Feedback from the Detailed Surveys was collected in two distinct phases that coincided with the 3rd and the 4th LAT meetings. These surveys were conducted during the LAT meeting with the participants of the four target groups: professionals, financial organizations, administration and policy makers and occupants (shown in Figure 112).

Questionnaires are useful tools to gather perceptual feedback about the operation of the different components of the NewTREND platform. The questions presented in these questionnaires allowed a critical look at the exploitation and the future application of the NewTREND' platform as they provide useful indications for possible tool enhancements.

The content of the interviews is tailored for each target user group. The feedback is calibrated based on typical skills and goals of a target user group. Below are some examples of questions asked of the involved stakeholders.

- *What is your profession?*
- *What sort of work does your organization normally undertake?*
- *What is your involvement in this project?*
- *Overall impression from your professional perspective about the functionality of the components of NewTREND platform.*
- *Can the tool be useful from your professional perspective?*
- *Which of the components of the platform do you consider most useful for the purposes of your professional activity?*
- *Within your working field, are people prepared to use the platform? If not, what is missing?*

The feedback collected from this activity was analyzed in depth to obtain useful information about potential improvements of the platform. These are reported in the Deliverable concerning LATs activities "D7.9 Final report on LATs activities".

Process indicators are defined for all processes of the new design tools and methodologies with in the testing feedback templates. These indicators were reduced to focus on important indicators that relate to the final result. The Feedback Templates to test the Data Manager, the Collaborative Design Platform and the IDM process contain process indicators.

Through the application of these tools it is possible to gather practical information and feedback on the improved workflow of NewTREND Platform features. Furthermore, considerations related to qualitative aspects can be included. Through the application of these process indicators, all available information will be collected to ensure an improvement of the overall workflow of the Platform.

7.3. STAKEHOLDER INVOLVEMENT – EVALUATION

The stakeholder engagement activities in this project were divided into two strands. Firstly, there were specific stakeholder engagement activities associated with the development of the NewTREND tools, primarily the LATs and surveys. This strand of activities focused on the types of stakeholders who would normally be involved in projects teams, such as those designing, building and financing projects. Earlier sections of this document describe the LAT process in more detail. The second strand of activities was primarily focused on building occupants and users, the often-overlooked stakeholders; this is the strand of stakeholder engagement to be discussed briefly in this section of the report, and, in comprehensive detail in the NewTREND deliverable D6.2 for Task 6.2 (Mac Sweeney et al 2018).

TABLE 18: LIST OF STAKEHOLDERS (PAUL MITTERMEIER, AHMED KHOJA 2017)

Occupants & Users	
Occupants	Residents, Tenants, In-Patients
Users	Staff, Students, Visitors, Patrons, Out-Patients
Sub-Groups	Representatives e.g Building Representative.
Owners	
Client	Project instigators, Building owner, developer, long-term lease-holder
Owners Representatives	Project Managers, Assistants, Client Representatives
Sub-Group	Administration, Personal Assistants, Accounts
Designers	
Architectural	Architect, Technician, Technologist, Interiors, Landscape,
Engineering	Engineers; civil, structural, mechanical, electrical etc,
Visuals	Draughtspersons, Architectural Artists, BIM tech, CAD tech, Model Makers, Graphic Designers
IT	UX Design, Web Design, Social Media Platforms
Sub-Group	Admin, Personal Assistants, Team Specialists, Document Control
Builders	
Main Contractor	Main Contractor, Sub-Contractors, Maintenance Contractors
Specialist Contractors	Demolition, Ground works, Enabling works, Installers (curtain walling, elevators, HVAC etc)
Sub-Group	Admin, Personal Assistants, Team Specialists, Document Control
Others	
Local Authorities	Building Control, Health & Safety, Municipalities and Local Government, Traffic Management, Planning Authority, Permits etc
Public Interest Groups	Neighbours, Residents Associations, Business Associations, Sports and other Local Clubs and Societies, Neighbourhood Watch, NGO's, Politicians etc
Sub-Group	Representatives, Points of Contact for large groups etc

Table 18 summarizes the breakdown all previous stakeholder types into five basic groups; those who **use** buildings, those who **own** buildings, those who **design** buildings, those who **build** them, and everyone else. This is based on the lifecycle of any building and is not specific to the use of the NewTREND tools, or financing options, it is intended as a broad and all-encompassing stakeholder identification process at the start of any building or retrofitting project. Stakeholders can be grouped in numerous other formats based on the specific task at hand, such as allocating access privileges to the NewTREND tools or assessing financial business models for the works. This simplification, however, is useful for casting a wide net to capture as many stakeholders as possible and ensuring none are overlooked from early on.

The NewTREND approach to stakeholder engagement is designed to be flexible. It focuses on guiding stakeholders through the critical questions that need to be asked in planning a process of occupant and user engagement, helping them navigate the many options available and ultimately choosing from those options to devise their own tailor-made solutions. At each step, several options are presented, with the aim of allowing stakeholders develop a process of occupant and user engagement, customised for their individual project. There are three main steps involved:

1. Deciding what level of occupant and user engagement is suitable for the project;
2. Choosing the appropriate suite of methods;
3. Combining these into a tailored engagement plan.

It is necessary at the outset of a project for the project manager to assess what level of occupant and user engagement is both feasible and desirable. This will depend on three sets of factors: the characteristics of the building and project, the characteristics of the traditional stakeholders (the client and the design & build teams), and the characteristics of the occupants and users. The budget and timescale will also have a bearing on this.

NewTREND Deliverable 2.6 (Paul Mittermeier, Ahmed Khoja 2017) outlines, in detail, several models of engagement which could be utilised to ensure participation of as many stakeholders as possible. It was designed on the principles of inclusion, and co-design (Figure 113). This step by step diagram is a generic indication of the types of stakeholder engagement models available and further detail on the specific types of engagement activities can be found in Deliverables 2.5 (O'Connor, MacSweeney, and Dunphy 2016), 2.6 (Paul Mittermeier, Ahmed Khoja 2017) and 6.2 (Mac Sweeney et al 2018).

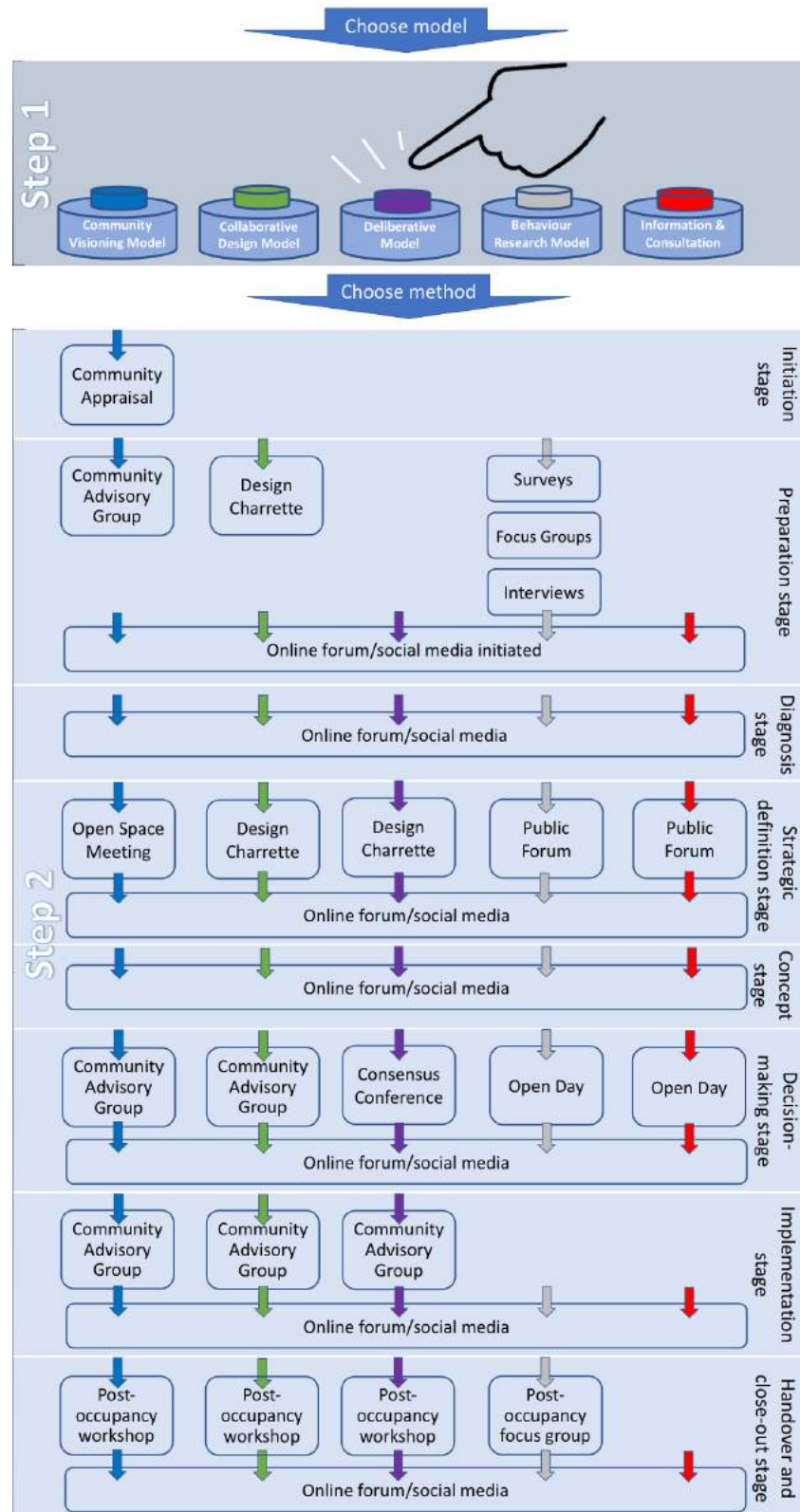


FIGURE 113: TYPES OF STAKEHOLDER ENGAGEMENT AVAILABLE (PAUL MITTERMEIER, AHMED KHOJA 2017)

Based on the engagement models outlined in D2.6, the NewTREND team designed and carried out a series of in-depth engagements with stakeholders, primarily in Spain, Finland, Hungary, Italy and Ireland for Work Packages 1, 2 and 6. The criteria for engagement was informed by the feasibility within the project budget and time frame, the limitations of the retro-fit projects at each of the three case-study demo-sites, and dependent on the availability of participants. Table 19 below indicates the suite of methods used, as outlined in T2.5.

TABLE 19: TYPES OF APPROACHES TAKEN IN THE CASE-STUDY DEMO-SITES (MAC SWEENEY ET AL 2018)

Approach	Description	Used in WP6
Public Forum	Not used. See deliverable T2.5 for more detail on this method.	No
Focus Group	To be described in more detail in Deliverable T6.2	Yes
Workshop	To be described in more detail in Deliverable T6.2	Yes
Brainstorming Session	Utilised as an activity within Focus Groups and Workshops rather than a stand-alone activity – described in T6.2	Yes – Adapted
Visioning	Utilised as an activity within Focus Groups and Workshops rather than a stand-alone activity – described in T6.2	Yes – Adapted
Open Space Technology	Local Advisory Teams LATs – discussed previously in this document	Yes
Design Charette	Was not feasible / suitable due to the nature of the projects being undertaken	No
One-on-One Consultation	Adapted for purpose to the building Diary process – more detail on this in T6.2	Yes – Adapted
Interviews	Utilised extensively in Work Package 1, and T6.2	Yes
Surveys	Used earlier in the project as part of another deliverable, and used as part of the LAT process (see above)	Yes
Open-Day	Used earlier in the project as part of another deliverable	N/A WP6
Participant Observation	Used throughout, for more detail see Deliverable T6.2	Yes
Walk-Through	Not used. See deliverable T2.5 for more detail on this method.	No
Design Games	Not used. See deliverable T2.5 for more detail on this method.	No
Opinion Poll / Online Poll	Used earlier in the project as part of another deliverable	N/A WP6
Community Appraisal	Community Appraisal is type of participatory research that involves capturing the perspectives of members of a community on issues. As part of the scope of NewTREND, three communities were chosen, one each in Spain, Finland and Hungary.	Yes, in the early stages of NewTRNED, not part of this deliverable.
Citizen Advisory Group	Not used. See deliverable T2.5 for more detail on this method.	No
DEMOCs	Not used. See deliverable T2.5 for more detail on this method.	No
Deliberative Polling	Not used. See deliverable T2.5 for more detail on this method.	No

21 st Century Town Meeting	Not used. See deliverable T2.5 for more detail on this method.	No
Consensus Conference	Not used. See deliverable T2.5 for more detail on this method.	No
Appreciative Inquiry	Not used. See deliverable T2.5 for more detail on this method.	No
Citizen's Jury	Not used. See deliverable T2.5 for more detail on this method.	No
E-Panel	Not used. See deliverable T2.5 for more detail on this method.	No
Online Consultation / Online Forum	Not used. See deliverable T2.5 for more detail on this method. Online consultation is available in the NewTREND tool and was utilised in survey format only. A forum was not used.	No
Public Participation GIS	Not used.	No
Hackathon	A Virtual Hackaton process was used in the software and tool development as the participants were spread across Europe in Ireland (UCD), The UK (IES), and Italy (STAM, iisBE, UniVPM)	Yes – Adapted
Social Media	Webpage: http://NewTREND-project.eu , Twitter Account: @NewTREND_EU, Linkedin: https://www.linkedin.com/company/NewTREND-eu-h2020/ Facebook: https://www.facebook.com/NewTREND.EU/	Yes

The process for Deliverable 6.2 began by asking occupants to carry out a diary exercise in which they were asked to write about their daily experiences with their buildings. Observations could include their thoughts, emotions, and any topic they wished that offered the team an insight into their relationship with the buildings they resided in. They were encouraged to write openly and candidly, as well as to draw, or take photos. Essentially, they were given the freedom to express their thoughts through the medium they were most comfortable with. They were asked to do this over a period of a week and were not instructed to confine their diary entries to energy related themes. They were then interviewed about the process, about what they wrote, and about their buildings. The outcomes of the diary exercise in turn informed the design of the focus groups and workshops that were carried out afterwards. These group exercises were designed with great care to ensure effective participation and communication; and to avoid common pitfalls associated with such events, where the organizers revert to giving what are essentially long lectures and presentations with minimal interaction from participants. This was to be avoided at all costs. The organizers' key role was to encourage and facilitate dialogue.

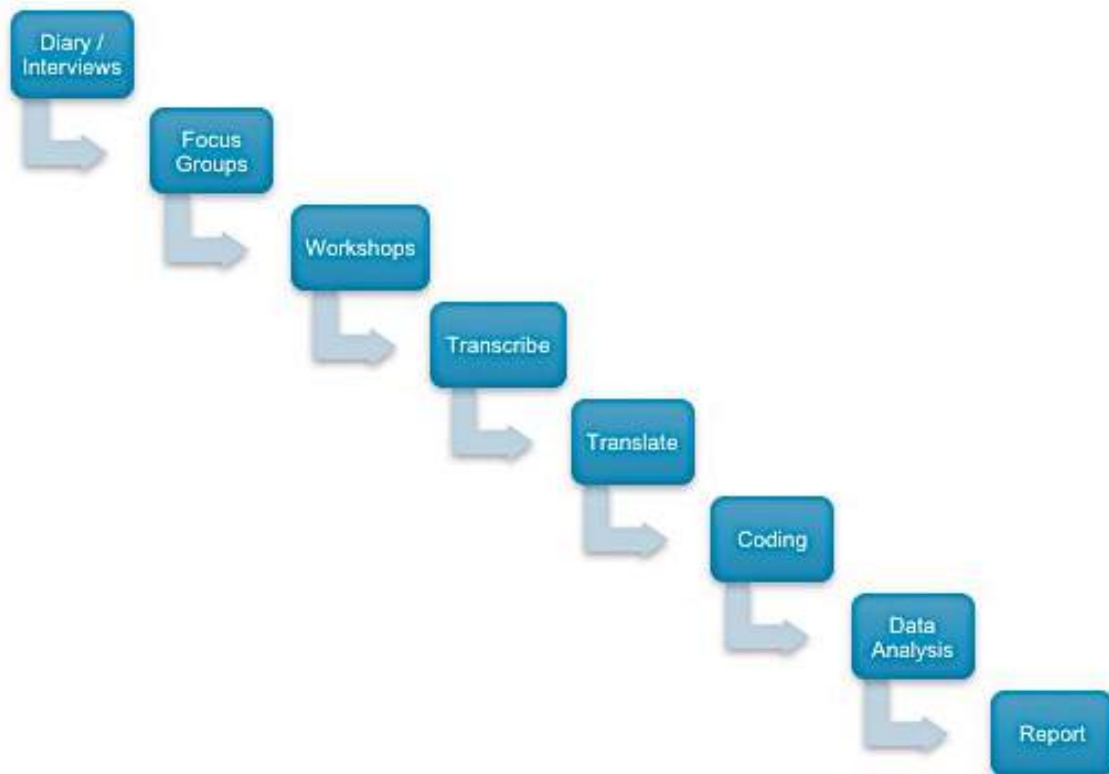


FIGURE 114: PROCESS FROM DIARY/INTERVIEWS TO THE REPORT

Each diary, interview and group event was recorded, transcribed and translated to English. Generally speaking, transcribing takes approximately four hours for every one hour of audio. However, this can vary depending on the quality of the audio, speed, the accent of speakers or the volume of speech, crosstalk, and typist speed. Translation quality varies according to the level of linguistic proficiency of the translator, and the quality of the transcription, especially for group events where there are several people speaking. This process also adds significant time to the extrapolation of data from each of the stakeholder engagements. The completed translated transcripts were then imported into Nvivo software for coding purposes. This was carried out by highlighting individual segments of each transcript and assigning a code for topics of discussion such as “decision-making”, “insulation”, or “thermal comfort”. Once all segments of text in all of the translated transcripts are coded data analysis of the findings can take place.

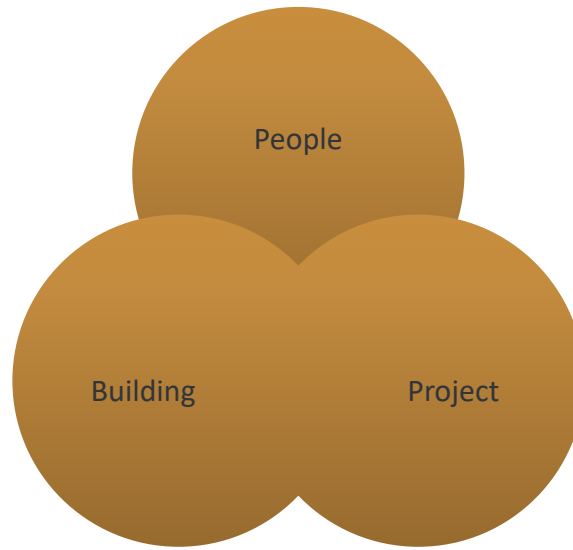


FIGURE 115: THE THREE MAIN SUBJECT AREAS FOR DISCUSSION (MAC SWEENEY ET AL 2018)

Figure 115 indicates the three main subject areas discussed, topics to do with the building, topics to do with the people, and topics to do with either the NewTREND project, or the retrofit project taking place. Table 20 below lists each of the various topics discussed under these three headings, in accordance with the stakeholders engaged as part of this strand. It is evident from the table that a wide range of topics was discussed and that many of topics relate directly and indirectly to energy use. The resultant report on this activity is the deliverable for Task 6.2 (Mac Sweeney et al 2018).

TABLE 20: TOPICS OF CONVERSATION CODED (MAC SWEENEY ET AL 2018)

Topics of conversation coded.

The Building	The People	The Project
Acoustics	Attitude of Opinions	Information provision
Building Services	Awareness	Post retrofit changes
Comfort Heating Cooling	Communication, Engagement, Consultation	Priorities
Energy efficiency & renewables	Anti-social behavior, annoying neighbors etc.	Project champion
Condensation Mold Dampness	Decision Making	Project specifics
Frequency of use and tenure	Education & Training	Success (or lack of)
Historical or cultural aspects	Experience	Timelines, Deadlines
Lighting (including natural and artificial)	Health & Safety, Poverty	Who was involved in the project

Location or siting, affluence, social housing, Local infrastructure, Nature / biodiversity, Quiet / Noisy area, Views from windows, balconies etc	Occupants & Users, including their behavior, & Occupant & User Expertise	Whose ideas were considered, who can I talk to, who should be involved, who was involved
Spatial layout, size, footprint, design	Public / Municipality policies, procurement, spending etc.	About The NewTREND project
Ventilation	Satisfaction (or lack of)	About the interview / diary process
Maintenance, Cleaning, Decorating & Ongoing Repairs	Communal or community culture	Previous, future or ongoing engagement
Monitoring, metering, energy auditing	Too many opinions	Appropriate data collection and use
Health & Safety	Discussion on global warming, climate change etc.	Coordination
Money, cost, bills, rent, mortgage etc	Apathy, Emotive Topics	Dissemination
Lovable buildings	Behavior change – nudges etc.	Project Feedback, Suggestion Box
Specific building issues	Climate change and global warming concerns	Genuine consultation Vs Time-wasting
Type of building Vs Type of user	Energy Habits & Turning off appliances	Other related projects locally
Water	Maintaining relationships (between owner & occupant, between occupants etc.)	Post occupancy evaluation
Working conditions, living conditions, trade unions	Sensations; the sense of smell, sight etc.	Project budget

7.4. IDM PROCESS TESTING UPGRADE

The IDM was tested and reviewed by both actual users of NewTREND as well as LAT members during the second NewTREND LAT meeting in 2017 and the application of NewTREND in the pilot cases. The collected feedback on the IDM is documented in D6.1 “Characterization of the buildings involved in the pilot (Evaluation and Data Collection)” and D7.8 “Second report on LATs activities”. Due to the fact that in all pilot cases, the actual retrofitting work has either just started or is about to start, only a handful of the

IDM phases were tested in real life conditions, nevertheless, and thanks to adopting the LAT approach over 50 experts from the various EU countries covering a large spectrum of the construction industry have provided the research team with a holistic review and feedback to all the phases of the IDM. The main feedback on the IDM can be seen as positive in general, lot of the LAT members praised NewTREND IDM approach included both the handover and the in-use phase, which is in today's normal practice not giving the necessary attention and are handled as byproduct at the end of the project. Furthermore, the reviews have positively greeted the developed methodology for the inclusion of the end users in each phase of the project and the use of cutting edge cloud technology, though they have casted some doubt on its applicability in real case studies especially by older generation or more traditional design and construction firms that lack the necessary training on investment to move from CAD based to BIM/DIM based working platforms. Thus, the general feedback on the IDM was that such IDM is more suitable for large development renovation projects and not for small projects. As the construction industry is usually very slow in adapting new technologies and working methods.

Both the LAT members as well as pilot cases have highlighted the difficulty they encounter in real projects in terms of data collection and data processing, though they have praised the progressive modeling approach of NewTREND IDM especially the Basic and Premium mode and in its coupling with the data manager tool, they still emphasized the reality that renovation projects face numerous challenges in collecting and processing all the necessary data in renovation projects as it is an iterative loop and do not come to an end at certain phase. As during the renovation project new information appears while the construction works progress, thus the planning team would need to re-run the diagnosis phase in order to update the previous results with the new information. That's why the interviewed experts deemed having a Premium mode model of the project by the end of the renovation work as very important as the project would, in the future, iterate through another renovation cycle. Without having constantly updated documentation and monitoring of the project, the data collection would remain one of the great challenges confronting the planning and construction team in renovation projects.

In summary we can say that although most of the practitioners in the construction industry that were interviewed, appreciated the added value of using IDM neighborhood approach. Further, they appreciated the merits of having a structured work flow for the phases of the project, as well as the active participation of the end user in each step. However, they commonly suggested that a lack of funds would impede the inclusion of such a new and novel approach in their normal daily practice. The IDM approach can be adopted in their view in real projects when the IDM becomes part of the standard practice requirements and all involved stakeholders have acquired the required training and technological know-how to implement it. Thus, the question of further fine-tuning the data collection process and the alignment of the IDM with national practices are going to be the focus of the further development of the IDM in the future.

8. MONITORING AND FOLLOW UP

This chapter presents the results of Task 6.5. “Monitoring and Follow-up”. The task addresses post-retrofitting activities on the demonstration sites, identifies occupants’ incorrect behavior and malfunctioning of the built-in technologies. This is done by monitoring the occupants’ behavior and the actual performance of the retrofitted buildings.

Methods and strategies, which help to identify sub-optimal practices and incorrect use of newly installed technologies by the users were discussed in Deliverable 2.4: “Progressive Strategies and Practices for a Comprehensive Post-retrofitting Controlling and Continuous Commissioning”. D2.4 also lists the methods and strategies that were to be adopted within the NewTREND project in order to improve building performance at the post-commissioning stage.

These post-retrofitting activities are harmonized with the pre-retrofitting monitoring and other personal feedback collection activities at each of the demonstration sites, to provide comparable results, and to quantify the improvements achieved during the retrofitting, by the use of KPIs. These help both the engineers to analyze data and draw clear conclusions, and the decision-makers to justify the costs and efforts required for the retrofitting. Last, but not least the technical and non-technical building users benefit from these strategies as well, since continuous commissioning and soft landing provides smooth transition between construction and operation and ensures optimization of the operational performance and comfort of the building occupants.

Further goals of this task are to provide feedback to the NewTREND methodology and toolset, to the stakeholders of the demonstration sites, and to future retrofitting projects using the NewTREND methodology.

8.1. REALIZED RETROFITTING ACTIVITIES ON THE DEMONSTRATION SITES

The demonstration sites, retrofitting activities and planned measures were discussed in Deliverable 6.1: “Characterization of the Buildings Involved in the Pilot (Evaluation and Data Collection)”. This chapter provides a review and update on the realized retrofitting activities and their schedules.

At the demonstration sites, some of the retrofitting phases were carried out in accordance with the pre-planned schedule, however, some phases were delayed due to financial, administrative or technical reasons. As a result, the completion of some renovations was delayed as well. Table 1 shows the updated retrofitting timeline of the demonstration sites.

ACCORDING TO

Table 21, four of the demonstration sites will finish their retrofit execution by the end of August 2018 (M36), and two of the demonstration sites are still in the design phase. In case of the latter group, it has been certain from the very beginning, that the retrofit execution will not begin before the end of NewTREND project. In case of the three Sant Cugat demonstration sites, delays were due to financial and administrative reasons, since the average period of the tenders has been extended with the law of public recruitment which became effective a few months ago in Spain. In Bókay School, Budapest, the retrofit execution has been extended by five months compared to the original schedule, resulting in being completed only in May 2018.

TABLE 21. TIMELINE OF THE RETROFITTING ACTIVITIES

	2015				2016								2017								2018															
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
	Year 1												Year 2												Year 3											
NewTREND	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35	M36
Seinäjoki																																				
35 rented apts. SC																																				
Pins del Vallès, SC																																				
2 Private Houses, SC																																				
Bókay Garden, BP																																				
Bókay School, BP																																				

Data collection, design phase, tender

Retrofit execution

Follow-up, validation

The following sections describe the updated planned or realized retrofitting activities for each of the demonstration sites.

8.1.1. RETROFITTING STATUS IN SEINÄJOKI

The scope of the retrofitting hasn't changed significantly for the Seinäjoki district and building level demonstration sites.

For the district area, renewable energies sources will be added, such as a hybrid heating system (district heating and ground source heat pump).

The purpose of retrofitting the buildings is to improve indoor air quality and to lower operational costs. Occupant surveys revealed complaints about the poor indoor air quality. Complaints were the followings: moisture, stuffy air, rooms being too cold during the winter and too hot during summer. The owner's (City of Seinäjoki) goal is to improve the indoor air quality for occupants while lowering operational costs of the buildings.

At the beginning of the project, the plan was to retrofit the whole building completely, but for now, most of the work will be done in the half of the building where Adult Education Centre is moving in. Work that will be done in Music school concerned floor insulation and replacement of underground piping (since it would be unreasonable to change it for only half of the building), and certain repairs on the exterior façade. Also, it is likely that LED lighting will be added in both parts of the building. At present some inner windows of the main building were taken to a workshop where single glazing will be replaced with double-glazing to assess the ability to retrofit inner windows and its costs. Regarding HVAC system, one building

half will get a new ventilation system and all radiators will get new thermostatic valves (with remote temperature sensor).

Another action which was decided to be done is to retrofit another building in the district as well; the so-called boiler room into performance center (musical and theatre performances).

Design should be finalized by September 2018, which means that final decisions and construction work won't be done during NewTREND project lifetime.

8.1.2. RETROFITTING STATUS IN THE 35 RENTED APARTMENTS, SANT CUGAT

Thermal panels on the roof have been replaced with two separate systems (PV for electrical demand of the common spaces and thermal for domestic hot water demands). The aim was to improve the performance of solar panels, replacing the old ones with panels with higher performance. PV production is feeding into the needs of electrical common services, while thermal panels partially cover Domestic Hot Water needs.

Further improvements on the hot water and heating system include replacement of collectors of hot water and the heating system. The current collectors for hot water and heating are without insulation and they are leaking in some places, causing losses in the system. Their replacement with other collectors with better thermal insulation is proposed.

In order to integrate the various thermal systems proposed, changes will be necessary to optimize the hydraulic functioning of the system.

The control system has been updated to integrate new elements of renewable energy.

Individual electrical meters were installed for each of the apartments, to meter individual electrical energy consumptions. The data collected is sent to a platform where users can monitor their consumption and compare them with the rest of the consumption of the building.

Light sensors in community spaces were replaced. Previously, they were on the walls, now they are placed on the ceiling, and they combine motion detection and brightness.

8.1.3. RETROFITTING STATUS IN PINS DEL VALLÈS SCHOOL, SANT CUGAT

Photovoltaic panels were placed on the roof of the school to partially cover electrical energy needs. In case of surplus, it will feed back into the electrical distribution network. Altogether 102 photovoltaic modules were installed with 27,03 kWp total installed power. The control system has been improved to integrate new elements of renewable energy.

The lighting system was upgraded, LED lamps were installed to replace the old system, reducing the power demand by 5 kW.

Improvements have been made to the heating system as well. Atmospheric boilers have been replaced by condensing boilers. Sectioning of the heating system was undertaken, to obtain energy consumption data for each building separately.

To reduce the heating energy demand, the façade has been insulated with External Thermal Insulation Composite System (ETICS / EIFS).

The current windows in the administration building and sports pavilion will be replaced.

8.1.4. RETROFITTING STATUS IN THE 2 PRIVATE HOUSES, LES PLANES

To reduce the heating energy demand, windows have been replaced, the roof and the walls have been insulated.

New mechanical ventilation system in bathroom and kitchen has been installed.

8.1.5. RETROFITTING STATUS IN BÓKAY GARDEN, BUDAPEST

In May 2016 a new development concept was created for the Bókay Garden. This development concept outlined the following interventions:

- Demolition of old buildings, which are in bad conditions;
- Extension of the swimming pool and renovation of the sports field infrastructure;
- Development of an information center.

The area has high potential in district scale synergies. Since the project is still in design phase, suggestions resulting from the simulation of the NewTREND tool can help to further improve the development plans. The proposed interventions based on NewTREND simulations are described in 8.6.5.

8.1.6. RETROFITTING STATUS IN BÓKAY SCHOOL, BUDAPEST

One of the main goals of retrofitting the Bókay School was to reduce heating energy demand to reduce the operational costs. Therefore, replacing the old windows and insulating the exterior walls was planned. The former has been done, triple-glazing plastic windows replaced the old ones. However, the latter intervention was cancelled, due to the historical nature of the building. Description of how the building became a protected building can be found in Deliverable 6.2. “Engagement of Stakeholders (Including Occupants)”.

Other parts of the building envelope, like the ceilings above the top floor and above the unconditioned basement have been insulated.

Photovoltaic panels have been installed on the roof to further reduce the operational costs.

8.2. PRE- AND POST-RETROFITTING CONTROLLING AND CONTINUOUS COMMISSIONING IN NEWTREND

As Deliverable 2.4 “Progressive Strategies and Practices for a Comprehensive Post-retrofitting Controlling and Continuous Commissioning” states, building operation can be improved via reducing user-driven energy consumption. This can be achieved both by changing the behavior of users or by better controlling of technologies and technical systems.

Deliverable 2.4 identified the method for demo site activities in the post-retrofitting phase, which is summarized in Deliverable 2.4 Figure 47. According to this method, 4 main steps are carried out on a refurbishment project which can be used for both improvement of the technical systems and the user behavior:

1. Data collection
2. Identification of problems
3. Finding solutions
4. Preventing suboptimal uses

For the demo sites, 4 types of data are collected; these are related to post-retrofitting improvements. These data types are summarized and categorized in Table 22.

TABLE 22. COLLECTED DATA TYPES ON THE DEMONSTRATION SITES

Target	Data collection frequency	Data type
Technical systems	Regular	Building systems' monitoring data
	One-time	Identification of implemented systems
User behavior	Regular	User behavior monitoring
	One-time	Identification of user and usage types

The table shows that four main topics are identified and these can help to improve the building's operation. These topics should be followed through with the four identified steps in order to optimize operations. In the following sections, the actions taken in NewTREND are described for all the topics; first for the identified systems and user types, then for the regularly collected data types.

8.2.1. IMPLEMENTED BUILDING SYSTEMS

The retrofitting plans for the demonstration sites show some similarities (Table 23), so here we only describe and analyze the most commonly used interventions at the six project sites.

TABLE 23: ACTIONS TAKEN FOR THE IMPLEMENTED BUILDING SYSTEMS

Steps identified in Deliverable 2.4	Actions taken	Goal of actions
Data collection	Identification of implemented building systems during retrofitting: <ul style="list-style-type: none"> High-performance windows External insulation PV system LED lighting 	Identification of the actual performance of the retrofitted buildings.
Identification of problems	Description of what kind of problems these interventions can have.	Identification of possible malfunctioning in the identified technologies
Finding solutions	Recommendations for improvements: <ul style="list-style-type: none"> Recommendations for solving the most common problems. Recommendations for maintenance of these interventions. 	Providing solutions to the identified problems, recommending adjustments to the current operation methods.
Preventing suboptimal uses		

8.2.2. IDENTIFIED USER AND USAGE TYPES

The retrofitting plans for the demonstration sites show some similarities, so here we only describe and analyze the most commonly identified user types in the six projects, namely school building usage types and school users as three of the demo building are schools (Table 24).

TABLE 24: ACTIONS TAKEN FOR THE IDENTIFIED USAGE AND USER TYPES

Steps identified in Deliverable 2.4	Actions taken	Goal of actions
Data collection	Identification of building user and usage types: <ul style="list-style-type: none"> School teachers and pupils. School usage type. 	Identification of the actual user behavior.
Identification of problems	Description of what kind of problems these interventions can have.	Identification of occupants' misbehavior.
Finding solutions	Recommendations for improvements: <ul style="list-style-type: none"> Recommendations for solving the most common problems. 	Knowledge transfer to users, motivation of positive user behavior.
Preventing suboptimal uses	<ul style="list-style-type: none"> Recommendations for maintenance of these interventions. 	

8.2.3. BUILDING SYSTEMS MONITORING

Table 25 lists the actions taken for collection and usage of building monitoring data. The objective is to have a reliable and high-quality data set.

TABLE 25: ACTIONS TAKEN FOR USAGE OF BUILDING MONITORING DATA

Steps identified in Deliverable 2.4	Actions taken	Goal of actions
Data collection	Description of pre-retrofit monitoring activities. Description of post-retrofitting monitoring activities: <ol style="list-style-type: none"> Projects in post-retrofitting phase: description of what has happened. Projects not yet complete: description of what will happen. 	Identification of the actual performance of the retrofitted buildings.
Identification of problems	Analysis of result: <ol style="list-style-type: none"> Projects in post-retrofitting phase: analysis of progress. Projects not yet completed: description of how planned data can be analyzed in the future. 	Identification of malfunctioning in the monitored technologies.
Finding solutions	Recommendations for improvements: <ul style="list-style-type: none"> Projects in post-retrofitting phase: recommendations based on analysis. 	Providing solutions to the identified problems, recommending adjustments to the current operation methods.
Preventing suboptimal uses	<ul style="list-style-type: none"> Projects that are incomplete: no recommendations. 	

8.2.4. USER BEHAVIOR MONITORING

TABLE 26: ACTIONS TAKEN FOR USAGE OF USER SURVEY

Steps identified in Deliverable 2.4	Actions taken	Goal of actions
Data collection	Description of pre-retrofit user surveys. Description of post-retrofitting user surveys: a) Projects in post-retrofitting phase: description of what has happened. b) Projects that are incomplete: description of what will happen.	Identification of the actual user behavior.
Identification of problems	Analysis of result: a) Projects in post-retrofitting phase: analysis of what has happened. b) Projects that are still incomplete: description of how the planned data can be analyzed in the future.	Identification of occupants' misbehavior.
Finding solutions	Recommendations for improvements: • Projects in post-retrofitting phase: recommendations based on analysis. • Projects that are still incomplete: no recommendations.	Knowledge transfer to users, motivation of positive user behavior.
Preventing suboptimal uses		

In the following sections, the four identified topics will be discussed in detail. In case of the data types with regular data collection the demonstration sites will be discussed separately. In case of the identified systems and user types, the only the topics mentioned a priori will be described in detail.

8.3. IMPLEMENTED BUILDING SYSTEMS

The main goal of this chapter is to identify the most common post-construction issues and their possible solutions for the demonstration sites. Deliverable 2.4 (Chapter 2.2) describes in detail the most common issues with building technical systems and their solutions. The main topics discussed are: ventilation, heating, electrical, domestic hot water, and energy production systems. Therefore, in this section, the main focus is on the implemented interventions during retrofitting of the demonstration sites. As most of the interventions are not yet realized, there is still a chance that they will be changed, we have chosen the most commonly used technologies in the 6 demonstration sites and assessed them in more detail. The selected technologies are:

- LED lighting
- High-performance double- or triple-glazed windows
- High-performance wall, floor and roof insulation
- Photovoltaics

Their assessment is described in the following sections by following the methodology presented in Table 23.

8.3.1. LED LIGHTING

The Spanish and Finnish demonstration sites include LED lighting as one of their refurbishment items.

LED lighting technology means a light-emitting diode (LED) which is a two-lead semiconductor light source. LEDs have many advantages over other light sources including lower energy consumption, longer lifetime, improved physical robustness, smaller size, and faster switching. However, LEDs are generally more expensive than other lighting sources, and require more precise current and heat management than compact fluorescent lamp sources of comparable output.

The LED technology is described in detail in the NewTREND technology library, which includes 3 types of LED lighting with different efficiencies:

- LED Indicative (60 lm/W)
- LED best (100 lm/W)
- OLED (120 lm/W)

These technologies are also included in the NewTREND CDP as possible interventions.

PROBLEM IDENTIFICATION, SOLUTIONS AND MAINTENANCE

LED lighting can be considered a technology with easy installation, low maintenance and with few operational problems. Lighting design has a great effect on occupant well-being and there are some viewpoints that are not always considered when designing and installing new LED lighting. This causes the most common problems mentioned by occupants:

- Lighting is too bright / too dark
- There is not enough contrast
- The color of lighting is too cold, or not natural
- The lighting is too tiring

The WELL Certification summarizes the most important aspects to be considered when designing and installing new lighting. The main requirements related to LED lighting are listed in Table 27⁷.

TABLE 27: WELL CERTIFICATION REQUIREMENTS FOR LIGHTING DESIGN TO ACHIEVE OCCUPANT WELLBEING

Feature	Goal	Requirements
Visual lighting design	To support visual acuity by setting a threshold for adequate light levels and requiring luminance to be balanced within and across indoor spaces.	<p>Visual Acuity for Focus</p> <p>The following requirements are met at workstations or desks:</p> <p>a. The ambient lighting system is able to maintain an average light intensity of 215 lux [20 fc] or more, measured on the horizontal work plane. The lights may be dimmed in the presence of daylight, but they are able to independently achieve these levels.</p> <p>b. The ambient lighting system is zoned in independently controlled banks no larger than 46.5 m² [500 ft²] or 20% of open floor area of the room.</p>

⁷ (<https://www.wellcertified.com/en>)

	Lighting design affects the nervous, endocrine and muscular systems of the human body.		c. If average ambient light is below 300 lux [28 fc], task lights providing 300 to 500 lux [28 to 46 fc] at the work surface are available upon request.
		Brightness Management Strategies	Maintaining luminance balance in spaces: a. Achieve maximum brightness contrasts between main rooms and ancillary spaces, such as corridors and stairwells, if present. b. Achieve maximum brightness contrasts between task surfaces and immediately adjacent surfaces, including adjacent visual display terminal screens. c. Achieve brightness contrasts between task surfaces and remote, non-adjacent surfaces in the same room. d. The way brightness is distributed across ceilings in a given room that maintains lighting variety but avoids both dark spots or excessively bright, glaring spots.
		Visual Acuity for Learning	The ambient lighting system at classroom desks for specified age groups meet the following: a. Early education, primary and secondary schools, and adult education for students primarily under 25 years of age: Able to maintain an average of 175 lux [16 fc] or more measured on the horizontal plane, typically 0.76 m [30 inches] above finished floor. The lights may be dimmed in the presence of daylight, but they are able to independently achieve these levels.
Circadian lighting design	Support circadian health by setting a minimum threshold for daytime light intensity. Affects the endocrine, digestive, nervous, muscular, immune and cardiovascular systems.	Melanopic Light Intensity in Learning Areas	At least one of the following requirements is met: a. Early education, primary and secondary schools, and adult education for students primarily under 25 years of age: Light models (which may incorporate daylight) show that at least 125 equivalent melanopic lux is present at 75% or more of desks, on the vertical plane facing forward 1.2 m [4 ft] above finished floor (to simulate the view of the occupant). This light level is present for at least 4 hours per day for every day of the year. b. Ambient lights provide maintained illuminance on the vertical plane of equivalent melanopic lux greater than or equal to the lux recommendations in the Vertical (Ev) Targets in Table 3 of IES-ANSI RP-3-13, following the age group category most appropriate for the school population. For example, art studios in primary and secondary school are provided with 150 equivalent melanopic lux from the electric lights.
Color quality	Enhance spatial aesthetics and color differentiation through the use of lamps with quality color rendering abilities. Affects the nervous system.	Color Rendering Index	To accurately portray colors in the space and enhance occupant comfort, all electric lights (except decorative fixtures, emergency lights and other special-purpose lighting) meet the following conditions: a. Color Rendering Index Ra (CRI, average of R1 through R8) of 80 or higher. b. Color Rendering Index R9 of 50 or higher.

Following these principles can solve the most commonly mentioned lighting problems, as follows:

- Lighting is too bright / too dark – Visual lighting design
- There is not enough contrast – Visual lighting design
- The color of lighting is too cold, or not natural – Color quality
- The lighting is too tiring – Circadian lighting design

Regarding the maintenance of the lighting systems, it requires low maintenance. It is recommended to have a monitoring plan of light replacements in place, as too frequent light burnouts can indicate a larger scale system malfunction. In parallel to the monitoring plan, a light replacement plan is recommended as well, to be able to predict the replacement times and frequencies.

8.3.2. HIGH-PERFORMANCE DOUBLE- OR TRIPLE-GLAZED WINDOWS

New high-performance windows used in refurbishment projects can have different frame and glazing types. The most typical frame types are: vinyl (made from rigid, impact-resistant PVC, with hollow chambers inside to help them resist heat transfer and condensation), aluminum, wood or clad-wood (wood on the inside but are covered on the exterior with aluminum). The most typical glazing types are double- and triple-glazed windows. Double- or triple-glazed windows have sealed glazing units with two or three panes of glass separated by an air gap (typically of 12-20 mm) which improves thermal insulation. Each pane of glass is separated by a spacer bar, which creates an air gap or cavity that is filled with gas. The cavities provide superior insulation performance when the glass is coated with low emissive coats and the air gap is filled with an inert gas such as argon. The main advantages of window replacement are:

- Reduction of thermal losses through the glazing
- Reduction of air infiltration
- Significant reduction of noise pollution

However, there can be some disadvantages of using new windows:

- Possible overheating of the room
- Reduction of the amount of light entering a room
- Can be significantly heavier than the original product

The technology is described in detail in the NewTREND technology library, which includes 3 types of glazing: Secondary glazing, Double glazing, Triple glazing.

The NewTREND CDP includes the glazing types as possible interventions listed in Table 28.

TABLE 28: GLAZING TYPES INCLUDED IN NEWTREND CDP AS POSSIBLE INTERVENTIONS

Glazing type	U vale (W/m ² K)
Window single	5,0
Window single + retrofit secondary glass	3,5
Window double glazed (air)	2,8
Window double glazed (gas)	2,2
Window double glazed (gas LowE)	1,6
Window double glazed (gas LowE warm edge)	1,4
Window triple glazed (gas LowE warm edge)	0,8

PROBLEM IDENTIFICATION

The most common problems mentioned by occupants after window replacement⁸:

- Condensation on the inside surface of the window
- Condensation on the outside surface of the window
- Mold growing around the window frames
- The windows are misted on the inside
- The windows catch on the bottom when opening and closing them

SOLUTIONS AND MAINTENANCE

The most common causes and recommended solutions for the identified problems are detailed in Table 29.

TABLE 29: THE MOST COMMON PROBLEMS, THEIR CAUSES AND POSSIBLE SOLUTIONS FOR REDURBISHED WINDOWS

Problem	Cause	Solution
Condensation on the inside surface of the window	Replacement windows seal up the interior more effectively, causing moisture to remain inside of the room. When the relative air humidity reaches its maximum point, water starts to condensate. Also, relative air humidity depends on air temperature (the warmer the air, the more vapor it can accommodate) which is why when moisture in the air makes contact with a cooler surface (outside wall or window) the air will become more concentrated and condensation is forming. Therefore, the condensation on windows can be caused by creating high humidity levels with the following typical household activities and not releasing them to the outside: showering, cooking, using heating, hanging clothes for drying.	Relative humidity in rooms can be lowered and the opportunities for condensation minimized by changing users' behavior or modifying the building systems. The user behavior changes can be: <ul style="list-style-type: none"> • Regular ventilation through window. • Also opening windows after vapor producing activities. • Cooking with lids on pans. The different building modifications can ensure circulation of air and avoid build-up of condensation without allowing the heat to escape. These technologies can be: <ul style="list-style-type: none"> • Using dehumidifiers (these are usually movable appliances). • Placing trickle vents on windows to provide continuous background ventilation. • Installation of / modification of mechanical ventilation system. • Installation of heating system with controllable air humidification capability.
Condensation on the outside surface of the window	The same principles that cause condensation to form on the inside of windows in cold weather can also apply outside. This is normally only a problem in through to spring when the outer pane of the glass can drop to a lower temperature than the air around it and condensation forms.	Condensation on the outside of windows is a short-term problem altering the interior building operations is not necessary.

⁸ (<https://www.kjmggroup.co.uk/blog/maintaining-windows-doors>)

Mold growing around the window frames	We're back to adequate ventilation! Black mold and mildew are in most cases caused by condensation on the coldest structures of the building. Where the condensation frequently occurs, and other factors are favorable (porous surfaces, availability of nutrients for mold), mold and mildew can grow.	To prevent mold growing the same techniques can be used to lower condensation as mentioned above. Where mold growing has already occurred, short-term solutions can be used to stop the spreading of growth: <ul style="list-style-type: none"> • Removing mold from surfaces with cleaning products. • Heating the affected areas to stop growth. • Usage of local ventilators to stop growth.
The windows are misted on the inside	Moisture inside the glass structure means that the inert gases that were originally filled into the voids between glass panes have escaped. This renders the structure less effective.	The problem is caused by a faulty product, so there is a need for replacement.
The windows catch on the bottom when opening and closing them	The problems with opening the windows occur when the window hinges have dropped, or the glass unit hasn't been fitted inside the window sash correctly.	The problems can be solved with minor adjustment of the hinges and refitting of the glazed unit inside the window and door sash In case the adjustments are not solving the problems, the window unit needs to be replaced.

Windows are considered low maintenance technologies. However, there are a few maintenance actions that should be done regularly (<https://www.kjmgroup.co.uk/customer-care/adjustmentlubrication>):

- Regular glass and frame cleaning.
- Lubrication on hinges and locking points.
- Inspection of weather-seals.
- Adjusting window hinges, which can loosen with time.
- Adjusting window handles, which can loosen with time.

8.3.3. HIGH-PERFORMANCE WALL, FLOOR AND ROOF INSULATION

Wall, roof and floor insulation can significantly reduce energy consumption in existing building. As the thermal envelope consists of different structures, materials or surfaces in different types of locations, several types of insulation are available to fill the high variety of requirements. There are several types of materials that can be used as insulation (e.g.: fiberglass, mineral wool, cellulose, natural fibres, polystyrene, polyisocyanurate, polyurethane, vermiculite and perlite, cementitious foam, phenolic foam) and they can be made in several forms (blankets, rolls, foam boards, rigid boards, loose-fill or blown in materials, sprayed foam, structural insulated panels, etc).

The NewTREND Technology Library describes in detail the following technologies:

- External wall insulation:
 - External thermal insulation composite system
 - Cavity wall insulation
- Internal wall insulation:
 - Inside wall insulation
- Flat roof insulation:
 - Polyurethane hard foam (PUR)
- Basement insulation:
 - Perimeter insulation / Foamglass
- Sloped roof insulation:
 - Between rafter insulation
 - Over rafter insulation
 - Under rafter insulation

The NewTREND CDP includes the following insulation options as possible interventions:

TABLE 30: INSULATION TYPES INCLUDED IN NEWTREND CDP AS POSSIBLE INTERVENTIONS

Insulation type	Thickness (cm)
Roof insulation	10; 20; 30
Loft insulation	10; 20; 30
Exposed floor insulation	2,5; 5; 7,5; 10; 15; 20
External wall inner insulation	2,5; 5; 10
Eternal wall cavity insulation	2,5; 5; 10
External wall timber frame insulation	10; 20; 25; 30
External wall outer insulation	4; 6; 8; 10; 12; 14; 16; 20; 24; 30

PROBLEM IDENTIFICATION, POSSIBLE SOLUTIONS AND MAINTENANCE

As insulation is a building material that is resilient and has a long lifespan there are few problems with it after proper installation. In the short term, after a building refurbishment, the main problem caused by insulation could be the molding in the interiors. As mentioned for windows this is caused by the increased humidity in the rooms due to the lowered infiltration through the building envelope. The possible solutions to avoid or solve this problem is listed in Table 29.

In the long-term, the clear marker of possible malfunctions with the insulation layer is the increased energy costs. To reveal the source of the increased costs a building audit is recommended. The correct function of the insulation layer can be discovered with visual inspection or thermal imaging. In case it is caused by the insulation, the most common problems are:

- Accidental punctures / penetrations post-installation;
- For floor and roof insulation damages due to foot traffic;
- New equipment is installed on wall/roof and
- Improper installation.

The damages in the insulation layer should be repaired or sections of the insulation replaced to regain its correct function.

Similarly, insulation is a low maintenance intervention. However, regular visual inspection of the implemented system is recommended. Inspection of the external surface should include checking for signs of cracking, distortion, damage, or corrosion; evidence of hot spots on high-temperature systems; and condensation and ice build-up on low-temperature systems. When necessary, external finish should be removed to enable inspection of the insulation and attachments⁹.

8.3.4. PHOTOVOLTAICS

Photovoltaics is a fast-growing renewable technology, the annual growth rate of PV installations was 24% between year 2010 to 2017¹⁰. Three main types of PV are available on the market: mono-, Polycrystalline and thin film panels. The share of multi-crystalline technology is the highest, with about 62% of total production. According to the research of Fraunhofer Institute, the energy payback time of PV systems (the time required to generate as much energy as is consumed during production and lifetime operation of the system) is around 1,5-2,5 years, depending on location and the type of technology installed.

The NewTREND Technology Library describes in detail the following types of PV:

- Mono-crystal PV – for district and building scale
- Polycrystalline PV – for district and building scale
- Thin film PV

The NewTREND CDP includes the following insulation options as possible interventions:

- District scale: 1 kW-500 MW, with optional specification of panel azimuth and inclination
- Building scale: 1 kW-160 kW

PROBLEM IDENTIFICATION, POSSIBLE SOLUTIONS AND MAINTENANCE

PV systems are also low maintenance, reliable and durable technologies. The main indicator of possible problems with the PV installation is when production losses are occurring. The main causes of production losses and possible solutions are detailed in Table 31.

⁹ <https://insulation.org/io/articles/insulation-systems-inspection-and-maintenance/>.

¹⁰ <https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf>

TABLE 31: MAIN CAUSES AND SOLUTIONS TO PRODUCTION LOSSES IN PV PANELS

Cause	Solution
<p>Product quality degradation, caused by (https://blog.greensolver.net/the-five-most-common-problems-with-solar-panels/):</p> <ul style="list-style-type: none"> • Hot spots on panels (caused by badly-soldered connections or are a result of a structural defect). • Micro-cracks (can occur during PV modules production, but also during shipping or due to careless handling). • Snail-trail contamination. • Potential induced degradation effect (voltage difference occurs between the panel and the earthing). • Internal corrosion, delamination (occurs when moisture penetrates into the panel). 	<p>Mitigation by expert or panel replacement.</p>
<p>Problems with the inverter, caused by¹¹:</p> <ul style="list-style-type: none"> • Faulty installation (physically misconnecting them to incorrect programming of the inverters). • Overheating (insufficient cooling/ventilation of the rooms housing the inverters). • Isolation Fault (occurs as a result of a short-circuit between various parts of the circuit by a combination of moisture and damage to the sleeve on the cabling, faulty installation, poor connection of the DC cables to the panel, or moisture in the connection part of the PV module). • Inverter does not restart after a grid fault. 	<p>System commissioning after installation, providing ventilation, problem mitigation by experts.</p>
<p>Physical environmental elements that are lowering the panel exposure to sunlight:</p> <ul style="list-style-type: none"> • Shade from surrounding trees or buildings. • Bird droppings and dust. • Build-up due to pollutants in the air. • Fallen leaves. • Snow. 	<p>Regular visual inspections, termination of the influencing factors.</p>

Photovoltaic panels are made to be resilient to environmental effects. The exterior system parts have no moving parts and are covered with impact resistant casing so that they can withstand a range of environmental conditions. Therefore, a PV system requires minimal upkeep and maintenance, which consists of the following actions:

- Continuous monitoring of the energy production system.
- Visual inspection of panels.
- Checking of inverter fuses and terminal boxes.
- Washing of panels when necessary.

¹¹ <https://blog.greensolver.net/the-five-most-common-problems-with-solar-panels/>

8.4. IDENTIFIED USER AND USAGE TYPES

The main goal of this chapter is to identify the most common post construction user behavior issues and their possible solutions for the demonstration sites. In this chapter the main focus is on the most common user and usage types of the demonstration sites, which is educational function with teachers and pupils as users as four of the six demo sites include educational facilities:

- Seinäjoki – music school and adult educational centre
- Bókay School – primary school
- Pins del Vallès School – primary school
- Bókay Garden – primary school and kindergarten

From user perspective the main indicator or occupant wellbeing is student productivity, as research shows that the quality of school facilities directly affects student performance (Meir et al. 2011). Lee et al. states in a case study for university classrooms that the decrease of student grades were in relation with the increase in complaints about indoor environmental quality factors (IAQ, ergonomics, visual comfort, acoustic comfort).

Research show that the main factors that contribute to student productivity:

- Indoor Air Quality (the building's ability to maintain the health and well-being of its users through adequate temperature, air quality and air humidity). The main factor of air quality that affects productivity is the CO₂ levels in a classroom. High CO₂ concentrations can cause tiredness and students tend to lose focus. The inadequate overall IAQ conditions in classrooms can lead to a reduction in children's performance of up to 30% (Saravia et al. 2018).
- Thermal comfort: temperatures between 20-24°C with around 50% relative humidity can be regarded as optimal for learning (Lewinski, 2015).
- Lighting levels: research shows that illumination is the main factor contributing to learning abilities, the quality of lighting has lesser effect. It is not only necessary to establish minimum illuminance levels but also there is a need to avoid over illumination (Lewinski, 2015).
- Building acoustics: high levels of noise can cause several negative health effects especially for younger children. Research show that the following factors are the most important when assessing acoustic comfort: reverberation time, sound insulation coefficients and ambient noise (Lewinski, 2015). Chapter 9.5 further details the acoustic comfort in the Budapest Bókay school demonstration site.

The previous and following chapters offer solutions and recommendations to solve the detected issues related to occupant comfort. However, it is equally important to not only solve critical system issues, but also to maintain high productivity by frequently monitoring the comfort conditions and also providing training for the building users. It is necessary to use tailor made user behavior surveys and training programs that can cater to the specific needs of teachers, students and consider the different usage patterns of schools.

8.4.1. USER BEHAVIOR SURVEYS

User satisfaction assessment is part of the post-occupancy evaluation method. International and national variations exist for measuring the user comfort in general building types. However, as schools are mainly used by children, specific thermal comfort criteria are needed as students have different metabolic rates, types of clothing, and levels of activity. Also, literature indicates that children in a classroom have a

different thermal perception compared to adults, suggesting that current adult-based comfort standards may not be applied to school children. Therefore, tailor made survey questionnaires are necessary to receive feedback. Literature introduces several types of questionnaires targeting children. These are mainly variations of the general adult surveys containing visual aids like colors and scales, leaving out questions that may be difficult to comprehend and with a length that suits the attention span of children. For example, Teli et al. (2012) and Haddad et al. (2012) uses a tailor-made questionnaire for 7-11-year-old students, Dias et al. (2014), Corgnati et al (2007) assessed the comfort levels of secondary school students.

8.4.2. BUILDING USER TRAINING

Alongside with constant monitoring, the training of students and teachers to the usage of their building is an important part of maintaining their comfort while minimizing energy consumption. Training of children can be incorporated into general teaching concepts by teachers. However, teacher themselves need education not only about the proper usage of the energy related building systems but also their attitude towards controlling classroom environment. Research shows that classroom comfort conditions strongly depend on the preferences and disciplinary methods of teachers (Giuli et al, 2012). For example, the case study of Bernardi & Kowaltowski (2006) described that children are subject to restricted spontaneous behavior when comes their individual comfort. The case study described that teachers gave permission to students to remove clothing, fan themselves or drink water in high temperature conditions, but other actions, like opening doors or closing curtains were subjected to permission. Also, during window opening statistical studies of the Bókay school, teachers were asked in semi-formal telephone interviews about their rules and customs in window opening. One teacher stated that students are allowed to adjust windows when they feel necessary during classes, however the other teacher had described the custom of opening the window every morning and between each class themselves.

8.5. BUILDING SYSTEMS' MONITORING

Since there are differences in the building typologies, climatic conditions, budget and retrofitting scope, different monitoring activities were used at the demonstration sites. The monitoring methodologies were chosen based on the data that is considered most beneficial for the project design team based on the individual characteristics of each building or district.

Building systems' monitoring methods were required to collect primary energy consumption data (mostly electrical and heating energy consumption) and to provide sufficient data for comfort assessments and calculations.

The following subsections describe the building systems' monitoring activities, the results and conclusions for each demonstration site. In each case, the same main analysis structure is used:

1. Pre-retrofitting monitoring activities
 - Pre-retrofitting monitoring activities are already discussed in Deliverable 6.1. Characterization of the Buildings Involved in the Pilot (Evaluation and Data Collection). This section provides a review and update on the realized activities.
2. Post-retrofitting monitoring activities
 - Planned, post-retrofitting monitoring activities are already discussed in Deliverable 6.1. This section provides a review and update on the realized activities.
 - Delays in the retrofit execution caused difficulties in gathering post-retrofit data, as the follow-up phase has been significantly shortened. In most of the cases, the follow-up phase falls completely after the closure of NewTREND project.

- However, after NewTREND project ends, post-retrofit data collection and evaluation will continue on. This section also describes the planned activities.
3. Analysis of the results of the monitoring activities
 - Actual results are analyzed, or recommendations are given where there are no results yet.
 4. Recommendations based on the results of the monitoring activities
 - Only where there are actual analyzed results.

8.5.1. SEINÄJOKI

PRE-RETROFITTING MONITORING ACTIVITIES

The following pre-retrofitting monitoring activities have been performed in Seinäjoki:

- Heating energy is manually read monthly for all four buildings.
- Electricity consumption is measured hourly for all four buildings.
- Thermal comfort / indoor air quality: indoor air temperature, relative humidity, CO₂ concentration were monitored for one week in 5 classrooms.

Measuring radiant temperature was planned as part of the thermal comfort and indoor air quality assessment, however this did not happen.

POST-RETROFITTING MONITORING ACTIVITIES

The following post-retrofitting monitoring activities will be performed in Seinäjoki:

- Heating energy will be manually read monthly for all four buildings.
- Electricity consumption will be measured hourly for all four buildings.
- Thermal comfort / indoor air quality: indoor air temperature, relative humidity, CO₂ concentration will be monitored. The timeframe, frequency and locations will be decided later.

ANALYSIS OF THE RESULTS OF THE MONITORING ACTIVITIES

TABLE 32. BUILDING SYSTEMS' MONITORING IN SEINÄJOKI

Monitored data in Seinäjoki	Related system	Potential findings
CO ₂ concentration	Ventilation system	Too high CO ₂ levels – not enough fresh air – improve the ventilation system, increase ventilation rates.
Indoor temperature	Heating and cooling systems	Temperature too high or too low – improve the heating or cooling systems, installing thermostats, revise setpoints.
Relative humidity	Ventilation system	Relative humidity too high, mold growth – increase ventilation rates.
Heating system – energy consumption	Heating system – primary and secondary systems	Inefficient heating systems – improvements on the primary and secondary heating systems, revise operational profiles.
Electrical energy consumption	Lighting system, HVAC and DHW system, appliances, auxiliary energy	Too high consumption: switch to LED lighting system, and to energy efficient HVAC and DHW systems and appliances. Use of renewables.

This demonstration site has not reached the post-retrofitting stage, therefore it is not possible to analyze the monitoring results. Instead, a summary is provided how the implemented monitoring system can be used to improve the related building systems.

RECOMMENDATIONS BASED ON THE RESULTS OF THE MONITORING ACTIVITIES

MONITORING OF THE INDOOR AIR QUALITY LEVELS

Within the NewTREND case studies a monitoring indoor air quality metrics based on the KPIs defined in T2.2. (indoor CO₂ ppm range [%]) has been undertaken in two school buildings in Budapest as well as Seinäjoki case study by the case study leaders. The Spanish case study in Sant Cugat was not monitored in terms of CO₂ indoor air concentration, as there are mostly residential buildings included, which are not assumed to reach uncomfortable indoor air quality levels in terms of indoor air CO₂ due to their lower occupancy and usage intensity (less persons in rooms) compared to classrooms in schools. The monitoring was done before the retrofitting actions were conducted in several classrooms in the two schools. As the retrofitting works were not finished until the project end (August 2018) in the Finnish case study only measurements of the indoor air quality in premium mode in the pre-retrofitting phase could be performed. The indoor air quality measurements of the post-retrofitting status will be conducted after the retrofitting works are finished during the follow-up and post-retrofitting phase, which will be continued outside the NewTREND project duration.

In general, the indoor air quality depends on a variety of sources, such as occupants, finishing materials, cleaning products, installed equipment, and activities carried out in the spaces; these sources emit various types of pollutants that are difficult to forecast and complex to monitor. However, the presence of people guarantees the presence of CO₂ from breathing, with the concentration in the indoor air rising as the occupants exhaust the available air. The assessment of CO₂ presence in the indoor air covers the overall air quality, as the air changes required to contain the CO₂ levels guarantee a reduction of the concentration of other, more dangerous, pollutants, increasing the quality of the indoor air and thus providing a healthier environment for the occupants. For the evaluation of the measurement results, using the NewTREND methodology and KPIs, the hourly CO₂ concentration values above outdoor are assessed against a set limit to identify the number of hours outside an acceptable comfort range in specific occupied the classrooms. In essence, this KPI is aimed at providing one comprehensive and straightforward way to assess and measure improvement in the building ventilation to guarantee the users' health and well-being. Indoor air quality requires room scale evaluations. In Premium mode, the CO₂ concentration values are acquired from on-site measurements, which were conducted in the two school buildings before the retrofitting works started to assess the as-is state of the buildings.

For the school building in Seinäjoki, for five average classrooms, indoor air quality measurements were undertaken for a 10 days period during December 2017 (240 h). During the measurements, the CO₂ outdoor concentration was 412 ppm.

The monitoring results for the five classrooms in the Finnish school building show for two of the classrooms (room numbers 419Y and 230Y) in the measurement period an excellent performance, which reached 100% of the KPIs performance benchmark. It has to be added, that these two rooms have only been occupied on two days during the measurement period. The three other rooms (213, 2019, 204A) show an average performance level, reaching a KPI performance range from 51,7% up to 83,4% of the benchmarking level of the KPI. In average the KPIs value aggregated on building level shows an average percentage of hours outside the range of 0,91% which results in an average KPI performance level of 81,7%. In general, the results show that the three rooms with a quite low window area below 10 m² and a comparable amount of floor area show significantly weaker performances than the other two rooms

with higher window area above 10 m². Especially room 213 showed during the measurement period a high CO₂ concentration of more than 1,600 ppm. The aim should be not to exceed a CO₂ concentration value of 1 000 ppm in the classrooms, as this would lead to a loss of performance in working capacity and ability to concentrate for the students using the classroom. 1 400 ppm is the upper limit for acceptable room air¹². The results also show that the CO₂ concentration levels can reach unacceptable levels of more than 1 400 ppm within less than one hour if the room is occupied. In order to achieve this, usually every 1 to 2 hours should be actively ventilated through opening the windows regularly. Especially, highly insulated and airtight buildings (e.g. after renovation) show a decreased infiltration rate, which leads to even higher CO₂ concentrations levels in shorter occupancy times. After retrofitting the building (e.g. envelop improvement, air tightness measures), it is recommended to install a mechanical ventilation system in the building, which automatically ensures that the indoor air quality can be kept to a high level of performance.

Constraints for CO₂-indoor air concentration measurements in Finnish case study (5 classrooms):

- Start Date: 11th of Dec 2017, 10:00 am
- End Date: 21st Dec 2017, 10:00 am
- Total occupied hours during the analysis period h_{tot} : 240 h
- CO₂-Outdoor Level: 412 ppm
- CO_{2,lim} = 500 ppm (new buildings and renovations)
- Ventilation: Natural ventilation

Classroom 219:

- Area: 44.5 m²
- Window area: 7.2 m²
- Hours outside the comfort range ($\text{CO}_{2,\text{above},i} \geq \text{CO}_{2,\text{lim}}$; if CO₂ indoor > 912 ppm): 2 hours

¹² <http://raumluft.linux47.webhome.at/natuerliche-mechanische-lueftung/co2-als-lueftungsindikator/>

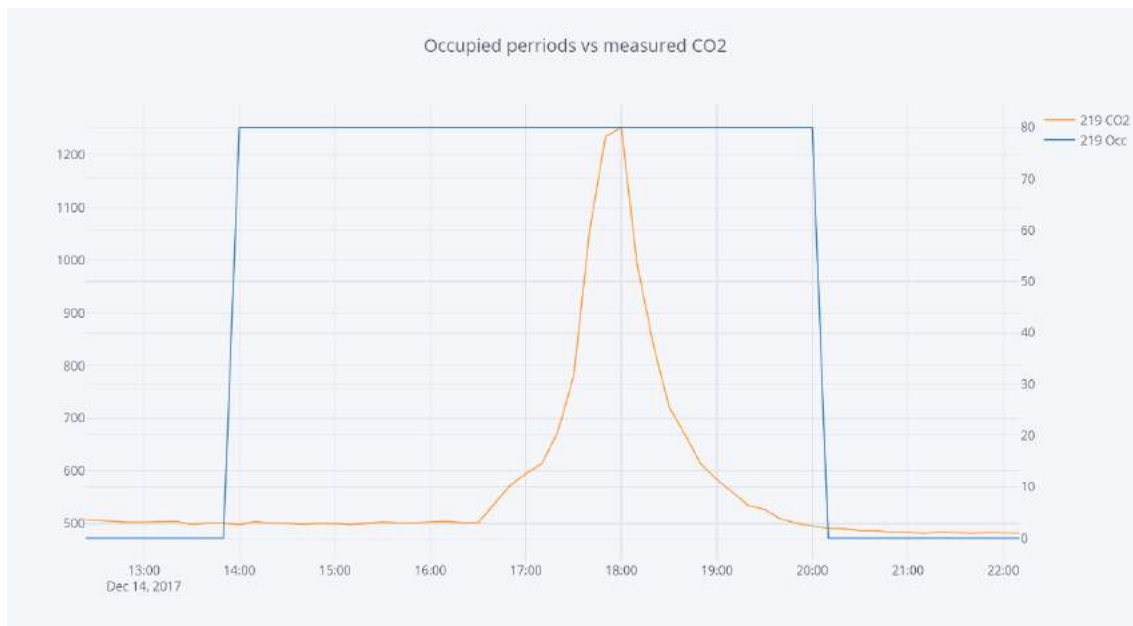


FIGURE 116. CO₂ CONCENTRATION AND OCCUPANCY IN CLASSROOM 219, SEINÄJOKI

- Percentage of occupied hours outside comfort range: 0.83%
- Premium mode KPI result as-is: 83.4

Classroom 213:

- Area: 58,5 m²
- Window area: 7.2 m²
- Hours outside the comfort range ($CO_{2,above,i} \geq CO_{2,lim}$; if CO₂ indoor > 912 ppm): 4 hours



FIGURE 117. CO₂ CONCENTRATION AND OCCUPANCY IN CLASSROOM 213, SEINÄJOKI

- Percentage of occupied hours outside comfort range: 1.66%
- Premium mode KPI result as-is: 66.8

Classroom 204A:

- Area: 56 m²
- Window area: 7.2 m²
- Hours outside the comfort range ($CO_{2,above,i} \geq CO_{2,lim}$; if CO_2 indoor > 912 ppm): 5.8 hours

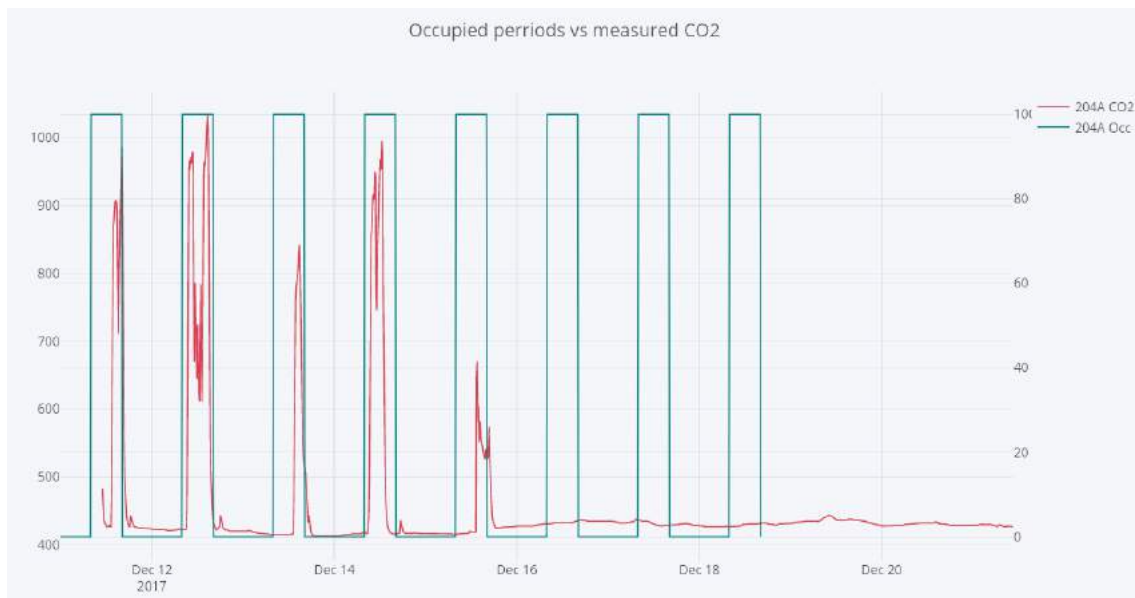


FIGURE 118. CO₂ CONCENTRATION AND OCCUPANCY IN CLASSROOM 204A, SEINÄJOKI

- Percentage of occupied hours outside comfort range: 2,416%
- Premium mode KPI result as-is: 51.7

Classroom 230Y:

- Area: 75.5 m²
- Window area: 12 m²
- Hours outside the comfort range ($CO_{2,above,i} \geq CO_{2,lim}$; if CO_2 indoor > 912 ppm): 0 hour



FIGURE 119. CO₂ CONCENTRATION AND OCCUPANCY IN CLASSROOM 230Y, SEINÄJOKI

- Percentage of occupied hours outside comfort range: 0%
- Premium mode KPI result as-is: 100

Classroom 419Y:

- Area: 60 m²
- Window area: 15.84 m²
- Hours outside the comfort range ($CO_{2,above,i} \geq CO_{2,lim}$; if CO_2 indoor > 912 ppm):
- 0 hour Percentage of occupied hours outside comfort range: 0%
- Premium mode KPI result as-is: 100



FIGURE 120. CO₂ CONCENTRATION AND OCCUPANCY IN CLASSROOM 419Y, SEINÄJOKI

8.5.2. 35 RENTED APARTMENTS, SANT CUGAT

PRE-RETROFITTING MONITORING ACTIVITIES

The following pre-retrofitting monitoring activities have been performed in the 35 rented apartments in Sant Cugat:

- Central heating system is monitored with individual heating consumption data.
- Electrical energy consumption data of the community spaces.
- Collection of energy bills.

Measuring indoor air temperature, relative humidity, CO₂ concentration was planned for thermal comfort and indoor air quality assessment. These measurements did not happen before the retrofit but will be carried out after the completion of the retrofit.

POST-RETROFITTING MONITORING ACTIVITIES

The following post-retrofit monitoring activities will be performed in the 35 rented apartments in Sant Cugat:

- Central heating system is monitored with individual heating consumption data.
- Electrical energy consumption data for the whole building.
- Individual electrical meters were installed for each of the apartments, to meter individual electrical energy consumptions. The data collected is sent to a platform where users can monitor their consumption and compare them with the rest of the consumption of the building.
- Collection of energy bills.
- Measurements of the indoor air temperature, relative humidity, CO₂ concentration in three apartments of the building. Indoor conditions will be measured during Autumn 2018.

ANALYSIS OF THE RESULTS OF THE MONITORING ACTIVITIES

This demonstration site has not reached the post-retrofitting stage, therefore it is not possible to analyze the monitoring results. Instead, a summary is provided how the implemented monitoring system can be used to improve the related building systems.

TABLE 33. BUILDING SYSTEMS' MONITORING IN THE 35 RENTED APARTMENTS, SANT CUGAT

Monitored data	Related system	Potential findings
Heating system – energy consumption	Heating system – primary and secondary systems	Inefficient heating systems – improvements on the primary and secondary heating systems, revise operational profiles.
Electrical energy consumption	Lighting system, HVAC and DHW system, appliances, auxiliary energy	Too high consumption: switch to LED lighting system, and to energy efficient HVAC and DHW systems and appliances. Use of renewable energy production.
Indoor air temperature	Heating system	Temperature too high or too low – improve the heating or cooling systems, installing thermostats, revise setpoints.
Relative humidity	Ventilation system	Relative humidity too high, mold growth – increase ventilation rates.
CO ₂ concentration	Ventilation system	Too high CO ₂ levels – there is not enough fresh air – improve the ventilation system, increase ventilation rates.

8.5.3. PINS DEL VALLÈS SCHOOL, SANT CUGAT

PRE-RETROFITTING MONITORING ACTIVITIES

The following pre-retrofitting monitoring activities have been performed in Pin del Vallès School, Sant Cugat:

- Central heating system is monitored for consumption data.
- Electrical energy consumption data for the whole building. Between August 2016 and January 2017, electricity consumption was analyzed using a monitoring system installed by AMB (Metropolitan Area of Barcelona).
- Collection of energy bills.

Measuring indoor air temperature, relative humidity, CO₂ concentration was planned for thermal comfort and indoor air quality assessment. These measurements did not happen before the retrofitting but will be carried out after the completion of the retrofitting.

POST-RETROFITTING MONITORING ACTIVITIES

The following post-retrofitting monitoring activities will be performed in Pins del Vallès School, Sant Cugat:

- Central heating system is monitored with individual heating consumption data.
- Electrical energy consumption data for the whole building.

- Collection of energy bills.
- Measurements of the indoor air temperature, relative humidity and CO₂ concentration in the different buildings of the school, after the sectioning of the school's heating system. Indoor conditions will be measured during Autumn 2018, for one month.
- The photovoltaic system will have a monitoring system of the generation of the inverter and the consumption and disposal of the surplus production feeding back to the electric distribution network.
- It is considered essential to install a real-time monitoring system that allows public display of the operation of the photovoltaic installation.

ANALYSIS OF THE RESULTS OF THE MONITORING ACTIVITIES

This demonstration site has not reached the post-retrofitting stage, therefore it is not possible to analyze the monitoring results. Instead, a summary is provided how the implemented monitoring system can be used to improve the related building systems.

TABLE 34. BUILDING SYSTEMS' MONITORING IN PINS DEL VALLÈS SCHOOL, SANT CUGAT

Monitored data	Related system	Potential findings
Heating system – energy consumption	Heating system – primary and secondary systems	Inefficient heating systems – improvements on the primary and secondary heating systems, revise operational profiles.
Electrical energy consumption	Lighting system, HVAC and DHW system, appliances, auxiliary energy	Too high consumption: switch to LED lighting system, and to energy efficient HVAC and DHW systems and appliances. Use of renewable energy production.
Photovoltaic system – energy production	Photovoltaic system	Production losses: check system for failures and external shadings.
Indoor air temperature	Heating system	Temperature too high or too low – improve the heating or cooling systems, installing thermostats, revise setpoints.
Relative humidity	Ventilation system	Relative humidity too high, mould growth – increase ventilation rates.
CO ₂ concentration	Ventilation system	Too high CO ₂ levels – there is not enough fresh air – improve the ventilation system, increase ventilation rates.

8.5.4. 2 PRIVATE HOUSES, LES PLANES

PRE-RETROFITTING MONITORING ACTIVITIES

The following pre-retrofitting monitoring activities have been performed in the 2 private houses, Les Planes:

- Electrical energy consumption data.
- Collection of energy bills.
- Measurements of the indoor air temperature, relative humidity, CO₂ concentration. Indoor conditions were measured during winter 2018 (one week). One sensor was installed at each house.
- In 2014, sensors of temperature and humidity were installed within the framework of the REC project

POST-RETROFITTING MONITORING ACTIVITIES

The following post-retrofitting monitoring activities will be performed in the 2 private houses, Les Planes:

- Electrical energy consumption data.
- Collection of energy bills.
- Measurements of the indoor air temperature, relative humidity, CO₂ concentration. Indoor conditions will be measured during Autumn 2018 for one month. Two sensors will be installed at each house (The sensors of temperature and humidity were installed in the design phase).
- Monitoring and validation of the retrofit actions executed.
- Validation of the social and medical improvement of families after the retrofitting.

ANALYSIS OF THE RESULTS OF THE MONITORING ACTIVITIES

This demonstration site has not reached the post-retrofitting stage, therefore it is not possible to analyze the monitoring results. Instead, a summary is provided how the implemented monitoring system can be used to improve the related building systems.

TABLE 35. BUILDING SYSTEMS' MONITORING IN THE 2 PRIVATE HOUSES, LES PLANES

Monitored data	Related system	Potential findings
Electrical energy consumption	Lighting system, HVAC and DHW system, appliances, auxiliary energy	Switch to LED lighting system, and to energy efficient HVAC and DHW systems and appliances. Use of renewable energy production.
Indoor air temperature	Heating system	Temperature too high or too low – improve the heating or cooling systems, installing thermostats, revise setpoints.
Relative humidity	Ventilation system	Relative humidity too high, mold growth – increase ventilation rates.
CO ₂ concentration	Ventilation system	Too high CO ₂ levels – there is not enough fresh air – improve the ventilation system, increase ventilation rates.

8.5.5. BÓKAY GARDEN, BUDAPEST

PRE-RETROFITTING MONITORING ACTIVITIES

The following pre-retrofitting monitoring activities have been performed in the Bókay Garden, Budapest:

- Walk-through method was used to collect data on the usage patterns, occupancy ratio and building condition categorization.
- In 2016, the municipality prepared a development plan for the area. This plan includes the description of the individual buildings and their conditions, the garden's natural and ecological values, ecosystems.
- The Hungarian Air Quality Network has a monitoring station nearby Bókay Garden. The station measures the following air quality components: SO₂, NO₂, CO, O₃, NO_x, NO, PM_{2.5}, PM₁₀ and benzene. Monitoring data in hourly breakdown is publicly available on www.olm.hu.

POST-RETROFITTING MONITORING ACTIVITIES

The following post-retrofitting monitoring activities will be performed in the Bókay Garden, Budapest:

- Monitoring the outdoor air quality will continue at the nearby station. The station measures the following air quality components: SO₂, NO₂, CO, O₃, NO_x, NO, PM_{2.5}, PM₁₀ and benzene. Monitoring data in hourly breakdown will be publicly available on www.olm.hu.
- The scope of further monitoring activities will be decided after the design phase is over.

ANALYSIS OF THE RESULTS OF THE MONITORING ACTIVITIES

This demonstration site has not reached the post-retrofitting stage; therefore it is not possible to analyze the monitoring results. Instead, a summary is provided how the implemented monitoring system can be used to improve the related building systems.

TABLE 36. BUILDING SYSTEMS' MONITORING IN BÓKAY GARDEN, BUDAPEST

Monitored data	Related system	Potential findings
Outdoor air quality components	Road networks, green surfaces, fossil fuel/wood burning.	Components exceed the limits: reducing traffic, increasing green surfaces, replacing old/inefficient heating systems in the surroundings.
Electrical energy consumption	Lighting system, HVAC and DHW system, appliances, auxiliary energy	Too high consumption: switch to LED lighting system, and to energy efficient HVAC and DHW systems and appliances. Use of renewable energy production.
Heating system – energy consumption	Heating system – primary and secondary systems	Inefficient heating systems – improvements on the primary and secondary heating systems, revise operational profiles.

RECOMMENDATIONS BASED ON THE RESULTS OF THE MONITORING ACTIVITIES

MONITORING OF THE OUTDOOR AIR QUALITY LEVELS

The Hungarian Air Quality Network has an air quality station on Gilice Square, from which data was obtained during a one-year interval, the station is within walking distance (500 m) from Bókay Garden.

The system measures the concentration of the following components in the outdoor air: SO₂, NO₂, CO, O₃, NO_x, NO, Benzene, PM₁₀, PM_{2.5} each hour for 365 days a year. It has to be mentioned that there were some missing data such as measurements of PM_{2.5} stopped on 6th April 2017. Unfortunately, no further data was collected. There were other 'no data' periods for the other components too, however the average of these is representative enough for the whole year. Limits from WELL Community Standard, WHO Guideline and Hungarian Limits of the above-mentioned components were collected if available, and compared to the measured average. Interesting findings were the averages of PM_{2.5} and PM₁₀, both being close to or well above the values of WELL and WHO Guideline, therefore further inspection was appropriate.

TABLE 37.: OUTDOOR AIR QUALITY LIMITS AND AVERAGE VALUES NEARBY BÓKAY GARDEN, BUDAPEST

	SO ₂ [ug/m ³]	NO ₂ [ug/m ³]	CO [ug/m ³]	O ₃ [ug/m ³]	NO _x [ug/m ³]	NO [ug/m ³]	BENZENE [ug/m ³]	PM ₁₀ [ug/m ³]	PM _{2.5} [ug/m ³]
WELL Limits	-	-	10 311	100	-	-	-	50	15
WHO Guideline	500	200	-	100	-	-	-	50	25
Hungarian Limit	250	100	10 000	-	-	-	-	-	-
Average Gilice	2,70	26,52	517,50	46,42	41,99	10,10	0,91	28,24	38,61

It was discovered that high values of PM₁₀ and PM_{2.5} were present mainly during the winter period (table below). This can be due to the location of the square. First, it is surrounded by a road and people tended to use private transportation methods during low temperatures. Second, it is located in a residential area, where family houses heat mainly with wood, therefore during winter time, wood heating increases compared to summer.

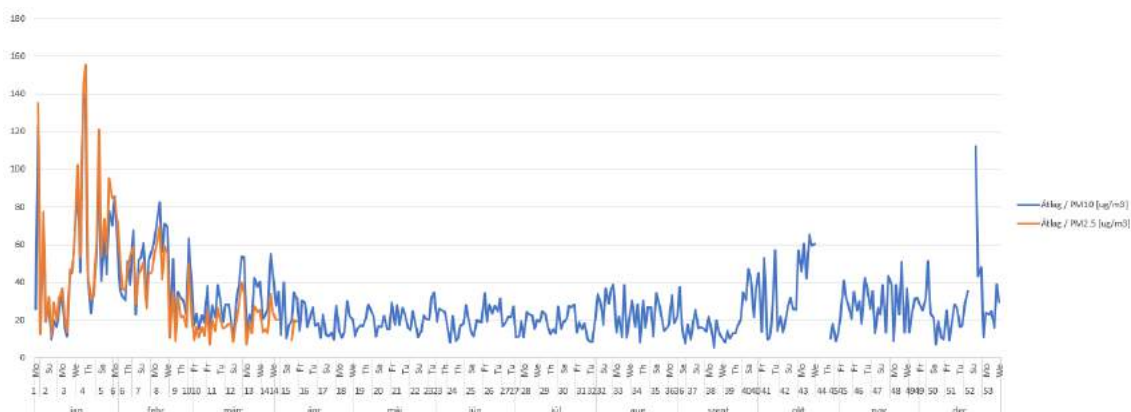


FIGURE 121.: DAILY AVERAGE PM10 AND PM2.5 CONCENTRATION DURING 2017 NEAR BÓKAY GARDEN, BUDAPEST

As Bókay Garden has sports facilities and serves as a recreational place for the people living nearby, the quality of the air is even more important. Poor outdoor air quality is considered the number one environmental cause of premature mortality worldwide (WHO, 2016), causing adverse health outcomes such as stroke, heart disease, lung cancer, asthma.

In October 2016, the council of the XVIII District, where Bókay Garden belongs, proposed a district construction regulation and regulatory plan, which discusses the protection of air quality. It proposes that, besides transportation reduction and limitation, as the number one factor in poor air quality, afforestation and planting of the area would be beneficial too. Other solutions could include the transition from wood heating to other alternative heating solutions, which are less polluting, such as district heating. The latter, of course, requires a district-level strategy, involving funding from the state, city and municipality.

8.5.6. BÓKAY SCHOOL, BUDAPEST

PRE-RETROFITTING MONITORING ACTIVITIES

The following pre-retrofitting monitoring activities have been performed in the Bókay Garden, Budapest:

- On-site laser scanning was used to collect geometric data of the building and its surrounding.
- Collection of energy bills (electricity and natural gas).
- Smart metering tools were installed in several parts of the building.
- Metering point in the boiler room monitors the following parameters in every four hours:
 - Outdoor temperature.
 - Natural gas consumption of the whole building.
 - Electricity consumption of the mechanical system.
- Metering point at the reception monitors the following parameters in every four hours:
 - Electricity consumption of the whole building.
- Metering points in two of the classrooms monitor the following parameters in every 30 seconds:
 - Indoor temperature.
 - CO₂ concentration in the classroom.
 - Window opening.
- Acoustic measurements were performed in three classrooms.

POST-RETROFITTING MONITORING ACTIVITIES

The following post-retrofitting monitoring activities were already or will be performed in the Bókay School, Budapest:

- Acoustic measurements in two of the classrooms.
- Smart metering tools were installed in several parts of the building, some of them are continuously collecting data.
- Metering point in the boiler room monitors the following parameters in every four hours:
 - Outdoor temperature.
 - Natural gas consumption of the whole building.
 - Electricity consumption of the mechanical system.
- Metering point at the reception monitors the following parameters in every four hours:
 - Electricity consumption of the whole building.
 - Production of the PV panels will be measured, once the PV panels are integrated into the electrical system.
- Metering points in two of the classrooms will monitor the following parameters every 30 seconds, once the school year starts:
 - Indoor temperature.
 - CO₂ concentration in the classroom.
 - Window opening.

ANALYSIS OF THE RESULTS OF THE MONITORING ACTIVITIES

Bókay School has reached the post-retrofitting stage in May 2018. This permitted execution of some of the post-retrofitting monitoring activities, like the acoustic measurements. The result and analysis of these monitoring activities are summarized later in this document. However, due to the summer holidays in the school, carrying out other types of monitoring activities did not make sense. Those will be

performed during autumn 2018. Namely, these are the window openings, CO₂ concentration and other measurements related to indoor comfort assessment.

The photovoltaic system was installed on the roof of the building; however, these are not yet connected to the electrical system, therefore their energy production could not be measured yet. It is planned to monitor from autumn 2018.

TABLE 38. BUILDING SYSTEMS' MONITORING IN BÓKAY SCHOOL, BUDAPEST

Monitored data	Related system	Potential findings
Acoustic characteristics	Walls, windows, internal surfaces	Choosing building structures with better acoustic performance, choosing interior surfaces with better acoustic characteristics, and less noisy building systems.
Heating system – energy consumption	Heating system – primary and secondary systems	Inefficient heating systems – improvements on the primary and secondary heating systems, revise operational profiles.
Electrical energy consumption	Lighting system, HVAC and DHW system, appliances, auxiliary energy	Too high consumption: switch to LED lighting system, and to energy efficient HVAC and DHW systems and appliances. Use of renewable energy production.
Photovoltaic system – energy production	Photovoltaic system	Production losses: check system for failures and external shadings.
Indoor temperature	Ventilation system	Temperature too high or too low – improve the heating or cooling systems, installing thermostats, revise setpoints.
CO ₂ concentration	Ventilation system	Too high CO ₂ levels – there is not enough fresh air – improve the ventilation system, increase ventilation rates.
Window opening	Windows, ventilation system	Can be assessed together with the CO ₂ concentration data.

RECOMMENDATIONS BASED ON THE RESULTS OF THE MONITORING ACTIVITIES

MONITORING OF THE INDOOR AIR QUALITY LEVELS

As in the Seinäjoki demonstration site, the indoor CO₂ concentration levels were monitored in Bókay School. The monitoring was done before the retrofitting actions were conducted in one classroom of the school. The retrofitting works in the school were finished too late, to be able for the project partners to perform meaningful measurements in August 2018, as the school was closed (classrooms not occupied during August 2018) due to public summer holidays. The indoor air quality measurements of the post-retrofitting status will be conducted after the retrofitting works are finished during the follow-up and post-retrofitting phase, which will be continued outside the NewTREND project duration (autumn 2018).

For the school in Budapest, indoor air quality measurement was undertaken in one classroom for a period of 39 weeks from spring 2017 until autumn 2017 (27th of February until 24th of September).

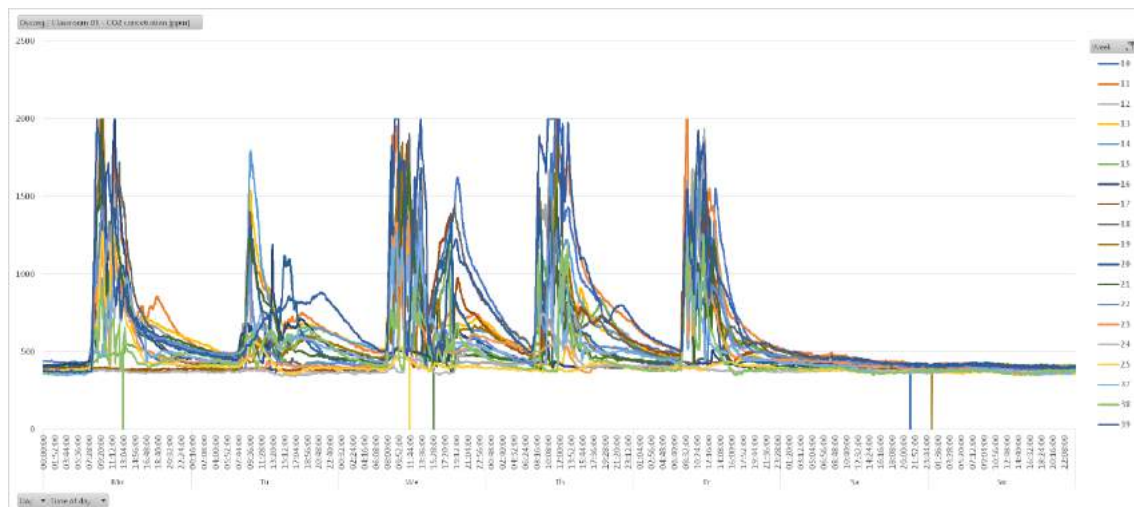


FIGURE 122.: WEEKLY VIEW OF THE CO₂ CONCENTRATION LEVELS (PPM) DURING THE MEASUREMENT PERIOD IN THE SCHOOL IN BUDAPEST FOR A SINGLE CLASSROOM

The results for the monitoring of one classroom in the school in Budapest show, that the room's performance is quite low compared to the KPIs benchmark set in the NewTREND methodology. The building's performance shows a performance level only 20%. The building shows an indoor CO₂ concentration of more than 912 ppm (more than 500 ppm above outdoor concentration) in more than 4% of the occupied hours of the classroom. The maximum CO₂ concentration level reached during the occupied hours was a level of 1691 ppm reached on Friday 26th of May at 10:40. This high value was caused by a time period of 35 minutes during a morning class, in which the windows in the room were not opened. After one hour of open windows in the classroom, the CO₂ concentration normalized with a value far below than 912 ppm in the room. The results show, that the student's ability to concentrate may decrease very quickly even during a single lesson, if the windows are not opened in the building. The measurement has been performed in the as-is state of the building, before the retrofitting measures have been implemented. In order to improve the indoor air quality for the students and teachers in the building and classrooms, it is highly recommended that a mechanical ventilation system with heat recovery be installed in the building. If this is not possible, teachers and students should at least be advised to open the windows regularly during the lessons, at least each 20 mins to ensure a high level of indoor air quality. However, during winter time it might be uncomfortable to use the room with natural ventilation, as the indoor air temperature and thus, the thermal comfort may decrease significantly.

Constraints for CO₂-indoor air concentration measurements in Budapest case study (1 classroom):

- Start Date: 22nd of May 2017, 0:00 am
- End Date: 8th of June 2017, 24:00 am
- Total occupied hours during the analysis period h_{tot} : 432 h
- CO₂-Outdoor Level: 412 ppm
- CO_{2,lim} = 500 ppm (new buildings and renovations)
- Ventilation: Natural ventilation
- Percentage of occupied hours outside comfort range: 4%
- Premium mode KPI result as-is: 20

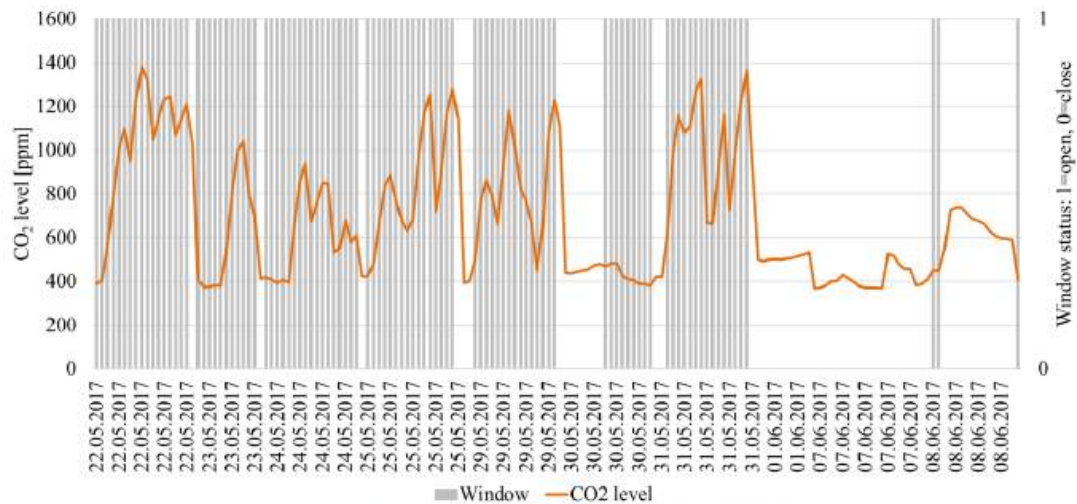


Figure 4 Classroom 2 datasets fragment: 22/05/2017-09/06/2017

FIGURE 123. WINDOW OPENING AND CO2 CONCENTRATION IN ONE OF THE CLASSROOMS IN BÓKAY SCHOOL

APPLICATION OF THE ACOUSTIC COMFORT MODULE

The Acoustic Comfort Module has been applied to the Budapest demo site, the Bókay Primary School. The acoustic comfort is based on the protection offered by the building envelope against external noise.

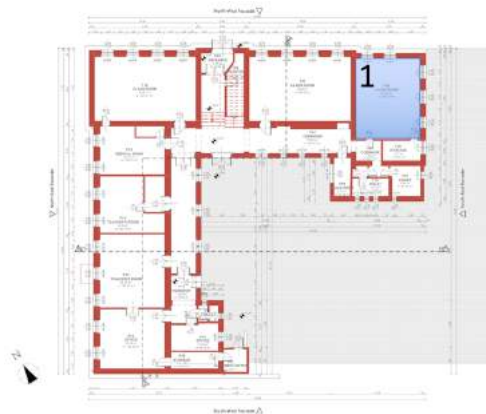


FIGURE 125. ACOUSTIC MEASUREMENT ON THE GROUND FLOOR, BÓKAY SCHOOL

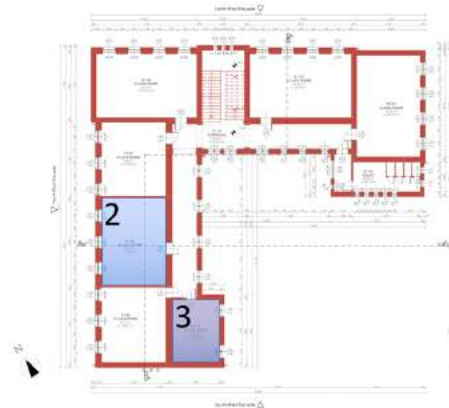


FIGURE 124. ACOUSTIC MEASUREMENT ON THE FIRST FLOOR, BÓKAY SCHOOL

The building is a brick wall structure. In particular, at the ground floor, the exterior façade is a 70 cm thick brick wall structure, including 2 cm of inner and outer plaster. At the first floor, the exterior façade is made up by 50 cm thick brick wall, including plaster. None façade-insulation interventions have been applied. At the NE and NW street façades and at the façade of the interior courtyard the windows were replaced partially a few years ago. Double-glazing plastic windows replaced the outdated traditional wooden windows. In the inner side façades there are still outdated windows. Replacing these is essential as they are not only in poor condition but also dangerous for the user well-being. For that reason, the retrofit

project of the school provides that the old wooden windows will be replaced by plastic windows with triple glazing, with Argon gas between the layers.

Since the data collection stage and the measurement campaign are highly time-cost spending, only three representative classrooms were object of the acoustic comfort analysis. Hence, the calculated KPI of the building is a partial result. In particular, the rooms highlighted in the following floor plans were investigated.

Two different modes have been implemented during the acoustic comfort analysis: Advanced Mode and Premium Mode. The first one is based on the simulation of the acoustic quantities, starting from a depth data collection process. In particular, the indoor sound pressure levels inside rooms are calculated from the simulation of the external noise levels and the façade sound insulation (according to the EN ISO 12354-3 calculation method), both for the pre-retrofit and post-retrofit case. Premium Mode has been applied to assess the current state of the acoustic comfort and the retrofit options based on the real measurements at room level, to monitor the actual performance of the building before and after retrofitting.

ADVANCED MODE

Acoustic Data Entry

Facades
Add New Facade
Download Facade File
Hide All

Facade ID	Facade Name	Building ID	Floor ID	Room ID	
7	Kitchen East Facing	1	1	1	Details
6	Bedroom 1 East Facing	1	1	1	Details
8	Bedroom 1 South Facing	1	1	1	Details

Scenarios
Add New Scenario
Hide All

Scenario ID	Scenario Name	Description		
1	As Is	Scenario - As Is - #0	Details	Run Simulation
3	Test Windows	New Windows	Details	Run Simulation
2	Test Insulation	Insulate Walls	Details	Run Simulation

FIGURE 125. ACOUSTIC DATA ENTRY

The data collection process has been based on the gathering of all the physical (materials' features of elements) and geometrical data (surfaces and dimensions) concerning the rooms and the elements of the rooms (wall and windows), gained through the IFC files of the BIM model. Starting from the materials' features, e.g. specific weight, the sound reduction indexes of the elements have been simulated (according to the calculation method of the EN ISO 12354-1). Information, such as, the typology and the features of the external noise sources have been collected manually through a web-based form for the data collection of input data required for the acoustic comfort analysis provided by the DIM Server. Even

additional data of the façades and the façades' elements identification have been done manually through the acoustic data entry.

When the required data was collected, the Acoustic Comfort Module was applied. In the following table, the pre-retrofit scenario' features were summarized. Since in room 1 and 2 the outdated wooden windows have been replaced few years ago with double-glazed plastic windows, the critical room, where the acoustic comfort conditions are inadequate, is represented by the classroom 3, characterized by old windows.

TABLE 39. PRE-RETROFIT SCENARIO FEATURES

Pre-Retrofit			
Room ID	Floor	Windows typology	Wall typology
1	Ground floor	Double-glazing plastic windows	70 cm brick wall structure
2	First floor	Double-glazing plastic windows	50 cm brick wall structure
3	First floor	Single-glazing wooden windows	50 cm brick wall structure

The following table shows the results of the acoustic simulation for the Advanced Mode.

ADVANCED MODE - pre retrofit					
Building KPI [%]	Building Class	Building Message	L_{int} Room 3 [dB(A)]	Room 3 Class	Room 3 Message
56	C	Acceptable level of building acoustic comfort	42	D	Bad level of room acoustic comfort

FIGURE 126. PRE- RETROFIT RESULTS OF THE ACOUSTIC SIMULATION FOR THE ADVANCED MODE

Hence, the post-retrofit scenario consists of the replacement of the old windows of classroom 3, with 3-layered glazing plastic windows ($R_w=39$ dB).

TABLE 40. POST-RETROFIT SCENARIO FEATURES

Post-Retrofit			
Room ID	Floor	Windows typology	Wall typology
1	Ground floor	Double-glazing plastic windows	70 cm brick wall structure
2	First floor	Double-glazing plastic windows	50 cm brick wall structure
3	First floor	3-layered glazing plastic windows	50 cm brick wall structure

Then, a new simulation was performed, obtaining a KPI for the post-retrofit assessment.

Results of the acoustic simulation after the application of the retrofitting are shown in the following table.

ADVANCED MODE - post retrofit					
Building KPI [%]	Building Class	Building Message	L_{int} Room 3 [dB(A)]	Room 3 Class	Room 3 Message
61	C	Acceptable level of building acoustic comfort	32	A	High level of room acoustic comfort

FIGURE 127. POST-RETROFIT RESULTS OF THE ACOUSTIC SIMULATION FOR THE ADVANCED MODE

The renovation intervention has led to an improvement of the indoor sound pressure level, and consequently, the room acoustic class (from D to A) but not to a KPI improvement such as to change the building class. If the retrofitting was applied at all the classrooms, in particular those having out-dated wooden windows, the building KPI would increase further and result in a jump to a better acoustic class. To better show this result, for the classroom 3, a KPI was calculated, before and after retrofitting, as representative of all the buildings' classroom.

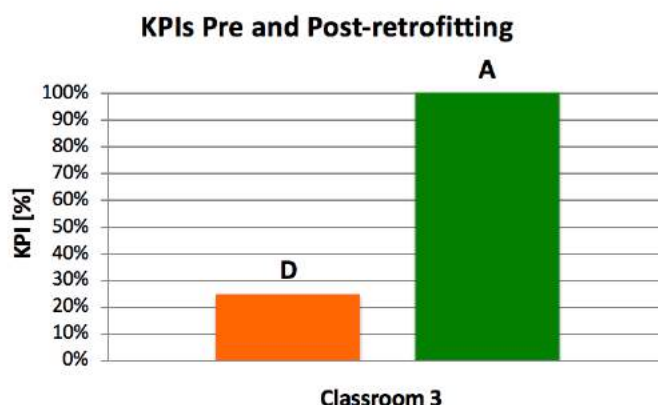


FIGURE 128. KPIS PRE- AND POST-RETROFITTING

Thanks to the replacement of the windows of room 3, the KPI changed from 25% (pre-retrofit) to 100% (post-retrofit). Hence, the retrofit solution appears suitable and it is reasonable to extend the intervention to the totality of the outdated windows of the building.

PREMIUM MODE

Acoustic measurements were performed only in the same three representative rooms of the building. The indoor sound pressure levels have been measured at different time of the day and different position in each classroom, was averaged over the time and the space. The measured indoor sound pressure levels are expressed in dB(A). In addition, even measurements of outdoor sound pressure levels using the traffic level as a sound source have been carried out. Since the traffic tends to be a variable sound source, the indoor and outdoor sound pressure levels shall be measured simultaneously. The average outdoor sound pressure levels have been determined at a distance of 2 m in front of the room façades with the microphone in front of the middle of the room façade. The measurement of the external sound pressure levels in front of the room façades were performed in order to compare the measured values with the ones obtained through the simulation.

As first, the measurement campaign was performed before the windows replacement in room 3, obtaining the following results:

PREMIUM MODE - pre retrofit					
Building KPI [%]	Building Class	Building Message	L_{int} Room 3 [dB(A)]	Room 3 Class	Room 3 Message
45	C	Acceptable level of building acoustic comfort	41	D	Bad level of room acoustic comfort

FIGURE 129. PRE-RETROFIT RESULTS OF THE ACOUSTIC SIMULATION FOR THE PREMIUM MODE

After the windows replacement, measurements were carried out in room 3 only, since the other two classrooms did not change).

PREMIUM MODE - post retrofit					
Building KPI [%]	Building Class	Building Message	L_{int} Room 3 [dB(A)]	Room 3 Class	Room 3 Message
61	C	Acceptable level of building acoustic comfort	30	A	High level of room acoustic comfort

FIGURE 130. POST-RETROFIT RESULTS OF THE ACOUSTIC SIMULATION FOR THE PREMIUM MODE

The indoor sound pressure level measured in room 3 is reduced considerably, thanks to the major acoustic insulation of the building envelope due to the high performing 3-layered plastic windows. The scale-leap is from D (Bad level of room acoustic comfort) to A (High level of room acoustic comfort). Since nothing changed in the other classrooms (no improvements on the façades nor the windows), the KPI value increased, but not enough to improve the building acoustic class. Premium Mode has shown the same qualitative results of the Advanced Mode, even if some discrepancies appear due to the calculation model's uncertainty.

REVERBERATION TIME

In order to assess if the high internal sound pressure levels of the analyzed rooms depend also to other acoustic problems, a further investigation concerning the reverberation time has been performed. The reverberation time within the three classrooms has been measured, using the interrupted noise method, as described in ISO 3382-2 in order to use these values in the acoustic comfort simulation for the Advanced Mode (Table 41). The measured reverberation time values at the middle frequencies (500 Hz) inside the classrooms are summarized in the following table:

TABLE 41. REVERBERATION TIME INSIDE THE CLASS ROOMS

Room ID	Reverberation time [s]
1	1.54
2	0.94
3	1.09

From results it emerges that the measured values are higher than the recommended ones for reverberation time inside classrooms (ideally, classrooms should have a reverberation time in the range of 0.4-0.6 seconds (Rasmussen, Brunskog, Hoffmeyer, 2012) (Table 41). Hence, further interventions aiming at improving the acoustic comfort in classrooms are those one able to reduce the reverberation time. A correct reverberation time value inside a classroom improve learning efficiency for pupils and work conditions for teachers, and reduce noise levels, thus the comfort of everyone increases. The best strategy is to move some of the absorption from the ceiling to the walls and keep the middle of the ceiling hard to reflect the lectures' voice toward the back of the classroom. Half absorptive and half reflective ceiling can be built with a standard ceiling grid, by placing acoustical ceiling tiles around the perimeter of the ceiling and gypsum board panels in the center of the grid. The ceiling can be shaped over the teachers' location at the front of the room, to reflect more sound to the back of the room. In addition, absorptive materials on the walls should be placed (e.g. fabric-covered glass fiber panels). Usually, classrooms are filled with hard surfaces: desk and plastic chairs, hard flooring. For that reason, the noise levels can be reduced by softening hard surface. For example, the sound absorption will be improved by upgrading to

upholstered chairs. In addition, curtains or blinds at the windows will help to absorb the sound within the classroom, helping also to protect against the sound coming from outside. Hard flooring is usually very used in classrooms, and it is very poor at absorbing noise and it is a major contributing factor to high background noise levels within classrooms. For that reason, adding thin carpeting to the floors (e.g. cushion-backed carpet tiles) reduce reverberation time, improving the general acoustic comfort of the classroom.

8.6. USER BEHAVIOR MONITORING

Since there are differences in the building typologies, owner and stakeholder structures, budget and retrofitting scope, different monitoring activities were used at the demonstration sites. The user behavior monitoring methodologies, questionnaire and interview types were chosen based on the data that is considered most beneficial for the project design team based on the individual characteristics of each building or district. These strategies were required to collect data regarding the habits and user preferences of the occupants and data regarding the usage pattern of buildings and district.

The following subsections describe the user behavior monitoring activities, the results and conclusions for each demonstration site. In each case, the same main analysis structure is used:

1. Pre-retrofitting user behavior monitoring activities
 - Pre-retrofitting user behavior monitoring activities are already discussed in Deliverable 6.1. Characterization of the Buildings Involved in the Pilot (Evaluation and Data Collection). This chapter provides a review and update on the realized activities.
 - Stakeholder engagement and involvement is also discussed in detail in section 7.4 of this document.
 - Stakeholders surveys and interviews are mainly discussed in the Deliverable 6.2. Engagement of Stakeholders (Including Occupants).
 - LAT meetings were also important and valuable for personal encounters and feedback. The LAT process in more detail is described in earlier sections of this document.
2. Post-retrofitting monitoring activities
 - Planned, post-retrofitting monitoring activities are already discussed in Deliverable 6.1. This chapter provides a review and update on the realized activities.
 - Delays in the retrofit execution caused difficulties in gathering post-retrofit data, as the follow-up phase has been significantly shortened. In most of the cases, the follow-up phase falls completely after the closure of NewTREND project.
 - However, after NewTREND project ends, post-retrofit data collection and evaluation will continue on. This chapter describes the planned activities, as well.
3. Analysis of the results of the monitoring activities
 - Actual results are analyzed, or recommendations are given where there are no results yet.
4. Recommendations based on the results of the monitoring activities
 - Only where there are actual analyzed results.

8.6.1. SEINÄJOKI

PRE-RETROFITTING USER BEHAVIOR MONITORING ACTIVITIES

A pre-retrofitting stakeholder survey has been performed in Seinäjoki, to help identify the main issues and problems. The questionnaires were filled out by the buildings' users, who belong to the Musical School and SEAMK.

The questions concerned the general condition of the building and its surrounding, and the general comfort in the building, including safety, indoor air quality, temperature, lighting levels and acoustics. The questionnaire helped to reveal further problems in the building like moisture, stuffy air, rooms being too cold during the winter and too hot during summer.

POST-RETROFITTING USER BEHAVIOR MONITORING ACTIVITIES

The scope of post-retrofitting stakeholder surveys and interviews is not finalized yet in Seinäjoki.

ANALYSIS OF THE RESULTS OF THE USER BEHAVIOR MONITORING ACTIVITIES

This demonstration site has not reached the post-retrofitting stage, therefore it is not possible to analyze the results. Instead, a summary is provided how the implemented user survey method can be used to improve the occupant behavior.

TABLE 42. USER BEHAVIOR MONITORING IN SEINÄJOKI

Survey data	Related system	Potential findings
General condition of the building	Building structures and systems (all)	
Indoor air quality	Ventilation system	Poor IAQ: upgrade on the control system, increase ventilation rates, regular maintenance of the system.
Indoor temperature	Heating and cooling system	Temperature outside of comfort range: thermostats – more intervention options for building users.
Lighting level	Lighting system	Complaints about glare and illumination: glare control, adjustable lighting levels and shading options.
Noise level	Building structures and systems	Acoustic comfort complaints: choosing building structures with better acoustic performance, choosing interior surfaces with better acoustic characteristics, and less noisy building systems.

8.6.2. 35 RENTED APARTMENTS, SANT CUGAT

PRE-RETROFITTING USER BEHAVIOR MONITORING ACTIVITIES

Pre-retrofitting personal interviews have been performed with the inhabitants in the 35 rented apartments in Sant Cugat. The stakeholders of this case study were interviewed at the same time and based on a similar method as the stakeholders of the other two case studies in Sant Cugat.

Prior to the interviews, inhabitants and building users were asked to carry out a diary exercise related to their building. The interviews were completely unstructured as they were part of the diary process, and the diary was what informed the discussion. The interviewees were asked about what they wrote in the diary and to elaborate on this. They were not asked to focus on energy, but instead to document whatever they wished to document with regards their daily interactions with the buildings. They were free to write about things that they really liked, or things that they really disliked. The process was occupant-led. This gave occupants and users a real voice in projects, a way to truly express their opinions, and a way for others on the project team to really listen to what they were saying, and what their requirements were. In large public meetings people may be afraid to speak up, and in interviews, people may want to please the interviewer by saying what they believe the interviewer wants to hear. With a diary people can document ideas and issues as they arise, and they have time to think about those topics while writing the diary, and before they have their post-diary interview so that their opinions are more considered and well-formed.

Furthermore, stakeholders filled out a questionnaire. The questions concerned the general condition of the building and comfort issues in the building, like indoor air quality, humidity, ventilation and disturbing noises. Energy efficiency-related questions were part of the questionnaire, as well.

To meter individual electrical energy consumptions, electrical meters were installed for each of the apartments. The collected data is submitted to the users, where they can monitor their consumption and compare them with the rest of the consumption of the building.

POST-RETROFITTING USER BEHAVIOR MONITORING ACTIVITIES

The scope of post-retrofitting stakeholder surveys and interviews is not finalized yet in the 35 rented apartments in Sant Cugat. Ideally, it would be recommended to do the same type of activities before and after retrofitting.

ANALYSIS OF THE RESULTS OF THE USER BEHAVIOR MONITORING ACTIVITIES

This demonstration site has not reached the post-retrofitting stage, therefore it is not possible to analyze the results. Instead, a summary is provided how the implemented user survey method can be used to improve the occupant behavior.

TABLE 43. USER BEHAVIOR MONITORING IN THE 35 RENTED APARTMENTS, SANT CUGAT

Survey data	Related system	Potential findings
General condition of the building	Building structures and systems (all)	
Indoor air quality/humidity	Ventilation system	Poor IAQ: upgrade on the control system, increase ventilation rates, regular maintenance of the system.
Indoor temperature	Heating and cooling system	Temperature outside of comfort range: thermostats – more intervention options for building users.
Lighting level	Lighting system	Complaints about glare and illumination: glare control, adjustable lighting levels and shading options.
Noise level	Building structures and systems	Acoustic comfort complaints: choosing building structures with better acoustic performance, choosing interior surfaces with better acoustic characteristics, and less noisy building systems.
Energy efficiency of the systems	Building systems	Inform users about energy consumption and savings, and renewable production.
Electrical energy consumption	Building systems	Platform for peer comparison to motivate user behavior.

RECOMMENDATIONS BASED ON THE RESULTS OF THE USER BEHAVIOR MONITORING ACTIVITIES

Monitoring and presenting the electrical energy consumption are a great platform to motivate user behavior. Peer comparison is a method to encourage building user behavior in a positive direction to compare their behavior with their peers. This is a simple method to provide feedback, while makes users more conscious of their consumption habits, and creates a sense of in-house competition between the users to encourage them to change their behavior even further.

8.6.3. PINS DEL VALLÈS SCHOOL, SANT CUGAT

PRE-RETROFITTING USER BEHAVIOR MONITORING ACTIVITIES

The pre-retrofitting stakeholder interviews in Pins del Vallès School, Sant Cugat was carried out in the same way as in the previous case study. For details, see the previous sections.

Questionnaires were carried out at this demonstration site, as well. The questions concerned the same topics, as in the previous case study.

POST-RETROFITTING USER BEHAVIOR MONITORING ACTIVITIES

The scope of post-retrofitting stakeholder surveys and interviews is not finalized yet in Pins del Vallès School, Sant Cugat. Ideally, it would be recommended to do the same type of activities before and after retrofitting.

ANALYSIS OF THE RESULTS OF THE USER BEHAVIOR MONITORING ACTIVITIES

This demonstration site has not reached the post-retrofitting stage, therefore it is not possible to analyze the results. Instead, a summary is provided how the implemented user survey method can be used to improve the occupant behavior.

TABLE 44. USER BEHAVIOR MONITORING IN PINS DEL VALLÈS SCHOOL, SANT CUGAT

Survey data	Related system	Potential findings
General condition of the building	Building structures and systems (all)	
Indoor air quality/humidity	Ventilation system	Poor IAQ: upgrade on the control system, increase ventilation rates, regular maintenance of the system.
Indoor temperature	Heating and cooling system	Temperature outside of comfort range: thermostats – more intervention options for building users.
Lighting level	Lighting system	Complaints about glare and illumination: glare control, adjustable lighting levels and shading options.
Noise level	Building structures and systems	Acoustic comfort complaints: choosing building structures with better acoustic performance, choosing interior surfaces with better acoustic characteristics, and less noisy building systems.
Energy efficiency of the systems	Building systems	Inform users about energy consumption and savings, and renewable production.

8.6.4. 2 PRIVATE HOUSES, LES PLANES

PRE-RETROFITTING USER BEHAVIOR MONITORING ACTIVITIES

The pre-retrofitting stakeholder interviews in the 2 private houses in Les Planes were carried out in the same way as in the previous two case studies, the 35 rented apartments and the Pins del Vallès School in Sant Cugat. For details, see the previous sections.

Questionnaires were not carried out at this demonstration site.

POST-RETROFITTING USER BEHAVIOR MONITORING ACTIVITIES

The scope of post-retrofitting stakeholder surveys and interviews is not finalized yet in the 2 private houses, Les Planes. Ideally, it would be recommended to do the same type of activities before and after retrofitting.

ANALYSIS OF THE RESULTS OF THE USER BEHAVIOR MONITORING ACTIVITIES

This demonstration site has not reached the post-retrofitting stage, therefore it is not possible to analyze the results. Instead, a summary is provided how the implemented user survey method can be used to improve the occupant behavior.

TABLE 45. USER BEHAVIOR MONITORING IN THE 2 PRIVATE HOUSES, LES PLANES

Survey data	Related system	Potential findings
General condition of the building	Building structures and systems (all)	
Energy efficiency	Building systems	Mitigation of problems on energy poverty.

RECOMMENDATIONS BASED ON THE RESULTS OF THE USER BEHAVIOR MONITORING ACTIVITIES

The 2 private houses in Les Planes are pilot projects in the RELS project (Rénovation Énergétique des Logements Energy Renovation of Housing) as well, which addresses the problems of Energy Poverty from an energy, social, economic and health perspective, focusing on the Mediterranean region. Besides the technical conditions of the building, the project concentrates on an energy rehabilitation methodology that helps to detect the behavior of the building users. During the project's lifecycle not just the energy savings are monitored, but the social and medical conditions of the families are evaluated.

8.6.5. BÓKAY GARDEN, BUDAPEST

PRE-RETROFITTING USER BEHAVIOR MONITORING ACTIVITIES

In Bókay Garden, Budapest, the pre-retrofitting stakeholder interviews were carried out in parallel with the interviews of the Bókay School, Budapest, since both demonstration sites are owned by the local municipality. In case of Bókay Garden, the decision-makers from the local municipality were interviewed. For details, see the following section.

POST-RETROFITTING USER BEHAVIOR MONITORING ACTIVITIES

The scope of post-retrofitting stakeholder surveys and interviews is not finalized yet in Bókay Garden, Budapest.

8.6.6. BÓKAY SCHOOL, BUDAPEST

PRE-RETROFITTING USER BEHAVIOR MONITORING ACTIVITIES

In Bókay School, Budapest, several groups of stakeholders were interviewed in-depth, before the retrofitting. Interviewees from the side of building users were the school's headmistress, several teachers, the school's caretaker a representative of the parental working group. Decision-makers were interviewed, as well, like the city manager, the energy retrofitting project manager and the head of Department Strategy and Project Management. From the technical stakeholders, the designer was interviewed.

Interview-questions concerned the level of involvement of the different stakeholders, their relationship to the building, and their satisfaction with the plans and the overall process of the retrofitting.

POST-RETROFITTING USER BEHAVIOR MONITORING ACTIVITIES

The following post-retrofitting stakeholder surveys and interviews were performed in Bókay School, Budapest.

- Building walkthrough and interview with the caretaker, focusing on the newly installed systems.
- Survey with the teachers, who occupy the classrooms, where the windows were replaced. Survey questions concerned the indoor air quality, acoustic comfort, lighting and shading, and intervention options on the indoor temperature, in the pre- and post-retrofit stages.

ANALYSIS OF THE RESULTS OF THE USER BEHAVIOR MONITORING ACTIVITIES

Bókay School has reached the post-retrofitting stage in May 2018. This allowed to carry out some of the post-retrofitting user behavior monitoring activities, like the building walkthrough and interview with the caretaker of the building. The result of this is summarized later in this document. However, due to the summer holidays in the school, filling out questionnaires concerning the post-retrofitting experiences in regard to indoor comfort, and evaluating the experiences did not make sense yet. The questionnaires will be filled out during autumn 2018.

TABLE 46. USER BEHAVIOR MONITORING IN THE BÓKAY SCHOOL, BUDAPEST

Survey data	Related system	Potential findings
Involvement in the planning		Improve stakeholder participation methods in renovation projects.
General condition of the building	Building structures and systems (all)	
Indoor air quality/humidity	Ventilation system	Poor IAQ: upgrade on the control system, increase ventilation rates, regular maintenance of the system. Awareness-raising on the importance of adequate natural ventilation.
Indoor temperature	Heating system	Temperature outside of comfort range: thermostats – more intervention options for building users.
Lighting level	Lighting system	Complaints about glare and illumination: glare control, adjustable lighting levels and shading options.
Noise level	Building structures and systems	Acoustic comfort complaints: choosing building structures with better acoustic performance, choosing interior surfaces with better acoustic characteristics, and less noisy building systems.
Installation of the new systems	Windows, insulations and PV panels	Importance of educating building users and maintenance staff.

RECOMMENDATIONS BASED ON THE RESULTS OF THE USER BEHAVIOR MONITORING ACTIVITIES

The building walkthrough and interview with one of the building's caretaker occurred on the August 8th, 2018 (There are two caretakers). Even though most of the retrofitting has been finished, he expressed his

concerns about the quality of the interventions, and on the information provided by the contractor through and after the construction works.

Despite the fact that he did not receive any information or education about the technical features of the built-in systems, neither from the contractor nor from the client, he was extremely well-informed and well-prepared. He looked after the built-in technologies and their maintenance on his own.

Even though it was not a problem here, it is highly recommended to organise a post-retrofit building walk-through led by the contractor or sub-contractor. It can be useful, when more complex systems are installed in the buildings, and can give valuable information not only for the technical, but for the non-technical building users as well.

8.7. FEEDBACK TO THE NEWTREND TOOL AND FUTURE PROJECTS

Beyond addressing post-retrofitting activities on the demonstration sites, as the last task of the NewTREND project, further aims were to provide feedback to the NewTREND methodology and toolset, to the stakeholders of the demonstration sites, and to future retrofitting projects using the NewTREND methodology. Task 6.4. “Evaluation and upgrade of the methodology and tools” also dealt with feedback collection on the tools and methodology, from NewTREND partners and external technical and non-technical individuals. The results of this task can be found in earlier sections of this document (Chapter 8-9.)

8.7.1. UPDATE OF THE NEWTREND TOOL, METHODOLOGY AND SOFTWARE

Based on the results, the strengths of the NewTREND methodology have been confirmed. The demonstration sites benefited a lot from detailed assessment of the building systems, pre-retrofit monitoring activities, stakeholder identification and active stakeholder involvements.

The Technology Library proved to be useful during this task. The four main interventions (LED lighting, high-performance glazing, high-performance envelope insulations and photovoltaics) used on the demonstration sites and described in this document are presented in detail in the Technology Library. However, it is recommended to apply the same structure, that is used in Chapter 9.3. Implemented Building Systems and extend the information with possible problems and solutions. Further improvement for the Technology Library could be to turn it into an interactive platform, where building users and other stakeholders can exchange experiences and look for recommendations. Another recommendation would be, to include protocols and more guidance on the monitoring and measurement systems.

The previously mentioned four interventions were represented in detail in the Collaborative Design Platform, too. These interventions offer several setup options to personalize the what-if simulations to ease the variant creations and the final decision-making. It would be recommended to facilitate the stakeholder involvement with predefined or already existing surveys and interview strategies. This could be uploaded into the CDP’s survey tool. This would be useful, since the compilation of a questionnaire requires extensive knowledge and professional skills.

Data Manager is a powerful tool to guide the users through the essential data requirements for any retrofitting project, so no building characteristic can be ignored. It provided a great support with the use of pre-defined structure characteristics and occupancy profiles. However, facilitating the data entry could make the Data Manager even more attractive.

8.7.2. FEEDBACK TO STAKEHOLDERS

Local Advisory Team meeting provided a great opportunity not only to get feedback, but also to share our intermediate and final results, based on the monitoring or the interviews and questionnaires. The retrofitting projects' stakeholders site benefited a lot from the aggregated data, quantifiable measurements, KPIs, and summarized feedbacks from the building users. Using the NewTREND methodology and toolset, the results on monitoring and feedback collecting activities, problems can be highlighted that otherwise would have been ignored by the decision-makers. Attention can be drawn to general issues, which can help future renovation projects.

9. CONCLUSIONS

This report contains all relevant work that was performed within the NewTREND project related to evaluating and assessing the methodology, the tools and processes. From basic software testing, through sophisticated user feedback to software tools, interactions with various stakeholders (including the occupants) to testing the overall methodology on three demo sites. User feedback was invaluable when understanding user interaction with each building and the software tools. This user feedback in turn, substantially enhanced testing of the software tools. In particular, the structured and systematic testing processes, developed by an independent project partner, proved to be very useful for gaining a better understanding of user issues, as well as likes and dislikes of the platform. Consequently, we have compiled a list of future enhancements that includes suggestions on how the tools and methodology could be improved in the future.

While most feedback focused on the GUI of the various tools, feedback also indicated that the main concept and core features of the methodology and tools were well received by users and were useful when applied at the demo sites. Unfortunately, some demo side project schedules were delayed, so that not all demo sites could be fully completed in context of the methodology.

Testing of the NewTREND methodology and tools revealed a number of key outcomes:

- The project made important steps toward defining how BIM and CityGML models should be made to be suitable for dynamic energy simulation software. The modular nature of the DIM server and API facilitated a range of stakeholder interactions through standardised and cloud-based data management.
- The data manager is a worthwhile interface for creation and manipulation of simulation information at the district scale. Future functionality that automates data upload (e.g.: excel upload) would further enhance usability of the tool.
- The section of the methodology that focuses decision making for retrofitting interventions is intuitive and the design of NewTREND platform aligns with the steps outlined.
- The NewTREND platform provides useful diagrams that enable a better understand of building operations and the potential for improvements. Expert knowledge is currently necessary for a deep understanding of the generated results in the context of the step by step nature of the methodology and could be enhanced.

The demo projects were delayed so only a subset of post retrofit activities were realized. However, a number of lessons were distilled from suitable NewTREND retrofit activities:

- early involvement of key stakeholders, especially occupants, is important for the project process and dramatically fosters acceptance of retrofit projects. This also pre-empts later occupant complaints and possible project delays due to occupant resistance or a range of other stakeholder issues.
- Further and deeper interaction with users is necessary so as to ensure that users better understand the new technologies in their building throughout operation
- A large variety of monitoring tools are available in the demo buildings and if they are used purposefully they can be used to keep up the increased building efficiency and comfort

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ACKNOWLEDGEMENTS

The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 680474.

ANNEXES

Annex 1: FEEDBACK TEMPLATE FOR TESTING

Annex 1.1: FEEDBACK TEMPLATE FOR USABILITY TESTING OF THE DATA MANAGER

USABILITY ASPECTS
WP6 - T6.4_TESTING FEEDBACK TEMPLATE (Data Manager)
User gets access and logs in the Data Manager
<i>How the user interface looks?</i>
<i>How easy is to navigate?</i>
<i>Are buttons name and menu options comprehensible?</i>
<i>Buttons work correctly?</i>
<i>Any ideas about helping ease the usage of the tool?</i>
NewTREND Data Manager_ Button Functionality
SECTION 1 _My Account (displays user details)
<i>How the user interface looks?</i>
<i>How easy is to navigate?</i>
<i>Are buttons name and menu options comprehensible?</i>
<i>Buttons work correctly?</i>
<i>Any ideas about helping ease the usage of the tool?</i>
SECTION 2 _Logout (logs user out of the system)
<i>How the user interface looks?</i>
<i>How easy is to navigate?</i>
<i>Are buttons name and menu options comprehensible?</i>
<i>Buttons work correctly?</i>
<i>Any ideas about helping ease the usage of the tool?</i>

USABILITY ASPECTS
WP6 - T6.4_TESTING FEEDBACK TEMPLATE (Data Manager)
User gets access and logs in the Data Manager
<i>How does the user interface look?</i>
<i>How easy is it to navigate?</i>
<i>Are interface elements setup in a meaningful manner?</i>
<i>Do all interface elements work correctly?</i>
<i>Do you have any ideas about improving the usage of the tool?</i>
NewTREND Data Manager_ Button Functionality
SECTION 1 _My Account (displays user details)
<i>How does the user interface look?</i>
<i>How easy is it to navigate?</i>
<i>Are interface elements setup in a meaningful manner?</i>
<i>Do all interface elements work correctly?</i>
<i>Do you have any ideas about improving the usage of the tool?</i>
SECTION 2 _Logout (logs user out of the system)
<i>How does the user interface look?</i>
<i>How easy is it to navigate?</i>
<i>Are interface elements setup in a meaningful manner?</i>
<i>Do all interface elements work correctly?</i>
<i>Do you have any ideas about improving the usage of the tool?</i>

USABILITY ASPECTS
WP6 - T6.4_TESTING FEEDBACK TEMPLATE (Data Manager)
User gets access and logs in the Data Manager
<i>How the user interface looks?</i>
<i>How easy is to navigate?</i>
<i>Are buttons name and menu options comprehensible?</i>
<i>Buttons work correctly?</i>
<i>Any ideas about helping ease the usage of the tool?</i>
NewTREND Data Manager_ Button Functionality
SECTION 1 _My Account (displays user details)
<i>How the user interface looks?</i>
<i>How easy is to navigate?</i>
<i>Are buttons name and menu options comprehensible?</i>
<i>Buttons work correctly?</i>
<i>Any ideas about helping ease the usage of the tool?</i>
SECTION 2 _Logout (logs user out of the system)
<i>How the user interface looks?</i>
<i>How easy is to navigate?</i>
<i>Are buttons name and menu options comprehensible?</i>
<i>Buttons work correctly?</i>
<i>Any ideas about helping ease the usage of the tool?</i>

SECTION 3_Attribute View (displays district and building information)

How does the user interface look?

How easy is it to navigate?

Are interface elements setup in a meaningful manner?

Do all interface elements work correctly?

Do you have any ideas about improving the usage of the tool?

Select Building, navigate to individual storeys and rooms within buildings

SELECT NewTREND MODE:

- **BASIC mode:** lowest data requirements, enter a minimum set of data to virtually acquire results about any building in the neighbourhood. The number of outputs in this mode is limited to energy and life cycle cost related outputs excluding user comfort related outputs

(Since Basic mode is designed for occasions where the data availability is limited, most of the inputs are pre-defined and offered in the form of drop down lists)

- **ADVANCED mode:** rely heavily on user inputted data to operate in good accuracy, high demand on data and a well detailed 3D BIM model. Advanced mode can perform comprehensive, detailed and accurate analysis on a single room level, results include environmental, user comfort and other analyses (Advanced mode allows the user to display and edit properties of a building in more detail at Room level)

- **PREMIUM mode:** used when real monitored values of the building are available. The user is able to get the most accurate representation of their building using this mode

(Data Manager allows entering monthly energy consumption and production data, which can be found on utility bills or energy metering systems. These include electrical energy (consumption and production), fuels used and energy consumed for heating and cooling

How does the user interface look?

How easy is it to navigate?

Are interface elements setup in a meaningful manner?

Do all interface elements work correctly?

Do you have any ideas about improving the usage of the tool?

BASIC Mode

How does the user interface look?

How easy is it to navigate?

Are interface elements setup in a meaningful manner?

Do all interface elements work correctly?

Do you have any ideas about improving the usage of the tool?

ADVANCED Mode

How does the user interface look?

How easy is it to navigate?

Are interface elements setup in a meaningful manner?

Do all interface elements work correctly?

Do you have any ideas about improving the usage of the tool?

PREMIUM Mode

How does the user interface look?

How easy is it to navigate?

Are interface elements setup in a meaningful manner?

Do all interface elements work correctly?

Do you have any ideas about improving the usage of the tool?

Annex 1.2: FEEDBACK TEMPLATE FOR FUNCTIONALITY TESTING OF THE DATA MANAGER

FUNCTIONALITY ASPECTS
WP6 - T6.4_TESTING FEEDBACK TEMPLATE (Data Manager)
Action 1: User gets access and logs in the Data Manager
URL address: http://uat7.iesve.com
User name: xx
Password: xx
Any problems encountered in Action 1? Insert here your comments
Action 2: Selection of the typology of User
Non-Expert: Y/N
Expert: Y/N
Admin: Y/N
Any problems encountered in Action 2? Insert here your comments
NewTREND Data Manager_ Button Functionality
SECTION 1 _My Account (displays user details)
Action 3: User enters in section "My Account"
Any problems encountered in Action 3? Insert here your comments
SECTION 2 _Logout (logs user out of the system)
Action 4: User enters in section "Logout"
Any problems encountered in Action 4? Insert here your comments

FUNCTIONALITY ASPECTS
WP6 - T6.4_TESTING FEEDBACK TEMPLATE (Data Manager)
Action 1: User gets access and logs in the Data Manager
URL address: http://uat7.iesve.com
User name: xx
Password: xx
Any problems encountered in Action 1? Insert here your comments
Action 2: Selection of the typology of User
Non-Expert: Y/N
Expert: Y/N
Admin: Y/N
Any problems encountered in Action 2? Insert here your comments
NewTREND Data Manager_ Button Functionality
SECTION 1 _My Account (displays user details)
Action 3: User enters in section "My Account"
Any problems encountered in Action 3? Insert here your comments
SECTION 2 _Logout (logs user out of the system)
Action 4: User enters in section "Logout"
Any problems encountered in Action 4? Insert here your comments

SECTION 4_File View (upload files from District to Room Level)

Action 20: In "part 1" choose to upload files, photos or write notes

Any problems encountered in Action 20? Insert here your comments

Expected Outcome of action:

Obtained Outcome:

Notes/Screenshots:

Action 21: In "part 2" indicate the chosen level

Any problems encountered in Action 21? Insert here your comments

Expected Outcome of action:

Obtained Outcome:

Notes/Screenshots:

Action 22: In "part 3" choose to upload files, photos or write notes

Any problems encountered in Action 22? Insert here your comments

Expected Outcome of action:

Obtained Outcome:

Notes/Screenshots:

Selection: Write Notes

Action 23: entering text using the device's keyboard within the text box, and select "Upload"

Any problems encountered in Action 23? Insert here your comments

Expected Outcome of action:

Obtained Outcome:

Notes/Screenshots:

Selection: Upload File

Action 24: choose a file, specify who can access it, and upload it on the DIM server

Any problems encountered in Action 24? Insert here your comments

Expected Outcome of action:

Obtained Outcome:

Notes/Screenshots:

Selection: Upload/Take Pictures

Action 25: take pictures while on site using device's camera and upload it to the system

Any problems encountered in Action 25? Insert here your comments

Expected Outcome of action:

Obtained Outcome:

Notes/Screenshots:

	SECTION 3 Attribute View (displays district and building information)
	Action 5: User enters in section "Attribute View"
	<i>Any problems encountered in Action 5? Insert your comments here</i>
TEST DISTRICT	Action 6: Test District , navigate in the various District projects assigned
	<i>Any problems encountered in Action 6? Insert your comments here</i>
	<i>Expected Outcome of action:</i>
	<i>Obtained Outcome:</i>
	<i>Notes/Screenshots:</i>
	Action 7: Get Attribute , lists of data attributes characterising each district element
	--> Direct input box , where user interacts by entering a value (Name and Location)
	<i>Any problems encountered in Action 7? Insert your comments here</i>
	<i>Expected Outcome of action:</i>
	<i>Obtained Outcome:</i>
	<i>Notes/Screenshots:</i>
	Action 8: Get Attribute , lists of data attributes characterising each district element
	--> Direct input box , where user interacts by entering a value (Conversion Factors)
	<i>Any problems encountered in Action 8? Insert your comments here</i>
	<i>Expected Outcome of action:</i>
	<i>Obtained Outcome:</i>
	<i>Notes/Screenshots:</i>
	Action 9: Get Attribute , lists of data attributes characterising each district element
	--> Pre-defined options , where the user selects the most suitable option from a drop-down list
	Power Station
	<i>Any problems encountered in drop-down Power Station list? Insert your comments here</i>
	Heat Generator
	<i>Any problems encountered in drop-down Heat Generator list? Insert your comments here</i>
	CHP (Combined Heat and Power) Plant
	<i>Any problems encountered in drop-down CHP Plant list? Insert your comments here</i>
	Photovoltaic Panel
	<i>Any problems encountered in drop-down Photovoltaic Panel list? Insert your comments here</i>
	Wind Turbine
	<i>Any problems encountered in drop-down Wind Turbine list? Insert your comments here</i>
	Electricity Storage
	<i>Any problems encountered in drop-down Electricity Storage list? Insert your comments here</i>
	Heating Storage
	<i>Any problems encountered in drop-down Heating Storage list? Insert your comments here</i>
	Action 10: Attribute Information , tooltip dialog of each attribute
	<i>Any problems encountered in Action 10? Insert your comments here</i>
	<i>Expected Outcome of action:</i>
	<i>Obtained Outcome:</i>
	<i>Notes/Screenshots:</i>

SECTION 4_File View (upload files from District to Room Level)

Action 20: In "part 1" choose to upload files, photos or write notes

Any problems encountered in Action 20? Insert your comments here

Expected Outcome of action:

Obtained Outcome:

Notes/Screenshots:

Action 21: In "part 2" indicate the chosen level

Any problems encountered in Action 21? Insert your comments here

Expected Outcome of action:

Obtained Outcome:

Notes/Screenshots:

Action 22: In "part 3" choose to upload files, photos or write notes

Any problems encountered in Action 22? Insert your comments here

Expected Outcome of action:

Obtained Outcome:

Notes/Screenshots:

Selection: Write Notes

Action 23: entering text using the device's keyboard within the text box, and select "Upload"

Any problems encountered in Action 23? Insert your comments here

Expected Outcome of action:

Obtained Outcome:

Notes/Screenshots:

Selection: Upload File

Action 24: choose a file, specify who can access it, and upload it on the DIM server

Any problems encountered in Action 24? Insert your comments here

Expected Outcome of action:

Obtained Outcome:

Notes/Screenshots:

Selection: Upload/Take Pictures

Action 25: take pictures while on site using device's camera and upload it to the system

Any problems encountered in Action 25? Insert your comments here

Expected Outcome of action:

Obtained Outcome:

Notes/Screenshots:

Annex 1.3: FEEDBACK TEMPLATE FOR USABILITY TESTING OF THE CDP

USABILITY ASPECTS
WP6 - T6.4_TESTING FEEDBACK TEMPLATE (Collaborative Design Platform)
User gets access and logs into the Collaborative Design Platform
<i>How does the user interface look?</i>
<i>How easy is it to navigate?</i>
<i>Are interface elements setup in a meaningful manner?</i>
<i>Do all interface elements work correctly?</i>
<i>Do you have any ideas about improving the functionality of the tool?</i>
NewTREND Collaborative Design Platform_ Button Functionality
AREA 1 _Administration (manage workgroups and members)
Workgroups
<i>How does the user interface look?</i>
<i>How easy is it to navigate?</i>
<i>Are interface elements setup in a meaningful manner?</i>
<i>Do all interface elements work correctly?</i>
<i>Do you have any ideas about improving the functionality of the tool?</i>
Members (physical person that has access to the various functionalities of CDP)
<i>How does the user interface look?</i>
<i>How easy is it to navigate?</i>
<i>Are interface elements setup in a meaningful manner?</i>
<i>Do all interface elements work correctly?</i>
<i>Do you have any ideas about improving the functionality of the tool?</i>

AREA 2_E-collaboration (manage social tools to encourage the exchange of information between members and to conduct surveys)	
<i>How does the user interface look?</i>	
<i>How easy is it to navigate?</i>	
<i>Are interface elements setup in a meaningful manner?</i>	
<i>Do all interface elements work correctly?</i>	
<i>Do you have any ideas about improving the functionality of the tool?</i>	
Forum Not implemented in this version of CDP	
Pool/Doodle is used to ask one simple question. (http://doodle.com/)	
<i>How does the user interface look?</i>	
<i>How easy is it to navigate?</i>	
<i>Are interface elements setup in a meaningful manner?</i>	
<i>Do all interface elements work correctly?</i>	
<i>Do you have any ideas about improving the functionality of the tool?</i>	
Surveys/Surveymonkey used to ask a wide range of questions. (https://www.surveymonkey.com)	
<i>How does the user interface look?</i>	
<i>How easy is it to navigate?</i>	
<i>Are interface elements setup in a meaningful manner?</i>	
<i>Do all interface elements work correctly?</i>	
<i>Do you have any ideas about improving the functionality of the tool?</i>	
Quiz/Onlinequizcreator (www.onlinequizcreator.com)	
<i>How does the user interface look?</i>	
<i>How easy is it to navigate?</i>	
<i>Are interface elements setup in a meaningful manner?</i>	
<i>Do all interface elements work correctly?</i>	
<i>Do you have any ideas about improving the functionality of the tool?</i>	
Notification Not implemented in this version of CDP	
Messenger Not implemented in this version of CDP	

AREA 3_Projects (manage projects, is related to the management of a DIM model that contains a representation of a district)	
Project	
<i>How does the user interface look?</i>	
<i>How easy is it to navigate?</i>	
<i>Are interface elements setup in a meaningful manner?</i>	
<i>Do all interface elements work correctly?</i>	
<i>Do you have any ideas about improving the functionality of the tool?</i>	
Phases	
<i>How does the user interface look?</i>	
<i>How easy is it to navigate?</i>	
<i>Are interface elements setup in a meaningful manner?</i>	
<i>Do all interface elements work correctly?</i>	
<i>Do you have any ideas about improving the functionality of the tool?</i>	
Task Management	
<i>How does the user interface look?</i>	
<i>How easy is it to navigate?</i>	
<i>Are interface elements setup in a meaningful manner?</i>	
<i>Do all interface elements work correctly?</i>	
<i>Do you have any ideas about improving the functionality of the tool?</i>	
Simulation - Scenario creation	
<i>How does the user interface look?</i>	
<i>How easy is it to navigate?</i>	
<i>Are interface elements setup in a meaningful manner?</i>	
<i>Do all interface elements work correctly?</i>	
<i>Do you have any ideas about improving the functionality of the tool?</i>	
Simulation - Simulation Launching and configuration	
<i>How does the user interface look?</i>	
<i>How easy is it to navigate?</i>	
<i>Are interface elements setup in a meaningful manner?</i>	
<i>Do all interface elements work correctly?</i>	
<i>Do you have any ideas about improving the functionality of the tool?</i>	
Simulation - Results visualization	
<i>How does the user interface look?</i>	
<i>How easy is it to navigate?</i>	
<i>Are interface elements setup in a meaningful manner?</i>	
<i>Do all interface elements work correctly?</i>	
<i>Do you have any ideas about improving the functionality of the tool?</i>	

Annex 1.4: FEEDBACK TEMPLATE FOR FUNCTIONALITY TESTING OF THE CDP

NewTREND Collaborative Design Platform_ Button Functionality	
AREA 1 _Administration (manage workgroups and members)	
Workgroups	
Action 2: User enters in the list of the workgroups	
<i>Any problems encountered in Action 2? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Action 3: User creates a Workgroup	
<i>Any problems encountered in Action 3? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Action 4: User edits a Workgroup	
<i>Any problems encountered in Action 4? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Action 5: User deletes a Workgroup	
<i>Any problems encountered in Action 5? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Members (physical person that can access to the various functionalities of CDP)	
Action 6: User checks Members included and not included of a Workgroup (name, password, workgroup, role, actions)	
<i>Any problems encountered in Action 6? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Action 7: User creates a new Member	
<i>Any problems encountered in Action 7? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Action 8: User edits a Member	
<i>Any problems encountered in Action 8? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	
Action 9: User deletes a Member who currently belong to the workgroup	
<i>Any problems encountered in Action 9? Insert here your comments</i>	
<i>Expected Outcome of action:</i>	
<i>Obtained Outcome:</i>	
<i>Notes/Screenshots:</i>	

NewTREND Collaborative Design Platform_ Button Functionality
AREA 1 _Administration (manage workgroups and members)
Workgroups
Action 2: User enters in the list of the workgroups
<i>Any problems encountered in Action 2? Insert here your comments</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Action 3: User creates a Workgroup
<i>Any problems encountered in Action 3? Insert here your comments</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Action 4: User edits a Workgroup
<i>Any problems encountered in Action 4? Insert here your comments</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Action 5: User deletes a Workgroup
<i>Any problems encountered in Action 5? Insert here your comments</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Members (physical person that can access to the various functionalities of CDP)
Action 6: User checks Members included and not included of a Workgroup (name, password, workgroup, role, actions)
<i>Any problems encountered in Action 6? Insert here your comments</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Action 7: User creates a new Member
<i>Any problems encountered in Action 7? Insert here your comments</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Action 8: User edits a Member
<i>Any problems encountered in Action 8? Insert here your comments</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Action 9: User deletes a Member who currently belong to the workgroup
<i>Any problems encountered in Action 9? Insert here your comments</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>

NewTREND Collaborative Design Platform_ Button Functionality
AREA 1 _Administration (manage workgroups and members)
Workgroups
Action 2: User enters in the list of the workgroups
<i>Any problems encountered in Action 2? Insert your comments here</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Action 3: User creates a Workgroup
<i>Any problems encountered in Action 3? Insert your comments here</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Action 4: User edits a Workgroup
<i>Any problems encountered in Action 4? Insert your comments here</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Action 5: User deletes a Workgroup
<i>Any problems encountered in Action 5? Insert your comments here</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Members (physical person that can access to the various functionalities of CDP)
Action 6: User checks Members included and not included of a Workgroup (name, password, workgroup, role, actions)
<i>Any problems encountered in Action 6? Insert your comments here</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Action 7: User creates a new Member
<i>Any problems encountered in Action 7? Insert your comments here</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Action 8: User edits a Member
<i>Any problems encountered in Action 8? Insert your comments here</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>
Action 9: User deletes a Member who currently belong to the workgroup
<i>Any problems encountered in Action 9? Insert your comments here</i>
<i>Expected Outcome of action:</i>
<i>Obtained Outcome:</i>
<i>Notes/Screenshots:</i>

Annex 1.5: FEEDBACK TABLE FOR TESTING THE IDM (EMPTY)

PHASE	ACTION/PURPOSES	Platform functions	PP FEEDBACK
Initiation	Develop Project Charter	<ul style="list-style-type: none"> DM- Setting up NewTREND Project Platform CDP- Define the project physical boundaries and stakeholders 	Feedback to contain demo project definition (input from D6.1) and description of NewTREND platform launch
	Define Project Boundaries		
	Soft launch of NewTREND Project website		
	Choosing NewTREND mode		
Preparation	Launching of NewTREND Platform	<ul style="list-style-type: none"> DM- Minimum data entry for building and neighbourhood level data and data from occupants DM- Freeze the model for the diagnosis phase CDP- Setting up users account for stakeholders CDP- Poll, ask for the availability of different stakeholders to schedule the Kick-Off meeting 	Summary of data collection methods (referencing D6.1) and data entry to the DM
	Collection of neighbourhood data		
	Collection of building data		
	Collection of occupant data		
Diagnosis	Freeze model for diagnosis	<ul style="list-style-type: none"> DM- Accessing the information on the DIM server DM- Creation of a Diagnosis Phase Summary Report 	Description of results of the current state analysis
	Neighbourhood current state analysis		
	Building current state analysis		
	Non-simulated aspects		
Strategic definition	Diagnosis phase summary report	<ul style="list-style-type: none"> DM- DIM editing and simulation (definition of constraints and restrictions) CDP- Surveys are a very good possibility for the "Design Team" to get the opinion of different stakeholders for the definition of targets, constraints and restrictions for the retrofitting concept CDP- Polls can be used in order to get the opinion of relevant stakeholders on certain aspects (e.g. max. investment cost) DM- The data manager can be used to view the entered building and neighbourhood info during the diagnosis phase to interpret the diagnosis results DM- export simulation results via interfaces to create a diagnosis phase summary report CDP- launch what if simulation (Building and District) 	Description of constraints (referencing D6.1) using the CDP functions
	Definition of Constraints and Restrictions for the Project		
	Reduce energy consumption		
	Improve energy supply efficiency		
Concept	Inclusion of renewable energies	<ul style="list-style-type: none"> DM- The data manager can be used to view the entered building and neighbourhood info during the diagnosis phase to interpret the diagnosis results DM- export simulation results via interfaces to create a diagnosis phase summary report CDP- launch what if simulation (Building and District) 	Determining design variants based on real design options or user preferences
	Inclusion of non-simulated aspects		
	Incorporation of financial aspects		
	Summary report of design variant		
	Approval of design variant		

Decision-making		<ul style="list-style-type: none">CDP- financial planning spreadsheets downloadCDP-variants KPIs analysis	Ranking of design variants, selection of ideal variant
	Ranking of design variant via MCDA	<ul style="list-style-type: none">CDP- Poll, determination of stakeholder's priorities. Used to determine the priorities of a group of involved relevant stakeholders for the decision making process based on poll results	
	Ranking of design variant based on weighting system		
	Develop project working drawing, specification, project cost and time plan		
Design development and tendering	Update BIM/DIM Model and KPIs	<ul style="list-style-type: none">DM- Update simulation modelCDP- Poll, planning of workshop meeting diagnosis resultsCDP- Survey, Gather opinions of "End-Users" on design preferencesCDP- Add new user accounts to CDP platform	Description of design and tendering process of the project and its connections to the NewTREND methodology.
	Implement End User engagement strategies and methods		
	Preparation of construction documentation and selection criteria		
	Initiate tendering procedure		
	Award project contract		
Construction	Develop and implement construction phase plan	<ul style="list-style-type: none">DM- Update simulation modelCDP- Poll, planning of times for retrofitting worksCDP- Survey, Gather opinions of "End-Users" on design preferencesCDP- Add new user accounts to CDP platform	Description of construction process of the project and its connections to the NewTREND methodology.
	Develop and implement complaint management procedure		
	Implement End User engagement strategies and methods		
	Develop hand over and in use strategies		
	Update and maintain the BIM/DIM model, project time line, budget and KPIs		
	Complete construction work		
	Apply testing and commissioning program		
	Apply handover strategies		
Handover and close-out	Update, hand over and check as-built DIM/BIM, building document and KPIs	<ul style="list-style-type: none">DM- Add premium data to modelCDP- Poll, planning of times for handover processCDP- Survey, gather hand over relevant information form "End-Users"CDP- Quiz, engage "End-Users" during construction processCDP- Add new users or tenants for post occupancy functions	Description of handover and close-out process of the project and its connections to the NewTREND methodology.
	Issue certificate of completion		
In-use	Monitor and optimize the project performance	<ul style="list-style-type: none">DM- Add premium data to model	Description of the in-use phase monitoring, optimization measures (references T6.5, detailed in Chapter 9 Monitoring and followup)

	Apply continuous post occupancy measures to avoid sub-optimal use	<ul style="list-style-type: none"> ▪ CDP- Poll, planning of times for maintenance works ▪ CDP- Survey, gather hand over relevant information form "End-Users" ▪ CDP- Quiz, engage "End-Users" during construction process ▪ CDP- Add new users or tenants for post occupancy functions 	
	Update and maintain the project BIM/DIM model and documents		

6: FEEDBACK TABLE FOR TESTING THE IDM (WITH FEEDBACK)