BOOSTEE-CE

DELIVERABLE T3.2.3

D.T3.2.3 – Handbook for energy planners on the integration of 3DEMS and OnePlace into daily use 05/2020

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A.T3.2 Evaluation of pilot actions for EE improvement

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1. Introduction and aim

The handbook for energy planners on the integration of 3DEMS and OnePlace into daily use was developed based on the gained experience during the project implementation and feedbacks from performed trainings. It aims to support a new user and reduce the discomfort he may experience when using a new, unknown tool. The handbook aims also to show that the OnePlace platform and especially 3DEMS tool could be easily replicate and use in other municipalities. This handbook presents approaches to use spatial and non-spatial energy-related data that rely upon GIS and 3D city models. This will demonstrate a step forward in using geospatial data for better planning and management of energy in public buildings.

2. OnePlace platform manual

The chapter introduces the web platform named OnePlace developed within the BOOSTEE-CE project. OnePlace allows using 3D city models for the visualization and query of energy-related information to better assess, understand and plan energy uses and flows. At the same time, the platform offers also guidebooks, tools and best practices to improve the energy efficiency of public buildings.

OnePlace platform (https://oneplace.fbk.eu/) for public authorities and energy end-users consists of 4 different modules:

- **Living Energy Marketplace** promotes relevant online databases helping to navigate amongst all kinds of different energy efficiency contractors and electronic devices. The Experts database contains for each participating country (Austria, Croatia, Czech Republic, Hungary, Italy, Poland and Slovenia) relevant information about experts implementing energy efficiency measures and it will be open to find the qualified contractors who can carry out energy efficiency investments;
- **3D Energy Management System** (3D EMS) is a webGIS viewer that allows its users to navigate a 3D urban environment (the buildings were reconstructed and visualized in 3D environment, equipped with the photovoltaics maps), select a building of interest and retrieve energy-related information, such as energy audit, cadastral/building data, thermal images, etc. The 3D EMS aims to harmonize different data sources in one database and visualize them within the OnePlace platform. The main advantage of the 3DEMS over more traditional applications is its simplicity and intuitive online solution that building operators, energy planners and municipality staff can use everywhere and every time without the need of special equipment;

OnePlace platform

enables users to exchange experiences, identify good practice & draw conclusions and remarks which they can disseminate to urban policy/ energy planners.

https://oneplace.fbk.eu/

WebGIS tool

for better assessment of energy use within the public buildings and visualization of energy audits **onto 3D city models.**

- **Energy Efficient Cities** enables exchange of experience and good practices within the energy efficiency sector for public authorities, municipalities and other public actors; it collects a range of approaches and measures that various European cities had used to undertake efficiency improvements and thus helps to guide cities in designing effective urban energy efficiency policies and programs. It promotes innovative and revolutionary solutions in the energy efficiency field;
- **Financing Energy Efficiency** is an attractive visual presentation of transnational strategy outcomes (financial road map), examples of best practices and practical steps to use national and EU-level resources. The module will assist local authorities and public bodies at their engagement in financing energy efficiency by presenting methods of financing energy efficiency investments and transferring them into Energy Efficiency Roadmaps of the participating regions. The module is a guide in order to find the most suitable financing solutions to finance energy efficient projects.

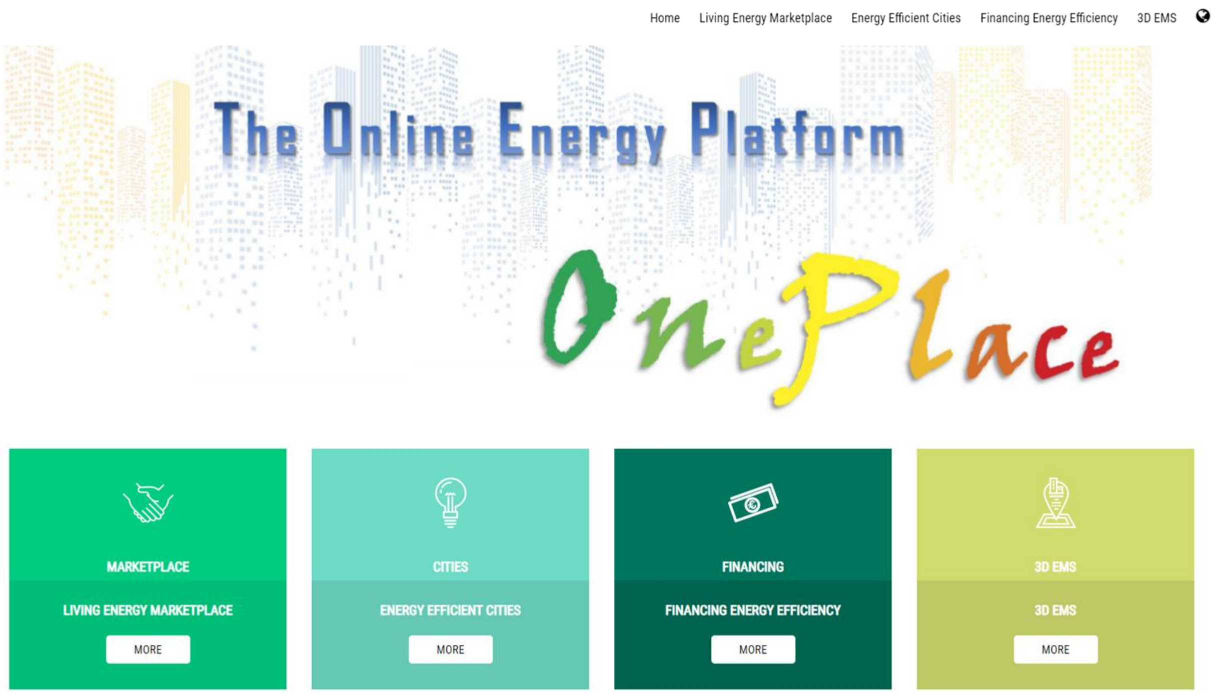


Figure 1: OnePlace home page (https://oneplace.fbk.eu/)

2.1. Living Energy Marketplace

The Living Energy Marketplace module is available by clicking on the menu at the top of the main page of the OnePlace platform (Figure 1) or scroll down and click on the modules frame – button “MORE”, the user has access to a database of energy devices to improve energy efficiency and a database of contractors, designers from this industry (Figure 2).

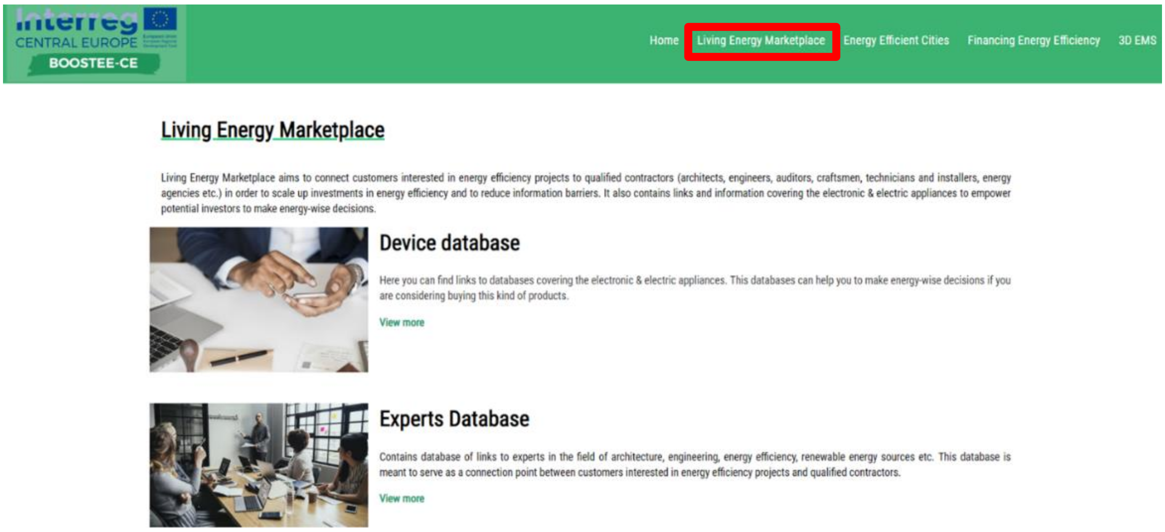


Figure 2: Living Energy Marketplace module

By clicking on the device database takes the user to a wide range of electric devices as well as smart metering systems (Figure 3). The database of energy efficiency specialists has been divided into individual participating countries. In this way, the user receives personalized information from services that experts can use in his country - just press the appropriate country.

Figure 3: Devices and Experts databases

The devices, from heating, through lighting, to office equipment and household appliances, as well as intelligent energy monitoring and management systems are available after selecting the database (Figure 4).

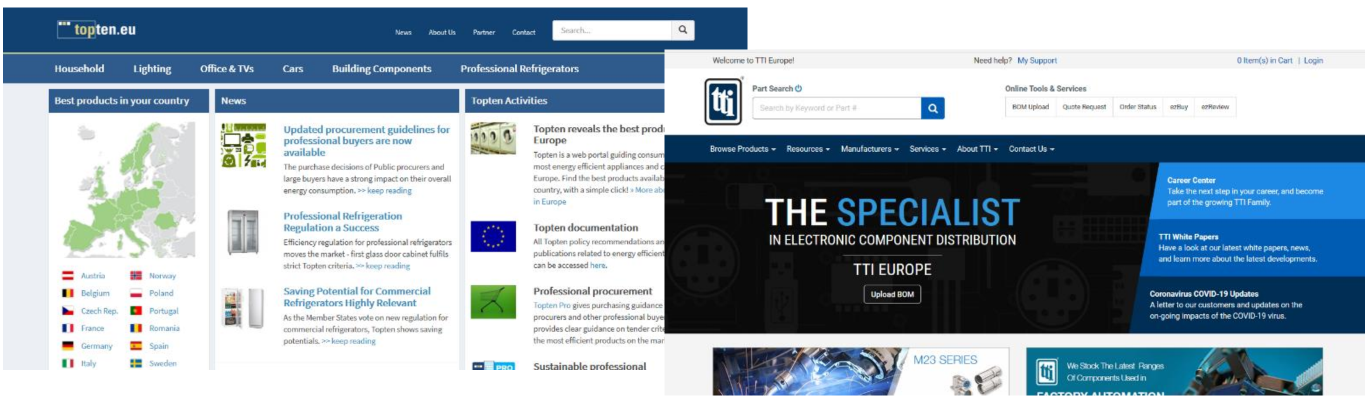


Figure 4: Appliances and smart metering systems databases

The expert databases include specialists like architects, energy agencies, auditors, contractors, engineers, ESCO companies helpful in financing EE investments (Figure 5).

Figure 5: Example of experts' database from Croatia

2.2. 3D Energy Management System

By clicking in the 3D EMS module (in the same way as with the Living Energy Marketplace module), the user can visualize pilot action buildings and solar potential maps (photovoltaic potential) in the participating countries (Figure 6).

The 3DEMS webGIS tool (Figure 7) allows users to interactively navigate 3D building models (LOD1-2) of an urban environment, select a building of interest and retrieve energy and other cadastral/building information, including non-spatial data by clicking the left mouse button on a selected building.

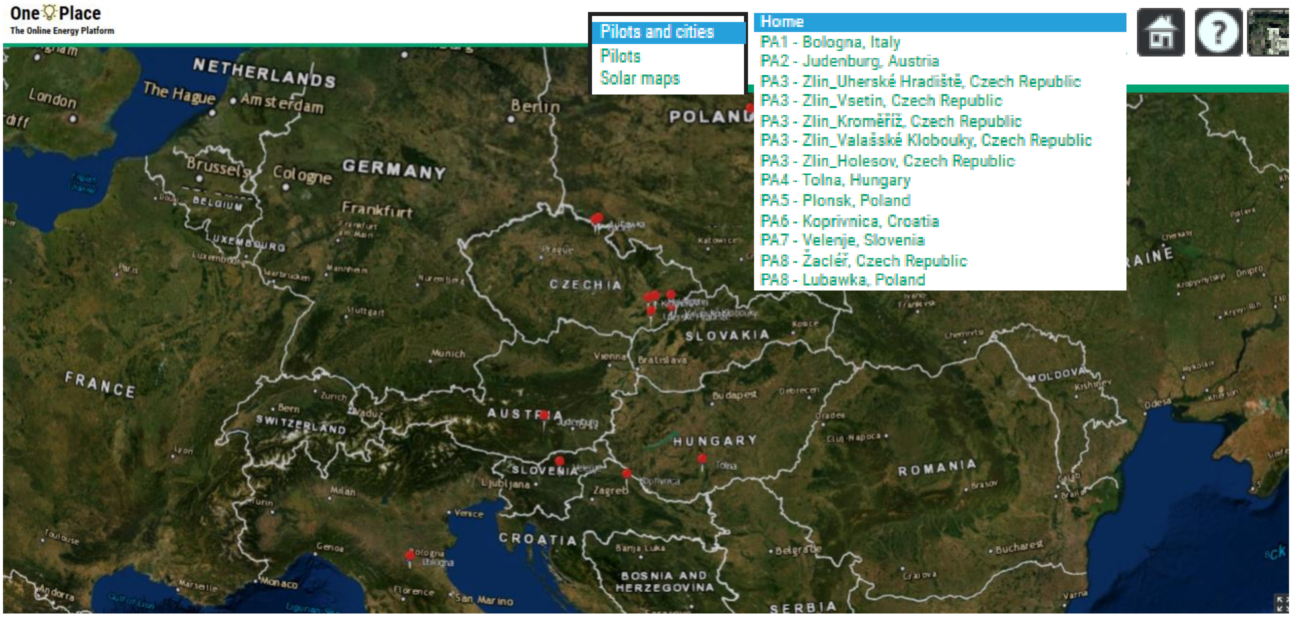


Figure 6: 3D EMS functionality

Figure 7: Visualization and energy-related information of urban environment

The included solar maps (Figure 8) allows users to find information about monthly and annual solar radiation for a selected building, thus supporting the decision-making process when investing in PV installations.

Figure 8: Example of urban solar potential

Using the 3D visualization tool, a user can better assess the surroundings of the considered object, such as the height of neighboring buildings, the shading situation, and the view. Query functions over the same area are also possible in order to visualize aggregation results and allow better analyses, simulations, etc. (Fig. 9 & 10). For example, the energy-related data available at building level are important e.g. to help the realization, implementation and monitoring of Sustainable Energy Action Plan (SEAP) at city level and the transition towards smart cities.

Figure 9: Example of aggregation functions within 3DEMS – energy sources used for buildings' heating

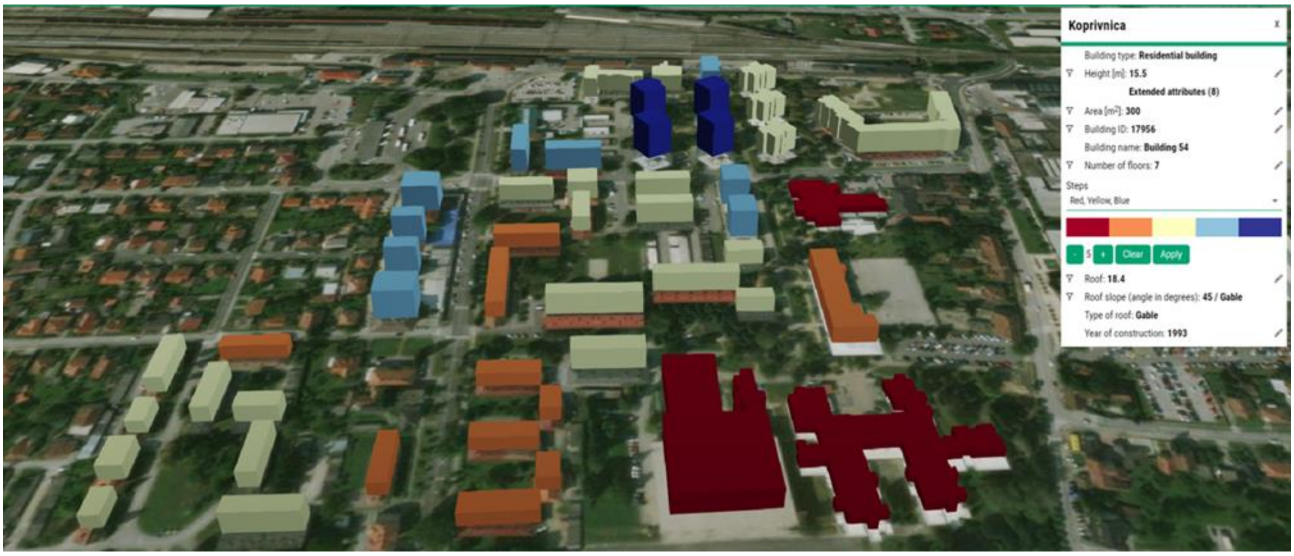


Figure 10: Example of aggregation functions within 3DEMS – number of floors

This module enables visualization of areas in four different views (Figure 11). Available map types on 3D EMS module are:

1. **ArcGis World** - a raster map is a digital representation of the map made in a specific scale and cartographic projection. It is suitable for mapping small areas due to the storage of object data in the form of regular surface elements called pixels. This is a raster image of the terrain surface resulting from the processing of aerial or satellite imagery. It is characterized by a uniform scale for the entire surface (however, there are no objects protruding above the surface, e.g. houses, trees). [14] [17]
2. **Google Maps Hybrid** - a hybrid map is a map using a vector model based on a raster model. Vector objects are applied to the calibrated raster layer to create the final effect. [15]
3. **Google Maps Roadmap** – a vector roadmap.
4. **OpenStreet-Map** - a vector map is a numerical cartographic development consisting of objects of the type: point, line, area and their variants, for which the coordinates have been saved in the database. [16]

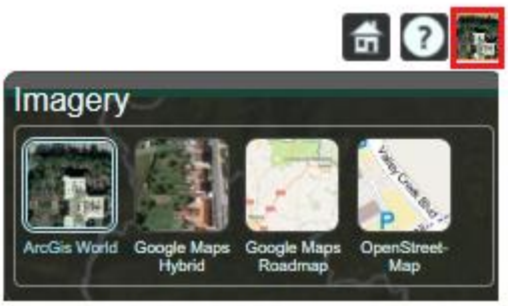


Figure 11: Types of maps available on 3D EMS module

The user can navigate the 3D Energy Management System module using a computer mouse:

left button + drag to pan view,

right button + drag or mouse wheel scroll zooms in / out,

middle + drag or CTRL + Left / Right button + drag rotates the view

or by hand (in the case of a touch screen):

dragging with one finger causes pan view,

pinching with two fingers zooms in / out,

dragging two fingers in the same direction tilts the view,

dragging with two fingers in the opposite direction rotates the view.

All navigation instructions can be found under the icon ?.

2.3. Energy Efficient Cities

After switching to the Energy Efficient Cities module, the user has access to the catalogue and database of completed investments in EE constituting the best practices.

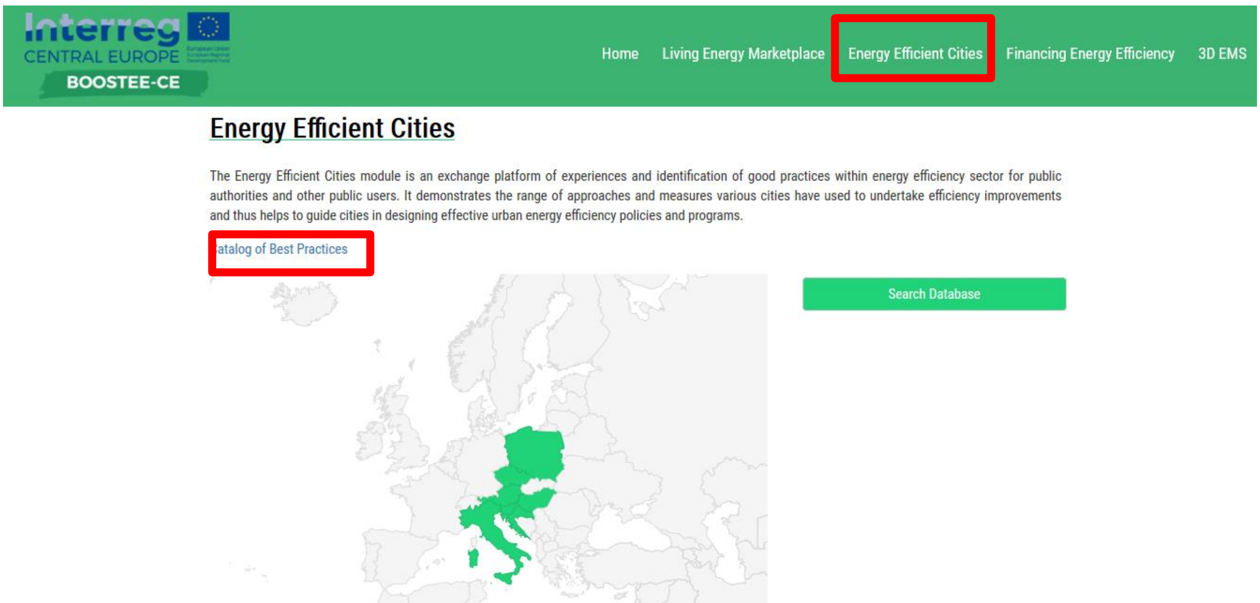


Figure 12: Energy Efficient Cities module

The investment database (Figure 13) contains 40 projects related to thermo-modernization of buildings, renewable energy installations and smart energy meters. It can be searched by location or type of investment.

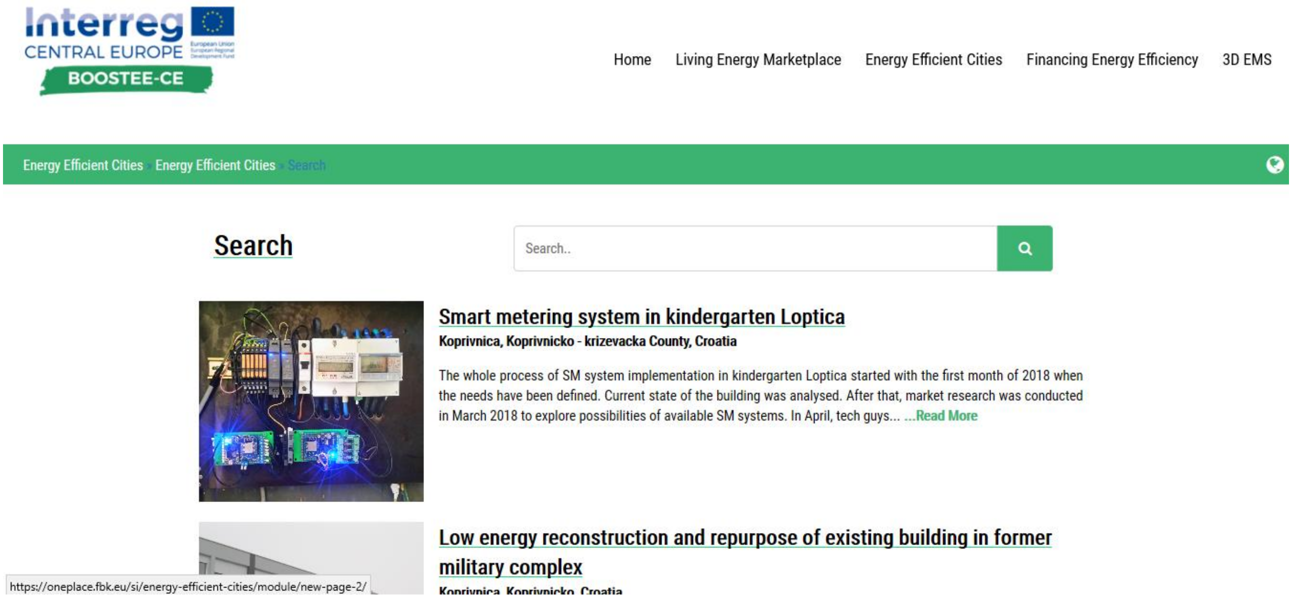


Figure 13: EE best practice database from 7 countries

When choosing a specific investment best practice, the user displays a description and achievements of the project. The user has also the ability to download a document with a description of the action under the photo.

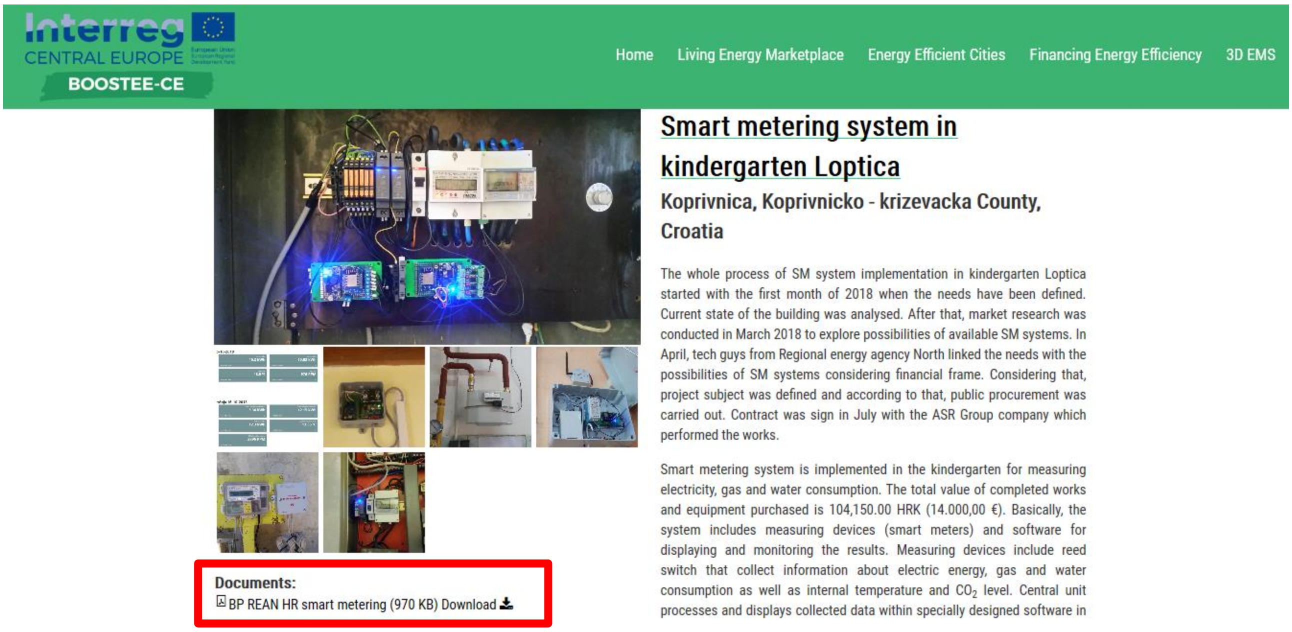


Figure 14: Example of investment in smart metering in Koprivnica

2.4. Financing Energy Efficiency

After switching to the module on financing energy efficiency, the user has access to the analysis of the financing scheme in partner countries, including subsidies / EU funds, possible normative obstacles, return on investments, models, etc.

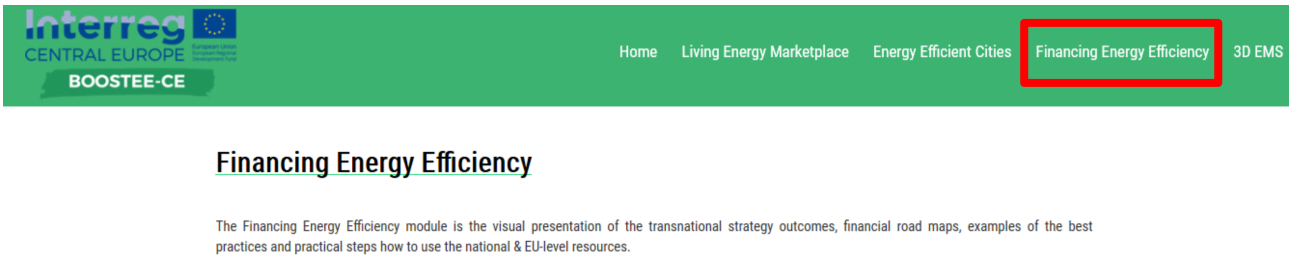
It presents experience and SWOT analysis in partner regions, EE financing strategies, indicative annual budget for EE financing, EE activities planned in the upcoming periods, self-assessment of the effectiveness of various financing methods and the process of monitoring the implementation of EE financing policies.

An extremely important element made available to the user is a review of the existing solutions and models for financing energy, that are or will be in the future the important factors enabling EE and energy savings in public infrastructures. Sources of financing for energy efficiency at European and national levels are described, as well as energy efficiency financing models such as: **Self-financing through energy savings, Debt financing, Subsidies from EU funds and operational programs, Energy Performance Contracting, Citizen Cooperatives, Crowdfunding, Green municipal bonds, On-bill financing and Revolving loan funds.**

The module also describes examination of barriers to investing, ways to deal with barriers and assessment of knowledge and experience regarding financing models for energy efficiency upgrades. It presents existing funds and assistance in Central European countries (Italy, Austria, Slovenia, Croatia, Hungary, the Czech Republic and Poland):

- Funding leveraged by ESIF
- National Funding

The user will also find there an assessment of proven financial instruments in partner countries with a description of the main factors that contributed to the success of each financial instrument, along with recommendations for further improvement as well as the possibility of transferring established financial instruments to partner countries that were not able to implement appropriate financial instruments.



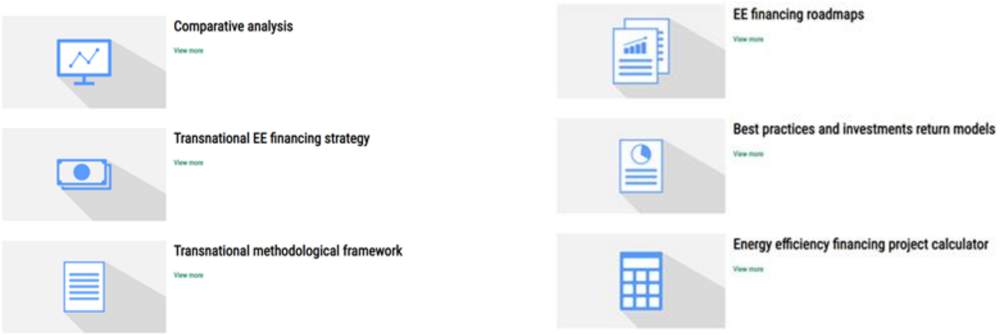


Figure 15: Content of the Financing Energy Efficiency module

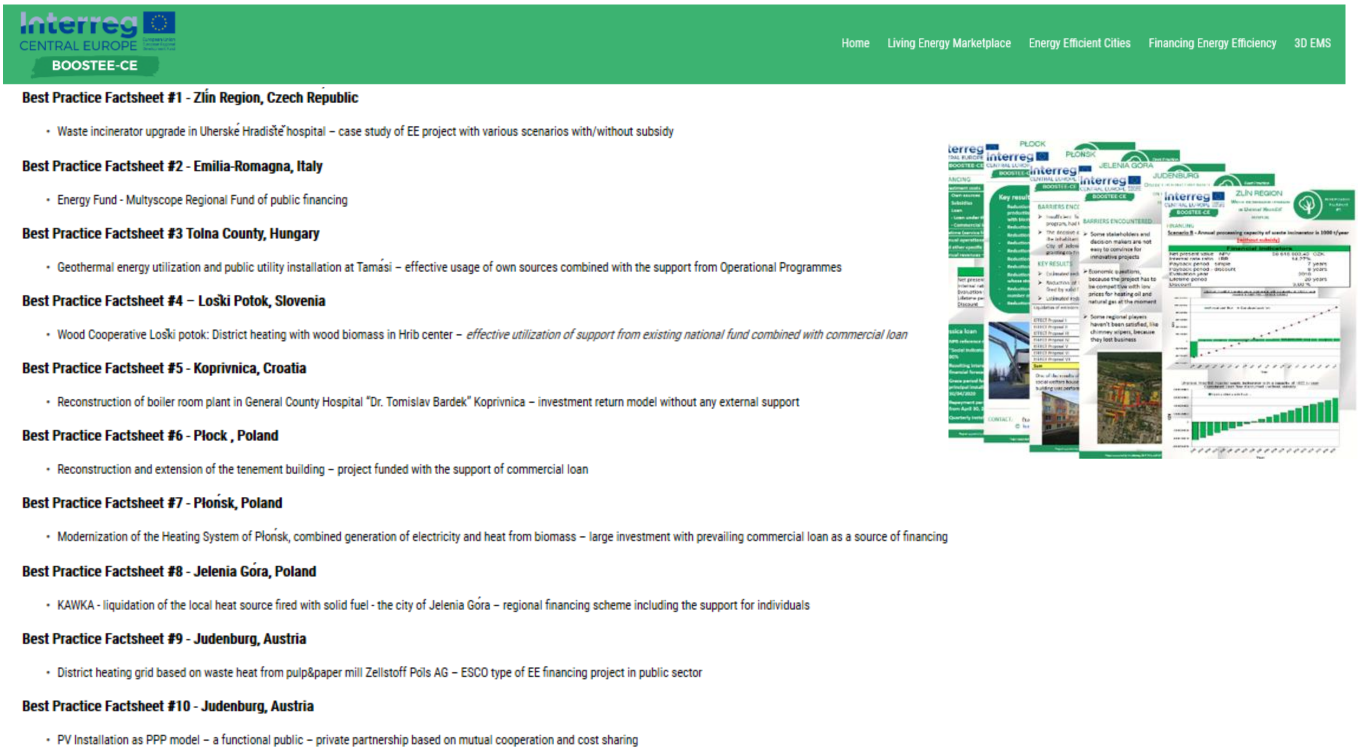
The Financing roadmaps are designed to achieve a desired goal of energy efficiency in public infrastructures in specific towns/municipalities in CE cities. The aim of the financial roadmap is to help public authorities to deal with many different financing grants in the EE domain. The methodological framework builds upon the practical knowledge of public institutions and provides an overview of financing models used to finance EE upgrades in the public sector with the specific focus on:

- financial models to minimize the load on public budgets;
- recommendations for decision-makers on identifying & implementing a suitable financing model;
- risks and measures in case of financial investments;
- case studies.

Energy Efficiency Financing Roadmaps are available for:

- Zlín Region, Czech Republic
- Regione Emilia – Romagna, Italy
- Mestna občina Velenje, Slovenia
- Tolna Megye, Hungary
- Grad Koprivnica, Croatia
- Stadtgemeinde Judenburg, Austria
- Lubawka, Poland
- Płońsk, Poland

Collection of the best practice examples from CE countries on various financial investments return models through which market-enabling actions for large investments are highlighted. The best practices are presented and analyzed on attractive factsheets as shown in Figure 16.



Home Living Energy Marketplace Energy Efficient Cities Financing Energy Efficiency 3D EMS

Best Practice Factsheet #1 - Zlín Region, Czech Republic

- Waste incinerator upgrade in Uherské Hradiště hospital – case study of EE project with various scenarios with/without subsidy

Best Practice Factsheet #2 - Emilia-Romagna, Italy

- Energy Fund - Multyscope Regional Fund of public financing

Best Practice Factsheet #3 Tolna County, Hungary

- Geothermal energy utilization and public utility installation at Tamási – effective usage of own sources combined with the support from Operational Programmes

Best Practice Factsheet #4 – Loški Potok, Slovenia

- Wood Cooperative Loški potok: District heating with wood biomass in Hrib center – *effective utilization of support from existing national fund combined with commercial loan*

Best Practice Factsheet #5 - Koprivnica, Croatia

- Reconstruction of boiler room plant in General County Hospital "Dr. Tomislav Bardek" Koprivnica – investment return model without any external support

Best Practice Factsheet #6 - Płock , Poland

- Reconstruction and extension of the tenement building – project funded with the support of commercial loan

Best Practice Factsheet #7 - Płońsk, Poland

- Modernization of the Heating System of Płońsk, combined generation of electricity and heat from biomass – large investment with prevailing commercial loan as a source of financing

Best Practice Factsheet #8 - Jelenia Góra, Poland

- KAWKA - liquidation of the local heat source fired with solid fuel - the city of Jelenia Góra – regional financing scheme including the support for individuals

Best Practice Factsheet #9 - Judenburg, Austria

- District heating grid based on waste heat from pulp&paper mill Zellstoff Pöls AG – ESCO type of EE financing project in public sector

Best Practice Factsheet #10 - Judenburg, Austria

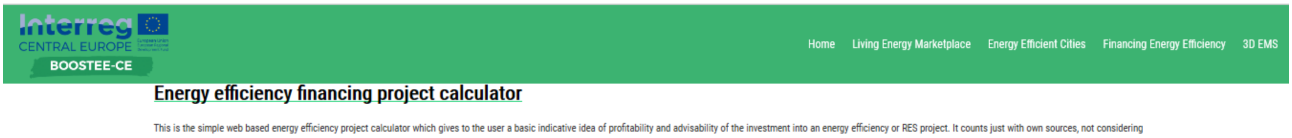
- PV Installation as PPP model – a functional public – private partnership based on mutual cooperation and cost sharing

Figure 16: Best practices in 7 countries of Central Europe

A simple energy efficiency project calculator available on the module site gives the user a basic indicative idea of the profitability and advisability of the investment into an energy efficiency or RES project.

It calculates just with own sources, not considering subsidies or loans which both can change foreseen values significantly (If subsidies are involved, the NPV and IRR are increasing and payback periods are shortening, while loans affect the investment in the opposite way).

Terms and definitions of basic financial indicators are included (NPV, IRR, Discount rate, payback period).



Home Living Energy Marketplace Energy Efficient Cities Financing Energy Efficiency 3D EMS

Energy efficiency financing project calculator

This is the simple web based energy efficiency project calculator which gives to the user a basic indicative idea of profitability and advisability of the investment into an energy efficiency or RES project. It counts just with own sources, not considering

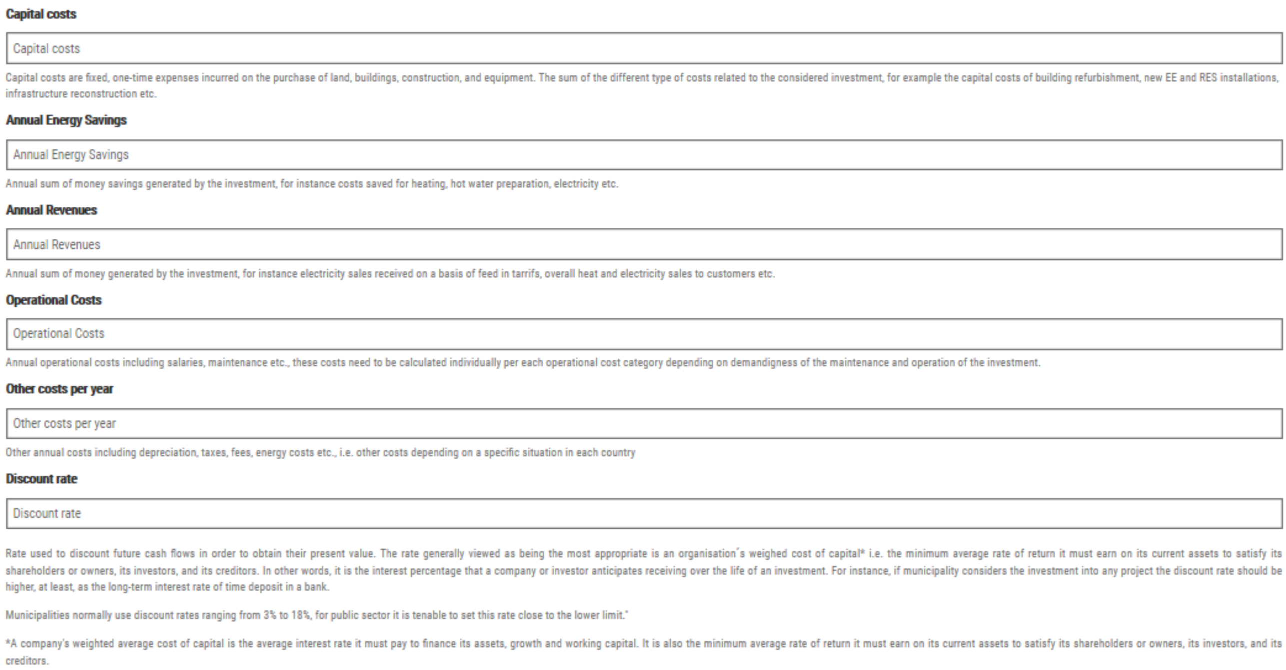


Figure 17: Energy efficiency financing calculator

Economic analysis includes a graphic illustration of cash flows and discounted cash flows as shown in Figure 18. The calculator is just an indicative tool, for concrete investment calculations it is highly advisable to carry out a proper financial analysis by a financial expert.

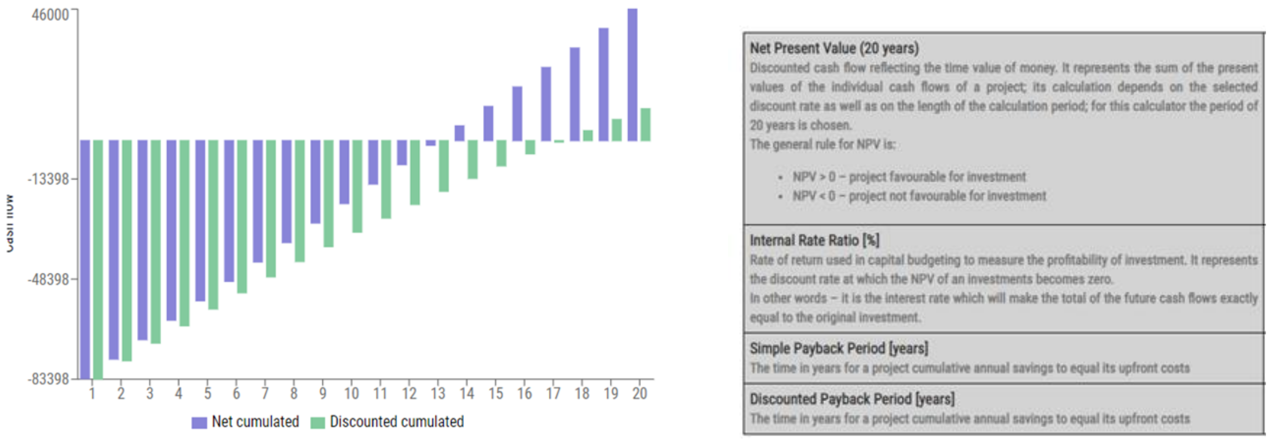


Figure 18: Results of economic analysis

3. Why apply 3D Energy Management System and OnePlace platform in daily use?

A rapid transition of urban areas towards energy efficiency and the adjustment to challenges created by climate change is highly required. It is also one of the major challenges for public authorities to reduce energy consumption and urban heat in cities without significant construction works. Therefore, public authorities, and in particular city planners and all urban actors willing to participate in the energy transitions, need to be equipped with simple but useful ICT tools, geospatial solution, strategies and methodologies for a proper energy monitoring and management to increase energy efficiency and renewable energy usage in urban spaces. Particularly in the building sector, energy consumptions and urban heat islands are influenced by the spatial organization. **The use of Geographic Information Systems (GIS) and their integration with 3D city models** have become a common and powerful asset of cities for planning, visualization and decision-making operations in the fields of energy management, energy efficiency as well as transportation, public infrastructures, etc. The use of such solutions in urban spaces is still confined and mainly applied to visualization purposes (e.g. Google Earth) although geospatial data and spatial analyses can solve many problems towards the creation of smart cities.

3.1. Increasing energy efficiency of public buildngs

Faced with the challenge of mitigating climate change, improving the energy efficiency of buildings is an important element in this direction. The public buildings have the largest share in energy consumption, which is why they can achieve the greatest savings, and thus higher investment outlays are incurred compared to other sectors. Figure 19 presents a detailed breakdown of funds from the EU cohesion policy budget allocated to energy investments in the period 2014-2020.

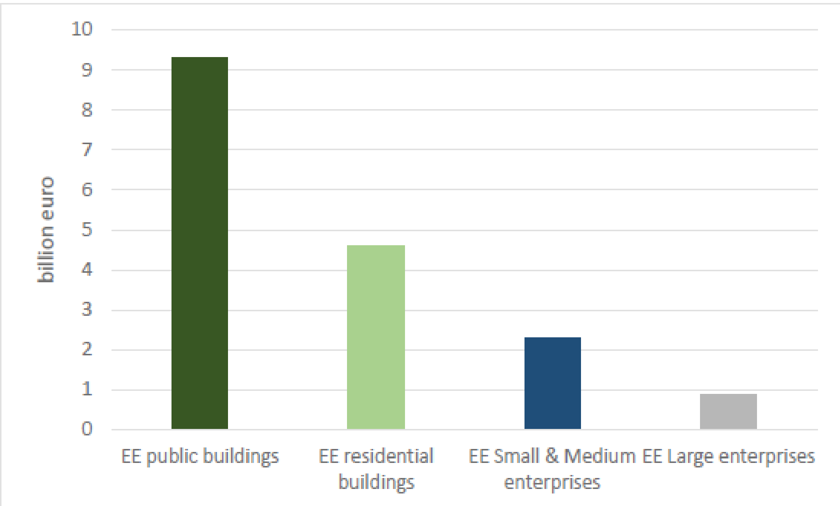


Figure 19: Breakdown of 2014-2020 EU Cohesion policy budget for energy efficiency investments. Source: EUROPEAN COURT OF AUDITORS

Directive (EU) 2018/2002 of the European Parliament and of the Council of 11 December 2018 on energy efficiency (EED directive) assumes increasing energy efficiency at national level as a goal presents increasing energy efficiency by at least 32.5% in 2030 at the same time assuming that in 2030 primary energy consumption will not be higher than 1 273 Mtoe, which is about 53.3 million TJ. It also imposes new requirements on metering energy consumption to ensure, to the extent that it is technically feasible, financially justified and proportionate to potential energy savings, end users of heat / cold, electricity and natural gas have the opportunity to purchase at competitive individual prices meters that accurately reflect the actual energy consumption of the final consumer and provide information on the actual time of use of energy.[2]

The changes introduced regarding metering and billing information say that after October 25, 2020, newly installed heat meters and heat cost allocators should allow remote reading to ensure cost-effective and frequent consumption information, and existing information will need to be replaced on such until 01.01.2027.

European Court of Auditors' recommendations for better investment planning and targeting, so as to better monitor progress in achieving energy efficiency and increase accountability are ideally suited to the integration with the design, planning, management and implementation of energy efficiency projects in urban space. They should be supported by modern ICT and GIS tools enabling better monitoring of the progress of building modernization.

It is estimated that despite the measures taken, the energy efficiency potential in construction remains large.

The basic principles of the Energy Union include provisions relating to energy efficiency, establishing it as the overarching principle of "energy efficiency first and foremost". It therefore pays special attention to the ways in which the EU can further improve the energy performance of buildings and accelerate the pace of renovation.

Increasing energy efficiency is a complex political, economic and social process, and the necessary synergy for these three groups of factors is a prerequisite for success [12].

Energy efficiency is currently perceived as one of the basic instruments for reducing the consumption of energy resources as well as reducing CO_2 emissions in a relatively short time. This term should be understood as the reduction of primary energy consumption, which occurs at the stage of changes in generation, transmission, distribution or final energy consumption, caused by technological changes, behavioral changes and / or economic changes, ensuring the same or higher level of comfort or services. [11]

The graph below presents the EU's energy goals and ambitions for 2020 and 2030.

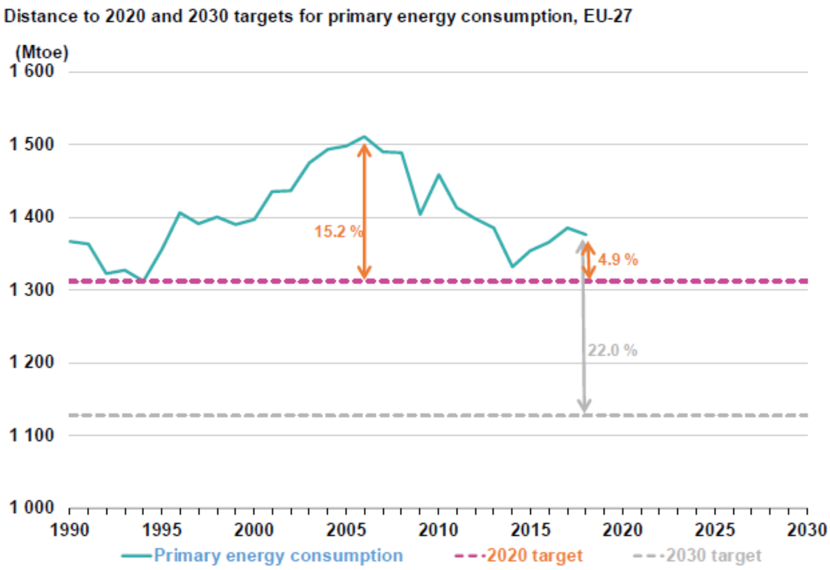


Figure 20: EU Member States' progress towards 2020 and 2030 energy efficiency targets (primary energy consumption) [8]

Figure 21 presents the analyses from 2020 regarding target, expected reductions in primary energy consumption in public buildings of EU countries. It illustrates in detail the achievements up to 2018 and the goals for 2023. Poland, Spain, the Czech Republic, Portugal and Hungary have the greatest potential.

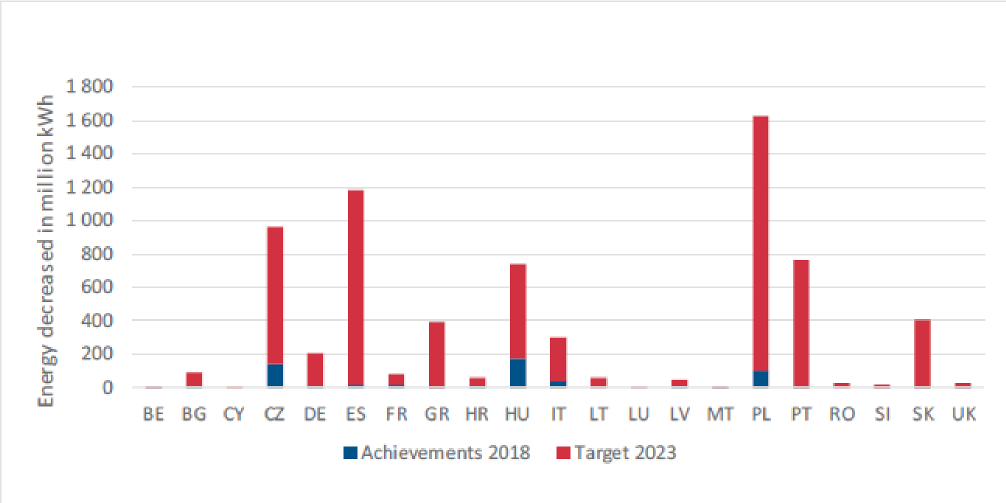


Figure 21: Decrease of annual primary energy consumption of public buildings. Source: EUROPEAN COURT OF AUDITORS

3.1.1. Challenges for EE investment in public buildings

Despite the measures taken, challenges remain for EE's investments in public buildings. Four main challenges remain for the development of EE methods in the public sector:

Technical challenges: Owners or users of public buildings often lack technical facilities and specialized knowledge to understand EE methods and technologies to reduce energy consumption and / or replace fossil fuel consumption with renewable energy sources. The first challenge is to make sure that public building managers are aware that there is a gap between the level of energy consumption at the facility they manage and the level that could be achieved if specific energy saving efforts were made and its financial value. This lack of awareness can usually be explained by the lack of methods to monitor energy consumption and adjust physical energy parameters.

Another technical challenge is to demonstrate that there are proven technologies, methods and services that can be used to significantly reduce energy consumption or replace energy consumed with other forms that can be cheaper and / or less polluting.

Economic challenges: Demonstrating the profitability of EE projects is generally problematic. EE projects have been subject to fluctuating energy prices over the past 30 years. There is often no incentive to save when budgets are allocated annually.

Similarly, if the operating costs overlap with the operating budget, in particular public authorities owning or renting the building will have little incentive to reduce costs. In addition, it can be difficult to convince managers to undertake projects that may become unprofitable when energy prices fall for a certain period of time. Guarantees regarding the profitability of such investments are key, both from a technical (physical savings) and economic (financial savings) point of view.

Figure 22 shows that more complex and ambitious renovations usually entail higher costs and payback times, hence a thorough analysis of the condition of buildings and selection of the optimal solution in an individual case is required.

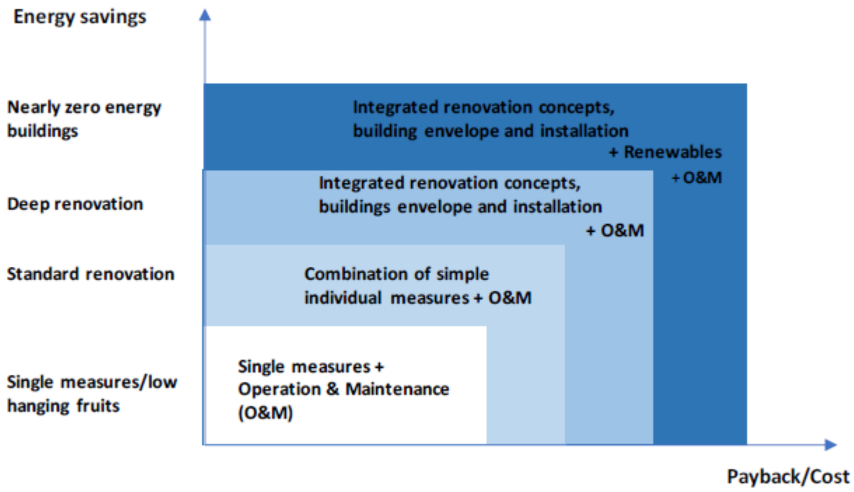


Figure 22: Categorization of energy efficiency investments. Source: European Commission (2014), "Technical Guidance on Financing the energy renovation of buildings with Cohesion policy funding"

Budgetary challenges: Public entities often face difficulties in raising funds for investment. They may not be able to finance the entire investment program directly from public funds. This requires them to set priorities and often overlook EE investments. In addition, the capacity of public entities to increase debt is increasingly limited. In some cases, this may be due to restrictions imposed by the regulatory framework or because of the inability to increase the level of debt while complying with the principles of prudent borrowing.

Legal and institutional challenges: The introduction of energy efficiency measures or the implementation of investments in energy efficiency in public buildings can also be hindered by a number of issues related to the legal, regulatory or institutional framework. EPCs will be difficult to implement if some of the following conditions are met:

- employees' concerns regarding working conditions and the possibility of outsourcing work performed by public employees;
- lack of specialist knowledge or awareness on the part of building energy managers;
- insufficient incentives to promote savings because energy tariffs are partially subsidized;
- conditions not conducive to investing in energy efficiency measures when operational budgets are reduced after a year;
- onerous procurement procedures related to conducting energy audits leading to long delays;
- the challenge of involving several different stakeholders from the public sector, because the PPP approach is more comprehensive than traditional procurement;

- PPP requirement for organizational changes and adapted processes and structures that can slow down and complicate the project.[9]

3.1.2. Energy efficient measures

Typical investments in energy efficiency include additional building insulation, energy-efficient windows, thermoregulation systems and the modernization of heating systems. An extended and detailed list of examples of energy efficiency improvement measures is provided in Table 1. These energy efficiency improvement measures must be easily measurable and verifiable or estimable in order to be taken into account when assessing energy saving plans.

Application area	Technology	Example
Public buildings sector	Lighting	Adjusting lighting to the requirements of the workplace, new efficient light sources and resistors, digital control systems, use of motion detectors in buildings, optimal use of daylight lighting
	Information and communication devices (ICT)	ICT devices that meet energy efficiency standards, e.g. Energy Star, use modern IT techniques, e.g. cloud computing, external data banks
	Other equipment and devices	Small cogeneration devices, new devices with increased efficiency energy, time controllers for optimal energy consumption, installation of capacitors to reduce reactive power, transformers with low losses
	Energy production from renewable energy sources (RES) and reduction of the amount of purchased energy	Solar collectors, heat pumps, small wind installations, geothermal energy, space heating and cooling with solar energy, electronic systems maximizing the use of RES
	Heating, hot water and cooling	The use of boilers with increased efficiency, the use of cogeneration, heat pumps, modern measuring methods and control, installation / modernization in terms of the efficiency of heating / cooling systems
	Insulation and ventilation	The insulation of walls and roofs, double / triple glazing, passive heating and cooling, heat recovery systems
	Power equipment	Transformers with correctly selected power for load, reactive power management e.g. individual compensation, limitation of reactive power flows, management systems energy consumption
	Electric drives	Modern integrated control systems and regulation of drives
	Fans, stepless drives and ventilation	New devices / systems, use of natural ventilation
	Active demand response management	Monitoring and load management systems, smart grid devices

Multisectoral measures	Standards and norms EC Regulations	Aiming primarily at improving the energy efficiency of products and services; energy management standards, energy audit standards; minimum standards energy efficiency of devices
	Performance labeling systems energy	Energy labels of products; building energy efficiency certificates
	Measurement, intelligent measuring systems	Systems for measuring and monitoring energy consumption, individual measuring devices equipped with remote control of the receiver, bills containing understandable information
	Training and education	In the use of energy-efficient technologies
Horizontal measures	Legal and regulatory regulations, taxes leading to reduced energy consumption by end users	Energy efficiency obligation systems, e.g. the White Certificate System, regulation eliminating barriers for RES and prosumers
	Information campaigns for promotion improving energy efficiency and measures her maids	Training employees on the possibilities of increasing energy efficiency, motivational reward systems

Table 1: Examples of energy efficiency improvement measures

3.1.3. Criteria for assessing energy efficiency measures

The methods for assessing energy technologies have become common using sustainability criteria similar to those for measures to increase energy efficiency. The effectiveness of the energy efficiency improvement measures (EEIM) used can be measured by the ecological effect, the absolute amount of energy saved or economic indicators.

Obtaining a specific ecological effect may be associated with varying amounts of energy saved. Reducing energy from coal will give much better ecological effects than, for example, from gas technology. The ecological effects resulting from saving energy generated in coal technology and from renewable energy can be given as an extreme example.

The economic indicators are, however, the basic criteria for assessing energy efficiency programs and measures. This applies in particular to financing from private funds and decisions taken at the level of local government units.

Criterion	Description	Assessment measure
Economic	• Currently dominant. • Using simple economic indicators. • Different EEIMs require different financial outlays. • They should include LCCA and external costs. • Costs for expanding the energy system without the use of EEIM. • The possibility of using TPF (Third Party Financing).	• Simple payback time: short, medium, long. • Investment costs: small, medium, large. • Fuel costs. • Maintenance costs. • Commitment to own capital. • Possibility of public support.

Energy	Type of energy saved.	Energy: electric, thermal, cold.
	Amount of energy saved.	Savings: small, medium, large, N / A.
	Production technology.	High-carbon, low-carbon, renewable energy.
Ecological	Reduction of gas and dust emissions. Reducing water consumption.	Adaptation to the requirements of EU directives and regulations.
Implementation	Saving strategy	Energy efficiency; energy conservation
	Activity type	Energy recovery, retrofit, optimization, new installation
Image	Social responsibility	Improvement, neutral
Distance from policy goals	Compliance with other goals and policies	Close, distant
	The need to involve new or specialized services	Yes, no
	The need to build or acquire new services, knowledge or skills	Yes, no
Frequency the need for control	The need to incur additional costs for inspections	One-time maintenance, periodic interventions
Indirect effects	Innovation	Number of improvements
	Improving the building culture	Adopting new technologies and technical, organizational solutions
	New jobs	Number

Table 2: Criteria for assessing energy efficiency improvement measures (EEIM)

3.1.4. EE investment estimation methods

Energy audits and energy performance certificates are a good basis for investment assessment and should be a common practice. The task of an energy audit is to acquire knowledge about the energy consumption profile, and then combine the way it is saved.

The increase in energy efficiency can be measured by the Odyssee Energy Efficiency Index (ODEX), which was developed to monitor indicative energy efficiency targets. This is an aggregated energy efficiency indicator of the final consumer. The technical ODEX indicator assumes that technologies in new buildings cannot be less energy-efficient than existing ones.

The ODEX formula [13] is given as:

$$\frac{I_{t-1}}{I_t} = \sum_i ec_{i,t} \cdot \frac{I_{i,t-1}}{I_{i,t}}$$

where:

I_t – energy consumption in year t

$ec_{i,t}$ – coefficient of the sector's share and in energy consumption in the year t

This formula says the indicator $\frac{I_{t-1}}{I_t}$ is the weighted average of sectoral indicators $\frac{I_{i,t-1}}{I_{i,t}}$ (for all sectors i) with weights equal to the coefficients of the sector participation I consumption in year t. With these markings $\frac{I_{t-1}}{I_t}$ is the main (regional) index.

The indicator i at the highest, sectoral level is from the set of sectors established in the ODEX method, namely: Industry, Services, Agriculture, Transport, Households, Public buildings, Other. The Public buildings category has been separated to emphasize its importance for achieving the main energy efficiency goals in the EU.

3.1.5. Benefits

Higher energy efficiency means using less energy input per equivalent quantity of products obtained [1]. By using energy more efficiently, you can reduce your own energy bills as well as contribute to protecting public health and the environment, and improving air quality.

The benefits of implementing EE:

- Save time and costs thanks to management principles that increase organizational efficiency;
- Energy saving and reduction of greenhouse gas emissions;
- Minimizing risk by increasing the building's ability to comply with laws and legal requirements;
- Acquiring knowledge and experience of how energy monitoring and management systems work and how their work should be optimized;
- Improving public awareness;
- Improving thermal comfort of building users;
- Knowingly making decisions about energy issues;
- Positive impact on public opinion by meeting modernity requirements and energy needs;
- Strengthening and highlighting the position as owner / manager of buildings thanks to the management system;
- Improving the image of the region / municipality / city;
- Improvement of production efficiency, including renewable energy use;
- Improving the maintenance and servicing practices of electrical installations, central heating and hot water.

3.2. Practices in implementing the tool

The creation of the OnePlace platform as a tool supporting activities to improve energy efficiency in public buildings was combined with testing and implementation in practice in participating countries (Austria, Croatia, Czech Republic, Hungary, Italy, Poland and Slovenia). Key target groups have been identified for which the tool is dedicated:

a) Energy planners

b) Regional/local authorities
c) Spatial planners
d) General public

The following sections provide an opinion on the possibility of using and the suitability of OnePlace in various geographical locations.

3.2.1 Austria

Energy planning is the most suitable fields of usage of OnePlace, especially to visualize supply areas of district heating, gas and other heating fuels, the distribution of solar energy and PV and possible areas of expansion. With the help of 3D EMS areas, the potential for refurbishment and expansion of renewable energy sources can be identified, especially if there is a special filtering option to display the distribution of district heating, gas, solar energy etc.

For public authorities the OnePlace tool can facilitate access to specialized information about EE services and products when planning measures in public buildings. Also, easily accessible information about financing possibilities is an important topic for authorities.

An interconnection of the 3D EMS database and public databases like the official address and buildings register containing all officially commissioned buildings could serve to keep EE data up to date and help to improve the accuracy and timeliness of official statistics.

Authorities which have buildings to manage could use the 3D EMS to store all necessary building information in one place and get information about the energetic performance with one click.

3D EMS in OnePlace offers a way to make GIS tools more accessible also to employees who are not so familiar with spatial information. OnePlace with its clear, comprehensive and up-to-date presentation of repositories can facilitate research for EE related contents.

The 3D visualizations can clearly be helpful for spatial planners if they do not yet have access to three-dimensional city models and also be useful for architectural competitions.

For private users the 3D visualization tool could be of general interest, and more specifically people who intend to purchase building land, buy or hire real estate can better assess the surroundings of the contemplated object (height of neighbouring buildings, shading situation, view).

The OnePlace databases also offer the general public easier access to EE related information without cumbersome internet research.

3.2.2 Croatia

OnePlace can be very useful for energy planners (EP), especially because EP can benefit from all four modules of the OnePlace Platform. The Living Energy Marketplace module and Energy Efficient Cities module can provide EP with information about best practices from European countries on EE projects as well as with information about energy experts within particular European countries. EP can use the Financing Energy Efficiency module in order to get information about financing schemes and funding sources with regard to proposed energy efficiency measures. In the last module – 3DEMS – the web GIS viewer allows EP to navigate a 3D urban environment, select a building of interest and retrieve energy-related information. Energy planners can use this platform in their every-day job without the need of special equipment.

The OnePlace platform can be widely used within the every-day job of different municipality departments. The most attractive content of the platform for the municipality staff is that of the Financing Energy Efficiency module and of course the 3DEMS module which can be used by those who are dealing with public buildings' management.

Similar to energy planners, spatial planners (SP) as well can benefit from the OnePlace platform, in particular from the Living Energy Marketplace module where SP can use the information about different energy experts who can play a big part in the spatial planning process. That way SP have the opportunity to use expert contacts from the existing OnePlace database in case they need to include someone in their spatial planning process. Another module, web GIS viewer allows SP to navigate a 3D urban environment, select a building of interest and retrieve spatial information they need.

OnePlace can be used by the general public in order to get information about best practices and experiences from this project which was mainly focused on public buildings but the project outputs and experience acquired within the project can be used for private buildings as well. Citizens can use data on the OnePlace platform to understand challenges and opportunities associated with energy efficiency improvements.

3.2.3 Czech Republic

Energy planners are satisfied with the idea of 3DEMS and found all the information in the OnePlace useful and possible to work with that. The complexity of this platform enables users to exchange experience, identify good practice & draw conclusions and remarks which they can disseminate to urban policy.

Zlín Region as a regional authority has several tools for planning but none like OnePlace. The 3D aspect of OnePlace significantly increases the usability of the maps. Furthermore, the filtering option according to the energy performance of buildings in the 3DEMS is very useful. 3DEMS collected heterogeneous useful information like cadastral maps, building type, construction style, energy audit, CO_2 emissions, heating losses, PV potential of public buildings that is unique for the one map.

The spatial planners like Geovap covering all regarding geodata, maps, orthoimages, LiDAR, aerial images, building footprints, 3D building models, 3D city modelling but the 3DEMS can combine all of these data together and show all in one.

General public prefer having additional documents attached to the building like energy class or sun irradiation. For the most of the users it was quite easy to actively use 3DEMS.

3.2.4 Hungary

The 3DEMS is a visually accurate and attractive representation of the Municipality of Tolna, and the majority of the users would use 3DEMS in their daily work as they could use it for prioritizing investments. As a relatively small proportion of experts speak and use English in their daily work, the usefulness of the OnePlace platform is not limited by the content per se, but rather by the ability of energy experts to use the platform.

Local and regional authorities have a certain role in energy efficiency financing, and they do not have a standard system in use that aids them in planning investments and keeping track of the consumption of the buildings operated by them. Their level of knowledge in EE investments/interventions varies greatly, therefore a simple knowledge base offering a wide range of information on different aspects of EE can be really useful if translated to Hungary as a whole. The 3D EMS is especially useful if a wide range of data can be displayed, and even smart metering data could be attached to each building, however that possibly would make the system very hard to manage as most public buildings can generate a huge amount of data.

Spatial planning is governed by the XXI. Law of 1996. which allocates certain responsibilities to certain spatial levels, and the smaller scale, more detailed plans have to fit to the larger picture, therefore the general guidelines are set on a national level, while the regional/local authorities can decide on less significant interventions. That means, that the 3DEMS, while being more detailed can be really useful on the level of a settlement (municipality), while the other modules of OnePlace can be used on a larger scale in that sense.

The general public can gather a wide range of information from OnePlace, but the complexity of the platform as a whole might make it too specific for them as the expected knowledge to successfully use the system might be higher than what we can expect from the general public. The 3D EMS here still can be a very useful system as it gives the user a general overview of how much data the building operators have to keep track of.

3.2.5 Italy

Energy planners engaged through the project activities found of interest the database of best practices, thanks to its transnational background and then to a different approach method.

A revision of those best practices and their feasibility approach in the national context would greatly help their implementation. A translation into the national language could help as well, even if it is not so important for younger planners.

The 3D webGIS remained a bit difficult to question in an energy efficiency way and it should be compiled by every single building owner before becoming useful and complete. Its overall view looks very interesting, probably for other uses.

Local authorities have shown interest in the webGIS model, thanks to the 3D visualisation that helps out intervention planning. At the actual state they cannot use the tool for decision making, because it requires too much effort, both economical and time consuming, to reach a TRL 9-10. It can still help to frame the state of the area in a short time.

The other instruments of the platform did not look interesting because they did not appear very innovative but more of commercial use.

The professionals and other stakeholders have shown interest in the overall OnePlace platform. For what concerns the professionals, the marketplace was seen as a good showcase for their skills, while they expected more from the Financing section, which is very potential but difficult to navigate through. The 3D webGIS could be interesting to find public buildings to which propose innovative solutions. The general stakeholders were particularly interested in the 3D webGIS map, because it made it easy to frame location and peculiarities of specific buildings. They found the calculator in the financing section interesting, because it was really easy to use.

3.2.6 Poland

Thanks to the platform, interested parties will be able to find interesting information on public buildings owned by the city of Płońsk and Municipality of Lubawka.

Energy experts and building managers are gaining a modern ICT tool for energy management in existing public buildings to increase energy efficiency and use renewable energy sources. They can identify and develop roof photovoltaic potential analyzes / studies. Energy experts obtain energy information about buildings that they can use in their work, e.g. when developing energy audits.

Urban planners can exploit the potential of geospatial data, three-dimensional city models and webGIS for better spatial planning and building management.

Local / regional authorities have free access to 3D visualization of their area along with information about relevant buildings. They gain a tool to support the process of planning further investments in improving energy efficiency. In addition, they have access to a database of experts and energy devices that can be useful in implementing further EE investments and best practices that can be an inspiration for better implementation of EE activities. Policy makers gain access to financial tools that allow a municipality with basic data on a planned investment to easily determine the payback period and thus the profitability of an investment. They can also use a list of available energy efficiency financing models / instruments.

The general public can raise energy awareness and change the ecological attitude associated with energy efficiency and the use of renewable energy sources. Residents can draw inspiration and examples from the best practices available and learn how to conduct various types of investments in the field of EE, they also receive free access to a database of experts and energy-saving devices that they can use when planning their own initiatives.

3.2.7 Slovenia

OnePlace is a very useful tool as it enables analysis and visualization of energy data. Photovoltaic potential in form of solar maps is very interesting as there is high demand from the potential investors.

OnePlace has a potential to serve as a municipality database for data on consumption of energy and resources. It could visualize the consumption data for all public buildings (monthly consumption would be recommended).

OnePlace can serve as a support for strategic planning for municipalities, energy agencies and local services (district heating, water supply).

Simple analysis and visualization of data are very useful for spatial planning – to select districts with highest energy consumption for renovation projects or districts with best PV potential. Because of the good visualization options, it is a very effective mean of communication, that is understood by a large group of people and replaces a lot of technical jargon – a very useful tool when presenting energy data to the public authorities or general public.

Simple analysis and visualization enabled by OnePlace are a great tool to show the general public the energy data, but also other publicly available data connected to the public buildings in a very understandable manner.

OnePlace is a useful tool for raising the general public's awareness on energy topics, but also a tool by which users' behaviors can be influenced.

4. How to design own 3D EMS for management of public buildings?

The goal of this chapter is to present the stages of identifying, gathering and harmonizing information **in the building's GIS database for managing public buildings**.

A 3D geoinformation system allows a user to **organise and use large amounts of data**. This data **is generally available in a wide variety of different formats, coming from many different sources** and is often produced at a **number of different geographical scales**. The first phase is designing a geodatabase to capture the necessary information for use in the subsequent phases.

In order to create a 3D GIS platform which would be a comprehensive tool for efficient public buildings management, there is a need to identify data the following categories:

- spatial data for the 3D GIS development,
- energy data for analysis of buildings energy saving potential.

BASE DATA

Map data over which other, thematic information is placed

Source: ESRI Dictionary

Creating your own 3D EMS data is an interdisciplinary task, because it requires knowledge and skills in several different fields - geodesy and cartography, computer science, energy.

4.1. Spatial data sources

Most 3D GIS projects begin with a search for **base data**. The development of GIS database is based on two data sources:

- **geographical layers:** it includes geographical layers that provide the basic spatial information needed for the generation of 3D buildings models (2D building footprints (vector) with the information about the height taken directly from an attribute table or from LiDAR data (Digital Surface Model – DSM) or Orthoimages);

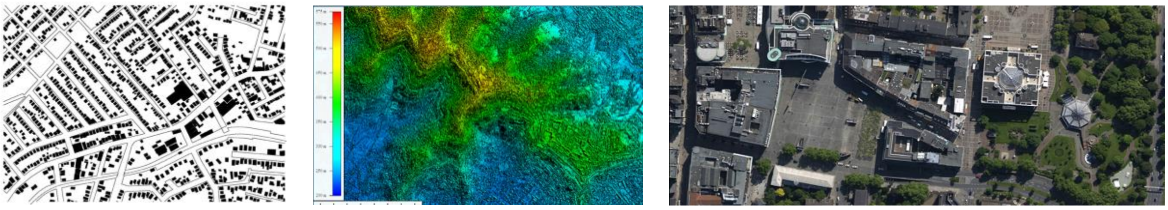


Figure 23: a) Building footprints; b) LiDAR point clouds, terrain models; c) orthoimages

- **specific layers**: this comprises additional spatial layers that would facilitate the computation of public buildings energy figures such as: solar rooftop cadaster, IR data

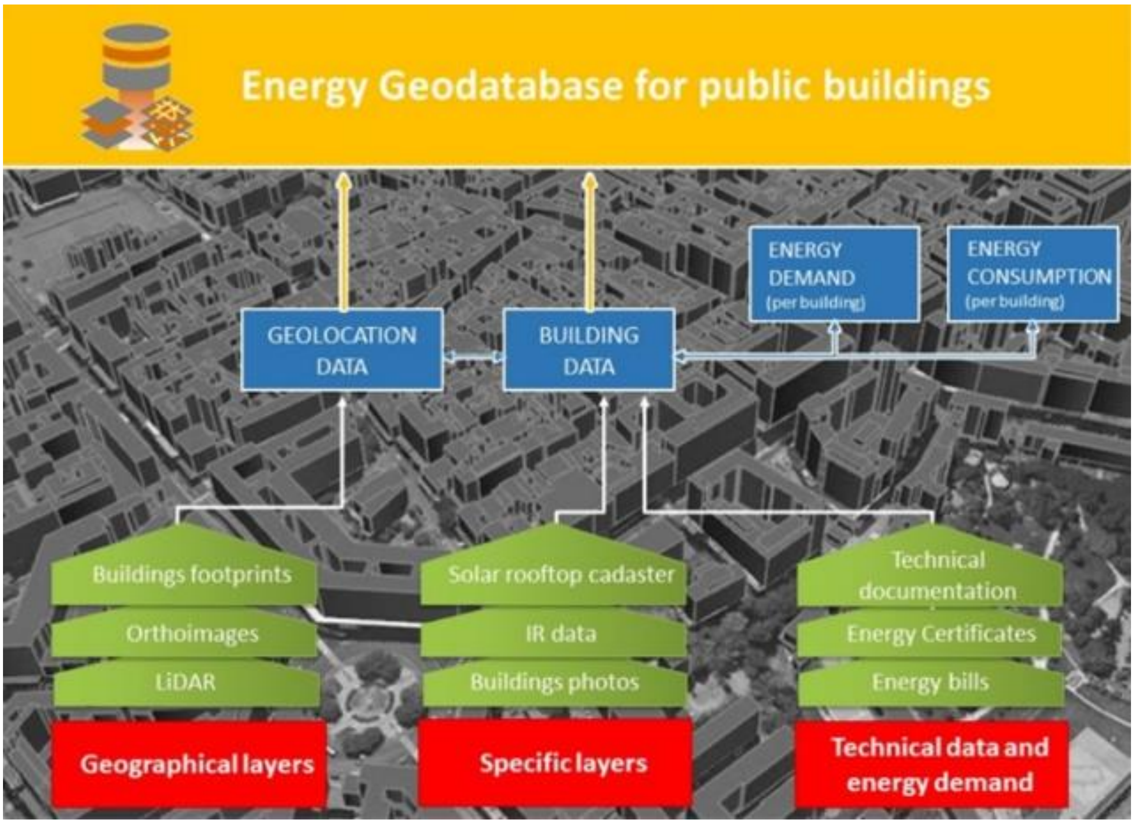


Figure 24: Source of spatial and non-spatial data to develop energy databases

The data is on a paper map and needs to be converted to a digital format to organize geospatial data and 3D building models for energy-related needs.

4.2. Generation of 3D building models and solar maps of building roofs

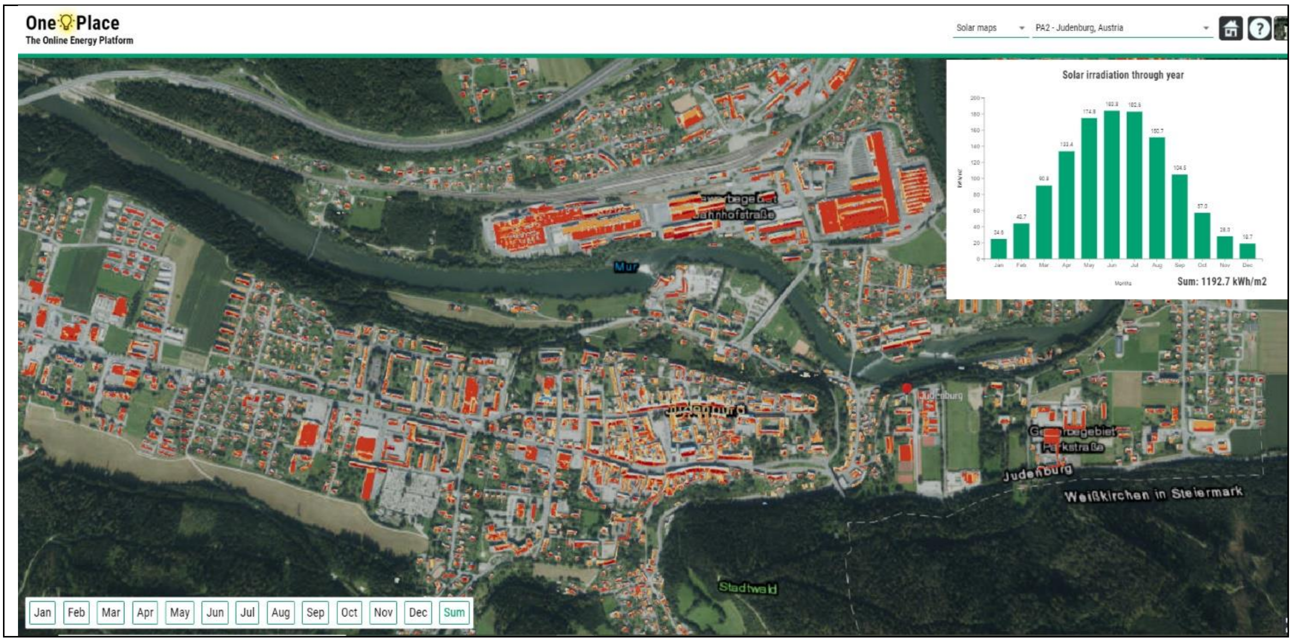
Generation of 3D Building Models (3D BM) in LOD1 or LOD2 format (Figure 25) rely on the available collected geodata harmonized and structured in geospatial databases (see chapter 4.3). Starting from these data, two methods have been adopted and upscaled in order to create the 3D building models:

a) building footprint with attribute information: the shp files of the PA's topographic maps contain locations and shapes of buildings. Each building (or group of buildings) is characterize by a polygon (its footprint) enriched with a table of information (generally called attributes). Among this information, we could find evidences of the building height or number of floors. Hence using extruding functions, a LOD1 building model can be generated. These 3D geometric entities keep the attributes and, in a dedicated viewer, can be queried to retrieve information;
b) LiDAR point clouds with building footprints: the 3D point clouds feature a variable density of points, going from few per square meter to some dozen points per square meter. The point clouds describe quite decently the shape of the buildings, particularly for the denser clouds. According to the point density, we have applied two methods:

- sparse point cloud (few points/sqm): geometric intersection of the point cloud with the available footprints, derivation of the highest point in the identified part of the cloud and extrusion of the footprint up to such height value to generate LOD1 building models.
- dense point cloud: geometric intersection of the point cloud with the available footprints, fitting of geometric primitives / shapes of building roofs to the identified part of the cloud and generation of LOD2 building models. The fitting procedure is performed in an iterative way, testing various roof shapes and identifying the shape leading to the smallest least square's residual.

Figure 25: Different Level of Detail (LoD) in 3D building models (source: TU Delft)

From the available geospatial data (see chapter 4.1 - in particular the Digital Surface Models – DSM), occlusions and shadowing effects should be considered and calculated in order to correctly estimate the incoming solar light (Direct, Diffuse and Global) on each roof. In the next figure the produced annual solar maps are presented for the areas with a high-resolution terrain model, trimmed using the available building footprints.



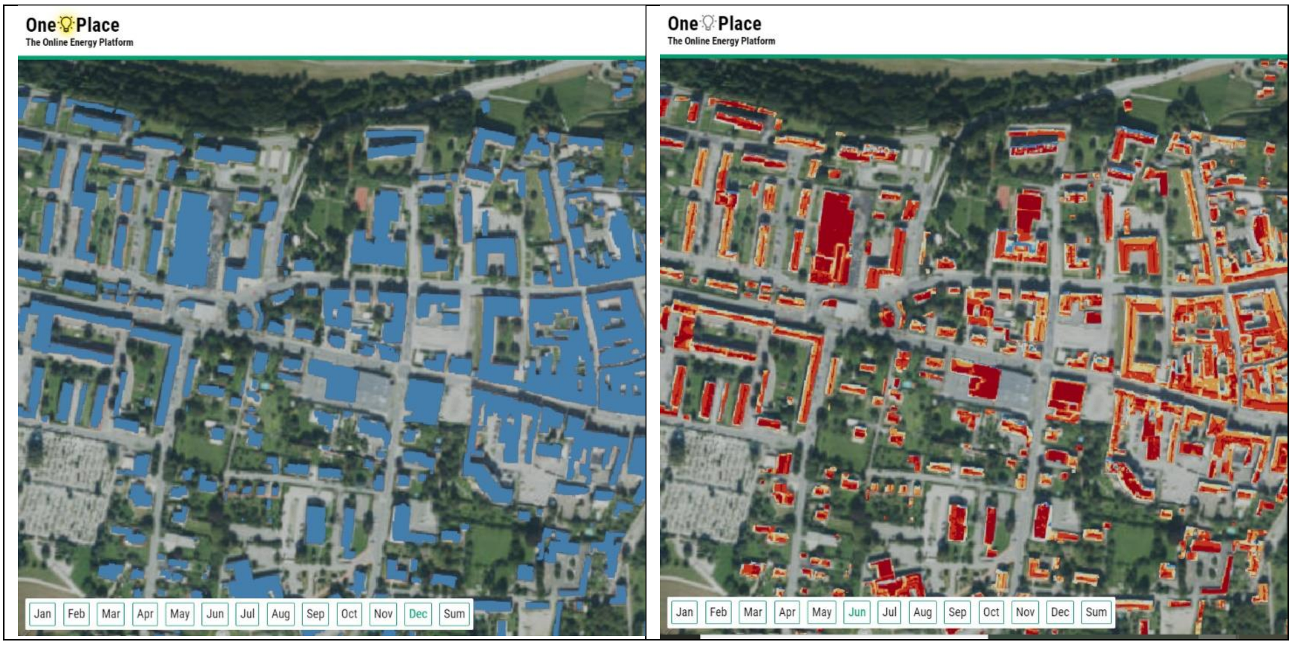


Figure 26: Judenburg-Lindfeld municipality (Austria) - photovoltaic PV maps in December (on the left) and June (on the right)

4.3. Energy data and additional information

Statistical and survey data sets (non-spatial data): this category comprises non-geographical data sets such as: construction plans, energy audit certificates, energy bills helpful to plan retrofits to save energy and improve energy efficiency. The information collected inside these data sets is always georeferenced (or can be) upon the geographical layers of the first category – figures or information related to every building.

A completed public building audit to create a GIS database should include the following information: (this scope can be extended and developed).

Field	Unit	Description
Official name	-	-
Year of construction	-	-
Building type	-	**Type of building:** residential, agricultural, civil, medical, educational, government, industrial, military, religious, transport.
Typology (number of floors)	-	-
Energy source type (heat)	-	**Type of the heat source:** geothermal energy, district heating, cogeneration unit, heat pump, biofuel boilers, solid fuel, electricity, natural gas, oil.
Energy audit	-	-
Energy consumption (heating)	GJ/year	-
Electricity consumption	kWh/year	-
The specific CO2 emissions	tons/year	-
The total CO2 emissions	tons/year	-
Technology used to harvest a renewable energy source	-	**Type of the technology:** photovoltaics (PV), solar collectors, biofuel boilers, heat pumps
Estimated photovoltaic potential of roof	kW	Calculated from the solar potential maps

EE measures already implemented in the building	-	**Type of the measures:** (i) reducing heating demand: improving the insulation, limiting the exposed surface area, reducing ventilation losses, selecting efficient heating system, new roof; (ii) reducing cooling demand, (iii) reducing energy use for lighting, (iv) reducing energy used for heating water, etc.
Recommended EE measures for the building	-	
Estimation of the amount of heating losses	MWh/year	-

Table 3: Public buildings audit data to create GIS database

Energy consumption and demand of buildings data (non-spatial data) can be obtained by:

- **monitoring energy consumption based on analysis of received bills**
  the easiest way of monitoring energy consumption is the analysis of received bills by the operator. Nevertheless, this method is outdated and consumes a lot of time during the operation comparing to other recent methods,
- **monitoring energy consumption with smart-metering technology (management of public buildings with new software that tracts consumption of individual building)**
  more recently, new smart-metering technology has been developed which can manage public buildings and monitor energy consumption. Information about energy consumption are shown on control panel.

The created geospatial databases allow to connect heterogeneous information (also non-spatial attributes available in the geoDB) with geometric/3D information, retrieving such info on demand and with specific tools.

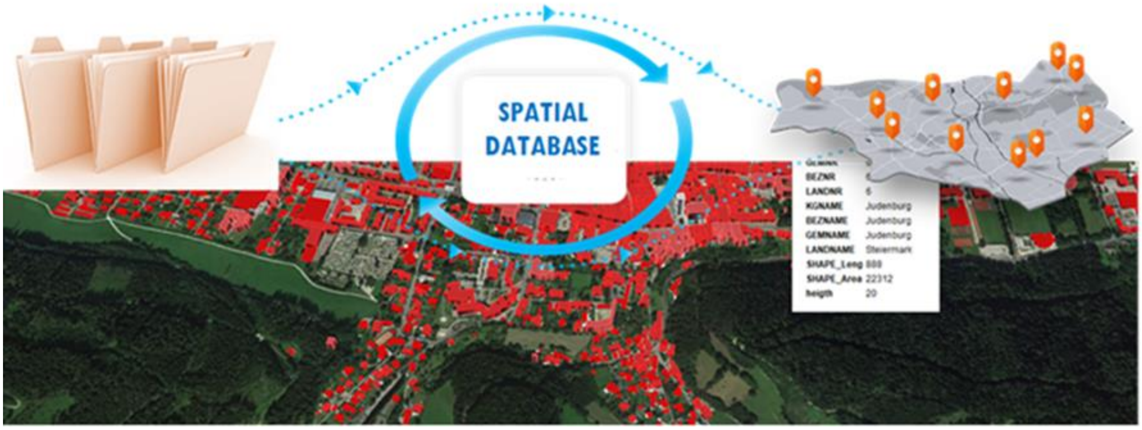


Figure 27: Data and geometry linking

All collected / generated information can be visualized online using OGC web platforms (e.g. Cesium). Queries can be performed producing new visualization scenarios in order to better understand energy flows, requests, etc.

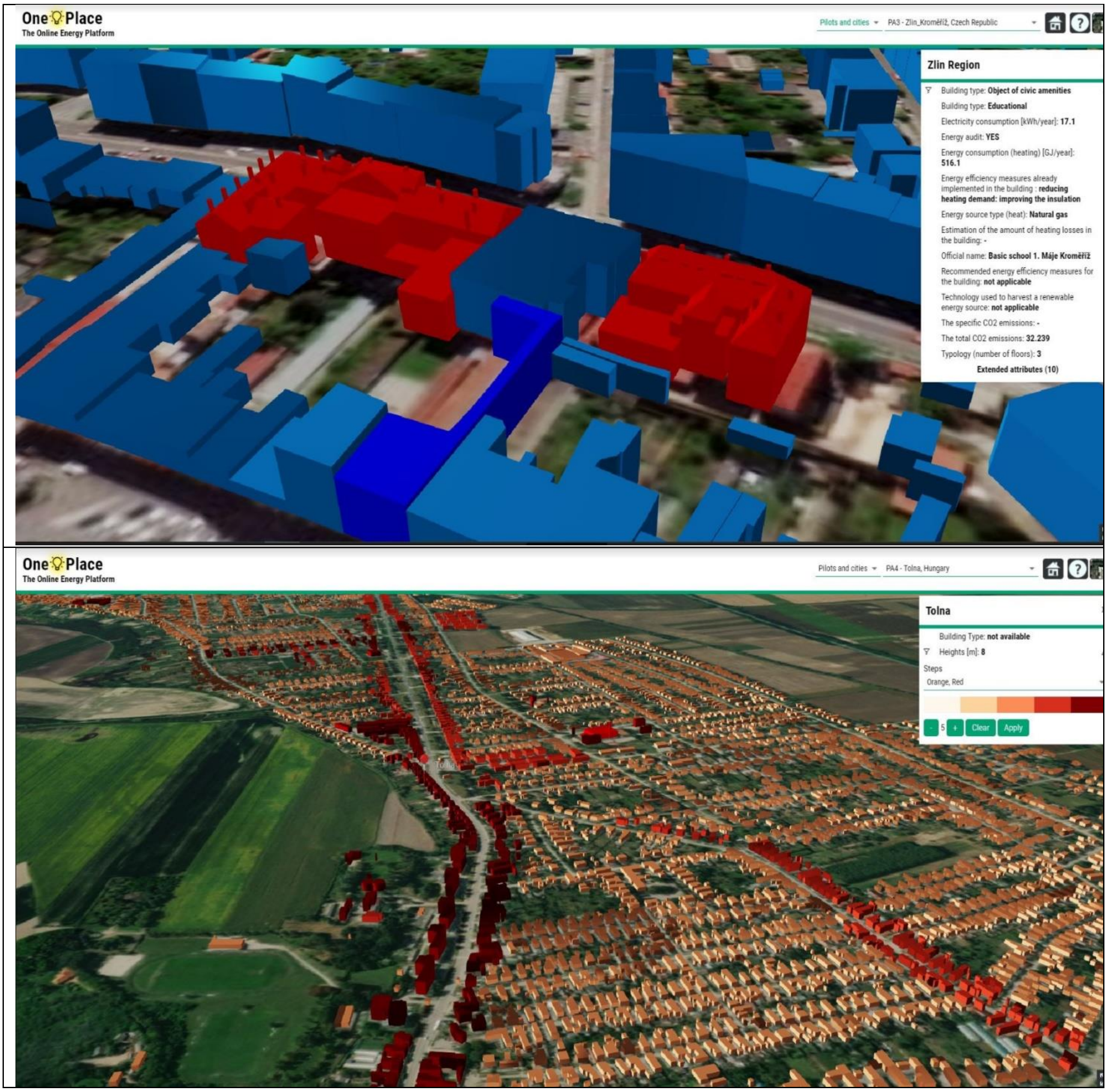


Figure 28: Data visualization on the web

4.4. Guidelines and metrics for sustainability and transferability

The guidelines are based on the promotion and dissemination of knowledge on energy efficiency measures in buildings, exchange of experiences and practices of carrying out EE investments in various political, social and technical conditions, raising the energy awareness of the society by publishing the best practice model and transferring to other facilities ending with cost savings, energy savings, pollution reduction and positive changes in society's behavior and attitude.

The results of the guidelines ensure the durability of the created tools through their repeatability and universality. They are as follows:

- creating a universal approach to modeling, visualization and presentation of buildings without dependence on the European region;
- creating best practice for saving energy, costs and CO_2 based on intelligent energy measurement and certification;
- ability to transfer results to other territories and interested parties, as the OnePlace platform can be implemented and find application in any region and under all conditions.

The indicators for sustainability and transferability are shown in Figure 29. They identify all significant aspects and at various scales from strategic documents developed to EE investments implemented, from countries implementing OnePlace to buildings defined in 3D EMS.

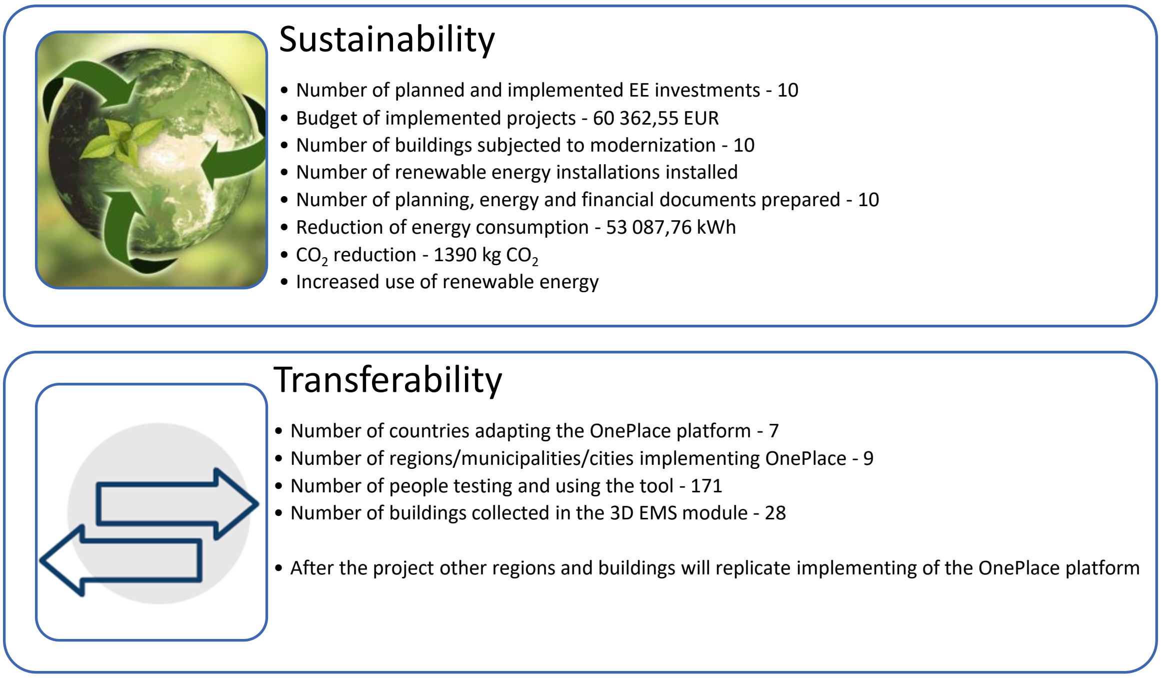


Figure 29: Sustainability and transferability indicators

5. Conclusions

This handbook introduces the new user to the content of OnePlace and provides tips on using the platform. In addition, it demonstrates and describes the need to use ICT tools to improve energy efficiency. It guides you step by step through the process of creating a 3D EMS module and an attached database. It presents approaches to the use of spatial and non-spatial data related to energy, which are based on GIS and 3D city models.

This handbook is mainly targeted at users dealing with public buildings, whether in the aspect of energy, planning, management or investment.

The study also deals with energy efficiency and available options for its improvement. It demonstrates how ICT, GIS and energy efficiency tools interpenetrate and support each other creating an innovative approach. It also presents the practices of using the 3D EMS module and OnePlace from 7 participating countries.

Finally, in the context of the more ambitious EU goals for energy efficiency, it is particularly important that recommendations for improvement in planning, targeting and monitoring investments are supported and linked to other areas, providing an interdisciplinary synergy that will bring greater benefits.

The platform was also created to stimulate investments in energy efficiency in the EU through the exchange of data and analysis of completed projects. We must use every tool available to encourage investments in energy efficiency and renewable energy. This is particularly important in stimulating the economy, both by launching large projects and supporting local SMEs and job creation.

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