METHODOLOGY FOR EVALUATING DEEP RENOVATION MEASURES OF PUBLIC BUILDINGS

Deliverable D.T1.2.2

Version 1

10 2018

The eCentral project summary

Addressing poor energy performances of public buildings is at the core of EU's Energy Efficiency Directive and Energy Performance Building Directive but also one of growing financial issues in Central European countries. To address that eCentral project will support key stakeholders to realize benefits of newly implemented building standard – nearly zero energy building (nZEB). eCentral project will prove that nZEB approach, although innovative, is optimal and cost-effective solution for renovation and construction of public buildings. Project aims to capitalise on results of previous and ongoing EU initiatives. Austria has a proven track record with nZEB renovation projects and will be leading other implementing partners (CRO, SLO, HUN) by example. Transnational cooperation will be used to receive maximum international visibility of selected pilot actions. Main outputs of the project are:

- energy performance certificate (EPC) Tool for public authorities
- deployment and promotion of innovative financing schemes
- training programme and project development assistance for nZEB projects
- building renovation strategies for selected regions
- state of the art pilot nZEB public buildings in selected regions
- established cooperation with scientific institutions and other nZEB initiatives

Transnational Assessment and Support Group, formed from project experts and scientific institutions will act as a support team and provide quality checks of each output. EPC Tool will be developed and used by public sector decision makers and project developers beyond eCentral project lifetime. Trained energy efficiency teams within the regional government will serve as a backbone for conducting future nZEB projects. The European Academy of Bolzano (EURAC), one of the leading centres of expertise on energy efficiency in the Central Europe region, will focus on policy analysis and dissemination of eCentral project results.

About this document

This document is part of activity A.T.1.2 of work package T1 and named D.T.1.2.2 "Methodology for evaluating deep renovation measures of public buildings". Energy Agency of Styria (EASt) is responsible for this deliverable. The output should be the development of a methodology for assessment of potential cost-effective nZEB measures and energy consumption forecasting selected from D.T1.2.1 will be chosen/adapted according to the needs of Living EPC Tool (D.T1.4.2) and Regional/Local renovation roadmaps (D.T2.4.2).

TABLE OF CONTENT

A. Report Summary

As the Living EPC tool is a core part of the EU-project eCentral there has to be an intense research prior to its development. This report gives concrete advices for the calculation methodology for the assessment of cost-efficient measures and energy consumption forecasting. Furthermore, this report gives proposals for the methodology for the process of the calculation by describing the input parameters, parameters needed in a central database, renovation measures and results from the tool.

For the theoretic background the "Comparative methodology framework EPBD to identify cost-optimal levels for nZEB renovation measures (DIRECTIVE 2010/31 Annex III)" was analysed. In a next step the tool Ecocities, that was determined in deliverable DT1.2.1. as one of the best fitting tools regarding the needs of the EPC tool. Therefore, Ecocities was analysed concerning its overall and specific calculation and assessment methodologies.

Derived from this research the overall methodology for the EPC tool was developed. Concerning the input parameters, the need for basic and advanced input values was identified because the users will have different information on their buildings and a list of needed input values was created.
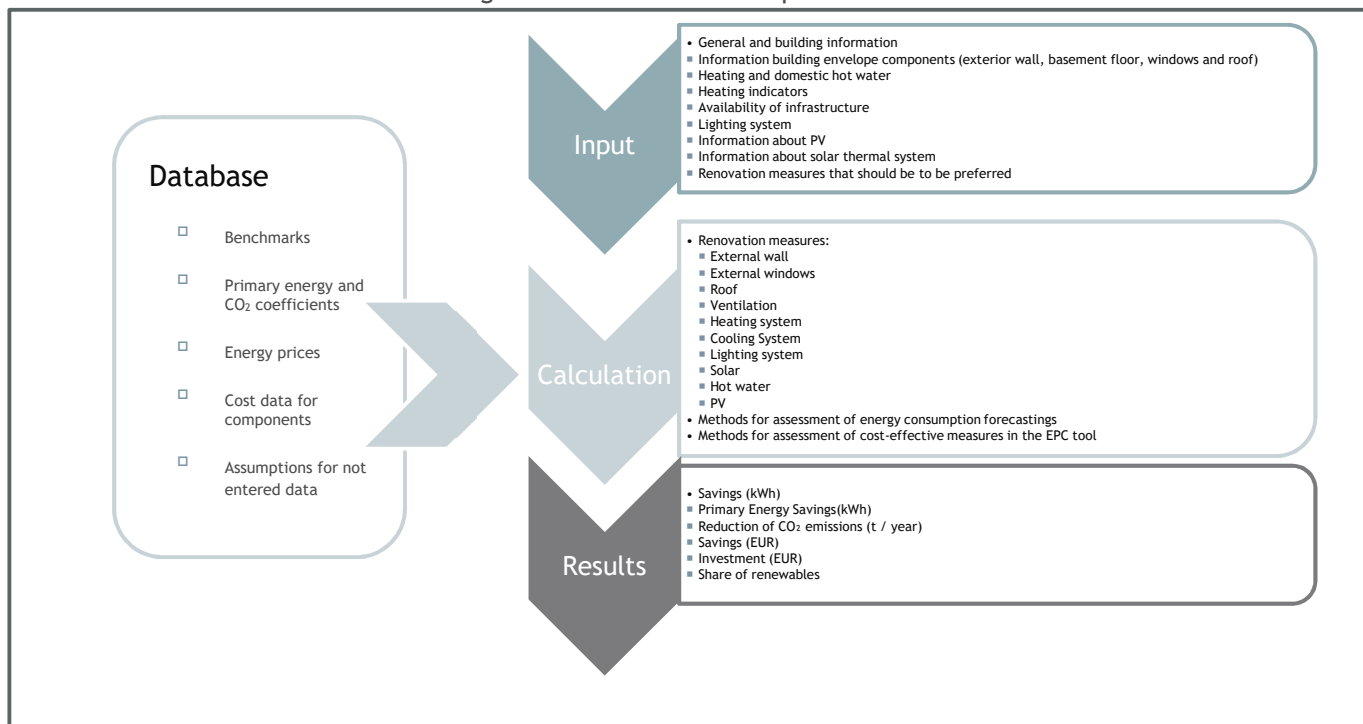

Database

- ☐ Benchmarks
- ☐ Primary energy and CO_2 coefficients
- ☐ Energy prices
- ☐ Cost data for components
- ☐ Assumptions for not entered data

Input

- General and building information
  - Information building envelope components (exterior wall, basement floor, windows and roof)
  - Heating and domestic hot water
  - Heating indicators
  - Availability of infrastructure
  - Lighting system
  - Information about PV
  - Information about solar thermal system
  - Renovation measures that should be to be preferred

Calculation

- Renovation measures:
  - External wall
  - External windows
  - Roof
  - Ventilation
  - Heating system
  - Cooling System
  - Lighting system
  - Solar
  - Hot water
  - PV
- Methods for assessment of energy consumption forecastings
- Methods for assessment of cost-effective measures in the EPC tool

Results

- Savings (kWh)
  - Primary Energy Savings(kWh)
  - Reduction of CO_2 emissions (t / year)
  - Savings (EUR)
  - Investment (EUR)
  - Share of renewables

Figure 1: Overall methodology for the EPC tool

The need of a database that supports the calculation was recognized and the necessary input into the database was recorded.

In a next step the renovation measures were defined and as a core part of this report the methodology to assess the energy savings and the cost-effectiveness was evaluated.

Finally, the results that shall be displayed were identified and listed according to the identified needs of the Living EPC tool.

B. Introduction

The EPC tool should aim to calculate the most cost-effective set of energy efficiency measures to achieve nZEB standard in public buildings. According to the results of DT1.2.1 the Living EPC tool shall be simple to use and available in each national language of the target regions (SLO; HR; HU). The inputs shall be the same in all three countries, but the output format can differ depending to the countries. The methodology for the calculation will still be the same in all variations. As the completed assessment shows, it is not only mandatory to provide information within the tool but also a detailed planned enrolment with periodic revisions. It shall also assist public authorities to adequately interpret the information on EPCs. Another requirement for the tool is to implement existing information from energy performance certificates (EPC).

Summarized the main requirements are:

- A library for making building inputs easy (also free input with real values shall be possible),
- A database for refurbishment costs as well as implementing obtained offers,
- The ability to set preferences throughout the refurbishment (exclude building parts, focus on primary energy demand, CO_2, …),
- Real energy prices (linked to online portal or something similar)
- Provide several refurbishment measures to analyse the differences
- A two-level software with an end-use interface as well as an expert client/portal,
- A result, which shows the most cost-optimized refurbishment
- Simple and as little as possible input from user
- Tool shall be translated in all national languages
- Same input for all countries
- Calculation methodology consistent
- Assumed values should be able to update
- Implement existing data from EPCs

1. Anaysis of the European methodology framework for nZEBs

To get an overview at the beginning of the research for the best fitting methodology for the Living EPC tool the European methodology framework for nZEBs that is described in the EPBD (Energy Performance of Buildings Directive) was analysed. This is a fundamental starting point to understand the calculation methodologies for the assessment of nZEB buildings measures. The calculation methodology in the EPBD was designed to support the EU countries to implement and develop their nZEB standards and definitions.

The EPBD (Energy Performance of Buildings Directive) is the European Union's main legislative instrument aiming to promote the improvement of the energy performance of buildings within the member states. (European Comission, 2017) It was inspired by the Kyoto Protocol in which the EU and all its parties commit to binding emission reduction targets. (United Nations Framework Convention on Climate Change, 2017) The first version was promoted in 2002. (European Commission, 2003) The directive targets, that the member states strengthen their building regulations and the introduction of energy performance certificates was required. Further the establishment for inspection schemes of heating and air conditioning systems were prescribed. The term "nZEB" was introduced and the member states shall set minimum energy performance requirements for new buildings, for buildings subject to major renovation, as well as for the replacement or retrofit of building elements. It is also stated that all new buildings shall be nearly zero energy buildings by 31 December 2020 and the same applies to all new public buildings after 31 December 2018. (European Comission, 2017)

1.1. Analysis "Comparative methodology framework EPBD to identify cost-optimal levels for nZEB renovation measures (DIRECTIVE 2010/31 Annex III)

The EPBD directive (DIRECTIVE 2010/31/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 19 May 2010 on the energy performance of buildings) ANNEX III is used as a guideline for a comparative methodology framework to identify cost-effective nZEB measures. Energy consumption forecasting is implemented in this comparative methodology and calculated in the framework. This comparative methodology framework will here be analysed.

The comparative methodology framework shall allow for taking into account the following (Official Journal of the European Union, 2010)

- Use patterns
- Outdoor climate conditions
- Investment costs
- Building category
- Maintenance and operating costs
- Earnings from energy produced (where applicable)
- Disposal costs (where applicable)

Figure 2 gives an overview of the procedure of the calculation of the cost optimal performance and summarizes the methodology framework.
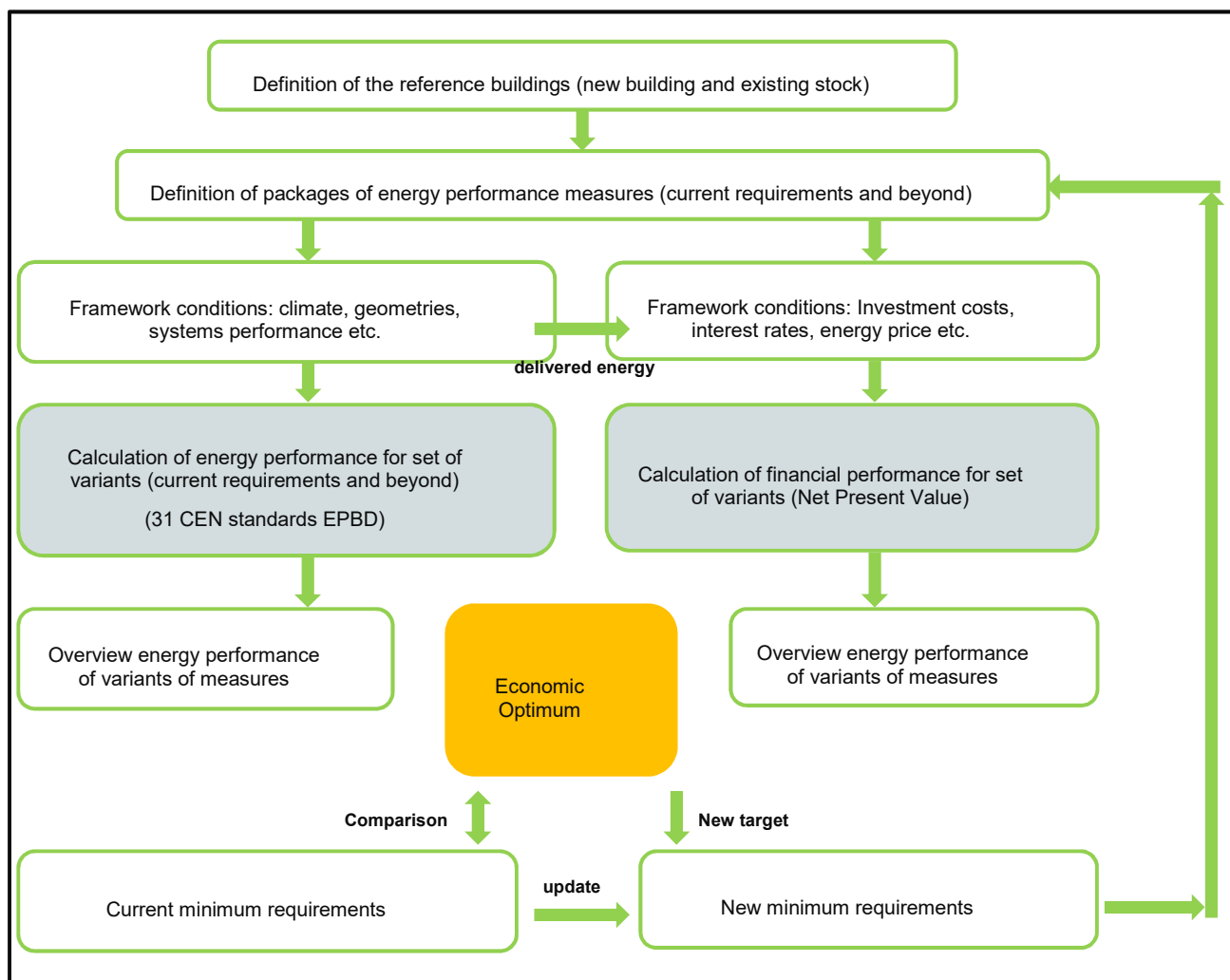
Figure 2: Overview of the procedure to calculate and implement cost optimal performance requirements, inspired by: (Thomas Boermans, 2015)

The main steps to determine this cost-effective nZEB measures in the EPBD are (Official Journal of the European Union, 2010):

1. Define a reference building/buildings

    Define reference buildings that are characterised by and representative of their functionality and geographic location, including indoor and outdoor climate conditions. The reference buildings shall cover residential and non-residential buildings, both new and existing ones.

2. Define energy efficiency measures

    Define energy efficiency measures to be assessed for the reference buildings. These may be measures for individual buildings as a whole, for individual building elements, or for a combination of building elements.

3. Energy calculation for reference building and deep renovation versions

4. Assess the final and primary energy need of the reference buildings and the reference buildings with the defined energy efficiency measures applied

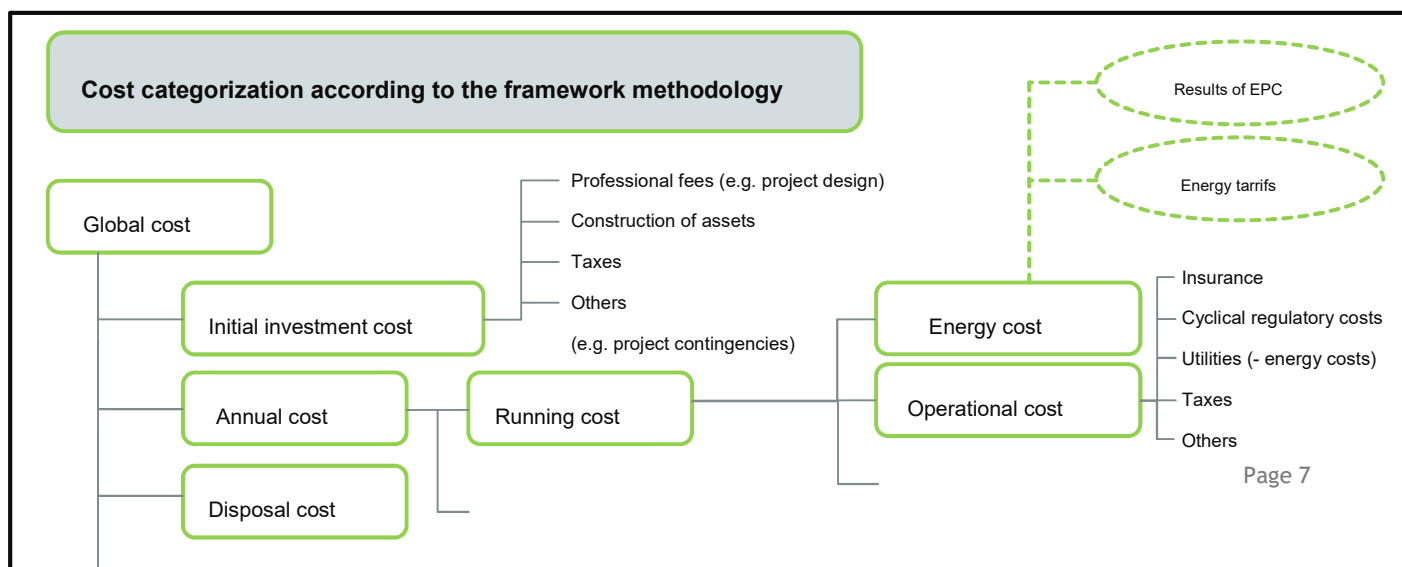5. Calculate the costs of the energy efficiency measures

Calculate the costs (net present value) of the energy efficiency measures (as referred to in the second indent) during the expected economic lifecycle applied to the reference buildings (as referred to in the first indent) by applying the comparative methodology framework principles.

By calculating the costs of the energy efficiency measures during the expected economic lifecycle, the cost-effectiveness of different levels of minimum energy performance requirements is assessed by the Member States. This will allow the determination of cost-optimal levels of energy performance requirement.

The calculation of the net present value (financial performance) of the variants is calculated according to the "global cost" methodology within EN 15459 "energy performance of buildings – economic evaluation procedure for energy systems in buildings" representing a „lifecycle cost analysis".

Figure 3 shows the cost categories according to the framework methodology.

Cost categorization according to the framework methodology

Global cost
- Initial investment cost
  - Professional fees (e.g. project design)
  - Construction of assets
  - Taxes
  - Others (e.g. project contingencies)
- Annual cost
  - Running cost
    - Energy cost
    - Operational cost
      - Insurance
      - Cyclical regulatory costs
      - Utilities (- energy costs)
      - Taxes
      - Others
- Disposal cost
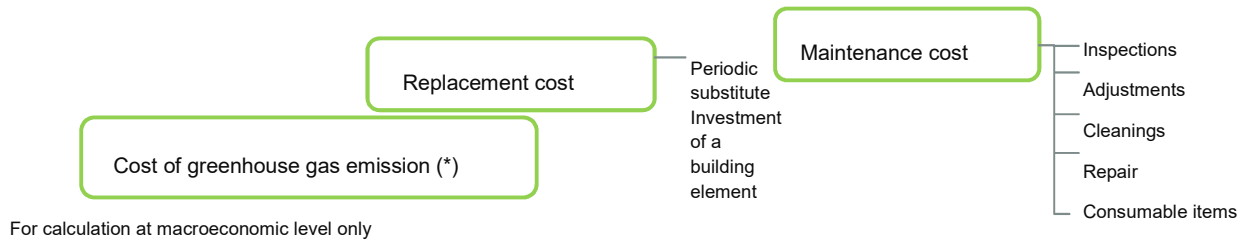
Results of EPC

Energy tarrifs

Figure 3: Cost categorization according to the framework methodology inspired by (Thomas Boermans, 2015)

2. Analysis of calculation methodologies

One of the core elements of this report is the analysis of methodologies for the assessment of cost-effective renovation measures and energy forecasting. A detailed look into common methods used for these methodologies is given in this chapter.

2.1. Methods for assessment of cost effective measures

Profitability methods can basically be differentiated into static and dynamic methods.

2.1.1. Static economic efficiency calculation

In the case of the static settlement procedures, the dates of the deposits and disbursements are not considered or are not taken into appropriate account. It is usually considered only a period of time, which is not representative and meaningful for multi period considerations. The simple handling is advantageous even with very little information. For investment decisions in energy-efficient building construction, however, these methods are unsuitable because they are expected here with long useful lives and by no means static price developments. In order to make a plausible statement about the profitability of variants, it is necessary to consider interest-rate effects as well as the timing of the inflows and outflows. (Energieinstitut Vorarlberg, 2012)

2.1.2. Dynamic economic efficiency calculation (net present value)

The main point of the dynamic procedures is the time consideration of the deposits and disbursements with the help of the compound interest calculation. By up-or discounting (adding and discounting) payments on a common reference date, these are made comparable. The classic dynamic methods include the net present value method (NPV), the internal rate of return method, the annuity method and the amortization comparison calculation. (Energieinstitut Vorarlberg, 2012)

Net Present Value (NPV) is the basis for all dynamic investment calculation procedures, as it is more or less possible to derive all others from it. The NPV makes investment alternatives comparable by discounting their cash and cash equivalents to a common reference date (primarily the date of the initial investment). Discounting is done with a predetermined costing rate. If the net present value of an investment is greater than 0, the investment is considered to be economic. Thus, a surplus is realized over the minimum return defined by the calculation interest rate. If the capital value is below 0, the alternative is not profitable. In a variant comparison, the one which gives the highest net present value is to be preferred. (Energieinstitut Vorarlberg, 2012)

2.2. Methods for assessment of energy consumption forecasting

The heat balance of a building includes all sources and losses of energy inside a building, as well as all energy flows through its envelope. This envelope encloses the volume which is kept above a set temperature (in general 20 °C) for all weather conditions by the use of heating energy. The extend of all heat flows, which do hereby occur, is either dependent on external or internal influence factors (weather, user). These heat flows can be arranged into five categories (Uni Siegen, 2002):

- Transmission losses LT are those amounts of heat, which flow through the building envelope from inside to outside by conduction or heat transfer, respectively.

- Ventilation losses LV are caused by exchange of warm indoor air with colder outdoor air. The user independent air exchange is through joints by infiltration or exfiltration, respectively. In addition, room air can be exchanged through open windows or by a mechanical ventilation system. Ventilation is indispensable, up to a certain extent, to assure the hygienically necessary air exchange rate.

- Solar gains GS are irradiations of solar energy through windows and other transparent or translucent constructional elements. Also added to the solar gains, is that part of the solar heating of the opaque building envelope, from which the indoor area benefits.

- Internal gains GI are heat outputs from persons, appliances, computers and other electric devices, as well as from illumination.

- Heating demand H is exactly that amount of energy, which is necessary to maintain the desired room temperature by compensating the excess of transmission and ventilation losses compared to the gains.

End energy whereas is the energy consumed by the consumer, such as fuels and fuels or electrical energy. Final energy should be distinguished from the primary energy from the natural sources used, but also from the ultimate useful energy and the benefits of the energy application. This benefit - such as keeping a house warm - is often not quantifiable as an amount of energy. (Paschotta, 17)

Final energy is also not always identical to the type of energy ultimately used by the consumer. For example, a consumer may receive final energy in the form of electrical energy and thus generate low temperature heat, either with an electric heater or an electric heat pump. Depending on the type of heat generation, very different amounts of required final energy result. (Paschotta, 17)

2.2.1. Real consumption data

A further opportunity to identify the consumption of a building is to identify the real consumption data. This can be done by measuring the consumption of all energy flows into the building. This can be done by measurement devices or just really simple by analysing energy bills, where the amount of kWh in a period is specified.

2.2.2. Dynamic building simulation

In the dynamic simulation, a realistic model of the object to be examined is imaged. A climate data set for the respective location is deposited in the calculation in order to record the external influences and to incorporate them. (AlpSolar, 2018)

Opportunities of dynamic building simulation can consider time-dependent (AlpSolar, 2018)

- Solar radiation through glass surfaces

- Influences of different shading systems

- Heating and humidifying the building by internal loads, e.g. Persons, PC, lighting or machines

- Room and surface temperatures depending on the heating and cooling system used

The field of application of dynamic simulations lies at the interface between object planning and building services planning, i.e. where architects and engineers should cooperate with an integral planning approach. (AlpSolar, 2018)

3. Analysis of existing tool "Ecocities"

Regarding the results of deliverable DT1.2.1. the Tool "Ecocities" was determined as one if the best fitting tool regarding the needs of the EPC tool. The tool CERPlan is due to lack of information and access not analysed in this report. In this chapter the tool Ecocities is analysed according to its input parameters the optimization indicators the considered renovation measures, the results and the calculation methodology. This is done to understand the methodology of a tool that is similar in function and results to the Living EPC tool. A further consequence is, that the methodology for the Living EPC tool can be deduced from the results of this analysis.

3.1. Input Data

To perform a calculation input data is needed. This input is made in an online mask and is quite complex and captures a lot of values for a building. Below all the input parameters and the appropriate units are listed.

- General information
    - ID
    - Lot Number
    - Description
    - Utility type
    - Utility type addition
- Building Information
    - Gross floor area (heated, in m²)
    - Scope of the building (to unconditioned areas, in m)
    - Construction year
    - Year of construction 2
    - Gross volume (in m³)
    - Building envelope (in m²)
    - Building type (new or renovated, preservation)
    - Compactness
    - Design
    - Ventilation
    - Mean U-value (in W/(m²K))
    - LEK value
    - Building height (in m)
- U-values
    - Exterior wall (in W/(m²K))
    - Basement floor (in W/(m²K))
    - Basement ceiling (in W/(m²K))

- Top floor ceiling (in W/(m²K))

- Window (in W/(m²K))

- Roof (in W/(m²K))

- Transmission losses (in kWh/(m²a))

- Ventilation losses (in kWh/(m²a))

- Heating load (in kW)

- Inner wall (in W/(m²K))

- Information about prior renovations

- Heating and domestic hot water

  - Year of installation (in a range or exact value)

  - Heating technology type

  - Heating heat supply location

  - Heating type of energy carrier

  - Boiler / system power (in kW)

  - Chimney available

  - Heat delivery system

  - Hot water technology type

  - Hot water heat supply location

  - Hot water type of energy carrier

- Heating indicators

  - Heating demand (gross floor area, in kWh/(m²a))

  - Heating demand (volume, in kWh/(m²a))

  - Hot water heat demand (in kWh/(m²a))

  - Heating technology energy requirement (space heating, in kWh/(m²a))

  - Heating technology energy demand (hot water, in kWh/(m²a))

  - Heating energy demand (total, in kWh/(m²a))

  - Heating energy demand (in kWh/(m²a))

  - Final energy consumption (in kWh/(m²a))

- Availability of infrastructure

  - Gas

  - District heating

- Geometry

  - Gross area (outer wall, in m²) (and also divided into compass direction)

  - Gross area without windows / doors (in m²)

- Window areas (in%)
- Floor area (in m²)
- Top floor ceiling (thermally relevant, in m²)
- Roof area (in m²) (also potential PV area)
- Roof area (thermally relevant, in m²) (and also divided into compass direction)
- Ground floor earth-touched
- Interior wall surfaces (thermally relevant)

- Consumer (light bulb type)
- Information about PV
  - Power (in kWp)
  - Yield (in kWh)
  - Surface (in m²)
  - Orientation
  - Installation Type
- Information about solar thermal system
  - Technology type
  - Alignment
  - Usage
  - Surface (in m²)
- Measures considered
  - Tick on and off measures that you want to prefer or not
- Values for economic calculation
  - Inflation rate (in %)
  - Calculation period (in years)
  - Feed-in tariff PV electricity (in €/kWh)
  - Calculated interest rate (in %)

3.2. Renovation measures

The component wise renovation measures can be suggested automatically or selected from pre-defined options. In the automated calculation there is the possibility to define additional information to the renovated components. It can be selected if the component should be maintained unchanged, optimized or definitely renovated.

Building components that can be optimized for renovation are:

- Basement ceiling
- Exterior walls

- Windows

- Top floor ceiling

- Roof

- PV system

- Solar thermal system

- Heat distribution (space heating)

- Heat distribution (hot water)

- Energy carrier (space heating)

- Energy carrier (hot water)

- Heating system configuration

3.3. Results

Ecocities automatically identifies energy efficiency measures capable to reach the desired target values in terms of overall budget constraints, CO_2 emission targets, and energy cost reduction goals. For each strategy Ecocities provides payback time and detailed advice on measures which have to be implemented to reach the set energy efficiency goals.

Displayed results in detail are:

- Heating demand

- Primary energy demand

- Investment costs

- Running costs per year

- Total annuity

- CO_2 emissions

- Share of renewable energy sources

- Energy production

- Amortization (initial investment)

3.4. Methodologies of the tool

The process of the Ecocities tool is shown in the graph below. A database is complementing the input parameters to be calculated to results.
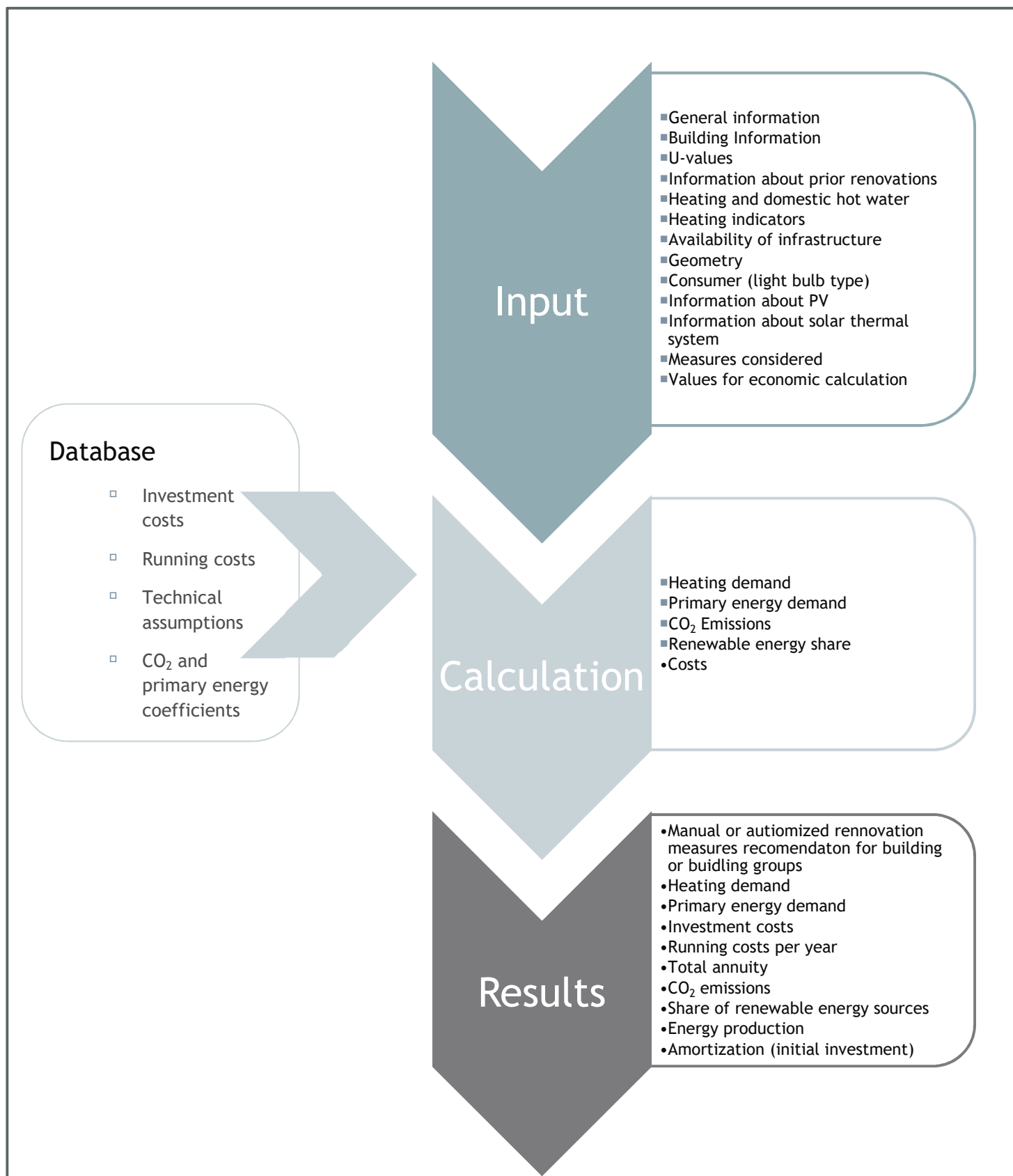
Input

- General information
- Building Information
- U-values
- Information about prior renovations
- Heating and domestic hot water
- Heating indicators
- Availability of infrastructure
- Geometry
- Consumer (light bulb type)
- Information about PV
- Information about solar thermal system
- Measures considered
- Values for economic calculation

Database

- Investment costs
- Running costs
- Technical assumptions
- CO_2 and primary energy coefficients

Calculation

- Heating demand
- Primary energy demand
- CO_2 Emissions
- Renewable energy share
- Costs

Results

- Manual or autiomized rennovation measures recomendaton for building or buidling groups
- Heating demand
- Primary energy demand
- Investment costs
- Running costs per year
- Total annuity
- CO_2 emissions
- Share of renewable energy sources
- Energy production
- Amortization (initial investment)

Figure 4: Calculation methodology of the Ecocities tool

3.4.1. Methods for assessment of cost-effective measures

The costs are also calculated in different ways in order to be able to model a complete picture of the monetary outlay: Costs are first divided into investment costs and running costs per year and the deviation in percentage, whereby the total annuity is considered in the optimization. As a result, different cost aspects such as required reinvestment (due to expected service life of measures), different running costs (energy costs, maintenance) and the amortization of the investment costs can be modeled and calculated. Savings or additional costs are also indicated by using colours green (savings) and red (additional costs). Costs are calculated with a static and a dynamic economic calculation.

The results are summed up and categorized into dynamic and static calculations:

- Static economic calculation

    □ Investment costs

    □ Running costs per year

    □ Amortization time (initial investment)

- Dynamic economic calculation

    □ Total annuity

3.4.2. Methods for assessment of energy consumption forecasting

For determining the heating demand, the building envelope, which is significantly influenced by the application of thermal renovation measures, must be considered. The heating demand is calculated according to the input of a lot of specific values. It is not calculated according to real energy consumption data. The calculation is based on a total energy balancing method that considers all the internal and external gains (passive solar heat, internal heat gains and gains by solar thermal systems) and external losses (transmission losses and ventilation losses) and the efficiency factors for boiler and heat distribution.

The calculation of the primary energy demand now includes the heating demand, as well as other energy requirements (household / operating electricity, heating energy demand, final energy demand, etc.) and the building services (i.e. used energy sources for space heating and hot water), considering the interdependencies of the measures of the calculation methodology become.

The primary energy demand and the CO_2 emissions are calculated by multiplying the final energy of the building with the respective factors. These factors are predefined and can be changed in the database.

The indicators summarized are

- Heating demand

- Primary energy demand

- CO_2 emissions

- Share of renewable energy sources

4. Methodologies for the EPC tool

The EPC tool should aim to calculate the most cost-effective set of energy efficiency measures to achieve nZEB standard in public buildings. Users with different backgrounds shall be able to use it with their range of possible input to the tool. Therefore, the tool also has to deliver results with really less obtained technical information of the building. That is why a database with assumed values that help the tool to identify renovation measures to suggest. As the benchmark is always the nZEB standard, that varies in the partner countries, the output parameters and the calculation methods for the suggested renovation measures always have to be adapted. In the Living EPC tool, several components for energy efficiency measures have to be included to cover a broad range and give the decision makers options to secure an implemented nZEB standard.

Derived from the EPBD methodology framework and the methodology of the Ecocities tool and adjusted to the needs of the EPC tool the following process for the calculation of suggested nZEB relevant renovation measures was determined:

1. Give inputs to the tool that define the status quo of the building and gives the calculation a reference. Different layers of input can be foreseen for different information of user

2. Define the benchmarks the measures are accordingly calculated for (in this case this will be at least the defined nZEB standards in the partner countries)

3. Calculation of energy related impact of different pre-defined renovation measures and combinations. This means assessing the results regarding energy consumption aspects and calculation of savings

4. Calculate the costs of the energy efficiency measures

5. A database has to support the calculation cause assumed values and benchmark values and technical and cost information have to be provided

6. Bring the results in an easy to understand format and give suggestions relating to different benchmark values
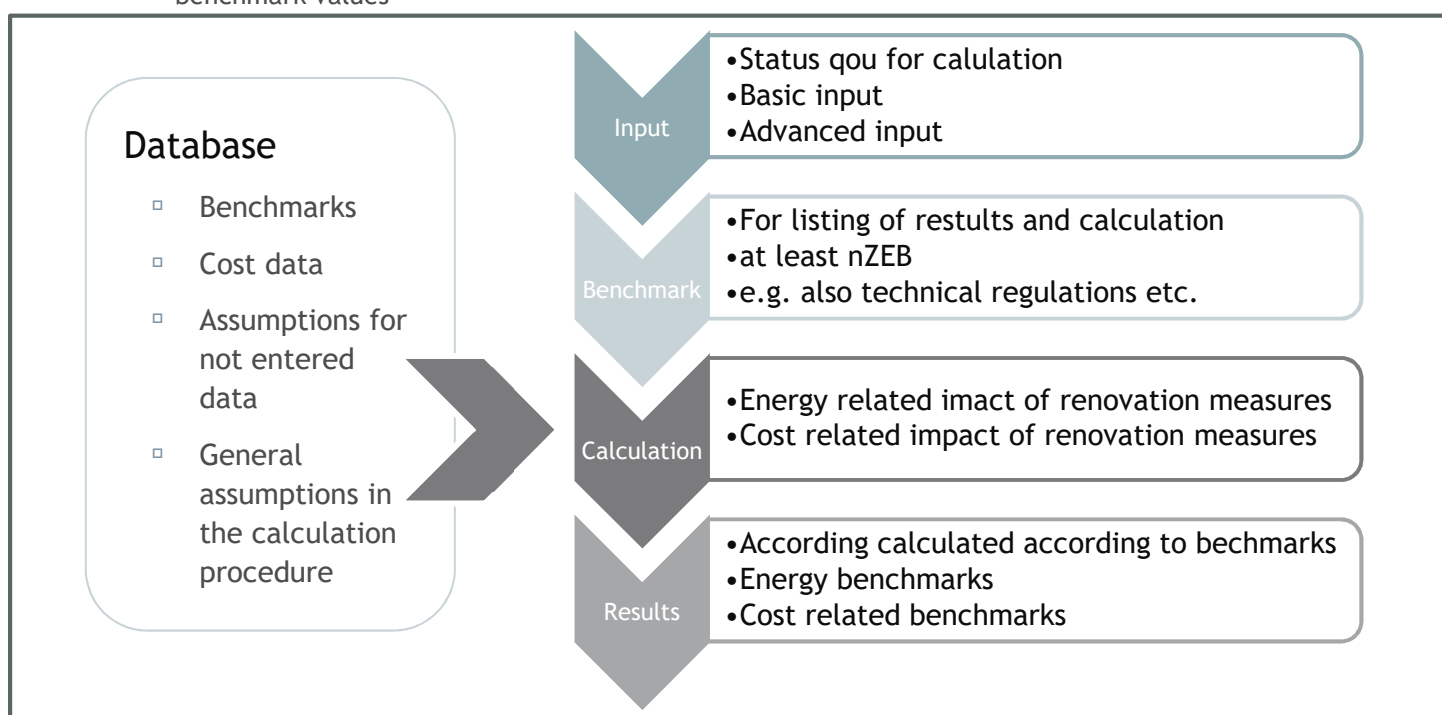

Figure 5: Calculation methodology for the EPC tool

4.1. Input parameters for the Living EPC tool

The input parameters are the basis for the calculation. They state the status quo of the building and give information's about the building construction the user and the needed energy. Not all of the data will be available in every case. There is a minimum amount of needed data that is required for the calculation procedure. Data that is not available has to be assumed by values from the database. The more information provided, the better will the recommendations for renovation measures be. This basic set of data has to be analysed and is called the "basic input" for the tool. "Advanced input" can come from already made EPCs from an energy audit or from other energy or cost related calculations.

- General and building information
    - Data entered by whom
    - Location
    - Building typology
    - Construction method
    - Construction year
    - Working hours
    - Description*
    - Gross floor area (heated, in m²)
    - Gross volume (in m³) (or floors and room heigth)
    - Unitary prices for energy used in the building
    - Ventilation
- Information building envelope components (exterior wall, basement floor, windows and roof)
    - Component area (m²)
    - Thickness of insulation
- Heating and domestic hot water
    - Year of installation (in a range or exact value)
    - Heating technology type
    - Heating type of energy carrier
    - Boiler / system power (in kW)
    - Heat delivery system
    - Hot water technology type
    - Hot water heat supply location
    - Hot water type of energy carrier
- Heating indicators
    - Heating demand (gross floor area, in kWh/(m²a))
    - Hot water heat demand (in kWh/(m²a))
    - Heating technology energy requirement (space heating, in kWh/(m²a))

- Heating technology energy demand (hot water, in kWh/(m²a))

- Heating energy demand (total, in kWh/(m²a))

- Final energy consumption (in kWh/(m²a))

- Availability of infrastructure

  - Gas

  - District heating

- Lighting system

  - Type of used lightbulbs

  - Number of lightbulbs

  - Installed Watts for lighting

- Information about PV

  - Power (in kWp)

  - Yield (in kWh)

  - Surface (in m²)

  - Orientation

  - Installation Type

- Information about solar thermal system

  - Technology type

  - Alignment

  - Usage

  - Surface (in m²)

- Renovation measures that should be to be preferred

  - Priorate renovation measures

4.2. Database for the Living EPC tool

The database has to support the calculation cause assumed and benchmark values and technical and cost information have to be provided. The database and its values have to be updated regularly. The main categories for information the database has to cover are listed in the graph below.
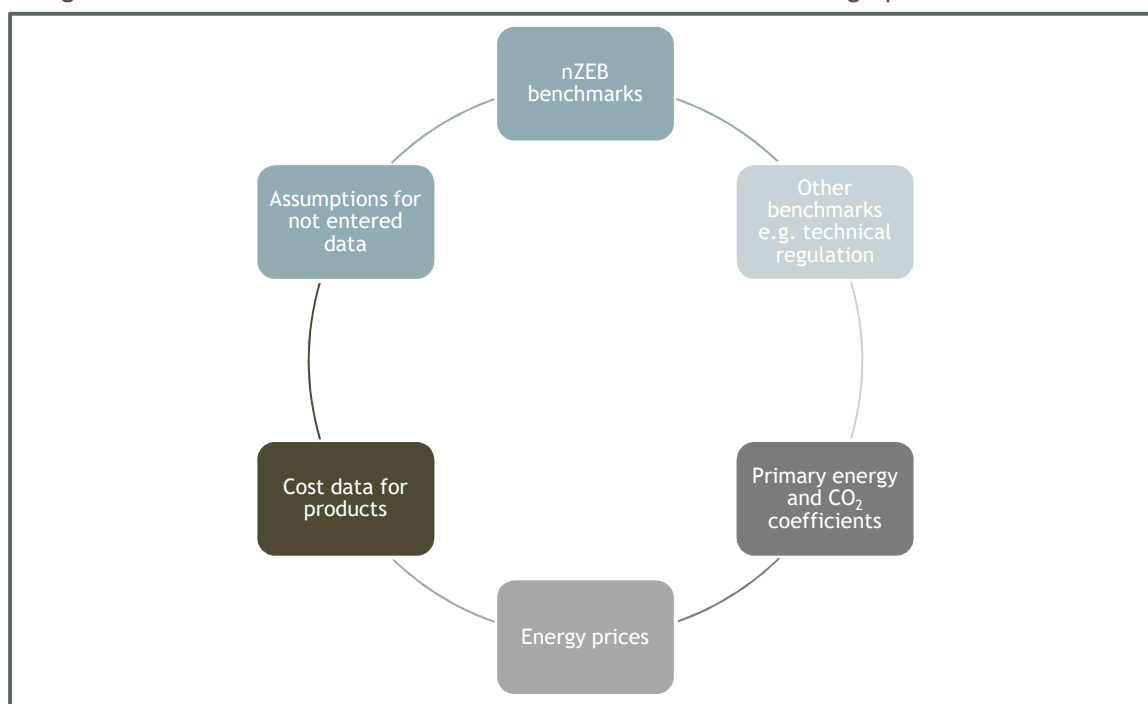

Figure 6: Components in the EPC database

4.2.1. nZEB benchmarks

These are country specific and were identified in the project deliverable DT1.1.1. "nZEB initiatives in Central Europe" and should be implemented in the database.

4.2.2. Other benchmarks e.g. technical regulation

These are country specific and have to be evaluated before implementation in a database.

4.2.3. Primary energy and CO_2 coefficients

These also have to be identified for the partner countries where the Living EPC tools is implemented.

4.2.4. Energy prices

Energy prices should be in the database as a value that can be automatically updated as well.

4.2.5. Cost data for components

Investment costs for renovation measures have to be in a database to let the program calculate economic efficiency. These are also country specific and have to be evaluated.

4.2.6. Assumptions for not entered data

As the calculation procedure can replace not entered data with assumptions there has to be a large number of categorized values in the database. This data has to be evaluated and complements the basic input in the EPC tool to calculate results for renovation measures.

4.3. Methods for assessment of energy consumption forecasting

The heating demand and in another consequence the final energy demand will be the target values to be calculated here. Therefore, a total heat balance of the building has to be made. All significant losses and gains that occur on a building have to be considered and summed up to the heating demand of the building. That includes the internal and external gains like passive solar heat, internal heat gains and gains by solar thermal systems. The losses on a building are transmission losses and ventilation losses through the building envelope. After the heating demand is calculated the energy needed for domestic hot water is added. Then the losses of the heating system for delivery, distribution, storage and generation are calculated (by using the efficiency coefficient of the heating system) and added to the heat demand of the building. After this the sum of electrical consumption in the building is added to this value (operating current (household and heating system), energy demand for lighting, energy demand for cooling). Then the final energy is calculated.

A major challenge is to determine the losses of the building. For simplification the listed losses will be estimated by calculating the transmission and ventilation conductance [W/K] of the system parts. The total conductance of the building is calculated by adding all the transmission and ventilation conductances and multiplying them to an efficiency coefficient for delivery, distribution, storage and generation to take these losses into account.

4.3.1. Transmission conductance building envelope

Three possibilities for calculation are possible:

4.3.1.1. Input by user as value

In the advanced input the user gives an input for the value

4.3.1.2. Calculated with input values

By calculating and adding the transmission conductance for external walls, transmission conductance for windows and the transmission conductance for roofs, the value can be calculated. This is done by multiplying the u-values of the components with their appropriate area.

4.3.1.3. Estimated

By using the total heat consumption and an estimated value for percentage allocation of losses per component to get a rough estimation

4.3.2. Transmission conductance ground

Three possibilities for calculation are possible.

4.3.2.1. Input by user as value

In the advanced input the user gives an input for the value

4.3.2.2. Calculated with input values

By calculating transmission conductance for basement floor, the value can be calculated. This is done by multiplying the u-values of the component with their appropriate area.

4.3.2.3. Estimated

By using the total heat consumption and an estimated value for percentage allocation of losses per component to get a rough estimation

4.3.3. Ventilation conductance infiltration

This is calculated by multiplying the heated air volume with the ventilation conductance for infiltration/total volume that is listed in the database dependent on the number of air changes per hour (from technical regulation per country)

4.3.4. Ventilation conductance natural ventilation

Dependent on building typology the numbers of air change per hour is calculated. This value is multiplied with the specific heat of air, air density and the heated air volume.

4.3.5. Savings for renovation measures

These are divided into the categories for the renovation measures.

4.3.5.1. Savings from renovation of walls and roofs

When performing a renovation, this affects the building envelope and the transmission conductance will be much less. A value for the total heat loss [kWh] for the construction part before and after renovation will be calculated. This is done by setting the transmission conductance of the component in relation to the total transmission conductance of the building (dividing) and multiplying this value with the total heating demand of the building.

4.3.5.2. Savings from renovation of windows

By calculating the savings from window renovation measures, the savings for the reduction of infiltration reduction have to be considered.

4.3.5.3. Savings from renovation of the ventilation system

Then the ventilation system is changed the savings arise due to the reduction in heat losses through heat recovery from the indoor air which is lost without heat exchangers and large reduction of heat losses due to ventilation, opening of windows, infiltration etc.

4.3.5.4. Savings from new heating system

To calculate the power of the new boiler the change in heating demand due to renovation measures has to be considered. Savings occur due to more efficient heating system.

4.3.5.5. Savings from new cooling systems

Saving in this component are generated by lowering the energy demand for cooling.

4.3.5.6. Savings from renovation of the lighting system

Saving in electricity occur due to more efficient lightbulbs and due to more effective management of the lighting system.

4.3.5.7. Savings from solar hot water

When a solar hot water system supports the production of domestic hot water, the energy demand for domestic hot water is shrinking and savings are generated.

4.3.5.8. Savings from integration of a PV system

Saving in electricity occur due to production of PV-electricity on the roof. Also saving possibility for export of electricity.

4.4. Methods for assessment of cost-effective measures in the EPC tool

A static economic calculation is suggested due to the simple and sufficient calculation procedure and its still existing meaningfulness. Also, the simple handling is advantageous even with very little information.

- Static economic calculation
    - Investment costs
    - Amortization time (initial investment)

First the investment costs [€] per renovation measure are calculated with the cost values from the database. The previous savings in kWh are transformed by using the energy price for the final energy into monetary savings per year [€/a]. Then the investment costs are divided by the savings per year and the static amortization time is the result.

When comparing a renovation with a set of renovated components the sums of each investment costs and savings per year have to be divided.

4.5. Renovation measures for the Living EPC-tool

According to the previous analysis of the tool Ecocities the following possible renovation measures are suggested to use in the Living EPC tool. These cover all the relevant parts of the building and are relatively easy to combine among each other.

- External wall
- External windows
- Roof
- Ventilation
- Heating system
- Cooling System
- Lighting system
- Solar hot water
- PV

4.6. Results of the Living EPC-tool

These indicators shall give the decision makers the options to choose a renovation strategy to implemented nZEB standard fitting to their preferences.

- Savings (kWh)
- Primary Energy Savings(kWh)
- Reduction of CO_2 emissions (t / year)
- Savings (EUR)
- Investment (EUR)
- Share of renewables

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