multEE

facilitating multi-level governance
for Energy Efficiency

Training Manual for Monitoring and Verification Platform (MVP)

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List of abbreviations

BU   Bottom Up

EE   Energy Efficiency

GUI   Graphical User Interface

MVP   Monitoring and Verification Platform

NEEAP   National Energy Efficiency Action Plan

TFES   Total Final Energy Saving

I   Introduction

This training manual describes the basics of the MVP web application platform, which should become the central database of implemented energy efficiency projects. The material covers the philosophy, general data structure and architecture of the application, all important for understanding the subject matter. The main purpose of the material, together with the practical part of the training, is to familiarize future users and /or administrators with the basics.

I.I   Training objective and required skills of the participants

During the design of the MVP web platform special attention was paid to user-friendliness and the main objective of the conceptual design was to make the web application usable by non-energy and non-IT experts. However, this should not discourage energy and IT experts from using the application. Indeed, the more skillful the users, the less possibility there is of incorrect data entry.

The application is designed intelligently, so that different operations require different basic skills and knowledge from users. Some tasks, like the process of assigning implemented measures to plans or administrative items (changing the reference values in *Codetables*) require a bit more knowledge, but not expertise in the field. In that regard, the main distinction is between the role of the **National System Administrator** and different roles of **Final Users**. The National System Administrator has access to all features of the MVP application and is responsible for overall maintenance of the application. Other users may have different roles, however most of them will have a task of collecting and entering data on implemented projects and action plans for different locations. Detailed explanation of roles and user rights is given in chapters *Architecture of the MVP web platform* and *User permissions and how to log in*.

However, the general preconditions for all future users are:

- ➢ Familiarity with the BU methodology,
- ➢ Experience with MS Windows and/or MS Excel,
- ➢ Willingness to learn new things.

As already mentioned in the text, no expertise in BU methodology is required. Basic understanding is required, in terms that the calculated energy savings and reductions in CO_2 emissions are consistent with the equations defined in the methodology.
The web platform can be as smart and accurate as the BU methodology and the equations, but not more than that.

After the training, the participants will be able to perform the following tasks:

- Register a new energy efficiency or CO_2 emission reduction action plan/program,

- Enter the data for different measures within the registered plan,

- Enter the data for already implemented project(s) or measures by using either reference or project specific data,

- Assign implemented measure(s) to an appropriate measure from the plan or the plan itself,

- Manipulate and customize the fields appearing in forms according to their specific needs,

- Create numerous different reports and further manipulate the data in MS Excel.

I.II Philosophy of the MVP web platform

The general goal of the MVP web platform is to have all relevant implemented projects registered in a single database. But the fact that really distinguishes the MVP web platform from other similar tools is that all implemented measures can be assigned to appropriate policy plans at different administrative levels. This practically means that implementation of different plans and programs at all levels within one country can be monitored via a single web application.

This is not only an elegant engineering solution, which undoubtedly decreases the costs of monitoring and reporting, but is of crucial importance in the interplay between different policy levels. As an example, a country may have the following structure, which corresponds to the right hand side of Figure 1:

- State level at the top,
  - Provinces or federal states,
    - Regions,
      - Municipalities/cities.

The design and data structure of the MVP web platform allows every level to have an arbitrary number of policy plans. The more complex the policy structure in the country - the more cost-effective monitoring via the MVP web platform becomes. Furthermore, when all data for implemented projects is registered at the local level these measures become visible at all higher levels in the structure.

The same applies to plans: if something is planned at the local level and registered in the platform, it can be taken into account during preparation of plans at all higher levels.

So the MVP web platform does not only aim to keep the data in a single place, but can also be seen as a way to change the philosophy of future actions to make them more consistent from the bottom to the top of the country - and vice-versa. The data structure of the web platform allows an arbitrary number of plans and measures to be registered in the web application.
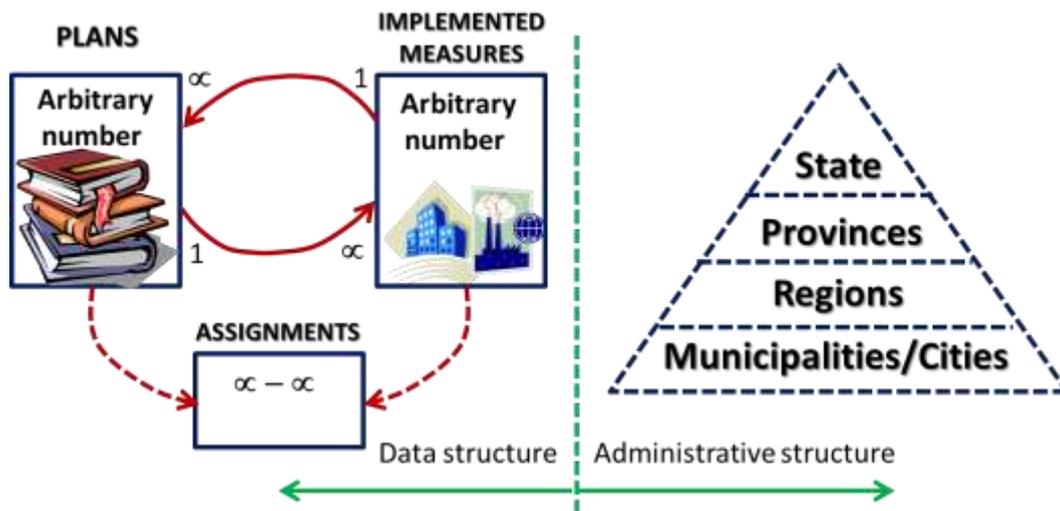
Figure 1: Simplified data structure (left) and administrative structure (right).

Figure 1 shows the data structure in the simplest possible form. One can see an arbitrary number of policy plans (measures from the plans), an arbitrary number of implemented measures, and different policy layers within the country on the right hand side. Also note the assignment table, shown in the middle, for which a many-to-many relationship exists. Many-to-many relationships are known to database experts, but what does this mean in our situation? An illustrative example is given in the text below.

Box 1 Many-to-many relationships between plans and implemented measures

IMPORTANT

One implemented measure may contribute to the municipal plan, to the regional plan, to the provincial plan and to the national plan at the same time, so this means that one measure is theoretically assigned to many policy plans. On the other hand, in order to achieve the target of a single policy measure, numerous measures in the field may need to be implemented. This means that one planned policy measure is related to many implemented measures in the field. Both statements say that there is a many-to-many relationship between plans and implemented measures.

The data structure of the MVP web application is designed to handle this situation. On top of that, this many-to-many relationship is then combined with an arbitrary number of policies and administrative layers.

Also note that the system allows full flexibility in defining policy layers according to practical needs. Namely, the national administrator can add or delete some of the existing policy layers if there is a need for this and/or depending on the design of the entire monitoring system in the country. In other words, the policy/administrative structure defined in the MVP web application does not necessarily have to reflect actual policy layers.

In some countries regional energy agencies cover several regions and, in that sense, it could be useful to introduce an additional layer, for example a group of regions, in order to evaluate the effectiveness of such energy agencies' activities.

This is just an illustrative example of what is possible in the MVP. In most cases the administrative structure defined in the MVP platform will be consistent with the actual administrative structure in the observed country.
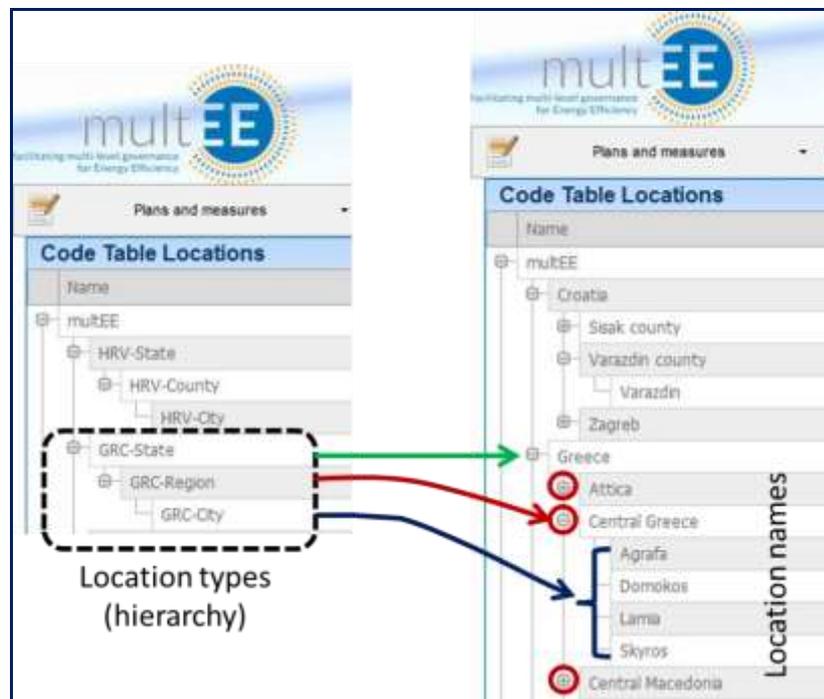
Figure 2: Location types and Locations as defined in the MVP web application.

Figure 2 shows a screenshot from the MVP web platform that deals with different policy layers. The left hand side shows *Location – types*. The National system administrator defines policy layers via a graphical user interface (GUI) and Figure 2 shows the multEE structure with already defined structures for Croatia and Greece. While the left side of Figure 2 shows the hierarchy or structure of countries, the right side represents actual regions and municipalities with their names (example for Greece). The form on the right in MVP is called *Locations* and can be manipulated by the national system administrator via a simple GUI.

Box 2: Defining administrative structure in MVP

IMPORTANT The structure determines policy/administrative layers in a country and *Locations* are always used when defining plans and implemented measures. Items defined as parts of one country in the *Locations* table will appear in the drop-down menu for **Locations** on data entry forms for plans and implemented measures. The National system administrator in charge of the system can update and insert new municipalities / regions in the existing structure at any time. As soon as the new location is added – it will appear in the drop-down menu on data entry forms.

I.III   Reference values – editable Codetables

The Bottom-Up methodology requires definition of reference national values for different equations, which may differ from country to country depending on national circumstances. Reference values may be used when exact data from the implemented project is missing. In that sense, MVP stores these reference values in the so-called *Codetables*.

Figure 3: List of generic *Codetables* with stored reference values.

Figure 3 shows the list of *Codetables*. The user should pay attention to the fact that *Codetables* are named in a structured manner, so that the name of the variable is given first and the equations in which these reference values are used are given in the brackets. Numeration of equations is consistent with the numeration in the BU methodology, which makes data manipulation easier.

Box 3 Updating the *Codetables*

IMPORTANT

National system administrators can access and change the values in *Codetables*. This offers additional flexibility. It is also true that as soon as values in *Codetables* are inserted (new values) or updated (existing data changed) or deleted from the list, users will be able to see the changes immediately.

The contents of a specific *Codetable*, in this case **SHD ref** (marked by a red rectangle in Figure 3), are shown in Figure 4 (upper part). The values which will appear on the final user's GUI are marked by the red rectangle. Appearance of the user form is shown in the lower part of Figure 4 and it can be seen that by clicking on the drop-down menu the same values appear.
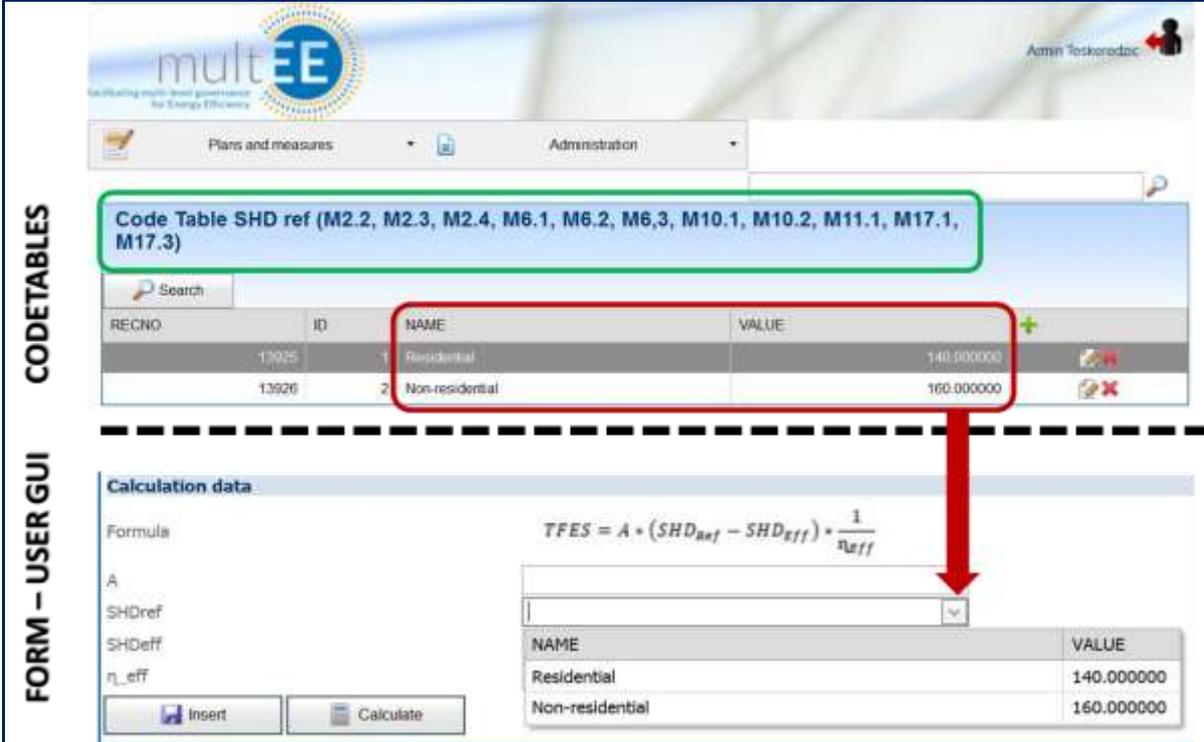
Figure 4: Content of the **SHD ref** *Codetable* (up) and the corresponding content of the drop-down menu on the form (down).

For example, as soon as the contents of the **SHD ref** *Codetable* are changed by the national system administrator, final users will immediately see updated content in the drop-down menu. Please note that these changes should be made carefully because these values appear in many equations – as can be seen from the green rectangle in Figure 4. In this case the **SHD ref** value is used in 11 different equations (measures). By changing the values in the **SHD ref** *Codetable*, the content of the drop-down menu will change for these 11 measures.

I.IVMVP platform dictionary

Form represents all data for the view chosen from menus and sub-menus. The default form in the MVP web application is the form *Plans views* shown in Figure 5.

Main menus (position 1 in Figure 5): *Plans and measures* and *Codetables* are the main menus visible and accessible from all active forms.

Command buttons (position 2 in Figure 5): are **Search**, **Customization** and **Export** (optionally **Change Series** button, available on some forms). Pressing the command button automatically executes the action associated with this button. The **Search** button refreshes the data on the form, based on the most recent settings for the form. The **Customization** button opens the container from which additional fields can be added to the form or to which fields can be removed from the form (*drag-and-drop* principle). **Export** button exports the data from the form (using the most recent settings) to an MS Excel file. The **Change Series** button is related to graphs and allows the final user to change the series which appear in the graph.

Figure 5: Description and characteristic menus, buttons and spaces on the forms.

Grouping area (position 3 in Figure 5): Grouping of data is possible by *drag-and-drop* of field headings (see **Field headings** below).

Action buttons (position 4 in Figure 5): ⓘ is **Select**, ⊞ is **Expand** (**Open the list** – available on some forms). Some forms also contain action buttons such as: 📝 **Edit**, ➕ **Add**, ✖ **Remove**, 💾 **Save** and ⛔ **Cancel**.

Field headings (position 5 in Figure 5): Titles of fields available in the database and their availability depends on the chosen form. They can change places by *drag-and drop-*principle.

Sorting fields (position 6 in Figure 5): Fields in which the user can type a search string to filter and sort data and to display only data that contains this combination of characters (this is not valid for all fields).

II User data manipulation

This section demonstrates general user data manipulation through examples.[1] It first describes the rationale of user privileges and then proceeds to discuss the core topic of the training. This section intends to cover the following:

➢ Registration of a new plan,

➢ Entering measures within the registered plan,

➢ Entering data for an implemented measure,

➢ Assignment of the implemented measure to plan(s) or measure(s) from the plan(s).

II.I Architecture of the MVP web platform

Some of the basic functionalities are already mentioned in the text, such as the basic data structure, hierarchy of locations and flexible *Codetables* where reference values are stored. One should always bear in mind that the core engine of the MVP web platform is the BU Methodology.
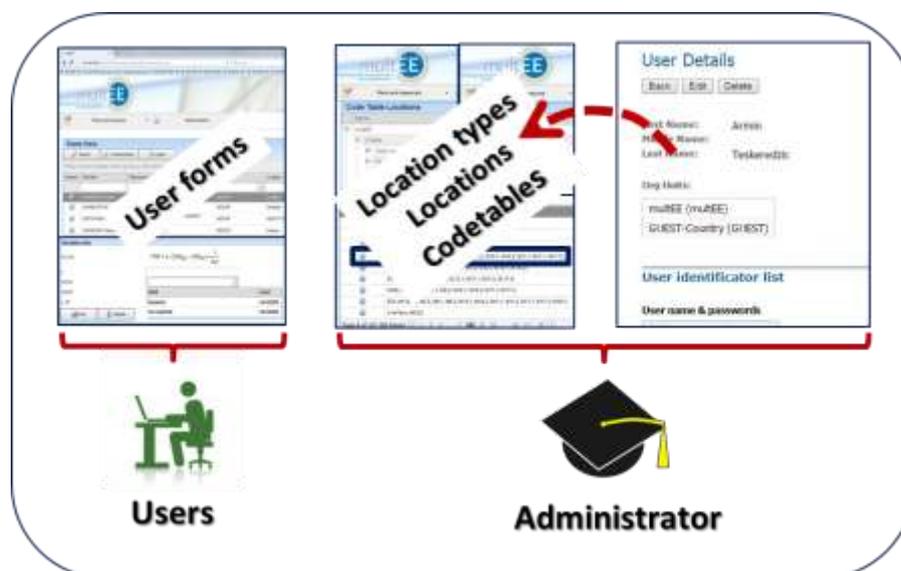
Figure 6: Graphical illustration of final user and administrator roles.

Figure 6 illustrates the roles of final users and the national system administrator. Please note that several people can be granted administrative access, in the sense that they can change/update *Codetables* and/or *Locations*.

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[1] It is the intention of author of the training material to design the exercises so that they can be performed independently of each other. This refers to sections titled Exercise 1 – 6.

Before presenting navigation through the application, it is necessary to summarize the necessary preconditions to put the web application in operation. Here we assume that the web application is physically installed on the dedicated server and that final users can access the web application via their browsers.

To start using the web application, the national system administrator should keep in mind the following steps:

- Engine is in place (BU Methodology is under the hub),

- *Location types* are defined (national structure is defined)

- *Locations* exist (can be updated with new locations at any time),

- Final users' accounts are defined (linked to locations),

- Reference values are defined in the *Codetables* (can be updated at any time).

Box 4: How is the MVP adapted to different countries' requirements?

REMINDER

The MVP web application was initially designed to be used in different countries. The MVP engine, as its main part, is more or less similar for all interested countries. There can be some changes in the number of equations but the core of web applications in two different countries is quite similar from the aspect of energy savings. However, administrative structures differ significantly from country to country. This is the reason why L*ocation types* should be defined by the national system administrator. Further, reference values for equations can be quite different. In MVP, these reference values are stored in editable *Codetables* which allows an additional degree of freedom.

II.II   User permissions and how to log in

User permissions are assigned following the basic logic of the application and the interaction between different policy layers within one country. To be able to assign new users it is necessary to define *Location types* and *Locations* (see Figure 2), since user permissions are related to specific location(s). In general, users at the top level, which is usually the national level, can see all data entered into the database. However, users at the local level may see and manipulate only the data for their particular location. Final users only need to manage data at their appropriate level.

Logging in into the MVP web platform is done by entering the **Username** and **Password** provided by the national system administrator in the required fields (shown in Figure 7) and clicking on the **Log on** link.[2]

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[2]Training participants will receive the IP address of the server hosting the application as well as their Username and Password during the training session.

Figure 7: MVP Login application form.

The *Login* form for the MVP web application is shown in Figure 7. Password will be assigned by the national system administrator and can be changed any time by clicking the **Change password** link.

II.III   Navigation in the MVP web platform

After the user logs into the application, the default form *Plans Overview* is displayed on the screen (Figure 8). The following section will briefly explain basic navigation around the MVP web application.

Default form *Plans View* is shown in Figure 8. Note that in the top right corner the user name is shown in green rectangle, while the main menus are shown in red rectangles. It is very important to note that **main menus are visible from all forms**, i.e. that navigation is quite simple and easy. If the user wants to go back, just choose the appropriate form from the main menus and it will be displayed immediately.
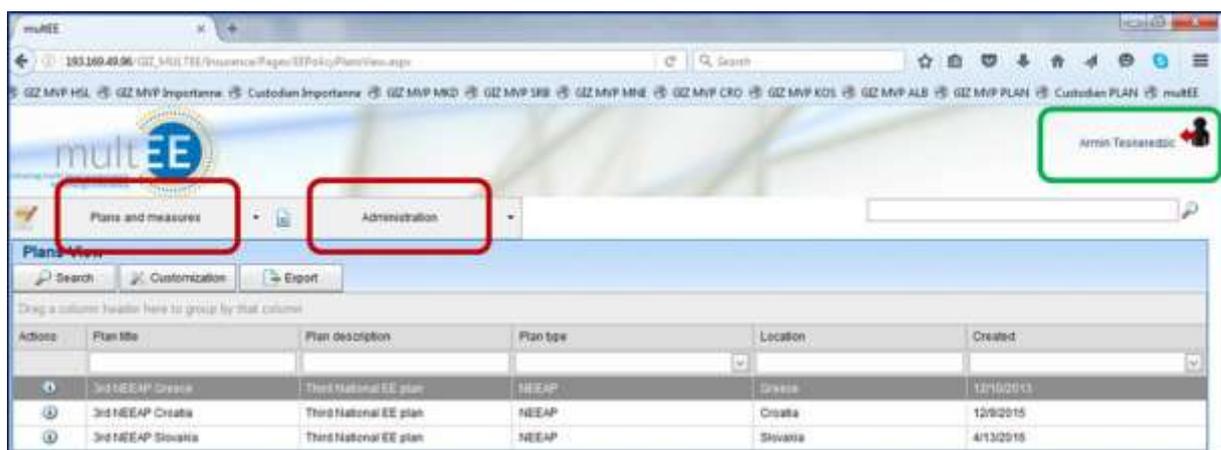
Figure 8: Default form *Plans View* after logging into MVP web application.

The **_Administration_** main menu opens the links to _Locations_, _Location – Types_ and _Codetables,_ as shown in Figure 9. The forms found on these links have already been described in previous sections and can be seen in Figure 2 and Figure 3. Note that clicking on the arrow marked in red opens the contents of the menu.

Figure 9: Administration main menu button and its components.

Box 5: Access to the _Codetables_

REMINDER

In the case that reference values in the BU methodology are changed or updated, the national system administrator can change reference values in the _Codetables_ via the GUI very quickly, without the need to change the source code of the web application! Also, reference values in the _Codetables_ can be updated while the system is online and running!

Another main menu, **_Plans and measures_**, opens the menu content by clicking on the red arrow shown in Figure 10. There are several options which lead the user to the desired form, labeled in an intuitive manner, so that it is quite clear and obvious where these links lead. Users should note two categories here. One category is an overview of plans, implemented measures and measure assignments, while the other is related to new data entries, such as new plans and new implemented measures.

Box 6: How many plans can be registered in MVP?

REMINDER

MVP web application does not pose any restrictions on the number of plans. There can be an arbitrary number of registered plans covering all municipalities/cities, regions, provinces, as well as national plans. However, the visibility of plans for any particular user will depend on permissions and the location he/she can access!

Figure 10: Attributes of the plans and measures and navigation to the three main reporting components in the MVP web application.

The **_Plans overview_** form, as already mentioned, is the default start page of the MVP web application. Once the user registers with his/her user name and password, the _Plans overview_ web page will be displayed. This form contains information on all registered plans in the MVP web application.

Implemented measures overview is a form where the user can see all registered implemented measures in the database, again depending on the privileges assigned by the national system administrator. Users can manipulate data, create reports from this page, or use this page to find a specific measure which needs to be analyzed or updated (this will be demonstrated in chapter Exercise 5: Implemented measures overview).

Measure assignment overview is the form which shows implemented measures linked with appropriate registered plans. On this web page one can analyze implemented versus planned energy savings and/or CO_2 emission reductions. This is another unique feature of the MVP web application, which serves as a platform for exchange of information between different policy layers in one country (local or municipal with regions or with national level).

Master search is the form that helps users to find any data they are looking for. The _master search_ is designed to search for a given set of characters appearing in the title and description of plans, planned measures or implemented measures.

Forms such as **_New plan_** and **_New measure implementation_** were not described above. These are covered in subsections _Exercise 1: Adding a new plan_ and _Exercise 3: New implemented measure_.

II.IV   Exercise 1: Adding a new plan

User can navigate to the *New plan* form (see Figure 10) by using the following path:

> ➤ Plans and measures command menu
>
>> ➤ New plan

The new form appears on the screen, as shown in Figure 11.

Figure 11 shows the section of the form for entering new plans. You may note that the main menus are visible at the top of the form (indicated with a green arrow). The *New plan* form has three sub-forms highlighted in the orange rectangle: *Plan* (currently open), *Planned measures* (explained in the section *Exercise 2: Adding a new measure in a plan*) and *Implemented measures* (see section *Exercise 3: New implemented measure*). The *Plan* form serves for defining the general data (upper part of the form) and cumulative targets per sector (lower part of the form).
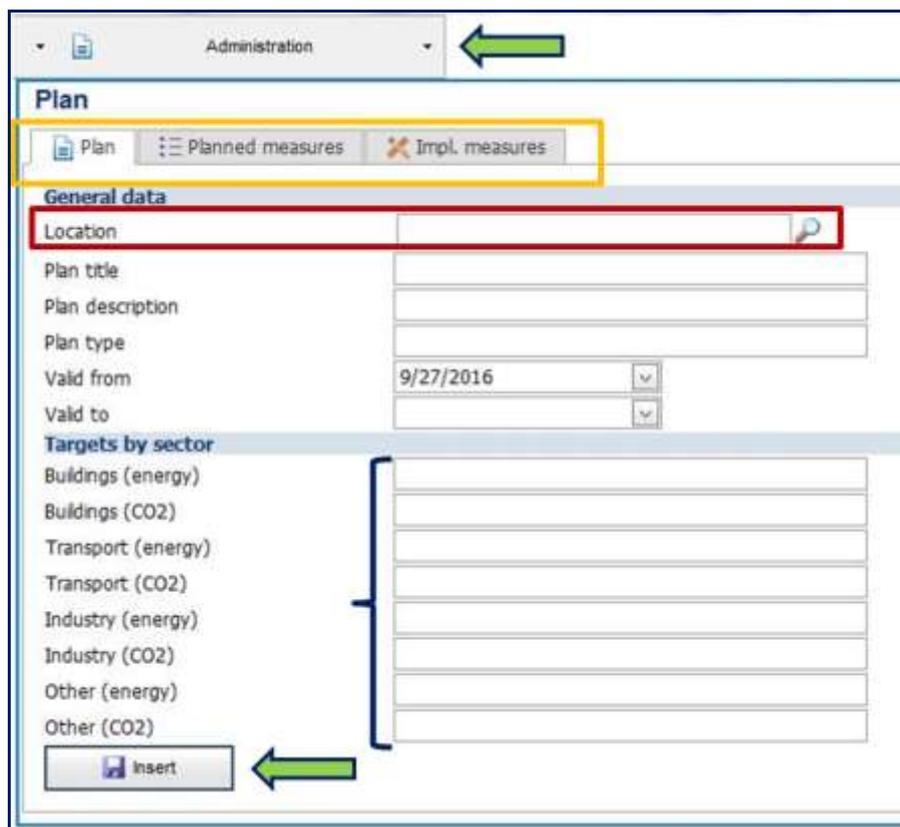
Figure 11: *New plan* form with characteristic sections highlighted in text.

General data contains the main attributes of the plan – **Title**, **Description** and the validity period defined by **Valid from** and **Valid to** fields. **Plan type** is a locked field and determines whether the plan is targeting energy or CO_2 emission savings.

In Figure 11, **Location** is highlighted in the red rectangle and is a required field for every plan and implemented measure. By clicking on the search icon on the right side of the red rectangle, the form with **Locations** opens up. Selection of appropriate location is demonstrated in Figure 12 with red circles and arrows, by expanding existing levels until the desired level is found.
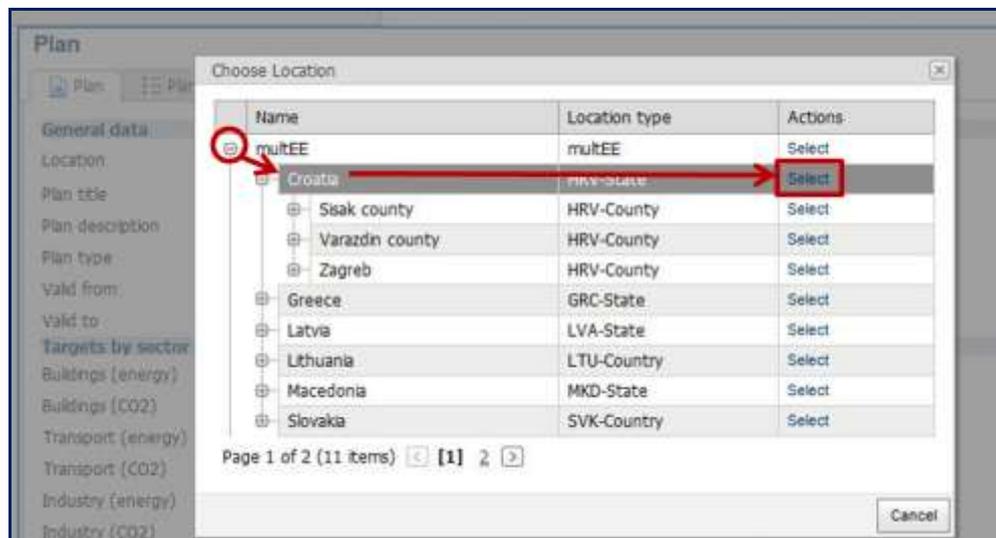
Figure 12: Choosing the appropriate location from the *Location* list.

Figure 12 demonstrates the process of selecting the **Location**. This process is identical for any form that requires Location be entered. The user expands the levels until he/she finds the desired location and then selects it by clicking the active link **Select** (in the red rectangle in Figure 12).

Box 7: Defining the *Targets* in a new plan

> **IMPORTANT**
>
> In the *Targets* section of the form, default energy units are **kWh** for energy saving targets and **tons** of CO_2 emissions for CO_2 targets. A plan can be registered without any cumulative targets but with the general attributes only! The numbers related to this form will appear on the *Plans overview* default form and give the user a general overview of how the targets are set under different plans.

After entering the remaining data in the form, the user can insert the new plan into the database by clicking the **Insert** command button, shown in Figure 13 (left). After the insertion, this plan will immediately appear in the list of plans and will become active. The right side of Figure 13 shows that, after the data is inserted, new command buttons appear at the bottom left corner of the form (marked in red arrow and rectangle), such as **Edit plan** and **Storn**. **Edit plan** allows all completed fields to be edited, including Location, while the **Storn** command permanently removes the record from the database.
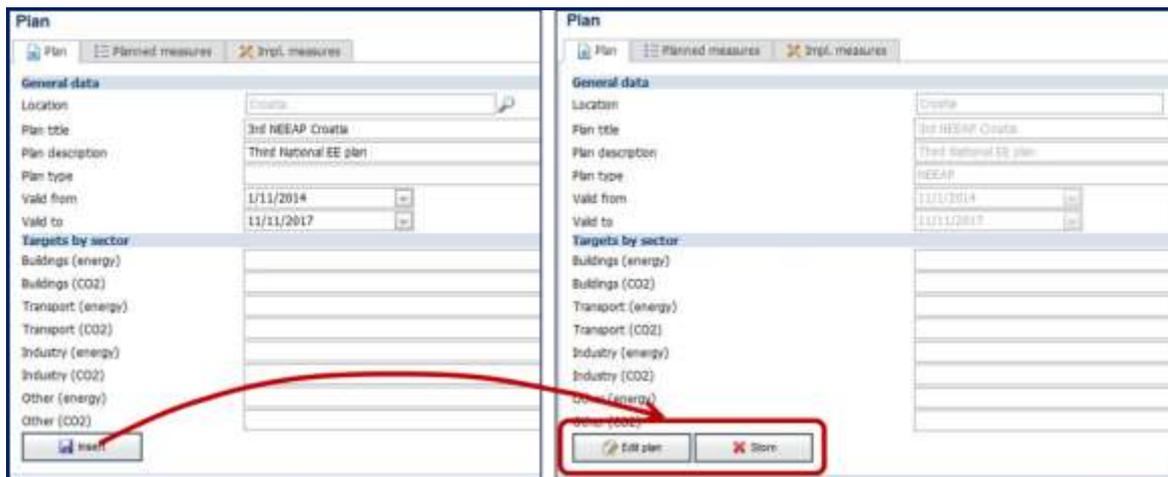
Figure 13: Inserting a new plan.

Please note: since the national level is selected, **Plan type** now appears with the shortcut NEEAP (Figure 13 – right).

II.V Exercise 2: Adding a new measure in a plan

Definition of a new measure within a plan can be done as soon as the plan is defined and inserted into the database, as demonstrated in *Exercise 1: Adding a new plan.* For the purposes of this exercise let us suppose that the user registered the plan and exited the application.

After logging in again, the user can find the registered plan in the *Plans overview* form (default form after opening the application, shown in Figure 8). In case the user was elsewhere in the application, he/she can navigate to the *Plans overview* form by choosing the *Plans and measures* command menu and selecting the *Plans overview* form (Figure 10).

The *Plans overview* form is shown in the upper part of Figure 14 and contains all plans registered in the database. If the number of plans is very large, which is possible when all plans at different levels are registered, a page by page search for the desired plan would be quite time consuming. However, the MVP web application allows the user to quickly find the appropriate record. This process is demonstrated in the lower part of Figure 14: a search for a set of characters "**roa**" is entered in the *Location* sorting field.
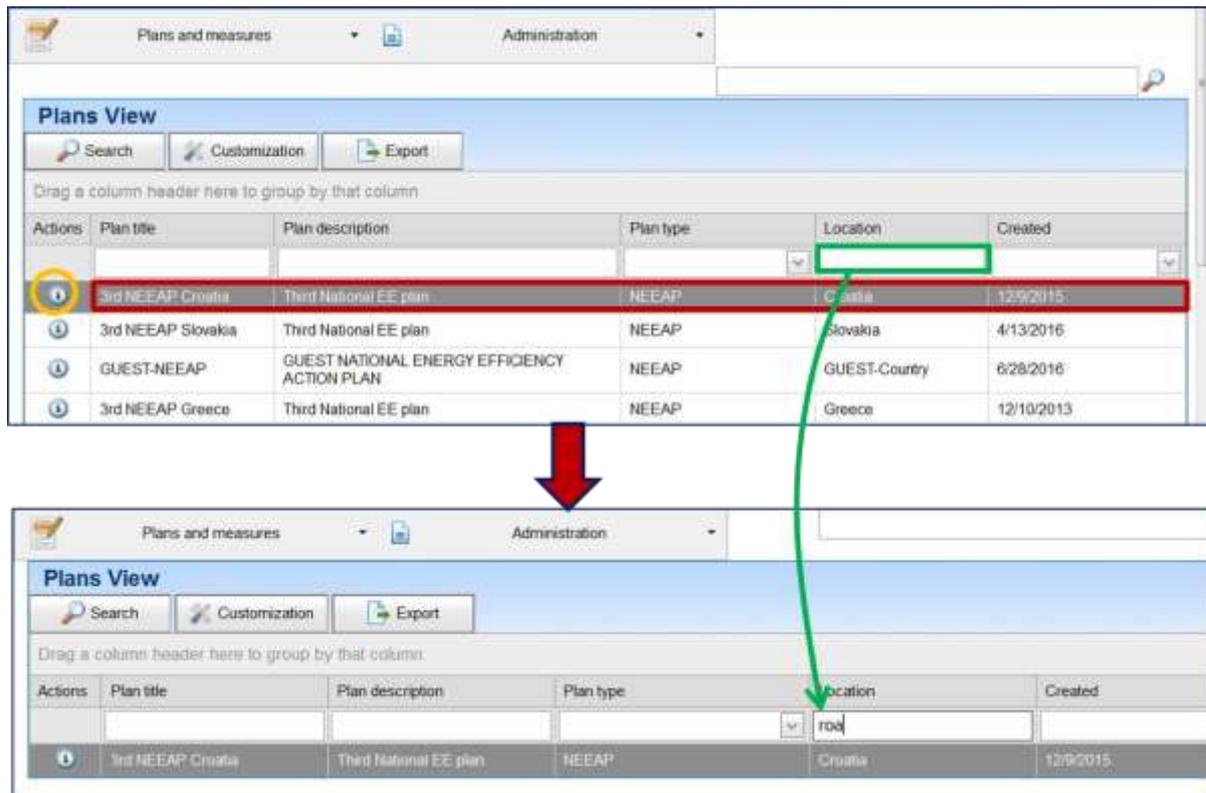
Figure 14: Illustration of how to find the appropriate plan in the list of plans.

The set of characters "**roa**" instructs the application to search for all records where "**roa**" appears in the Location field. In our case this is C**roa**tia.

Box 8: Finding the specific record in lists of plans or measures

REMARK

This demonstration applies to all other forms: the user can search for a specific record by filtering the list on the form using a certain set of characters. Please note that this option is not available for all fields!

After the desired plan is found, the user should click on the action button ⓘ (indicated by the orange rectangle in Figure 14) and the form for the specific plan will open immediately. This form is already presented in Figure 13 (right). Since the objective of this exercise is to enter a new planned measure within an existing plan, the user should open the subform *Planned measures* (see orange rectangle in Figure 11).

Figure 15 illustrates the process of defining a new measure. In order to define a new measure within an existing plan the user should click on the ✚ sign in the orange circle in the upper part. An additional form for data entry will open, as shown in the bottom part of Figure 15.

For defining a new measure the required data is the following: **Planned measure title**, **Description** and **Validity period** (from – to) which may vary depending on the validity of the plan.
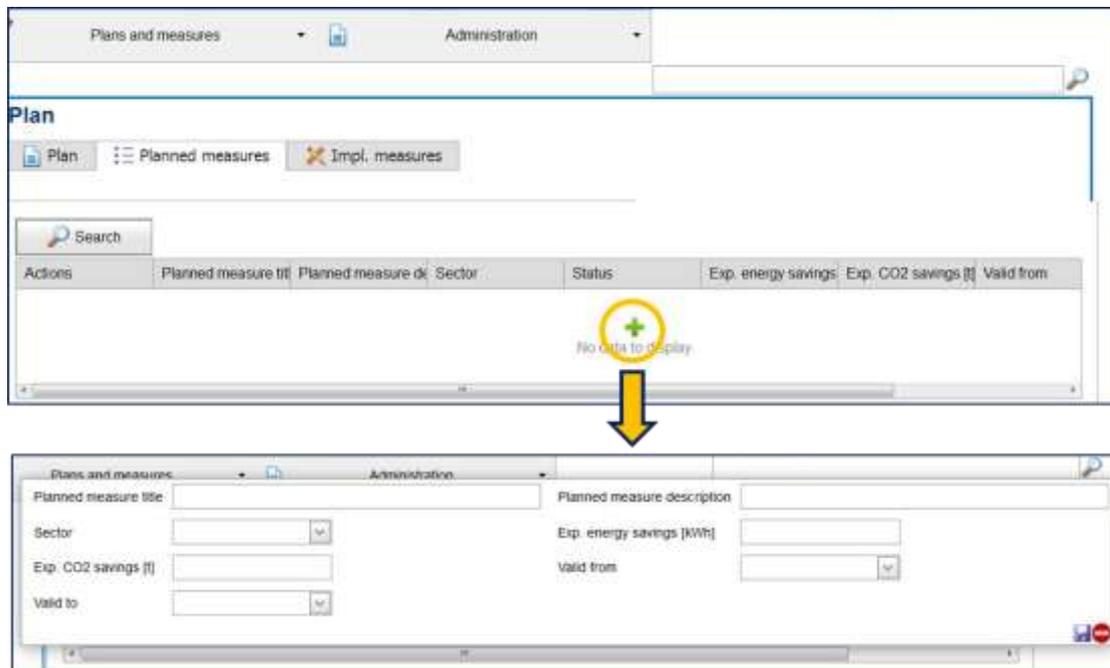
Figure 15: Definition of a new measure within an existing plan.

The **Sector** to which the measure belongs also has to be defined, as well as the **Expected energy savings** or **Expected CO₂ emission reduction** (or both). This is a dummy part of the application as there is no check whether the target reduction of CO_2 emissions can be achieved through the entered expected energy savings.

Box 9: Comparing achieved to expected energy savings

> **IMPORTANT**
>
> When an implemented measure is assigned to a measure from the plan it will compare achieved energy savings (calculated using BU equations) to expected energy savings defined in the planned measure (see also *Exercise 4: Assignment of implemented measure to planned measure).*

Figure 16 shows how to enter data for the new measure within an existing plan. After clicking on the 💾 icon, the measure is registered and stored in the database (lower part of Figure 16).
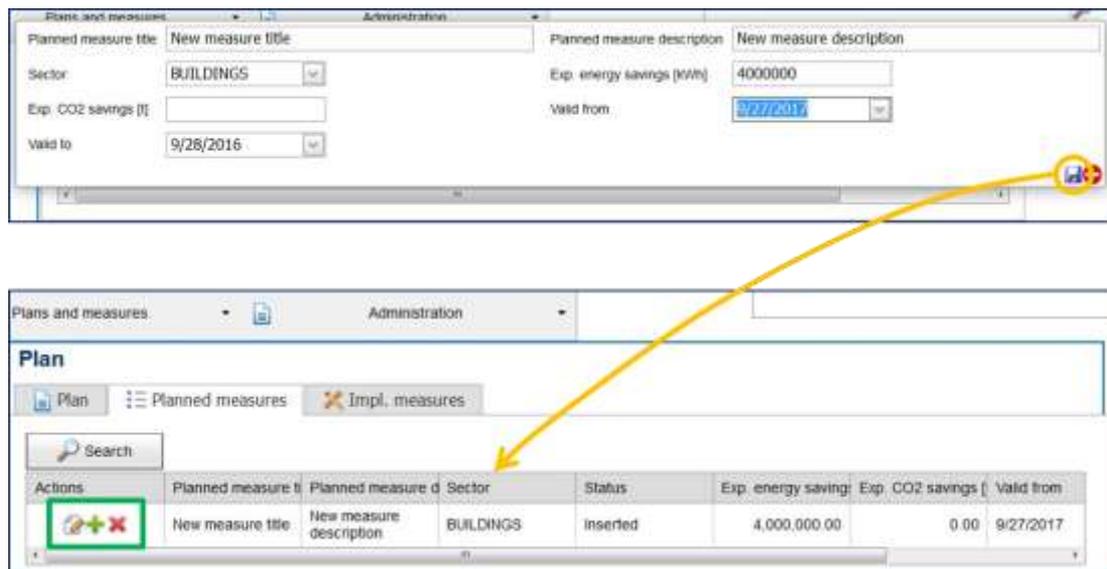
Figure 16: Illustration of how to save the record of a new measure within an existing plan.

If the user wants to edit the existing measure, he/she can do so by clicking the 📝 icon. The measure can be deleted by clicking the ✖ icon. If the user wants to add a new measure to the plan, he/she should use the ➕ icon. All icons are marked with the green rectangle in Figure 16. Please note that each plan can contain an arbitrary number of measures, without limitation.

II.VI   Exercise 3: New implemented measure

As already mentioned, the main purpose of the MVP web platform is to store the data for implemented projects in the database. What follows in this exercise is the most important section for final users. It is assumed that the largest number of users will be in charge of registering new implemented measures, while assignments and planning will be reserved for people in charge of energy issues at different levels.

Since this exercise is related to implemented projects, final users should be familiar with the basics of the BU methodology in order to be able to use the proper equation for the implemented project. Let us assume that the implemented project is related to refurbishment of an existing building (or building components), where the heating system is modified to use a different fuel by replacing the old heating oil boiler with a new natural gas boiler.

In this case the user should choose the equation titled: *Thermally improved building envelope of refurbished residential building (M2.3)*. For more details please check the BU Methodology, which describes the measure in more details. The process of finding and entering the data is described in details in the text which follows.
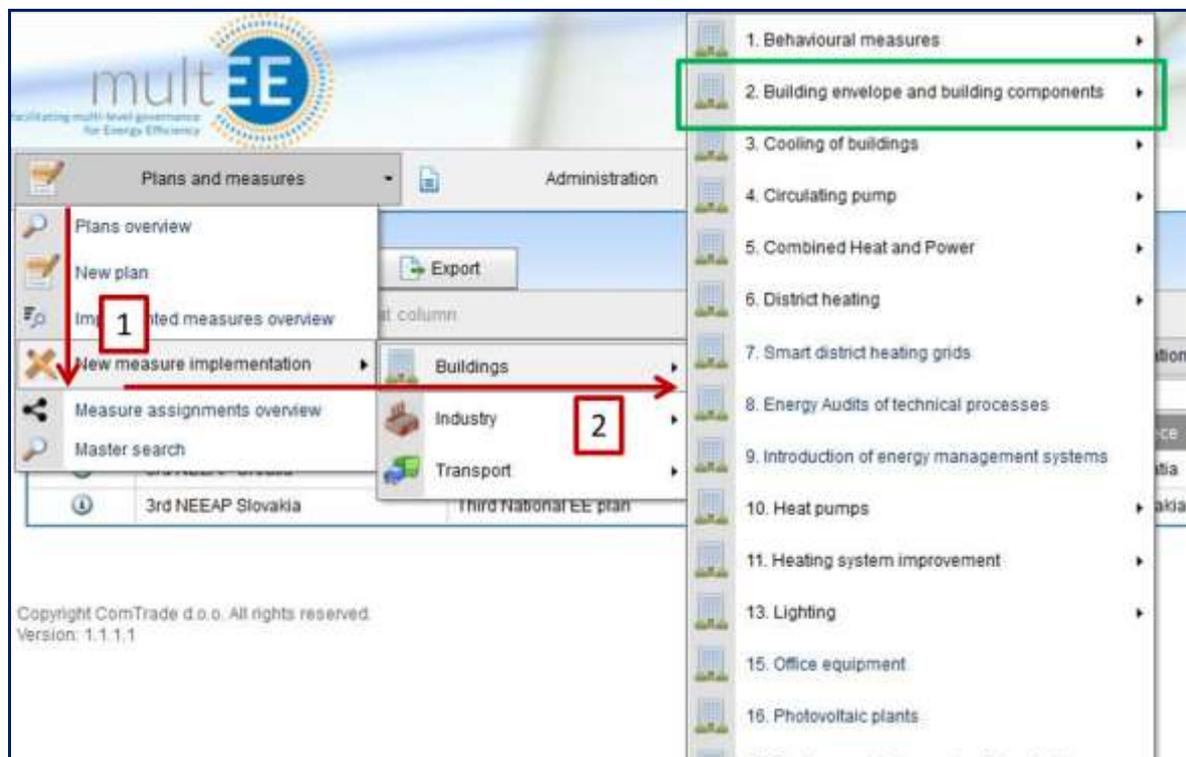
Figure 17: List of measures in *Buildings* sector in MVP platform.

Figure 17 and Figure 18 show how to navigate to the desired existing measure titled: *Thermally improved building envelope of refurbished residential buildings (M2.3)*. The navigation process is shown in numbers and arrows in Figure 17, describing the following:

➢ Click on *Plans and Measures* in the main command menu,

   ➢ Position mouse over *New measure implementation* (step 1),

      ➢ Navigate via the *Buildings sector* (step 2) to the list of all available measures for the *Buildings sector*,

         ➢ Find the measure related to the building envelope and building components (Figure 18 left),

            ➢ Choose measure M2.3 from the submenu on the right hand side shown in Figure 18 (marked in red rectangle).
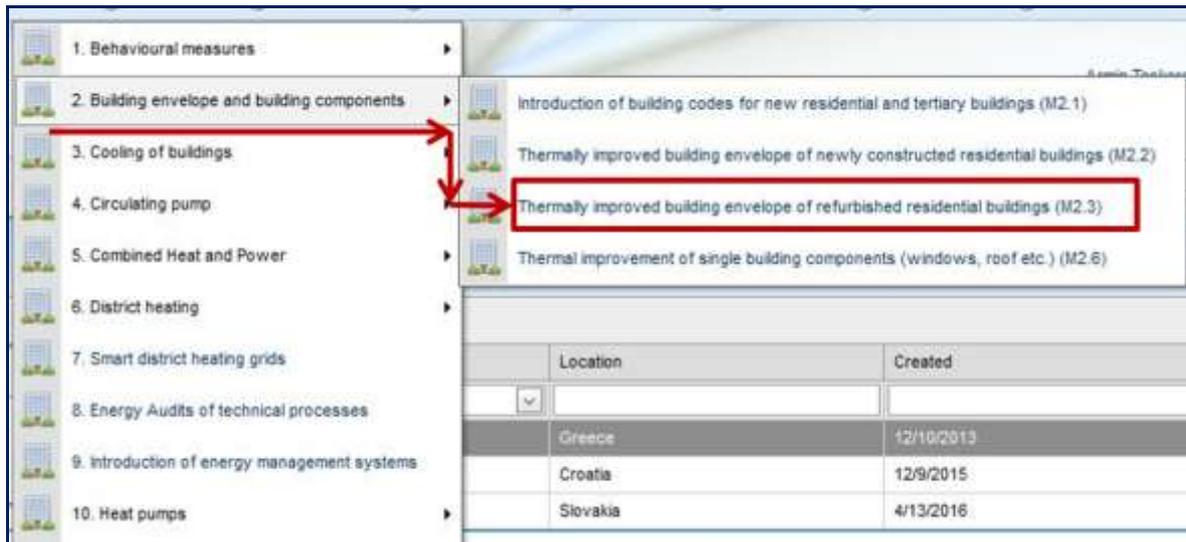
Figure 18: Example of navigation to measure M2.3 in the MVP proto platform.

All measures from the BU methodology are sorted according to the consumption sector to which they belong. The default sectors are as follows:

- ✓ Buildings,
- ✓ Industry,
- ✓ Transport.

Sub-categorization within the sector is also required to make the data more useful for purposes of subsequent reporting and analysis. If we take the example of the industry sector, then subdivision in reporting per industry type is also possible.

Figure 19 illustrates the example of measure M2.3. After the user navigates through the menus and selects measure M2.3 from the list, the web page for entering the data on implemented measures appears, as shown in Figure 19.

This form contains three different parts:

- General data,
- Savings and costs,
- Calculation data.

Three main parts of the web page shown in Figure 19 are identical for all measures and all sectors in the MVP web application. This will preserve consistency and expedite final users' familiarization with the MVP.

The first part of the form contains general information about the project (see the orange rectangle in Figure 19).
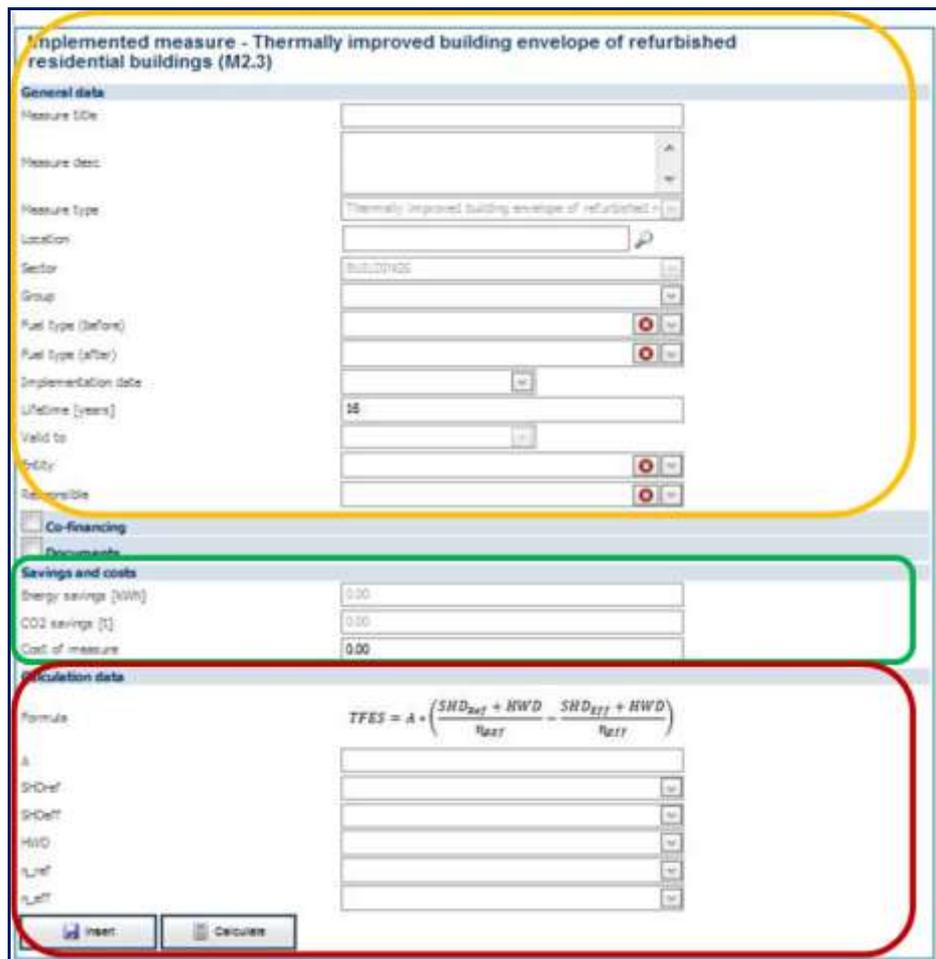
Figure 19: Characteristic form components for entering a new implemented measure.

Lowest part shown in Figure 19 (in the red rectangle) shows the equation for measure M2.3 and the required parameters present in this equation. The middle part of Figure 19 (green rectangle) shows **Energy savings** in kWh and **CO$_2$ emission reduction** in tones. These two fields are not editable and their values depend on the values of parameters selected or entered on the lowest part of the page (*Calculation data*).

Box 10: Additional menus in *New implemented measure* form

REMARK

There are two additional expandable menus: *Co-financing* and *Documents* (Figure 19). These expandable menus can be used for additional details about the financing of the implemented measure (if required for reporting) and for storing additional documentation such as the feasibility study, measurement results, pictures and similar.

The only editable parameter in the *Savings and costs* part of the form is the **Cost of measure** field. Final users are expected to enter this data – if required by the M&V system structure and if available.

Figure 20 explains the *General data* section in more detail. The required data fields are marked with a red rectangle:

- **Measure title**,

- **Measure description**,

- **Measure type** (non-editable and predefined by the choice of measure),
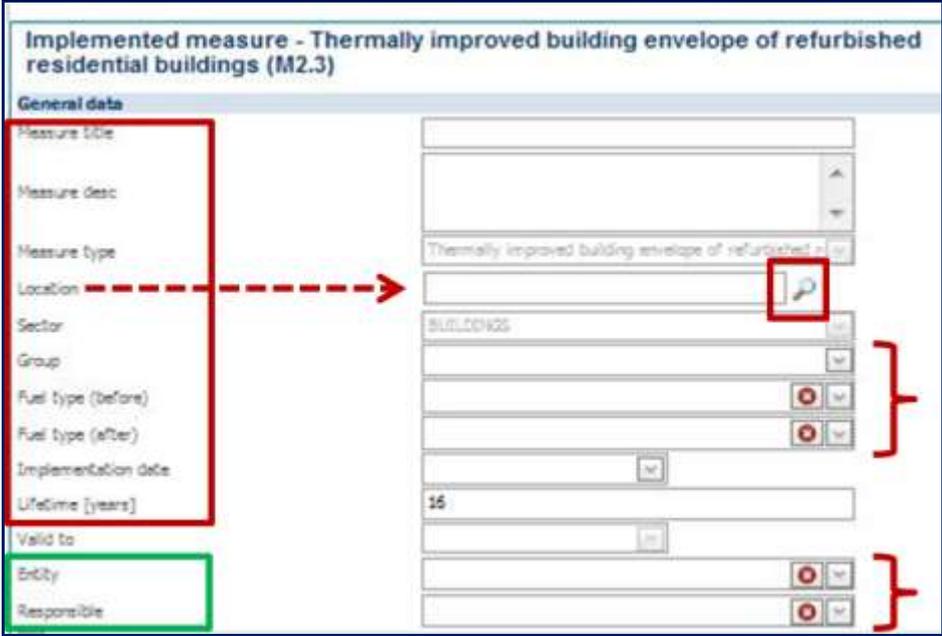
Figure 20: *General data* section with required (red rectangle) and optional fields (green rectangle).

- **Location** (see Figure 21),

- **Sector** (non-editable and predefined by choice of sector),

- **Group** (see Figure 22 top),

- **Fuel type (before)** and **Fuel type (after)** relevant for calculation of CO_2 emission reductions (see Figure 22 bottom),

- **Implementation date** (see Figure 23), and

- **Lifetime** (recommended value will be displayed and can be edited).

Green rectangle in Figure 20 marks the fields **Entity** and **Responsible,** which are optional and their use depends on the M&V system. These two optional fields can be used afterwards for different grouping and reporting purposes.

One example of use of the **Entity** field can be a large hospital complex that undergoes EE refurbishment in three or four years. By registering an **Entity** and assigning this entity to all interventions in the hospital complex, it is possible to easily aggregate all relevant energy savings and CO_2 emission reductions in the reporting.

The **Responsible** field can be used for M&V schemes where some official administrative unit is responsible for implementation of certain categories of measures. Same as previously, subsequent reporting and grouping of data will be much easier if the user assigns the **Responsible** field to all implemented measures in this category.

Figure 21 shows the sub-form which opens when the user clicks on the **Location** tab (small icon in the red rectangle in Figure 20).
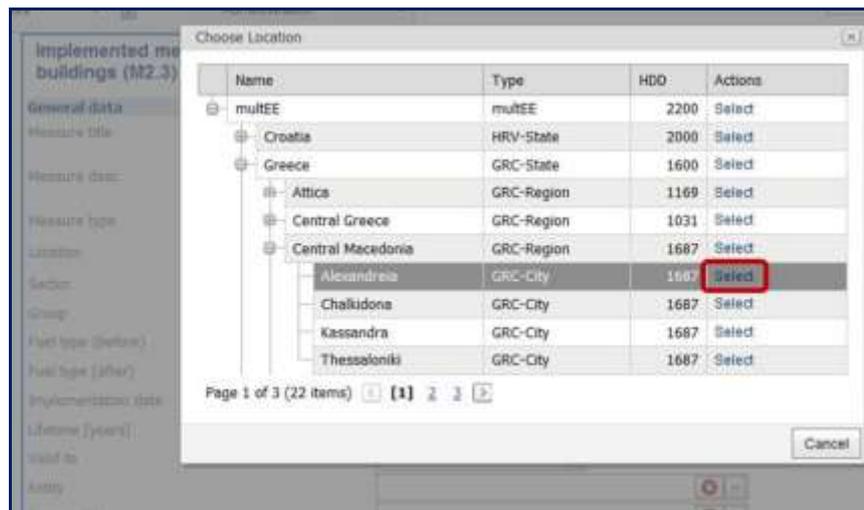
Figure 21: Location sub-form and selecting the city from the list.

The Location list is consistent with previously entered list of cities and regions within the country.[3] List of available cities can also be entered via GUI by the national system administrator, as described in the section *Philosophy of the MVP web platform*. When the user clicks the **Select** button shown in the red rectangle in Figure 21, **Location** is selected and the user can proceed to enter other relevant data.

Top section of Figure 22 shows selection of the **Group**. Again, different categories of **Groups** for different sectors can be entered and updated at any time by the national system administrator.

Fuel type before and **after** (Figure 22, bottom) are also mandatory fields. As already mentioned, these parameters are relevant for calculation of CO_2 emission reduction resulting from implementation of the EE project. This list can be also accessed and updated by the national system administrator via the GUI, including definition of new fuels with their CO_2 emission values. Both parameters are selected from drop-down lists, which means that free user entries are not allowed here.

---

[3]Please note that multEE is a top-defined structure here and will be visible only during the testing phase. After the MVP web application is transferred to the host server in Country X, Country X will be on the top level.
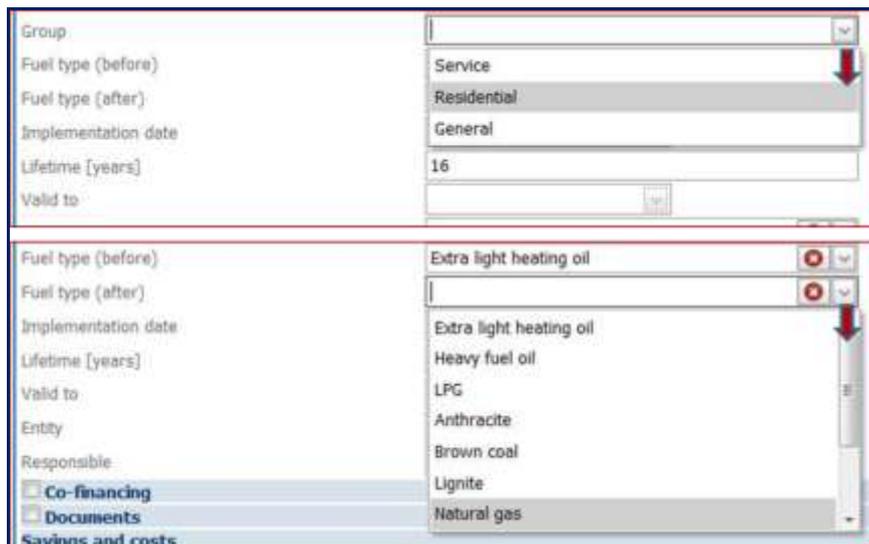
Figure 22: Illustration how **Group** and **Fuel type (after)** fields are chosen from the drop-down list.

Figure 23 shows the Calendar which pops-up after the user clicks on the drop-down arrow marked in Figure 23. The user can either enter the date or select a date from the Calendar with a click of the mouse. It is important that the Date & Time system settings are recognized here and the valid data entry (for free entry) has to be consistent with the date & time system settings (depending on your settings).
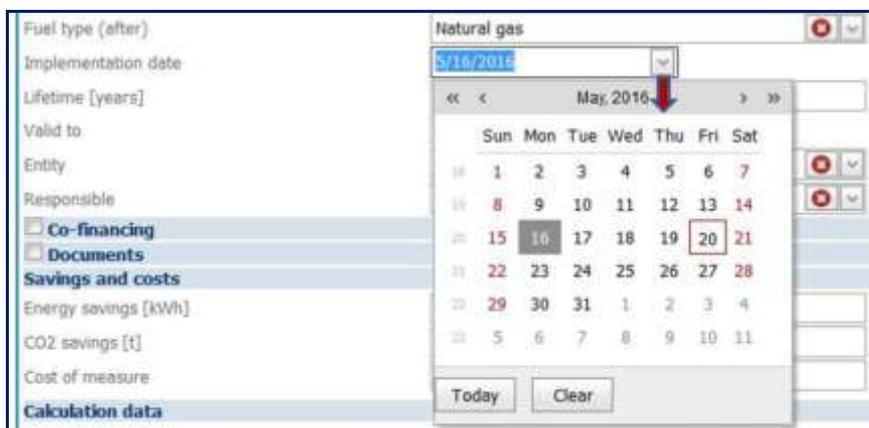
Figure 23: Choosing the date from the Calendar – **Implementation date** field drop-down list.

The relevant data for calculation of energy savings should be entered in the *Calculation data* part of the window. The top of the *Calculation data* section of the form shows the equation and the relevant parameters are listed on the left side of the window (see Figure 24).
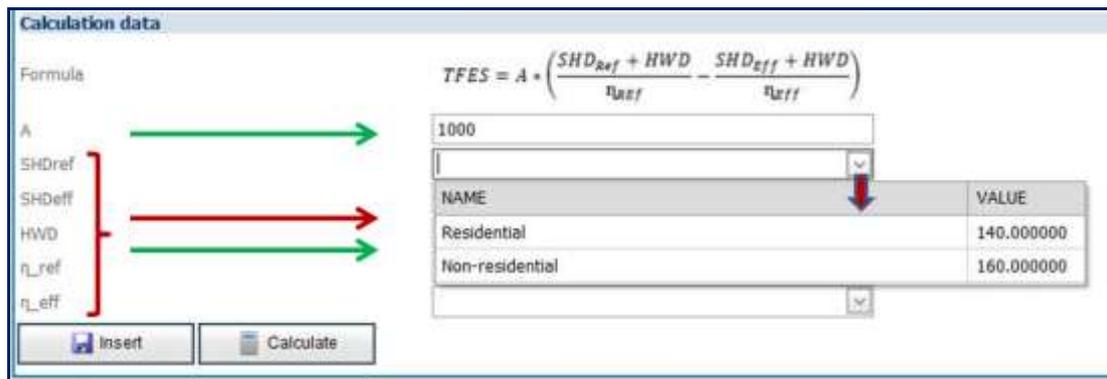
Figure 24: Calculation data for an implemented project, free entry and/or default values.

It is important to note that free entry in this case is reserved for **Area of the building**, marked with a green arrow in Figure 24. Other parameters, such as specific heat demand and efficiencies denoted by *ref* and *eff,* can either be chosen from the drop-down menu or entered as a free entry by the user (or as any combination of these two).

Figure 25 demonstrates the process of inserting a record into the MVP database.
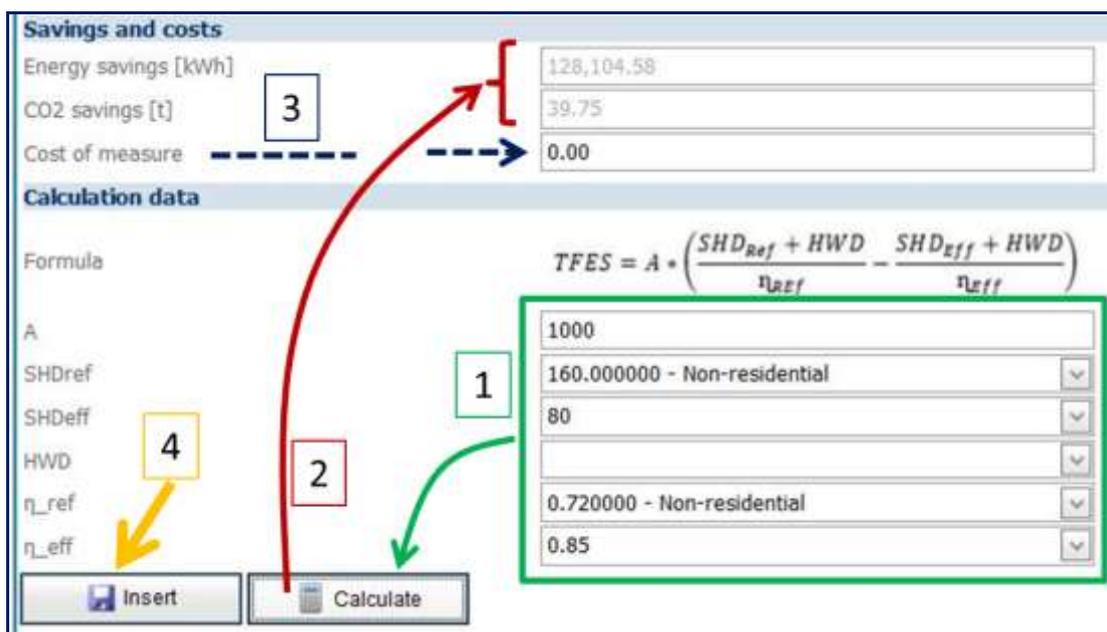
Figure 25: Calculation of energy savings and CO_2 emission reduction and insertion into the database.

First, the data in the green rectangle has to be entered, either by using default values or free entries or any combination of these two (step 1). After all data is entered, the user clicks on the **Calculate** command button (step 2) and the values of energy savings and CO_2 emission savings appear in the *Savings and Costs* section of the form (see red arrows and the values in red brackets). After that (can be done even before or during data entry into the *General data* section) the user enters the costs of the project (step 3).

When all data is entered and the calculation of energy and CO_2 savings is completed (non-zero values), the user can insert the record into the MVP web application database. This is done by clicking the **Insert** command button (step 4 in Figure 25).

What is demonstrated above is valid for all measures from the catalogue or for all measures defined by the BU Methodology. Numeration of measures is consistent with the numeration of measures in the *Document with general formulae of bottom-up methods to assess the impact of energy efficiency measures*. For guidelines on how to enter data specific to each BU method, see *Annex A.*

Box 11: Importance of the document with Bottom-Up methodology

IMPORTANT

Final users of the MVP web application are encouraged to become familiar with the BU methodology. This may reduce training time for future MVP users, since the MVP web application is a software tool that uses BU methodology as an engine.

When the user clicks on the **Insert** command the measure is stored in the database and can be accessed by other users immediately. At this stage the logical follow-up would be to assign the implemented measure to the appropriate plan(s). The user can proceed to do so according to the guidelines explained in *Exercise 4: Assignment of implemented measure to planned measure.*

II.VII   Exercise 4: Assignment of implemented measure to planned measure

In general, the assignment process makes sense when both the implemented measure and the planned measure are already registered in the database. [4]

The assignment process starts with finding the implemented measure in the list via the navigation, as follows:

➢ Click on *Plans and Measures* in the main command menu,

    ➢ Select *Implemented measures overview*,

        ➢ Find the measure in the list either by searching measure by measure or by using sorting fields (Figure 26).

---

[4] In Exercise 3 the new measure is implemented and it would be logical to continue with the assignment process immediately. However, in order to familiarize future users with the MVP web application every exercise is prepared as a standalone exercise.

Figure 26 demonstrates the process of finding the implemented measure. The top of this figure displays the list of all implemented measures in the database. Please note the attributes in the *Status* field, here given as a combination of **Assigned** and **Unassigned** measures. It is very important to remember that when an implemented measure is assigned to at least one planned measure it is attributed as **Assigned**. This is relevant for measures that will be assigned to more than one plan – on different policy/administrative levels.
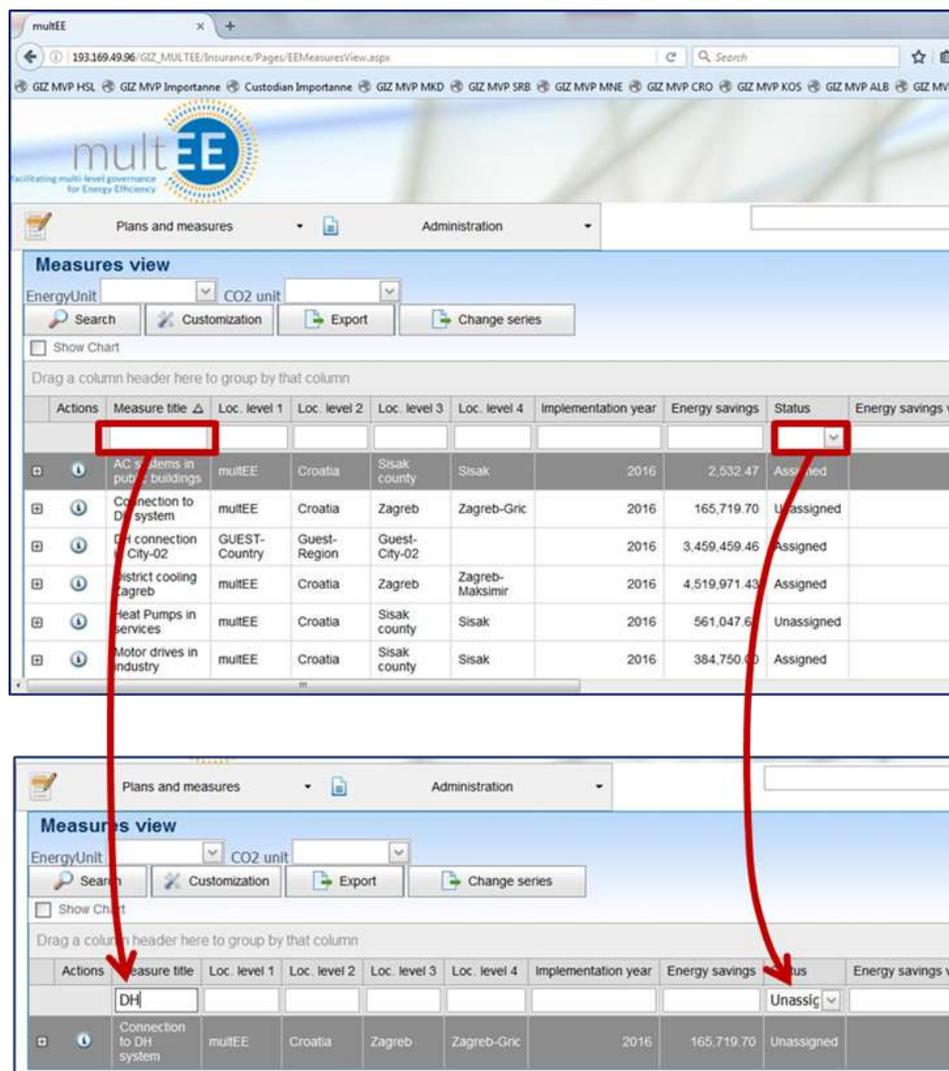
Figure 26: How to find the implemented measure which needs to be assigned.

Let us suppose that we would like to assign the measure related to the new district heating connection, a project which was implemented in Zagreb, Croatia. The user can either search record by record or can use sorting fields, as illustrated in the bottom of Figure 26. Here, the "DH" set of characters is entered in the sorting field under the *Measure title* and the **Unassigned** attribute is selected from the drop-down menu in the field *Status* (red rectangles with arrows in Figure 26).

By clicking the action button ⓘ the user is redirected to this exact implemented measure and the form appears on the screen, as shown in Figure 27 (top).

Note that the lower portion of the *Implemented measure* form is shown at the top of Figure 27 for illustration purposes only.

By clicking the **Assign** command button a new window/form opens, as shown at the bottom of Figure 27. Again, the filtering feature is used to find the Croatian NEEAP (measure is implemented in Zagreb, Croatia).
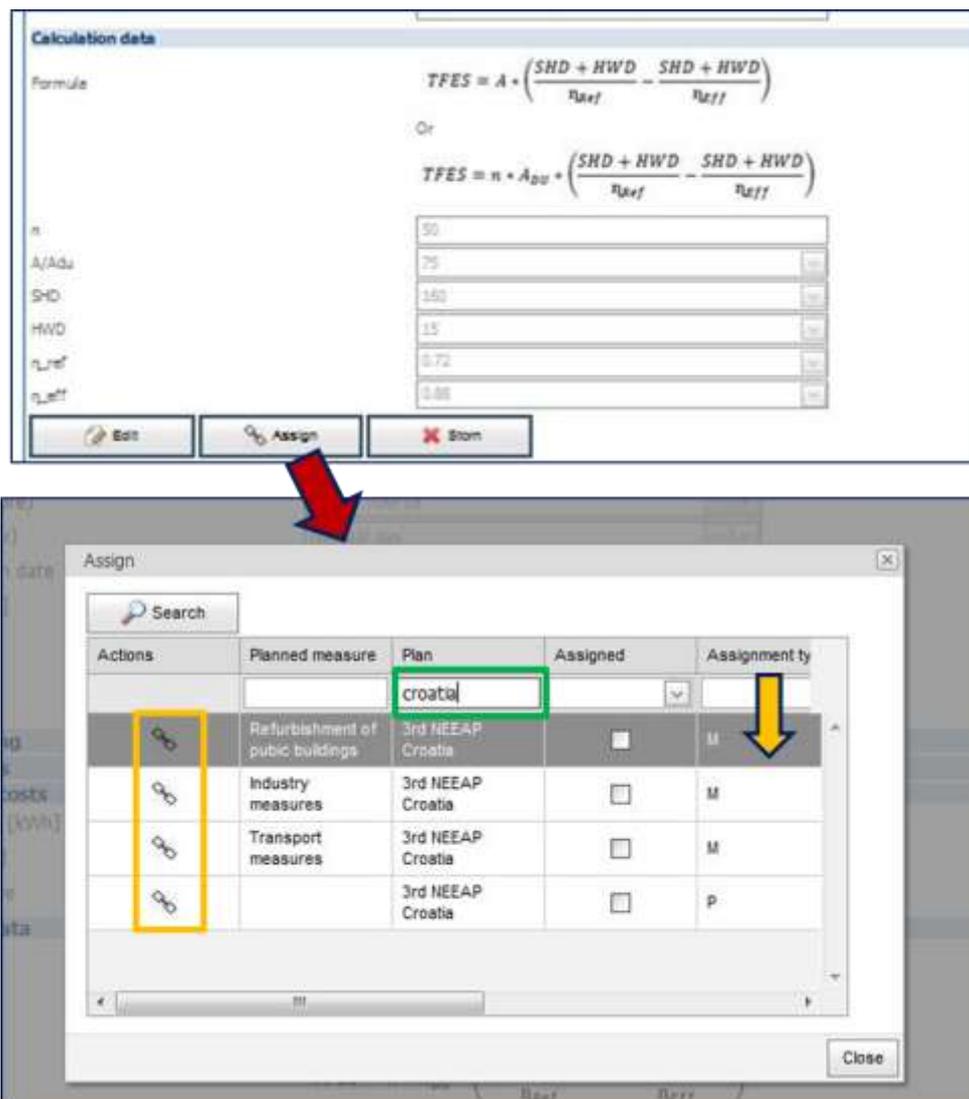
Figure 27: Part of the implemented measure (top) and assignment window (bottom).

Since we are looking for NEEAP from Croatia, the set of characters "**Croatia**" was typed into the sorting field *Plan* (green rectangle in Figure 27). Please note the action buttons in the *Assigned* field, highlighted with an orange rectangle in Figure 27. When the user clicks the 🔗 action button the measure is assigned and it gets the **Assigned** attribute (see Figure 28).

Also, note the *Assignment type* field marked with an orange arrow in Figure 27. As it can be seen there are two assignment types: **P–type** and **M–type**. **M-type** assignment means that the implemented measure is assigned to the measure from the plan, while **P-type** assignment means that the implemented measure is assigned to the plan itself.

The rationale behind this is the following: it can happen that field implementation of projects does not fully reflect the planned measures. So, if the implemented measure does not exist in the list of planned measures – the implemented measure is assigned to the plan and this can be used as relevant information in the next policy plan cycle.
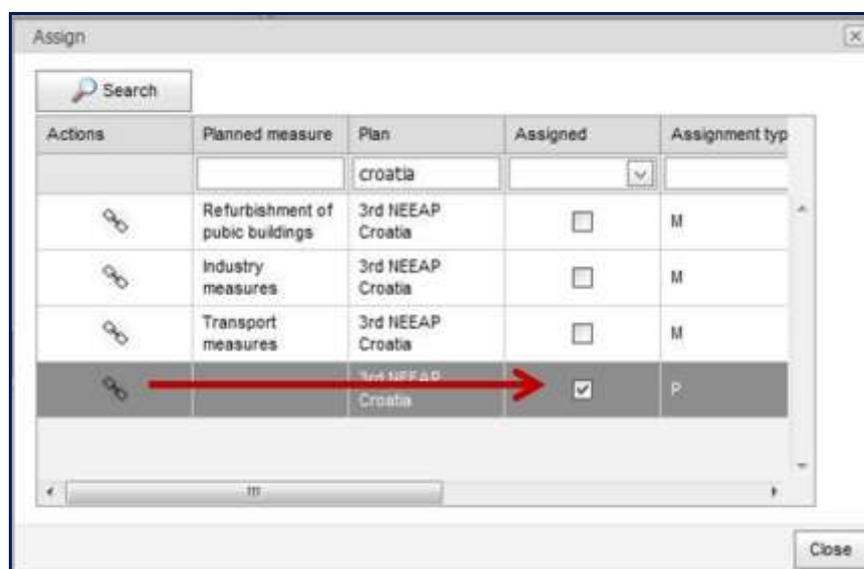
Figure 28: P-type assignment of the implemented measure and the plan.

After assigning the measures, as explained above, the *Assignment* window can be closed. An implemented measure can be assigned to multiple measures from different plans, in the same manner as described for the Croatian NEEAP above. For example we can search for the local Zagreb plan and assign the measure to it using the same principle.

Figure 29 shows the *Measure assignment overview* form and an illustration of how to navigate to this form (red arrow and rectangle).

Also, please note that the newly assigned measure related to district heating connection in Zagreb, Croatia appears on the form. The field on the left (in the orange rectangle) is empty. This is the field that contains the title of the planned measure.
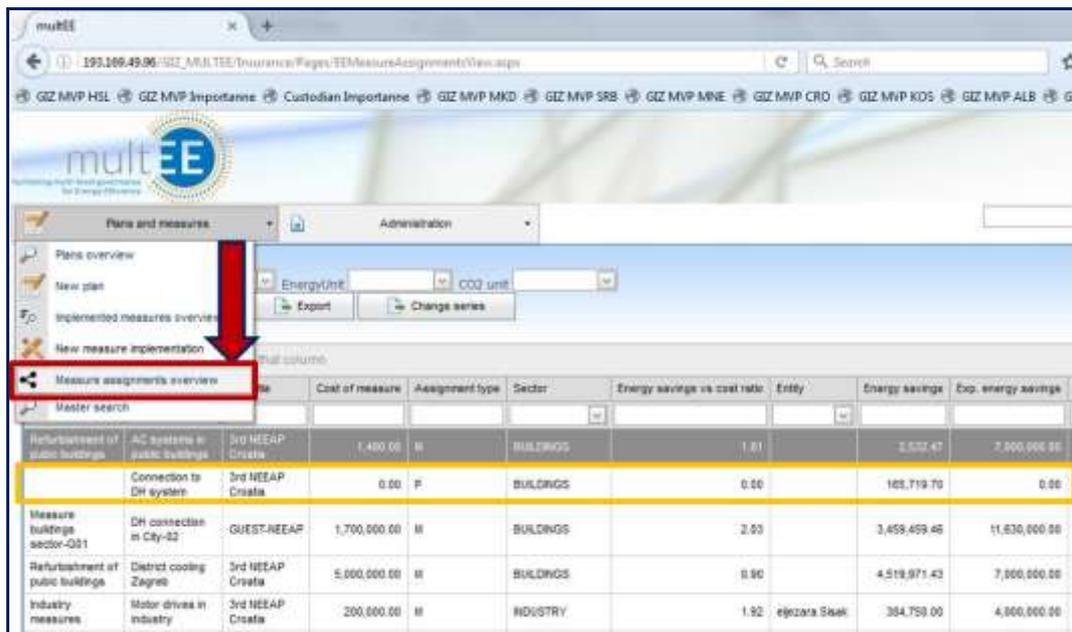
Figure 29: Measure assignments overview and appearance of newly assigned implemented measure.

In this case, since the implemented measure is assigned to the plan (**P–type**), there is no title of the planned measure. Working with the *Measure assignment* form will be further explained in the chapter Reporting in the MVP web application.

III   Reporting in the MVP web application

In the MVP, three main forms are used for overviews, analysis and reporting purposes - as highlighted in Figure 30. Before demonstrating the specifics of these forms it is useful to define some common principles applicable to all.

Figure 30: Highlighted links to the reporting forms (left), command buttons (right).

Three main reporting forms are shown in Figure 30, highlighted in orange:

- ✓ Plans overview,
- ✓ Implemented measures overview,
- ✓ Measure assignments overview.

Navigation to these forms is already mentioned in the text and goes via *Plans and measures* command menus as shown in Figure 30. A simple click on any of the links redirects the user to the chosen form. Specifics of different overview forms will be discussed in the text and examples below.

Command buttons are shown in the red rectangle in Figure 30 (right):

- **Search,**
- **Customization,**
- **Export,**
- **Change Series.**

Search sometimes plays a role of the refresh button and users are advised to use the **Search** command button every time when making a new grouping. This is usually done automatically, but one more click does not cost much. Also, when a search criterion is entered in the search fields (red rectangle in Figure 14) the **Search** button executes the operation.

Customization allows users to reshape the look of the existing forms, rearrange the appearance of the columns and to add at or remove some fields from the form. After clicking the **Customization** command button, the user can simply add fields or remove the existing fields from the form using the *drag-and-drop* principle.

Export command button executes the export of the existing form to an MS Excel file (2007 or later). The exporting principle is – ***what you see is what you get*** and, after rearranging the form, grouping data and/or adding graphs, it is possible to export the data with just one click of the **Export** button.

Change Series command button allows changing of the values that will appear in the graph. Please note that the parameters of the **Change Series** option are different for *Implemented measures overview* and *Measure assignments overview*. The main features for reporting are explained in *Exercise 5: Implemented measures overview* and *Exercise 6: Measure assignments overview*.[5]

III.I Exercise 5: Implemented measures overview

When the implemented measure is registered in the MVP web platform it is immediately visible on the *Measure Implementation form*. It means that all projects registered in the MVP database can be viewed on this form. However, depending on user permissions granted by the national system administrator, final users will be able to view all measures at their appropriate level. It means that the user with permissions at the top level (Loc. Level 1 – see Figure 31) will be able to view all measures, since the Loc. Level 1 is the top level in the MVP hierarchy.

Figure 31 (left) shows the *Measure implementation overview* form with all registered projects displayed. Let us suppose here that the current user has administrative rights for the entire MVP hierarchy.

The right side of the Figure 31 illustrates two important things. One is the filtering of data by entering the "**cro**" set of characters in the sorting field (already demonstrated in *Exercise 2: Adding a new measure in a plan*) and the grouping of data by *dragging-and-dropping* the field heading to the *Grouping area* (see Figure 5).

---

[5]Other features will be demonstrated at the live session training.

Figure 31: *Measure implementation overview* (left) and grouping of data (right).

Here grouping is done for Local Level 3, which in case of Croatia is the level of counties. It is important to note that Local levels 1 through 5 are numerated from the top level. [6] By choosing to filter and group the data, the user gives an instruction to the application that he/she wants to see data implemented in Croatia and grouped by counties in Croatia (see Figure 31, right).

Also, in Figure 31 (right) one may notice the small red rectangle near the **Show chart** label. Checking the check box next to this label indicates that graphical representation of data is required. In addition, the user may select the data to be shown in the chart (see Figure 32).
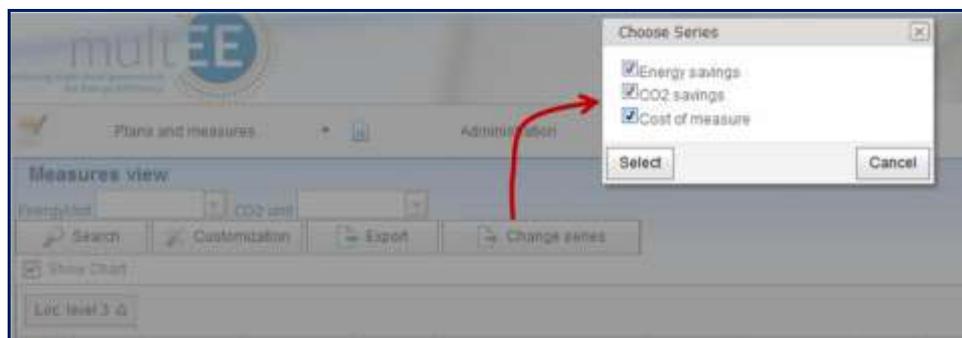
Figure 32: Change the series displayed in the graph

Figure 32 shows the dialogue box which appears after clicking the **Change series** command button.

By default, *Energy savings* and *CO_2 savings* are the recommended options for the chart. If the user checks the checkbox next to the *Cost of measure* field (Figure 32) this parameter will be added to the chart. After the user selects the preferred columns, one final click on **Select** closes the dialogue box and generates the chart. The same procedure is used to remove parameters from the chart. The user only needs to uncheck the checkbox next to the relevant field and confirm changes by clicking the **Select** command button.

---

[6] During the testing phase the multEE structure is defined at the top of the hierarchy (Local level 1).

Figure 33 shows the selected option, grouping of data by Local level 3, with the filter prescribed for Local Level 2 so that only data where the *Loc. Level 2* field begins with the characters "**cro**" appears on the screen. Please note that the checkbox next to **Show Chart** should be checked (see red rectangle in Figure 33) and the graph with the selected fields will appear. The result of above actions will be a report on implemented projects in Croatia, grouped by counties, with graphical representation of energy savings, CO_2 emission reduction and money invested in energy efficiency projects.
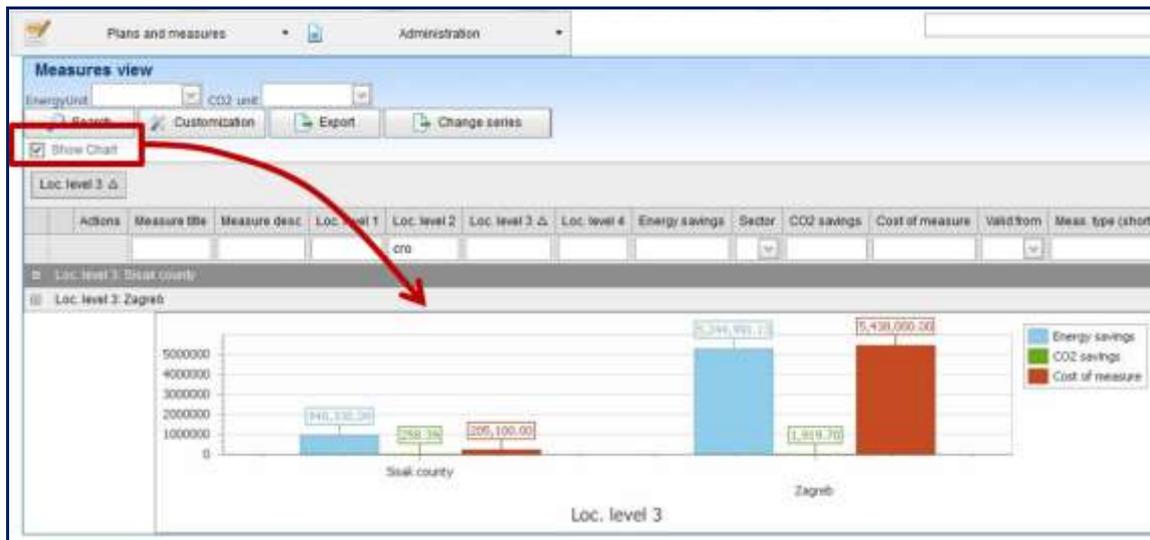
Figure 33: Displayed chart after grouping of data (energy savings, CO_2 emission reduction and costs).

The *drag-and-drop* principle is already mentioned in the section dealing with grouping of data. It is important to know that the user can design and rearrange the appearance of the data in forms using the same principle. Namely, it is possible to *drag-and-drop* field headings and change their position and order of appearance.

Figure 34 shows the report exported to MS Excel. Excel report is generated by clicking on the **Export** command button. Creation of reports in the MVP web application is based on the ***what-you-see-is-what-you-get*** principle. It means that the user prepares the forms, rearranges the positions of columns, adds/removes columns, adds a graph to the form and, finally, exports the data to MS Excel.

Box 12: Data manipulation in exported MS Excel file

IMPORTANT

The exported MS Excel file is an ordinary excel file which allows further data manipulation. It is, however, important to mention that the graph is exported as a picture and there is no dynamic link between the data in MS Excel and graph properties. In other words, if some manipulation with numbers is done in MS Excel after the export, it will not be reflected in the graph. The user always has an option to create a new graph in MS Excel with the selected data.
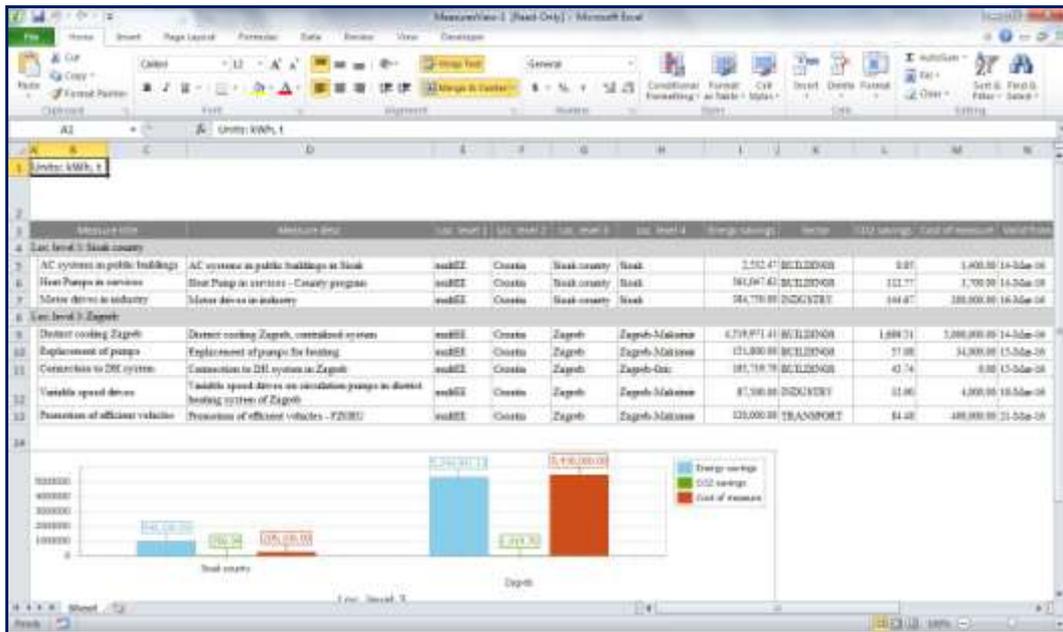
Figure 34: Report exported to MS Excel according to prepared form from Figure 33.

Figure 35 demonstrates two features mentioned in the text. Figure 35 left shows how to add a new field from the container. The container opens when the user clicks the **Customization** command button. By simply *dragging-and-dropping* the user can position the new field on the active part of the form (see Figure 35 left).
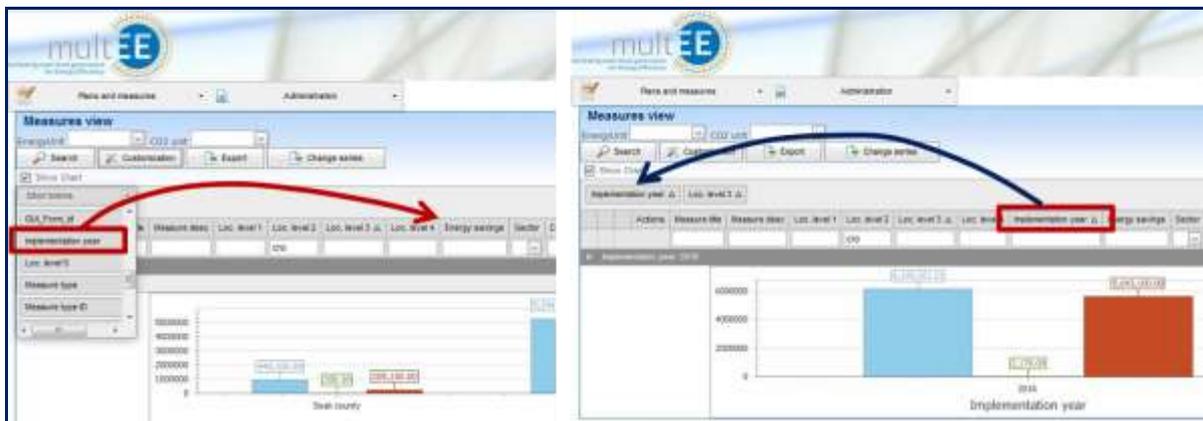
Figure 35: Adding new field to the form (left), grouping by new field added to the form (right).

It is now possible to group the data in the form by year of implementation (*Implementation year* is added from the container). To perform the grouping, the user only needs to *drag-and-drop* the heading *Implementation year* and put it in front of the already existing *Loc. level 3* grouping criterion.

Figure 35 (right) shows that graph values now correspond to the first grouping criteria and that the values in chart are changed. It is important to notice that Figure 35 (right) shows multiple grouping of data. In the MVP users may set an arbitrary number of grouping criteria, whenever it makes sense.

Box 13: Grouping criterion for chart in MVP application

REMARK
The chart in MVP web application that provides graphical representation of data always corresponds to the first grouping criterion (first on the left), as shown in Figure 35 (right).

In general, the *Implemented measures overview* is the form to use for different types of analyses, such as:

➢ Overall achieved savings and CO_2 emission reductions,

➢ Savings by different administrative levels,

➢ Public or total money spent on EE projects,

➢ Implementation dynamics by year,

➢ Finding the national champions in savings,

➢ etc.

Exercise 5 demonstrates the main functionality of form manipulation and reporting. It is not difficult to conclude that flexible data manipulation in grid forms allows the user to reach every single piece of data very quickly. The number of different reports that can be generated by the MVP web platform is in the thousands. Another important thing to note is that the application uses cookies and remembers the last user settings in terms of selected data and order of appearance of different fields. The point is that once you design the forms the way you like, you can rest assured that the forms will be exactly the same next time you log in.

III.II Exercise 6: Measure assignments overview

While the *Measure implementation overview* provides a list of all implemented projects, the *Measure assignment overview* offers a list only of implemented measures that have been assigned to any of the existing plans or measures from the plans. The assignment process is demonstrated in *Exercise 4: Assignment of implemented measure to planned measure*.

As soon as the measure is assigned to any plan or measure from the plan (P- or M-type assignment) the status of this measure changes from **Unassigned** to **Assigned** and the measure will appear in the *Measure Assignment Overview* form.

Box 14: Link between an implemented measure and different policy plans

One of the main advantages of the MVP web platform is the fact that one implemented measure can be assigned to different policy plans. Namely, the measure implemented in city X will contribute to the planned energy savings at the level of city X but will also contribute to the planned savings in region Y to which city X belongs. This is valid for all administrative and policy levels in one country.

The status of the implemented measure can be checked in the *Measure Implementation Overview,* as shown in Figure 36. Navigation to this form is shown in Figure 30 (left).

Figure 36 shows the *Implemented measures overview* form. Orange rectangles indicate two chosen measures with different statuses. Also, red rectangles with arrows show how to expand and display the link to the appropriate plan by using the ⊞ action button.

Figure 36: Implemented measure overview and status field values

Note that the measure with the status **Assigned** shows that the measure is assigned to the 3rd NEEAP in Croatia (upper part of Figure 36). The second measure, with the **Unassigned** status, displays an empty record of assignment (lower part of Figure 36). This is the way to check whether the implemented measure is linked to all desired plans. [7]

---

[7] Demonstration part of the training will introduce participants to an MS Excel patch that can help users to find unassigned implemented measures.

Figure 37 presents the *Measure Assignments overview* grouped by *Plan title*.
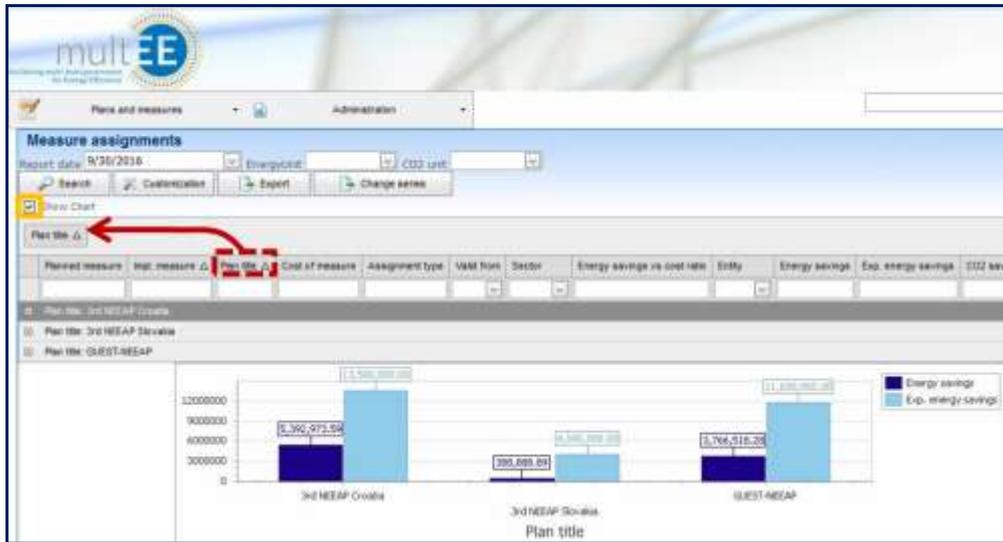
Figure 37: *Measure assignment overview* grouped by the *Plan type* field.

Box 15: Avoiding double counting in *Measure assignment overview* form

IMPORTANT

Users should be cautious here, since there is a possibility that one implemented measure could appear more than once in this list. This practically means that the achieved energy savings would not be a simple sum of all listed savings. Namely, if the implemented measure is linked to two plans the same measure will appear twice in this overview.

Another common situation is that multiple implemented measures are assigned to one planned measure. This is demonstrated in Figure 38.
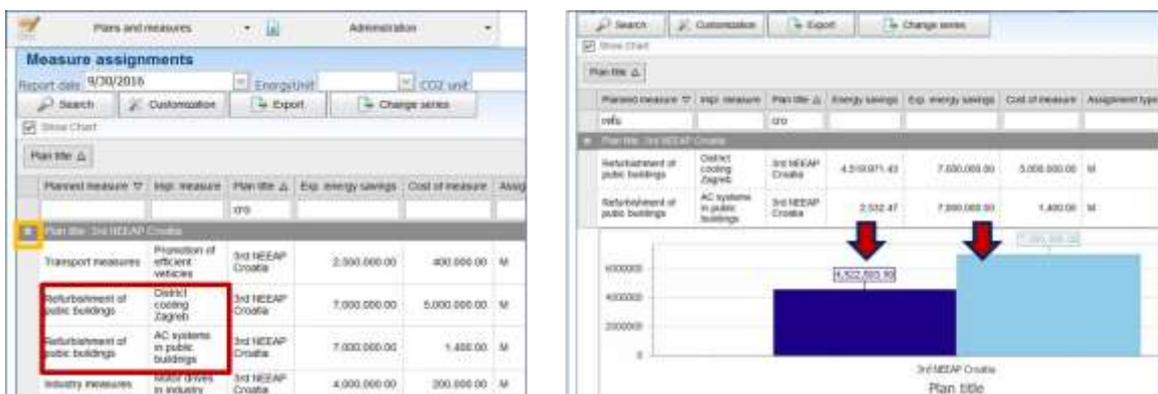
Figure 38: *Measure assignments overview* with the same planned measure.

Figure 38 (left) shows all assigned measures in Croatia after clicking the **Expand** action button - so that the full list of assigned measures is visible. Note that two implemented measures are assigned to the same planned measure – red rectangle in Figure 38 left.

On the right hand side of Figure 38, these two measures are isolated and shown (for demonstration purposes) by using the sorting field under the field heading *Planned measure*. It can be seen that the web chart recognizes that these measures are linked to the same planned measure and displays the sum of achieved energy savings, while the target remains equal to the target of the planned measure (not its double value).

By removing all text from sorting fields and keeping the grouping by *Plan title,* it is possible to create different reports here. Two examples are shown in Figure 39. Achieved energy savings, planned energy savings and money spent are shown on the left hand side. The right hand side plots the cost-effectiveness of different measures, which is done by selecting the option *Energy savings vs cost ratio* which displays achieved energy savings per 1 euro invested.
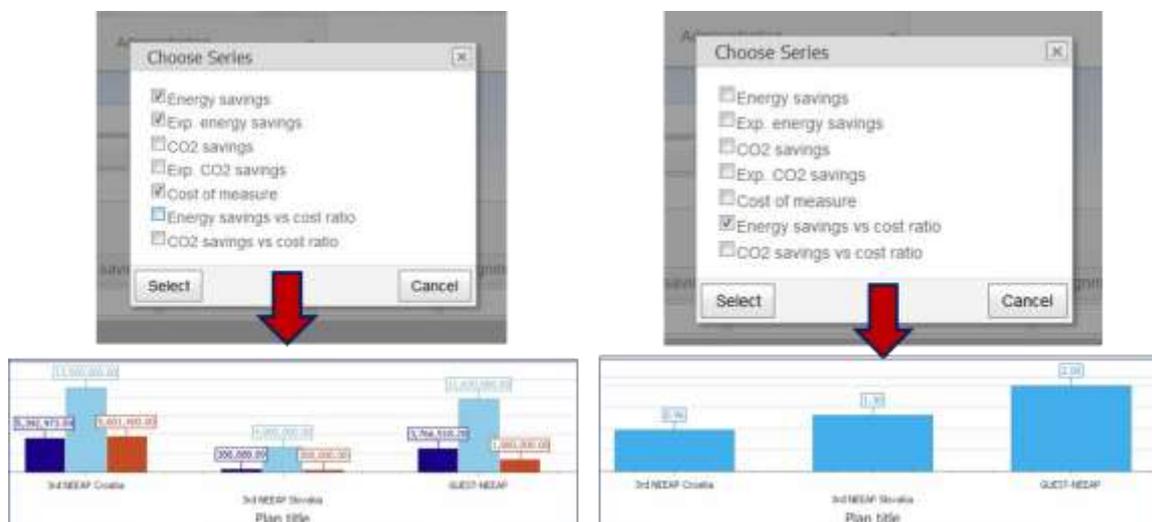
Figure 39: Selecting different options for chart and graphical representation of values.

This form was originally designed to show achieved savings versus planned savings. However, reporting possibilities are numerous and some of the applications can be as follows:

  ➢ Achieved versus planned energy savings for all plans,

  ➢ Invested public or total money for all plans,

  ➢ Comparative cost-effectiveness of implementation of different plans,

  ➢ Cost effectiveness of different measures,

  ➢ Achieved versus planned CO_2 emission reductions,

  ➢ etc.

IV   Conclusions

This document represents the core manual for the training. It starts with the global philosophy of the web application and the main goals of a well-functioning monitoring system. It presents a brief overview of the data structure and the role of the national system administrator. It aims to introduce the basic logic and should be helpful to new users in the initial use of the platform. The manual contains 6 exercises designed to be performed in combination with practical work during training. Exercises are carefully selected to cover all main aspects of the web platform. There are also features which were not mentioned in this manual but should be covered in the training session. Introduction training is planned to last one day and should ensure that users are familiar with most features and are able to use the MVP platform individually.

V   Annex

Annex A: Guidelines for entering a *New implemented measure* based on Bottom-Up methodology

Calculation of energy savings in the MVP web application is based entirely on equations from *Document with general formulae of bottom-up methods to assess the impact of energy efficiency measures*, which was developed as Deliverable 2.1 of multEE project[8]. Since this document provides detailed descriptions of equations, parameters, reference values and their application, this section provides only guidelines for entering the collected data in the MVP application. It is strongly recommended to use this training manual together with the corresponding Bottom-Up methodology.

The concept of form for all BU methods is the same and is described in the chapter *Exercise 3: New Implemented measure*. This section provides supplementary instructions for entering the parameters for calculation of energy savings and CO_2 emission reduction for different BU methods. The main point of the following text concerns the manner of data entry. In general, parameter values can be entered in the corresponding fields (marked as **FREE** entry) or the user can choose a reference value from the drop-down list for certain parameters (this will be marked as **CT** + Name of the *Codetable* where corresponding reference values are stored). Both options are available for most of the parameters.

1. Behavioural measures

SECTOR: Buildings

Awareness Raising (M.1.1)

Target sector: households

EQUATION:

$$TFES = n * FEC_{person} * S_Q$$

Label	Parameter	Entry
FEC_{person}	Final energy consumption of a person (kWh/a)	CT: FEC_per_person (M.1.1), FREE
S_Q	Savings factor of the awareness raising campaign (%)	CT: Savings_factor (M.1.1), FREE
n	Number of persons of a specific target group	FREE (numeric)

---

[8] The document can be found at http://multee.eu/content/report-general-formulae-bottom-methods.

Energy audits for households (M.1.2)

Target sector: households

EQUATION:

$$TFES = n_{Qi} * FEC_{HH} * S_{Qi}$$

Label	Parameter	Entry
n_Q	Number of energy audits at a specific quality level	FREE(numeric)
FEC_{HH}	Final Energy Consumption of household(s) (kWh/a)	CT: FEC_per_household (M.1.2, M.1.3), FREE
$S_{Q1,2,3}$	Savings factor of an energy audit at a specific quality level (%)	CT: Audits_HH_Savings_factor (M.1.2), FREE

Smart Meters and informative billing (M.1.3)

Target sector: households

EQUATION:

$$TFES = n * FEC_{HH} * s_{Smart}$$

Label	Parameter	Entry
N	Number of smart meters installed in households	FREE (numeric)
FEC_{HH}	Final Energy Consumption of household(s)	CT: FEC_per_household (M.1.2, M.1.3), FREE
S_{Smart}	Savings factor (%)	CT: Smart_Meters_Savings (M.1.3), FREE

2. Building envelope and building components

SECTOR: Buildings

Introduction of building codes for new residential and tertiary buildings (M.2.1)

Target sector: residential and tertiary buildings

EQUATION:

$$TFES = A * \left(\frac{SHD_{inocode}}{n_{iinicode}} - \frac{SHD_{newcode}}{n_{new}} \right)$$

Label	Parameter	Entry
A	Heated floor area of the newly constructed building (m^2)	CT: Heated_gross_floor (M.2.1), FREE
SHD$_{inicode}$	Specific Space Heating Demand (kWh/m^2/a)	SHD_inicode (M.2.1), FREE
SHD$_{newcode}$	Specific Space Heating Demand (kWh/m^2/a)	CT: SHD_newcode (M.2.1), FREE
$\eta_{linicode}$	Annual efficiency of the heating system	CT: Eta_inicode (M.2.1), FREE
η_{lnew}	Annual efficiency of the heating system	CT: Eta_new (M.2.1), FREE

Thermally improved building envelope of newly constructed residential buildings (M.2.2)

Target sector: residential buildings

EQUATION:

$$TFES = A * \left(SHD_{Ref} - SHD_{Eff} \right) * \frac{1}{\eta_{Eff}}$$

• Label	• Parameter	• Entry
• A	• Heated gross floor area of the newly constructed building (m^2)	• CT: Heated_gross_floor (M.2.1), FREE
• SHD$_{Ref}$	Space Heating Demand of the reference building (kWh/m^2/a)	CT: SHD_ref (M.2.2, M.2.3, M.2.4, M.6.1, M.6.2, M.6,3, M.10.1, M.10.2), FREE
• SHD$_{Eff}$	Space Heating Demand of the energy efficient building (kWh/m^2/a)	CT: SHD_eff (M.2.2, M.2.3, M.2.4, M.6.1, M.6.2, M.6,3, M.10.1, M.10.2), FREE
• η_{lEff}	Efficiency of the heating system in the newly constructed building	CT: Eta_eff (M.2.2, M.2.3, M.2.4, M.11.1, M17.1, M17.2, M.17.3), FREE

Thermally improved building envelope of refurbished residential buildings (M.2.3)

Target sector: residential buildings

EQUATION:

$$TFES = A * \left(\frac{SHD_{Ref} + HWD}{\eta_{REf}} - \frac{SHD_{Eff} + HWD}{\eta_{Eff}} \right)$$

Label	Parameter	Entry
A	Heated gross floor area of the refurbished building (m^2)	Heated_gross_floor (M.2.1), FREE
SHD_{Ref}	Space Heating Demand of the reference building ($kWh/m^2/a$)	CT: SHD_ref (M.2.2, M.2.3, M.2.4, M.6.1, M.6.2, M.6,3, M.10.1, M.10.2), FREE
SHD_{Eff}	Space Heating Demand of the energy efficient building ($kWh/m^2/a$)	CT: SHD_eff (M.2.2, M.2.3, M.2.4, M.6.1, M.6.2, M.6,3, M.10.1, M.10.2), FREE
HWD	Domestic Hot Water Demand ($kWh/m^2/a$)	CT: HWD (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2), FREE
η_{Ref}	Efficiency of the heating system in the reference building	CT: Eta_ref (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2, M.11.1, M11.2), FREE
η_{Eff}	Efficiency of the heating system in the efficient building	CT: Eta_eff (M.2.2, M.2.3, M.2.4, M.11.1, M17.1, M17.2, M.17.3), FREE

Thermally improved building envelop of newly constructed non-residential buildings

MEASURE MERGED WITH M.2.2

Thermally improved building envelop of existing non-residential buildings

MEASURE MERGED WITH M.2.3

Thermal improvement of single building components (windows, roof etc.) (M.2.6)

Target sector: residential and non-residential buildings

EQUATION:

$$TFES_{env} = \left(U_{Ref\_env} - U_{Eff\_env}\right) * A * HDD * f * \frac{1}{\eta_{Ref}}$$

Label	Parameter	Entry
U_{Ref_envl}	U-value of the reference building component (W/m^2K)	CT: U_ref_env (M.2.6), FREE
U_{Eff_env}	U-value of the efficient building component (W/m^2K)	CT: U_eff_env (M.2.6), FREE

• Label	• Parameter	• Entry
• A	• Area of the building component refurbished (m^2)	• FREE
• HDD$_{AC}$	• Heating degree days (Kd/a)	• **Location table**
• F	• Conversion intermittency factor (kh/d)	• CT: Conversion_factor (M.2.6)
• η$_{lRef}$	• Annual use efficiency of the heating system	• CT: Eta_ref (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2, M.11.1, M11.2)

3. Cooling of buildings

SECTOR: Buildings

Sectors: households and services (residential and non-residential buildings)

Air conditioning

Central compression cooling system (M.3.1.1)

Target sector: residential and non-residential buildings

EQUATIONS:

-
- **Option 1:**

$$TFES = (P_C * h_{FL}) * \left(\frac{1}{ESEER_{Ref}} - \frac{1}{ESEER_{Eff}} \right) * n$$

-
- **Option 2:**

$$TFES = A * \left(SCD_{Ref} * \frac{1}{ESEER_{Ref}} - SCD_{Eff} * \frac{1}{ESEER_{Eff}} \right)$$

• Label	• Parameter	• Entry
• P$_C$	• Installed cooling power (kW)	• FREE (Numeric)
• h$_{FL}$	Full-load hours for max capacity (h)	CT: Cooling_full_load_hours (M.3.1.1, M.3.1.2), FREE
• ESEER$_{Ref}$	Seasonal Energy Efficiency Ratio reference	CT: ESEER_ref (M.3.1.1)
• ESEER$_{Eff}$	Seasonal Energy Efficiency Ratio efficient	CT: ESEER_eff (M.3.1.1)

• Label	• Parameter	• Entry
• n	• Number of cooling systems	• FREE (Numeric)
• A	Cooled floor area of the building (m^2)	CT: Cooled_area (M.3.1.1, M.3.1.2)
• SCD$_{Ref}$	Specific Cooling Demand reference (kWh/m^2/a)	CT: Cooling_SCD_ref (M.3.1.1, M.3.1.2)
• SCD$_{Eff}$	• Specific Cooling Demand efficient (kWh/m^2/a)	• CT: Cooling_SCD_eff (M.3.1.1, M.3.1.2)

- TFES calculated according Option 1 if user prescribes P$_C$, h$_{FL}$, n
- Otherwise TFES calculated by using SCD$_{Ref}$, SCD$_{Eff}$ and A

Room air conditioner < 12 kW cooling capacity (M.3.1.2)

Target sector: residential and non-residential buildings

EQUATIONS:

- **Option 1:**

$$TFES = (P_C * h_{FL}) * \left(\frac{1}{SEER_{Ref}} - \frac{1}{SEER_{Eff}}\right) * n$$

- **Option 2:**

$$TFES = A * \left(SCD_{Ref} * \frac{1}{SEER_{REF}} - SCD_{Eff} * \frac{1}{SEER_{EFF}}\right)$$

• Label	• Parameter	• Entry
• P$_C$	• Installed cooling power (kW)	• FREE (Numeric)
• h$_{FL}$	Full-load hours for max capacity (h)	CT: Cooling_full_load_hours (M.3.1.1, M.3.1.2), FREE
• SEER$_{Ref}$	Seasonal Energy Efficiency Ratio reference	CT: SEER_ref (M.3.1.2)
• SEER$_{Eff}$	Seasonal Energy Efficiency Ratio efficient	CT: SEER_eff (M.3.1.2)
• n	• Number of cooling systems	• FREE (Numeric)
• A	Cooled floor area of the building (m^2)	CT: Cooled_area (M.3.1.1, M.3.1.2)
• SCD$_{Ref}$	Specific Cooling Demand reference (kWh/m^2/a)	CT: Cooling_SCD_ref (M.3.1.1, M.3.1.2)
• SCD$_{Eff}$	• Specific Cooling Demand efficient (kWh/m^2/a)	• CT: Cooling_SCD_eff (M.3.1.1, M.3.1.2)

- TFES calculated according Option 1 if user prescribes P$_C$, h$_{FL}$, n
- Otherwise TFES calculated by using SCD$_{Ref}$, SCD$_{Eff}$ and A

District cooling (M.3.2)

Target sector: residential and non-residential buildings

EQUATION:

$$TFES = \left(\frac{Q_b}{COPS_d} * t_d \right) * nb - \left[\left(\frac{Q_b * nb * f_{sf} + q_l * l}{COPS_c} \right) * t_c \right] - P_P * t_c$$

Label	Parameter	Entry
Q_b	Cooling load per building (kW)	CT: Cooling_load (M.3.2)
$COPS_d$	System COP (decentralized)	CT: COPS_decentralized (M.3.2)
t_d	Yearly operating hours (decentralized) (h/a)	FREE (Numeric)
Nb	Number of buildings	FREE (Numeric)
f_{sf}	Simultaneity Factor	CT: Simultaneity _factor (M.3.2)
q_l	Specific distribution losses (kW/m)	CT: Specific_distribution_losses (M.3.2)
l	Length of distribution grid (m)	FREE (Numeric)
$COPS_c$	System COP (centralized)	CT:COPS_decentralized (M.3.2)
t_c	Yearly operating hours (centralized)	FREE (Numeric)
P_P	Power of distribution pump (kW)	FREE (Numeric)

4. Circulating pump

SECTOR: Buildings

Installation of a new heating circulating pump (M.4.1)

Target sector: residential and non-residential buildings

EQUATIONS:

$$TFES = n * \left(\frac{P_{Ref} * t_a - P_{eff} * t_a * fLPr}{1000} \right)$$

$$f_{LPr} = t_{Q100\%} * Q_{100\%} + t_{Q75\%} * Q_{75\%} + t_{Q50\%} * Q_{50\%} + t_{Q25\%} * Q_{25\%}$$

Label	Parameter	Entry
• n	• Number of installed circulating pumps	• FREE (Numeric)
• P_{Ref}	• Power of reference pump (average on market or inefficient) (W)	• FREE (Numeric)
• P_{eff}	• Power of efficient pump available on market (W)	• FREE (Numeric)
• t_a	Yearly operating hours (h/a)	CT: Pump_yearly_operating_hours (M.4.1, M4.2)
• f_{LPr}	• Factor load profile	• PREDEFINED-CONSTANT (see below)
• Q	Delivery rating of the pump	CT: Pump_factor_load_profile (M.4.1, M.4.2)
• t_Q	• Relative load time	• CT: Pump_factor_load_profile (M.4.1, M.4.2)

- Parameter **f_{lpr}** will always be constructed as SUMPRODUCT or the sum of multiplied values from columns 1 and 2. The approach allows future change of factor load profile for pumps!

Replacement of an existing heating circulating pump

MEASURE MERGED WITH M.4.1

5. Combined Heat and Power (CHP)

SECTOR: Industry

CHP plants in industry (M.5.1)

Target sector: industry

EQUATION:

$$TFES = \left(\frac{P_{el,CHP}}{\eta_{el,Ref}} + \frac{Q_{th,CHP}}{\eta_{th,Ref}} - \frac{P_{el,CHP}}{\eta_{el,CHP}} \right) \cdot t_{100} \cdot (1 - f_{PG})$$

$$f_{PG} = \frac{Q_{th,PG} + W_{el,PG}}{Q_{th,CHP} + W_{el,CHP}}$$

Label	Parameter	Entry
$P_{el,CHP}$	• Electrical power of the CHP plant (kW_{el})	• FREE (Numeric)
$\eta_{el,Ref}$	Electrical efficiency of the reference electricity plant (%)	CT: Electric_efficiency_reference (M.5.1) •

Label	Parameter	Entry
$Q_{th,CHP}$	• Thermal power of the CHP plant (kW$_{th}$)	• FREE (Numeric)
$\eta_{th,Ref}$	Thermal efficiency of the reference heat generation plant (%)	CT: Thermal_efficiency_reference (M.5.1)
$\eta_{el,CHP}$	• Electrical efficiency of the CHP plant (%)	• FREE (Numeric)
t_{100}	• Average yearly full load hours of the CHP plant (h/a)	• FREE (Numeric)
f_{PG}	• Factor for feeding electricity and heat into the public grid	• FREE (Numeric)
$Q_{th,PG}$	• Heat fed into the public grid (DH)	• FREE (Numeric)
• $W_{el,PG}$	• Electricity fed into the public grid	• FREE (Numeric)
• $Q_{th,CHP}$	• Heat generated in CHP plant	• FREE (Numeric)
• $W_{el,CHP}$	• Electricity generated in CHP plant	• FREE (Numeric)

6. District heating

SECTOR: Buildings

Connection to the district heating grid (non-refurbished existing residential buildings) (M.6.1)

Target sector: households (residential buildings)

EQUATION:

Option 1:

$$TFES = A * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}} \right)$$

Option 2:

$$TFES = n * A_{DU} * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}} \right)$$

Label	Parameter	Entry
• n	• Number of dwelling units connected to the DH grid	• FREE (Numeric)
• A/A$_{DU}$	Heated gross floor area connected to DH (m^2)	CT: Area_dwelling_unit (M.6.1), FREE
• SHD	Space Heating Demand (kWh/m^2/a)	CT: SHD_inicode (M.2.1), SHD_ref (M.2.2, M.2.3, M.2.4, M.6.1, M.6.2, M.6,3, M.10.1, M.10.2), FREE
• HWD	• Domestic Hot Water Demand (kWh/m^2/a)	• CT: HWD (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2), FREE
• η$_{Ref}$	• Annual efficiency of reference heating system	• CT: Eta_ref (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2, M.11.1, M11.2), FREE
• η$_{Eff}$	Annual use efficiency of the efficient heating system	CT: District_heating_eta_eff (M.6.1), FREE •

- If user prescribes number of dwellings n than this number will multiply the Area. Otherwise, if n is omitted the Area will be treated as gross are of the building.

Connection to the district heating grid (thermally refurbished residential buildings)

MEASURE MERGED WITH M.6.1

Connection to the district heating grid (newly constructed residential buildings)

MEASURE MERGED WITH M.4.1

7. Smart district heating grids (M.7)

SECTOR: Buildings

Target Sectors: energy generation and distribution, households and services (residential and non-residential buildings)

EQUATION:

$$TFES_{th} = EC_{th} * f_{SG,th}$$

Label	Parameter	Entry
• EC$_{th}$	• Total thermal energy consumption (kWh/a)	• FREE (Numeric)
• f$_{SG, th}$	Energy saving factor (%)	CT: Smart_DH_Grid_saving_factor (M.7)

8. Energy Audits of technical processes (M.8)

SECTOR: Industry

Sectors: business and industry

EQUATION:

$$TFES = \left(\frac{E_{before}}{P_{before}} - \frac{E_{after}}{P_{after}} \right) * P_{after}$$

• Label	• Parameter	• Entry
• E_{before}	• Energy consumption before implementation (kWh/a)	• FREE (Numeric)
• E_{after}	• Energy consumption after implementation (kWh/a)	• FREE (Numeric)
• P_{before}	• Production volume before implementation	• FREE (Numeric)
• P_{after}	• Production volume after implementation	• FREE (Numeric)

9. Introduction of energy management systems (M.9)

SECTOR: Industry

Sectors: business and industry

EQUATION:

$$TFES = FEC_{EL} * S_{EL} + FEC_{H} * S_{H}$$

• Label	• Parameter	• Entry
• FEC_{EL}	• Consumption of electricity (kWh/a) in the last year before EM	• FREE (Numeric)
• S_{EL}	EM Savings factor for electricity	CT: EM_saving_factor_electricity (M.9)
• FEC_{H}	• Consumption of heat (kWh/a) in the last year before EM	• FREE (Numeric)
• S_{H}	EM Savings factor for heat	CT: EM_saving_factor_heat (M.9)

10. Heat pumps

SECTOR: Buildings

Installation of a soil-, water or air-source heat pump in new buildings (M.10.1)

Target sector: households (residential buildings)

EQUATION:

- **Option 1:**

$$TFES = A * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}} \right)$$

- **Option 2:**

$$TFES = n * A_{DU} * \left(\frac{SHD + HWD}{\eta_{Ref}} - \frac{SHD + HWD}{\eta_{Eff}} \right)$$

• Label	• Parameter	• Entry
• n	• Number of dwelling units concerned	• FREE (Numeric)
• A/A$_{DU}$	• Heated gross floor area or area of the dwelling unit (m²)	• CT: Area_dwelling_unit (M.6.1), FREE
• SHD	• Space Heating Demand (kWh/m²/a)	• CT: SHD_inicode (M.2.1), SHD_ref (M.2.2, M.2.3, M.2.4, M.6.1, M.6.2, M.6,3, M.10.1, M.10.2), FREE
• HWD	• Domestic Hot Water Demand (kWh/m²/a)	• CT: HWD (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2), FREE
• η_{Ref}	• Annual use efficiency of the reference heating system	• CT: Eta_ref (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2, M.11.1, M11.2), FREE
• η_{Eff}	Annual use efficiency of the efficient heating system	CT: Heat_pump_eta_eff (M.10.1, M.10.2)

- If user prescribes number of dwellings n than this number will multiply the Area. Otherwise, if n is omitted the Area will be treated as gross area of the building.

Installation of a soil-, water or air-source heat pump in existing buildings

MEASURE MERGED WITH M.10.1

11. Heating system improvement

SECTOR: Buildings

Improvement of heat generation, distribution, emission and control (M.11.1)

Target sector: residential and non-residential buildings

EQUATION:

$$TFES = A * SHD * \left(\frac{1}{\eta_{Ref}} - \frac{1}{\eta_{Eff}} \right)$$

- $\eta_{Ref} = \eta_{rb} \ \eta_{re} \ \eta_{rd}$

$\eta_{Eff} = \eta_{eb} \ \eta_{ee} \ \eta_{ed}$

Label	Parameter	Entry
A	Heated area of the building (m^2)	FREE (Numeric)
SHD	Specific Heating Demand (kWh/m^{2}a)	CT: SHD_ref (M.2.2, M.2.3, M.2.4, M.6.1, M.6.2, M.6,3, M.10.1, M.10.2), FREE
η_{Ref}	Efficiency of referent heating system	CT: Eta_ref (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2, M.11.1, M11.2), FREE
η_{Eff}	Efficiency of condensing heating system	CT: Eta_eff (M.2.2, M.2.3, M.2.4, M.11.1, M17.1, M17.2, M.17.3), FREE
η_{rb}	Efficiency of referent boiler	CT: System_eta_boiler_ref (M.11.1), FREE
η_{re}	Efficiency of referent emission system	CT: System_eta_emission_ref (M.11.1), FREE
η_{rd}	Efficiency of referent distribution system	CT: System_eta_distribution_ref (M.11.1), FREE
η_{eb}	Efficiency of efficient boiler	CT: System_eta_boiler_eff (M.11.1), FREE
η_{ee}	Efficiency of efficient emission system	CT: System_eta_emission_eff (M.11.1), FREE
η_{ed}	Efficiency of efficient distribution system	CT: System_eta_distribution_eff (M.11.1)

- Product of boiler, emission and distribution efficiency should be equal to system efficiency, both for reference and efficient!
- If user prescribes system efficiency than boiler, emission and distribution efficiency will be neglected and vice versa.

Improved thermal insulation of warm water tanks (M.11.2)

Target sector: residential and non-residential buildings

EQUATION:

$$TFES = \frac{Q_{loss-old} - Q_{loss-new}}{\eta}$$

• Label	• Parameter	• Entry
• n	• Number of insulated tanks	• FREE (Numeric)
• $Q_{loss-old}$	Yearly heat loss of a non-insulated tank (kWh/a)	CT: Heat_loss_tank_old (M.11.2), FREE
• $Q_{loss-new}$	Yearly heat loss of a well-insulated tank (kWh/a)	CT: Heat_loss_tank_new (M.11.2), FREE
• η	• Efficiency of the existing heating system	• CT: Eta_ref (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2, M.11.1, M11.2), FREE

Thermal insulation of pipes in the heating system (M.11.3)

Target sector: residential and non-residential buildings

EQUATION:

$$TFES = \frac{(q_{init} - q_{new}) * L * HD * 24 * c}{1000}$$

• Label	• Parameter	• Entry
• q_{init}	Initial pipe heat loss (W/m)	CT: Heat_loss_pipe_old (M.11.3)
• q_{new}	Pipe heat loss after thermal insulation (W/m)	CT: Heat_loss_pipe_new (M.11.3)
• L	• Length of insulated pipes (m)	• FREE (Numeric)
• C	Intermittency coefficient	CT: Intermittency (M.11.3)
• HD	Number of heating days	CT: Heating_days (M.11.3)

Installation of thermostatic valves on radiators (M.11.4)

Target sector: residential and non-residential buildings

EQUATION:

$$TFES = A * SHD * \frac{1}{\eta_{boiler} * \eta_{dis}} * \left(\frac{1}{\eta_{ini}} - \frac{1}{\eta_{new}}\right)$$

• Label	• Parameter	• Entry
• SHD	• Specific heating demand (kWh/m²/a)	• CT: SHD_ref (M.2.2, M.2.3, M.2.4, M.6.1, M.6.2, M.6,3, M.10.1, M.10.2), FREE
• A	• Heated floor area (m²)	• FREE (Numeric)

Label	Parameter	Entry
η_{boiler}	Efficiency of heat generation	CT: System_eta_boiler_ref (M.11.1), System_eta_boiler_eff (M.11.1), FREE
η_{dis}	Efficiency of heat distribution	CT: System_eta_distribution_ref (M.11.1), System_eta_distribution_eff (M.11.1), FREE
η_{ini}	Efficiency of initial heat emission (NO TSV)	CT: System_eta_emission_eff (M.11.1), FREE
η_{new}	Efficiency of new heat emission (WITH TSV)	CT: System_eta_emission_eff (M.11.1), FREE

12. Industrial Motors

SECTOR: Industry

Measures related to industrial motors comprise the replacement of electric motor drives, the use of rotational electrical motors and the installation of variable speed drives (VSDs).

Replacement of electric motor drives in industry (M.12.1)

Target sector: Industry

EQUATION:

$$TFES = P * t * f_l * \left(\frac{1}{\eta_{ref}} - \frac{1}{\eta_{eff}} \right) * n_m$$

Label	Parameter	Entry
P	Power of the installed motor drive (kW)	FREE (Numeric)
t	Yearly operating hours (h/a)	CT: Motor_operating_hours (M.12.1. M.12.2, M.12.3), FREE
f_l	Average load factor (%)	CT: Motor_load_factor (M.12.1), FREE
η_{ref}	Efficiency of replaced motor drive (%)	FREE (Numeric)
η_{eff}	Efficiency of new motor drive (%)	FREE (Numeric)
n_m	Number of identical electric motors replaced	FREE (Numeric, INTEGER)

Resizing of rotational electrical motors (M.12.2)

Target sector: industry

EQUATION:

$$TFES = \left(\frac{P_{Ref} * f_{Ref}}{\eta_{Ref}} - \frac{P_{eef} * f_{Eff}}{\eta_{Eff}} \right) * t * n_m$$

Label	Parameter	Entry
P_{ref}	Power of the existing motor (kW)	FREE (Numeric)
P_{Eff}	Power of the resized motor (kW)	FREE (Numeric)
t	Yearly operating hours (h/a)	CT: Motor_operating_hours (M.12.1. M.12.2, M.12.3), FREE
f_{Ref}	Load factor of existing motor (%)	CT: Motor_load_factor_ref (M.12.2), FREE
f_{Eff}	Load factor of resized motor (%)	CT: Motor_load_factor_eff (M.12.2), FREE
η_{ref}	Efficiency of the standard motor (%)	FREE (Numeric)
η_{eff}	Efficiency of resized motor (%)	FREE (Numeric)
n	Number of resized motors	FREE(Numeric, INTEGER)

Variable Speed Drives (M.12.3)

Target sector: industry

EQUATION:

$$TFES = P * t * f_{VSD} * \frac{1}{\eta} * n_{VSD}$$

Label	Parameter	Entry
P	Power of the installed motor drive (kW)	FREE (Numeric)
t	Yearly operating hours (h/a)	CT: Motor_operating_hours (M.12.1. M.12.2, M.12.3), FREE
f_{VSD}	Energy saving factor VSD (%)	CT: Energy_saving_factor_VSD (M.12.3), FREE
η	Efficiency of the installed motor drive (%)	FREE (Numeric)
n_{VSD}	Number of VSD installed	FREE (Numeric, INTEGER)

13. Lighting

SECTOR: Buildings, Industry

Energy efficient lighting in residential buildings (M.13.1)

Target sector: residential buildings

EQUATION:

$$TFES = \frac{n * \left(P_{Stock_{Average}} - P_{Best_{Market_{Promoted}}} \right) * t}{1000}$$

• Label	• Parameter	• Entry
• n	• Number of lamps replaced/sold	• FREE (Numeric, INTEGER)
• $P_{Stock\_Average}$	Power average of existing lamp (W)	CT: Lighting_power_Stock_average (M.13.1), FREE
• $P_{Best\_Market\_Promoted}$	• Power of the market promoted efficient lamp (W)	• CT: Lighting_power_Best_Market (M.13.1), FREE
• t	Yearly operating hours (h/a)	CT: Lighting_average_hours_res (M.13.1), FREE

Energy efficient lighting in non-residential buildings (M.13.2)

Target sector: non-residential buildings

EQUATION:

$$TFES = \frac{A * \left(P_{Ref} - P_{Eff} * F_{red} \right) * t}{1000}$$

• Label	• Parameter	• Entry
• A	• Floor area of office building where lighting system is refurbished (m^2)	• FREE (Numeric)
• P_{Ref}	Installed lighting power before replacement per m^2 (W/m^2)	CT: Lighting_power_per_m2_ref (M.13.2), FREE
• P_{Eff}	Installed lighting power after replacement per m^2 (W/m^2)	CT: Lighting_power_per_m2_eff (M.13.2), FREE
• F_{red}	Reduction factor (e.g. dimming)	CT: Lighting_reduction_factor_nonres (M.13.2), FREE
• t	Yearly operating hours (h/a)	CT: Lighting_average_hours_nonres (M.13.2), FREE

Energy efficient lighting in gastronomy and hotels (M.13.3)

Target sector: services buildings

EQUATION:

$$TFES = \frac{n * \left(P_{Stock_{Average}} - P_{Best_{Market_{Promoted}}} \right) * t}{1000}$$

Label	Parameter	Entry
• n	• Number of lamps replaced/sold	• FREE (Numeric, INTEGER)
• $P_{Stock\_Average}$	Power of the existing lamp (W)	CT: Lighting_power_services_ref (M.13.3), FREE
• $P_{Best\_Market\_Promoted}$	Power of the market promoted efficient lamp (W)	CT: Lighting_power_services_eff (M.13.3), FREE
• t	Yearly operating hours (h/a)	CT: Lighting_average_hours_services (M.13.2), FREE

Energy efficient street lighting (M.13.4)

Target sector: public lightning

EQUATION:

$$TFES = \left(\left(L_{Ref} \cdot P_{Ref} \right) - \left(L_{Eff} \cdot P_{Eff} \cdot F_{red} \right) \right) \cdot t$$

Label	Parameter	Entry
• L_{Ref}	• Number of light points of inefficient street lighting	• FREE (Numeric, INTEGER)
• L_{Eff}	• Number of light points of efficient street lighting	• FREE (Numeric, INTEGER)
• P_{Ref}	Power output per light point of the energy inefficient (W)	CT: Lighting_power_street_ref (M.13.4), FREE
• P_{Eff}	Power output per light point of the energy efficient (W)	CT: Lighting_power_street_eff (M.13.4), FREE
• F_{red}	Reduction factor (e.g. dimming)	CT: Lighting_reduction_factor_street (M.13.4), FREE
• t	Yearly operating hours (h/a)	CT: Lighting_average_hours_street (M.13.2), FREE

Lighting in industrial buildings (M.13.5)

Target sector: Industrial buildings

EQUATION:

$$TFES = \frac{(P_{Ref} - P_{Eff} * F_{red}) * t}{1000} * n$$

Label	Parameter	Entry
P_{Ref}	Installed lighting power before (W)	CT: Lighting_power_industry_ref (M.13.5), FREE
P_{Eff}	Installed lighting power after (W)	CT: Lighting_power_industry_eff (M.13.5), FREE
F_{red}	Reduction factor (e.g. dimming)	CT: Lighting_reduction_factor_industry (M.13.5), FREE
t	Yearly operating hours (h/a)	CT: Lighting_average_hours_industry (M.13.5), FREE
n	Number of lighting systems	FREE (Numeric, INTEGER)

14. Mobility

SECTOR: Transport

Target sectors: households, companies

Alternative vehicle technologies (passenger cars) (M.14.1)

Target sector: Transport

EQUATION:

$$TFES = n * (sFEC_{Ref} - sFEC_{Eff}) * \frac{Mil}{100}$$

Label	Parameter	Entry
n	Number of efficient cars purchased	FREE (Numeric, INTEGER)
$sFEC_{Ref}$	Specific FEC of reference passenger car (kWh/100 km)	CT: SFEC_passenger_car_reference (M.14.1), FREE
$sFEC_{Eff}$	Specific FEC of efficient passenger car (kWh/100 km)	CT: SFEC_passenger_car_efficient (M.14.1), FREE
Mil	Yearly mileage (km/a)	CT: Milage_passenger_car (M.14.1), FREE

Eco-driving (M.14.2)

Target sector: Transport

EQUATION (For eco-drive trainings related to private cars, commercial vehicles of fleet-operating companies):

$$TFES = \frac{n_{EP,i}}{n_{TP,i}} * n_{vehicles,i0} * FEC_{ave,i} * S_{ee,i}$$

• Label	• Parameter	• Entry
• i	Vehicle category	CT: Eco_driving_vehicle_category (M.14.2), LIST
• $n_{EP,i}$	• Number of eco-driving training participants	• FREE (Numeric, INTEGER)
• $n_{TP,i}$	• Total number of persons (trained + untrained)	• FREE (Numeric, INTEGER)
• $n_{vehicles,i}$	• Total number of vehicles of a specific vehicle category	• FREE (Numeric, INTEGER)
• $FEC_{ave,i}$	FEC of specific vehicle category (kWh/a)	CT: Eco_driving_FEC_average (M.14.2)
• $S_{ee,i}$	Savings factor of specific vehicle category (%)	CT: Eco_driving_savings_factor (M.14.2)

- Note that the summation index is omitted. For each category separate entry will be required. If there is a need, arbitrary number of entries can be grouped around Entity or Responsible field!

Efficiency improvement through use of new lubricants and efficient tyres (M.14.3)

Target sector: Transport

EQUATION:

$$TFES = En_{Ref} * \left(1 - \frac{En_{Eff}}{En_{Ref}} * EV_{lub} * EV_{tyr}\right) * \frac{Mil}{100} * n_i$$

• Label	• Parameter	• Entry
• n_i	Number of vehicles	FREE (Numeric, INTEGER)
• En_{Ref}	Average specific fuel consumption of reference vehicle (kWh/100 km)	CT: Enref_vehicles (M.14.3), LIST
En_{Eff}	Average specific fuel consumption of efficient vehicle (kWh/100 km)	CT: Eneff_vehicles (M.14.3), LIST
EV_{lub}	Efficiency value for fuel-saving lubricants (0;1)	CT: Fuel_saving_lubricants (M.14.3), LIST
EV_{tyr}	Efficiency value for fuel-saving tyres (0;1)	CT: Fuel_saving_tyres (M.14.3), LIST

Label	Parameter	Entry
Mil	Average yearly mileage (km/a)	CT: Milage_vehicles_lubricants_tyres (M.14.3), FREE

Modal Shifts in Passenger Transport (M.14.4)

Target sector: Transport

EQUATION:

$$TFES = Np_{,Region} * \sum_{i=1}^{N} Mil_i * \left(MC_{Ref\ i} - MC_{Eff\ i}\right) * En_i$$

Label	Parameter	Entry
• Np_{Region}	Number of persons for evaluated mobility mix is based on	FREE (Numeric, INTEGER)
• Mil_i	Average yearly mileage travelled in a transport mode (km/a)	CT: Milage_mode_of_transport (M.14.4)
• $MC_{Ref,\ i}$	Share of mode of transport i used (Modal Choice), baseline (0;1)	FREE (Numeric, bounded 0;1)
• $MC_{Eff,\ i}$	• Share of mode of transport i used (Modal Choice), new (0;1)	• FREE (Numeric, bounded 0;1)
• En_i	Specific energy consumption of mode of transport i (kWh/person-km)	CT: Consumption_mode_of_transport (M.14.4)

- • Note that summation index is omitted, each entry will be treated separately and more of individual entries can be grouped around Entity or Responsible!

15. Office equipment (M.15)

SECTOR: Buildings

Target sectors: public and private services (tertiary buildings)

EQUATION:

Active mode:

$$TFES = n * \frac{\left(PA_{referenceyearstockaverage} - PA_{referenceyearbestperfmarket}\right)}{1000} * h_{active}$$

Standby mode:

$$TFES = n * \frac{(PS_{referenceyearstockaverage} - PS_{referenceyearbestperfmarket})}{1000} * h_{standby}$$

Improvement of usage mode:

$$TFES = n * (\frac{PA_{referenceyearstockaverage} * h_{active} + PS_{referenceyearstockaverage} * h_{standby}}{1000}$$

$$- \frac{(PA_{new} * h_{active} + PS_{new} * h_{standby}))}{1000}$$

All options (equation to be displayed):

$$TFES = n * (\frac{(PA_{ref} * h_{active} + PS_{ref} * h_{standby})}{1000} - \frac{(PA_{new,refb} * h_{active} + PS_{new,refb} * h_{standby})}{1000})$$

• Label	• Parameter	• Entry
• n	• Number of equal office equipment	• FREE (Numeric, INTEGER)
• PA_{ref}	Power input in active mode (W)	CT: Office_power_active_mode_ref (M.15)
• $PA_{new,refb}$	Power input efficient eq. market or after modification – active mode (W)	CT: Office_power_active_mode_refb(M.15), Office_power_active_mode_new (M.15), FREE
• PS_{ref}	Power input in standby mode (W)	CT: Office_power_standby_mode_ref (M.15)
• $PS_{new,refb}$	Power input efficient eq. market or after modification – standby mode (W)	CT: Office_power_standby_mode_refb(M.15), • Office_power_standby_mode_new (M.15), FREE
• h_{active}	Hours in active mode (h/a)	CT: Office_hours_active_mode (M.15)
• $h_{standby}$	• Hours in standby mode (h/a)	• CT: Office_hours_standby_mode (M.15)

16. Photovoltaic plants (M.16)

SECTOR: Buildings

Target sectors: residential and non-residential buildings

EQUATIONS:

- **Option 1:**

$$TFES = P_{PV} * t * PR * \left(1 - ee_{grid}\right)$$

- **Option 2:**

$$TFES = P_{PV} * \frac{1}{sP_{PV}} * Hm * \eta_{el} * (1 - P_{Loss}) * \left(1 - ee_{grid}\right)$$

Label	Parameter	Entry
P_{PV}	Installed peak power of the PV system (kW_{peak})	CT: PV_plants_peek_power (M.16), FREE
t	Sunshine duration at 1000 W/m^2 at site (h/a)	CT: PV_plants_sunshine_duration (M.16), FREE
PR	Performance ratio of the PV plant (%)	CT: PV_plants_performance_ratio (M.16), FREE
ee_{grid}	Share of electricity that is fed into the grid (%)	CT: PV_plants_electricity_grid (M.16), FREE
sP_{PV}	Specific peak power of PV system (kW_{peak}/m^2 module)	CT: PV_plants_specific_peek_power (M.16), FREE
H_m	Global irradiation per square meter received by the modules (kWh/m^2)	CT: PV_plants_global_irradiation (M.16), FREE
η_{el}	Average electric efficiency of the module	CT: PV_plants_electric_efficiency (M.16), FREE
P_{Loss}	Combined PV system losses (% of H_m)	CT: PV_plants_system_losses (M.16), FREE

- Option 1 is calculated when user prescribes PR and t, otherwise option 2 is valid!

17. Replacement of energy inefficient boilers

SECTOR: Buildings

Target sectors: residential and non-residential buildings

Replacement of an old gas- or oil boiler with an efficient gas- or oil boiler (M.17.1)

Target sectors: residential and non-residential buildings

EQUATION:

$$TFES = n * A * (SHD + HWD) * \left(\frac{1}{\eta_{Ref}} - \frac{1}{\eta_{Eff}}\right)$$

Label	Parameter	Entry
n	Number of boilers replaced	FREE (Numeric)
A	Heated floor area of the building (m^2)	CT: Heated_gross_floor (M.2.1), FREE
SHD	Space Heating Demand (kWh/m²/a)	SHD_ref (M.2.2, M.2.3, M.2.4, M.6.1, M.6.2, M.6,3, M.10.1, M.10.2), FREE
HWD	Domestic Hot Water Demand (kWh/m²/a)	CT: HWD (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2), FREE
η_{Ref}	Efficiency of the existing heating system	CT: Eta_ref (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2, M.11.1, M11.2), FREE
η_{Eff}	Efficiency of the new heating system	CT: Eta_eff (M.2.2, M.2.3, M.2.4, M.11.1, M17.1, M17.2, M.17.3), FREE

Replacement of an old boiler with an efficient biomass boiler

MEASURE MERGED WITH M.17.3

Biomass boilers (escorted with old existing ones as additional energy source) (M.17.3)

Target sectors: residential and non-residential buildings

EQUATION:

$$TFES = n * A * Q_{Biomass} * \left(\frac{(SHD + HWD)}{\eta_{Ref}} - \frac{(SHD + HWD)}{\eta_{Eff}} \right)$$

Label	Parameter	Entry
n	Number of biomass boilers	FREE (Numeric)
A	Gross floor area of the building (m^2)	CT: Heated_gross_floor (M.2.1), FREE
SHD	Space Heating Demand (kWh/m²/a)	SHD_ref (M.2.2, M.2.3, M.2.4, M.6.1, M.6.2, M.6,3, M.10.1, M.10.2), FREE
HWD	Domestic Hot Water Demand (kWh/m²/a)	CT: HWD (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2), FREE
$Q_{Biomass}$	Ratio of biomass boiler (BL or PL) (%)	FREE (Numeric)
η_{Ref}	Efficiency of the existing heating system	CT: Eta_ref (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2, M.11.1, M11.2), FREE

Label	Parameter	Entry
η_{Eff}	Efficiency of the new heating system (biomass boiler)	CT: Eta_eff (M.2.2, M.2.3, M.2.4, M.11.1, M17.1, M17.2, M.17.3), FREE

- Equation covers both peak load and base load biomass boiler!

18. Solar thermal panels

SECTOR: Buildings

Solar assisted space heating (M.18.1)

Target sectors: residential and non-residential buildings

EQUATION:

$$TFES = A * Q_{ave_{yield}} * \frac{1}{\eta_{Ref}}$$

Label	Parameter	Entry
A	Installed collector surface (m^2)	FREE (Numeric)
Q_{ave_yield}	Yearly heat output per collector surface ($kWh/m^2/a$)	CT: Solar_panels_heat_output (M.18.1), FREE
η_{Ref}	Efficiency of the existing heating system	CT: Eta_ref (M.2.3, M.2.5, M.6.1, M.6.2, M.10.1, M.10.2, M.11.1, M11.2), FREE

Water heating with solar energy

MEASURE MERGED WITH M.18.1

19. Standby killer in households (M.19)

SECTOR: Buildings

Target sector: households (residential)

EQUATION:

$$TFES = n_{SBK} * \frac{P_G * t_{SB} - P_{SBK} * t_\alpha}{1000}$$

Label	Parameter	Entry
n_{SBK}	Number of standby killers installed	FREE (Numeric, INTEGER)
P_G	Standby power of appliance(s) (W)	CT: Standby_killer_power_appliance (M.19), FREE
P_{SBK}	Own consumption standby killer (W)	CT: Standby_killer_own_power (M.19)
t_a	Annual hours standby killer is in use (h/a)	CT: Standby_killer_hours_inuse (M.19)
t_{SB}	Annual hours appliance is on standby (h/a)	CT: Standby_killer_hours_standby (M.19)

20. Systems for heat recovery in buildings (M.20)

SECTOR: Buildings

Target sectors: residential and non-residential buildings

EQUATION:

$$TFES = A * h * \beta * t * c * \rho * \Delta T * \eta * n$$

Label	Parameter	Entry
A	Heated floor area of the building (m^2)	CT: Heated_gross_floor (M.2.1), FREE
h	Height of the ventilated area (m)	CT: Heat_recovery_room_height (M.20), FREE
β	Air exchange rate (h^{-1})	CT: Heat_recovery_air_exchange (M.20), FREE
t	Yearly operating time of the ventilation system (h/a)	CT: Heat_recovery_operating_time (M.20), FREE
c	Specific heat of air	See below
ρ	Air density	See below
ΔT	Avg. temperature difference in heating season	Location table
η	Rate of heat recovery	CT: Heat_recovery_rate (M.20), FREE
N	Number of ventilation units installed	FREE (Numeric, INTEGER)

- In backend of the application use Constant as product of specific heat and density as: Constant = 0,000347 kWh/K.
- ΔT is coming from Location Table as HDD/HD (both available in Location table).

21. White goods

SECTOR: Buildings

Purchase of highly efficient white goods (M.21.1)

Target sector: households

EQUATION:

$$TFES = n * (E_{ave} - E_{eff})$$

Label	Parameter	Entry
• n	• Number of energy efficient goods	• FREE (Numeric, INTEGER)
• E_{ave}	Avg. energy consumption of least efficient eq. on the market (kWh/a)	CT: White_goods_ave (M.21.1)
• E_{eff}	Avg. energy consumption of highly efficient eq. on the market (kWh/a)	CT: White_goods_eff (M.21.1)

Early replacement of white goods (M.21.2)

Target sector: households

EQUATION:

$$TFES = n * (E_{stock} - E_{eff})$$

Label	Parameter	Entry
• n	• Number of energy efficient goods	• FREE (Numeric, INTEGER)
• E_{stock}	Avg. energy consumption of existing eq. in stock (kWh/a)	CT: White_goods_stock (M.21.2)
• E_{eff}	• Avg. energy consumption of highly efficient eq. on the market (kWh/a)	• CT: White_goods_eff (M.21.1)

Calculation of CO$_2$ emission reduction

General approach valid for existing MVP web application, which calculates the CO$_2$ emission reduction according to the following expression:

$$\Delta CO_2 = E_{before} * f_{before}^{CO2} - E_{after} * f_{after}^{CO2}$$

where E$_{before/after}$ are energy consumption before and after EE measure implementation, respectively and f$_{before/after}$ are CO$_2$ emission factors of fuel before and after the measure implementation.

Some cases in the official multEE Bottom-Up methodology will require different approach for calculation of emission reductions and these cases will be dealt with special attention.

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