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«Horizon 2020 - MORE-CONNECT»

Methodological framework and instructions for the selection of favourable concepts for the pilot projects (Task 6.1 part 1)

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Content

1 Introduction

The methodological framework and instructions described in this documented are intended to be used in the different geo-clusters covered by the MORE-CONNECT project for the selection of favourable concepts for the pilot projects.

Work packages 2 and 3 of the MORE CONNECT project result in the identification of a range of options for MORE-CONNECT elements and MORE-CONNECT solutions which could be chosen for the implementation in the pilot projects. Options may differ among others with respect to the following aspects:

- the **scope of the renovation**: The types of building elements included in the renovation project
- the **ambition level of energy efficiency for the single building elements** as defined by the structure/construction type, the properties of the materials used and the thickness of insulation
- the **type of heating systems** for heating and domestic hot water
- possible **on-site energy generation devices** like PV, solar thermal, hybrid collectors, building integrated or mounted detached

Different combinations of such options are here referred to as «renovation concepts». It consists of one energy related renovation measure or of a package of energy related renovation measures. It is a task within Task 3.4, 3.5 and especially Task 6.1 to pre-select favourable concepts to develop and to be tested in the pilots, based on a choice of such renovation concepts.

As a basis for carrying out the selection of favourable concepts, the methodological framework and the instructions in this document explain how to assess the energy impacts, the climate impacts and the economic impacts of different options for the renovation concepts to be carried out in the pilots. The idea is that the assessment then provides the necessary overview to take an informed decision on what renovation concept to implement in each geo-cluster.

2 Overview of the chosen approach

2.1 Scope of the assessment and system boundaries

Assessed energy use and emissions

Energy use and related greenhouse gas emissions of a building comprise operational energy use for:

- space heating
- space cooling
- domestic hot water
- ventilation
- auxiliary electricity demand for building integrated technical systems such as fans, pumps, electric valves, control devices, etc.,
- appliances *(to be discussed at the MORE-CONNECT January 2016 meeting)*
- lighting.

The yearly energy need of the building is calculated following the principles of EN ISO 13790, taking into account energy performance of the building envelope, outdoor climate, target indoor temperature and internal heat gains. Greenhouse gas emissions and primary energy use are calculated by taking into account conversion efficiencies of the heating systems and emission factors as well as primary energy factors of the energy carriers including up-stream emissions and energy use. It is recommended to use national primary energy and GHG emissions conversion factors. Depending on the problem the primary energy and the GHG-emission factors should be based on the national/regional mix of electricity consumed or alternatively if available on the marginal mix of electricity produced or substituted. Political conversion factors or conversion factors used for labels are not appropriate and do not reflect the real resource use.

Embodied energy associated with the materials and installations added by the renovation is taken into account for the assessment of the building. Total embodied energy use and corresponding embodied GHG-emissions are transformed to a yearly energy use and yearly emissions respectively, by dividing embodied energy (emissions) by the number of years of expected service livetime of the renovated building elements.

Indicators for both primary energy use and greenhouse gas emissions, indicate yearly values per m^2 conditioned gross floor area.

Costs

The integration of the cost perspective is based on a life cycle cost approach. A private cost/benefit perspective is assumed, comprising

- initial investment costs
- replacement costs
- energy costs, including existing energy taxes and CO_2 taxes
- maintenance and operational costs
- replacement costs for the replacement of building elements within the evaluation period.

The life-cycle-cost and cost-effectiveness calculations have to be carried out dynamically, either with the annuity method or with the global cost method (discounted cash flow method). Investment costs are transformed into yearly costs by making use of the annuity method (see Appendix A1 for further information), assuming typical service lives for the renovation measures in question. Alternatively, also the global cost method can be used.

The costs for the renovation options including the MORE-CONNECT solutions, are supposed to refer to the cost levels to be achieved for introduction of the concepts to the market, i.e. they are not supposed to refer to the costs of the first prototype, they are rather supposed to include economies of scale as can be expected for the introduction of the concepts to the market.

Basically, subsidies for energy related measures are excluded from the assessment of costs and benefits to have an assessment which is undistorted by currently prevailing subsidy programs which might change over time. To represent the situation of a specific investor, subsidies may be included in a second alternative and specific assessment. Social costs, including external costs, benefits and co-benefits are not included, although it is important that they are considered by policy makers for target setting and for the design of energy and emissions related programs.

Cost indicators indicate specific yearly values per m^2 conditioned gross floor area.

System boundaries, on-site electricity or heat production

The system boundary considered is «net delivered energy», comprising energy carriers delivered to the building minus on-site generated energy exported from the building to the grid or to a heating/cooling energy distribution system. For energy exported to the grid or to a heating/cooling energy distribution system, reductions of primary energy use and of greenhouse gas emissions are taken into account which corresponds to the related average energy replaced in the grid or energy distribution system. It can be assumed that the energy replaced corresponds to the average energy consumed in the grid or the energy distribution system. Alternatively, marginal changes in the energy consumption mix can be taken into account to value fed back energy, i.e. determining more precisely which energy is replaced by additional energy fed into the grid or the into energy distribution system. Revenues from exports of energy to the grid or an energy distribution system are taken into account.

2.2 Comparison with a reference case

To correctly determine the impacts of the renovation packages with MORE-CONNECT solutions on costs, primary energy use and greenhouse gas emissions, it is necessary to define a common reference renovation case as it would be carried out if no energetic renovation with MORE-CONNECT solutions was implemented. This reference renovation is called «anyway renovation». It comprises the restoration of the functionality of the renovated building elements, yet without improvement of their energy performance. Typical anyway renovation measures carried out are repairing and panting of the façade, replacement of worn-out elements by elements of the same kind, painting and repairing of windows, replacement of a fossil heating system by a new fossil heating system of the same kind, etc.

The renovation packages taken into consideration are then compared to this «anyway renovation».

This approach is illustrated in the following figure:

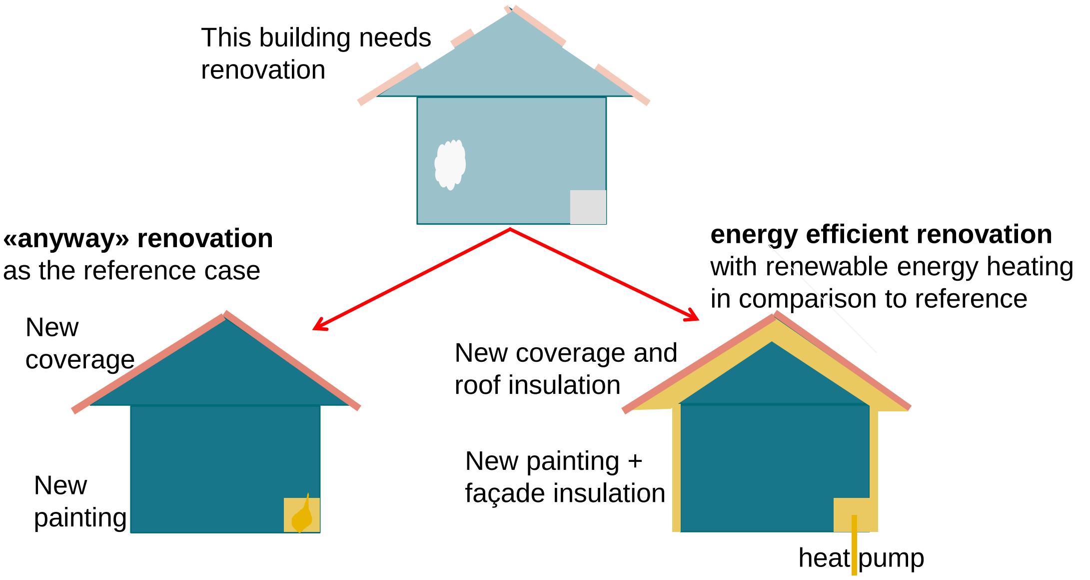

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Figure 1 «Anyway renovation» vs. «energy efficient renovation with MORE-CONNECT solutions »: Different renovation packages improving the energy performance of the building are compared to a renovation which would be necessary «anyway» to restore the building's functionalities.

2.3 Expected main output

As a main output of the assessment, graphs as shown in the following example are created:

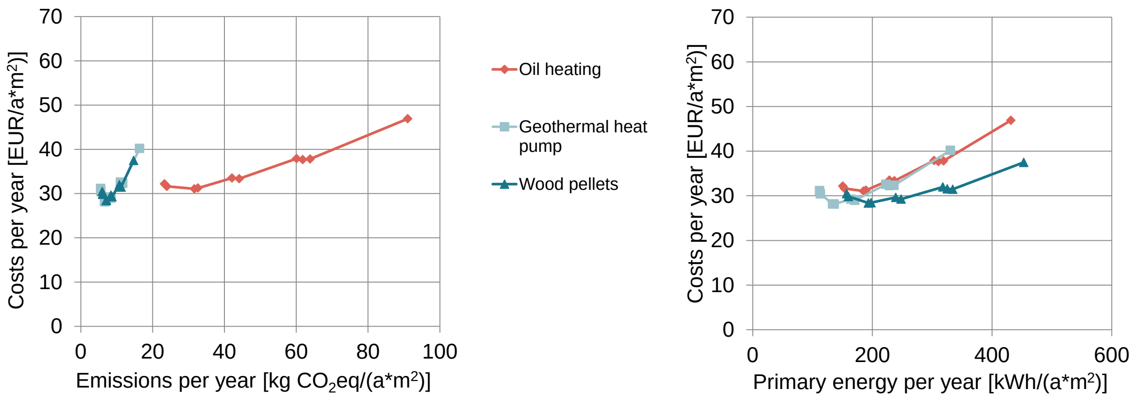

Figure 2 Example for graphs to assess energy impacts, GHG emissions impacts and economic impacts of different renovation measures or packages of renovation measures Each curve shows the impacts of different renovation concepts with a specific heating system. Each point on the curve represents a concept consisting of a specific combination of renovation measures. The lower a point in the graph, the more cost-effective is the related renovation package; the more to the left a point is in the graph, the lower are primary energy use or greenhouse gas emissions of the related renovation package.

In a first graph, greenhouse gas emissions and costs of different renovation packages are shown. Renovation packages involving the same type of heating system are shown on a curve having the same colour. Different renovation packages on a curve differ in the number of building elements included in the renovation or in the efficiency level of related renovation measures. Accordingly, a second graph illustrates primary energy use and costs of different renovation measures and packages.

Embodied emissions and embodied energy use are converted to yearly emissions and energy use and then included in the total greenhouse gas emissions and total primary energy use indicated.

The final selection of the renovation concepts to be applied in the pilot projects can then be made by comparing and evaluating energy impacts, climate impacts, and economic impacts with the help of these graphs.

3 Assessment procedure

The assessment to be carried out for evaluating different renovation options with MORE-CONNECT measures involves in particular the elements described below. Two xls-templates are provided to the participants of MORE-CONNECT to assist in the data gathering for the assessment of the impacts of MORE-CONNECT solutions ad for the creation of the graphs in which the results are presented:

— «**Data template**»: This templates facilitates data gathering on the reference building, the framework parameters, measures in the reference case, as well as the different renovation measures from which the renovation packages are created
— «**Graph template**»: This template facilitates the presentation of calculated results in the way as shown in Figure 1 for the assessment of MORE-CONNECT solutions.

1. Definition of the reference building

For each geo-cluster, participants define at least one reference building which is typical for existing and not yet renovated residential buildings to be targeted by MORE-CONNECT solutions and the MORE-CONNECT market concepts. This can be the same building as the one which is renovated in the pilots. However, if for some reason that building is not typical for the buildings to be targeted, it is more appropriate to provide generic data for a typical reference building.

For the selected reference building(s) the properties regarding dimensions, energy relevant equipment and energy performance levels of the building elements are determined.

2. Definition of framework parameters

For each geo-cluster investigated, the framework parameters have to be determined. These include economic parameters like energy prices, interest rates and exchange rates, emission factors, primary energy factors and climate data, national and local regulations having possibly an impact on renovation solutions, etc.

It is recommended to reflect future increases in energy prices over the next 40 years. If no national projections on energy prices are available, it is recommended to assume a linear increase of real prices similar to estimates in the Annual Energy Outlook by the U.S. Energy Information Administration[1] for the 2012-2040 period: 0.6% per year for oil, 1.5% for natural gas, and 0.4% for electricity. Regarding the initial value of the energy prices, it is important to take a weighted average over several years as a basis, as energy prices often vary considerably from year to year or even faster.

The interest rate to be used is recommended to be a real interest rate of 3% per year unless more specific national values are available.

3. Definition and assessment of the reference case

In line with the distinction between «anyway renovation» and «energy efficiency renovation with MORE-CONNECT solutions» as described above, a reference case is defined which includes hypothetical measures to be carried out «anyway» regarding the heating system and the building envelope to maintain the functionality of the building, without the goal of improving its energy performance. Primary energy use, greenhouse gas emissions and costs are then calculated for this reference case on a yearly basis and per m^2 of conditioned gross floor area, as $kWh/(m^2{*}a)$, kg $CO_{2eq}/(m^2{*}a)$, and $EUR/(m^2{*}a)$, respectively.

4. Definition and assessment of different renovation packages

A range of possible renovation measures with MORE-CONNECT solutions is defined. The related options are characterized in terms of energetic properties and costs. Individual renovation measures are grouped into renovation packages.

A renovation package consists of energy efficiency measures on the building envelope in combination with a replacement of the heating system with an identical conventional system and/or with a new RES-based heating system and/or solar systems (PV, building integrated PV, solar thermal, hybrid).

Starting from the reference case, which implies some rehabilitation measures without improving the energy performance (the so called «anyway renovation»), for each reference building a series of renovation packages with progressing ambition levels related to the resulting en-

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[1] U.S. Energy Information Administration (2014) Annual Energy Outlook 2014, with projections to 2040, at: www.eia.gov/forecasts/aeo

ergy performance of the building is investigated. Renovation packages distinguish themselves both by the type of building elements included in the improvement of energy performance and the MORE-CONNECT solutions applied. Furthermore, measures to improve the energy performance of the building by upgrading or installing technical systems (MORE-CONNECT engine) such as ventilation with heat recovery or a PV system can be taken into account. It is advisable to start by including the most cost-effective renovation options in the first renovation packages, adding more and more also less cost-effective renovation options, which enable further reductions of energy needs and of non-renewable energy consumption in order to be able to recognize which renovation packages are cost optimal or cost-effective with respect to the reference case.

The heating system is supposed to be replaced in all renovation cases, also in the reference case of an anyway renovation. The heat distribution system including the radiators is assumed to remain the same, unless there are reasons to assume otherwise. For each reference building, we recommend to consider combinations with several different types of heating systems. We recommend that at least one of the heating systems investigated is a conventional heating system partly or fully based on fossil fuels, at least one is a heat pump based heating system, and at least one is a biomass based heating system. If the building is connected to a district heating system, at least one of the heating options is usually the connection to the district heating system, taking into account costs for renewing the substations in the building to connect to that system.

The dimension of the heating system is calculated as the required peak capacity to be able to maintain the target indoor temperature despite heat losses during winter time. The effect of down-sizing new heating systems due to better insulation is taken into account

Primary energy use, greenhouse gas emissions and costs are calculated for the renovation packages on a yearly basis and per m^2 of conditioned gross floor area, as kWh/(m^2*a), kg CO_2 eq/(m^2*a), and EUR/(m^2*a), respectively.

5. Impact determination and comparison with the «any way» reference case

For the reference case and for different renovation options with MORE-CONNECT measures and different heating systems, the calculated impacts on greenhouse gas emissions, primary energy use and costs are summarized in two graphs as shown in Figure 1. In these summary graphs, the reference case and different renovation packages can be compared.

6. Sensitivities

In order to evaluate the robustness of the results and possible changes among different framework conditions, it is advisable to carry out sensitivity calculations, taking into account in particular the following aspects:

— A low price and a high price energy scenario

— Different energy performance levels of the reference building prior to renovation

7. Evaluation and selection

Based on assessments presented in the graphs and including results from sensitivity calculations, the most appropriate renovation package with MORE-CONNECT measures to be applied in the pilots is determined, taking into account the marketability of the related concepts as defined in particular by their costs and environmental impacts.

8. Summary of assessment procedure

The following figure summarizes the assessment procedure:

1. Definition of reference building

Collect necessary building data for the assessment: Dimensions and energetic properties of all building elements having an influence on the energy performance and GHG emissions.

2. Definition of framework parameters

Define economic parameters such as energy prices, interest rates and exchange rates, emission factors, primary energy factors and climate data etc..

3. Definition and assessment of reference case

Define «anyway renovation» measures for the reference case, determine related service lives, associated costs, maintenance costs, energy needs. Calculate impacts on primary energy use, greenhouse gas emissions and costs for the reference case.

4. Definition and assessment of different renovation packages

Define which MORE-CONNECT measures are investigated. Aggregate measures to renovation packages, starting with the most economical first. Determine related service lives, associated costs, maintenance costs, energy needs. Calculate impacts on primary energy use, greenhouse gas emissions and costs for the renovation case with MORE-CONNECT measures.

5. Comparison

Compare the impacts of the reference case with different renovation packages of MORE-CONNECT measures and with different heating systems on greenhouse gas emissions, primary energy use and costs in the graphs as shown in Figure 1.

6. Sensitivities

Carry out sensitivity calculations, at least with respect to energy prices and initial energy performance of the reference building.

7. Evaluation and selection

Evaluate and take informed decision on which renovation concept to choose for pilots.

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Figure 3 Overview of assessment procedure for the selection of favourable concepts for the pilot projects

Appendix

A-1 Annuity method

The annuity method transforms investment costs into average annualized costs, yielding constant annual costs during the life span of the investment considered. Minimal time horizon for the assessment period is usually the service life of the building element with the longest life expectancy. Yearly energy costs, operational costs and maintenance costs are added to yearly annuity costs of initial investment, yielding constant yearly global costs during the evaluation period. If energy prices as well as yearly operational costs and maintenance costs are not constant during the calculation period, it is necessary to determine and apply an adjustment factor[2] to take into account real future energy price increases or real future cost increases.

The formula for calculating the annuity is:

Annuity a: $$a = \frac{i*(1+i)^t}{(1+i)^t-1}$$

a annuity for constant real prices (costs)

t time range of cost evaluation

i real interest rate

If the energy prices or the costs are rising, it is necessary to calculate an average energy price or cost value, which dynamically takes into account the price or cost increases in the period t. This can be done by calculation of an average or medium adjustment factor **m** which has to be multiplied with the energy price or the annual costs at the beginning of t with prices or costs increasing annually by a rate r (e.g. 0.02 for an annual rate of 2%):

$$m = \frac{\left(1+\frac{i-r}{1+r}\right)^t-1}{\left(\frac{i-r}{1+r}\right)*\left(1+\frac{i-r}{1+r}\right)^t} * a$$

m general average adjustment factor

r rate of yearly increase of energy prices, maintenance costs or operational costs

Example*:*

*For a real interest rate **i** = 0.03 (3% per year), price or cost increases **r** of 0.04 (4% per year) during the calculation period **t** of 20 years, the resulting average price (cost) increase factor **m** is:* ***m = 1.49***

*Hence yearly capital cost **c** for an initial investment **I** are:* ***c = a*I***

*If yearly energy costs **e** are increasing by 4% p.a. and the real interest rate **i** is 3% p.a. the adjusted average annual energy costs e_a during period t are:* $e_a = e*m$

2 The general average adjustment factor for price or cost increases applying the annuity method

The annuity method is favourable in the case of parametric cost assessments of various packages of renovation measures. By using the annuity method, it is not necessary to determine residual values at the end of a preset assessment period for measures which have a longer life than the assumed time horizon of the cost assessment. Hence it is easy to obtain average yearly costs (or costs/m^2 per year) for measures with different service lives. In the annuity method it is assumed that building elements are replaced at the end of their element-specific service life (i.e. corresponding replacement investment is taken into account).

Literature

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