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SuFiQuaD - Results

Sustainability, Financial and Quality evaluation of Dwelling types

DURATION OF THE PROJECT
01/01/2077 - 31/01/2011

BUDGET
790.292 €

KEYWORDS
Building element, dwelling stock, environmental external costs, life cycle assessment, life cycle costing, optimisation, policy, quality assessment, sustainability

CONTEXT

Current approaches in Belgium aiming at a sustainable development of the building sector focus on different aspects separately (e.g. building materials, energy use, transport), while abstracting the complex interrelations. This allows for a detailed analysis but misses a global objective by losing the overall picture. Since the design of a building (amongst others typology, lay-out, dimensions, orientation and location) determines the overall environmental impact, a building cannot be equated to the sum of its constituting components. However, a life cycle assessment of a building to date is most often carried out at the level of materials or components. Moreover, financial decisions are to date most often exclusively based on investment costs not considering the life cycle consequences. An evaluation tool based on representative environmental and financial data for the Belgian context which enables such a comprehensive life cycle assessment is therefore required.

The originality of the integrated approach of this research lies in the fact that the analysis is carried out at the building level, considering all interrelated influences and stakeholders. All aspects of interest are considered by integrating financial evaluation techniques (i.e. investment cost evaluation and life cycle cost analysis (LCC)), environmental evaluation methods (i.e. LCA and environmental external costs) and performance evaluation (multi-criteria analysis (MCA)).

OBJECTIVES

The project departed from the need for an integrated approach to search for actions in order of priority to reduce the environmental impact of the building and housing sector, taking into account building performances and financial consequences. The aim was to develop a methodology and tool to evaluate both the initial and future costs (financial and environmental external) and benefits (qualities) of different housing types. Through the investigation of a number of technical, spatial and user behaviour parameters recommendations for the stakeholders and a basis for policy making were aimed at. More particularly, the goal was to clarify possible conflicts between decisions based on financial investment costs, life cycle financial costs, environmental investment costs, life cycle environmental costs, the sum of both and finally these costs in relation to the performance of the dwellings. A background document for policy making which considers policy measures to move towards a more sustainable building and housing sector was the final objective.

CONCLUSIONS

An important outcome of the research is an **integrated assessment method and tool** for the evaluation of life cycle environmental external costs, financial costs and qualities of buildings (or building parts), based on data representative for Belgium. The tool allows the identification of priority of actions to efficiently move towards a more sustainable dwelling stock. Thanks to the flexibility and transparency of the tool, future adjustments based on new insights concerning environmental indicators, monetary values, scenarios (transport, end-of-life, cleaning, maintenance, and replacement frequencies) are possible, as well as expansion for new innovative materials, products and techniques.

Several aspects were investigated through the **implementation** of the developed assessment tool. It concerns the analysis of building elements (e.g. outer and inner walls, flat and pitched roof, and floor on grade), the analysis of representative newly built dwellings, the analysis of renovation measures and how they compare with further use of the non-refurbished dwelling and new construction, as well as the evaluation of current policy measures related to sustainability of dwellings. The most important findings for each of these implementations are summarised in the subsequent paragraphs.

The **analysis of the building elements** considered 'all' current available materials, products and techniques for which the necessary environmental and cost data were available. Valuable information is retrieved as outcome for designers and building owners providing a comparison of the initial and life cycle (financial, environmental and total) costs of most currently available technical solutions for each building element. Moreover, for each element of the building envelope, the optimal insulation thickness for the different considered insulation materials was determined and can be used in building practice.

In general, it can be concluded that the current insulation requirements of the energy performance standard are too low compared to the life cycle financial and environmental optima. Beside the insulation level, the finishing was identified as important parameter for the life cycle environmental external cost (often more determinant than the building structure). Both the production process and the service life (and thus replacement rate) of the materials were identified as important aspects for the life cycle environmental external cost of materials. Wood and wood-based products led to unexpectedly high environmental costs due to land use. As the uncertainty of the external cost of land use is high, further research is recommended.

SSD SCIENCE FOR A SUSTAINABLE DEVELOPMENT

TRANSVERSAL ACTIONS

The search for the priority of actions for reducing the life cycle environmental, financial and total (sum of both) cost was based on the **analysis of 16 representative newly built dwellings**. The most important conclusions to move towards a more sustainable dwelling stock were the following.

For an efficient reduction in life cycle external cost, the location, choice of building characteristics (e.g. size of the dwelling, thermal compactness, glazed area and orientation), insulation level, air-tightness and choice of technical systems were proved to be the order of priority. For the insulation level one should focus on the complete building skin, striving for the optimal insulation thicknesses as defined based on the assessment at the element level. For a limited budget, actions in order of priority should be defined. These depend on the efficiency of the cost reduction of each element, the ratios of the elements and the available budget. In addition, it is important to take into account the (im)possibility of improvements later on in the life cycle at reasonable costs (e.g. floor insulation).

Both the priorities and optima based on financial and environmental external costs differ. Indeed, from an environmental perspective the dwellings should be insulated better than would be done solely based on financial costs. However, energy-reduction measures based on life cycle financial costs proved to result in lower life cycle environmental costs than those solely based on financial investment costs. An integrated assessment of each measure remains however required because not all measures based on life cycle financial costs are in line with those based on life cycle environmental costs (e.g. Asian bluestone is cheaper but has a higher environmental external cost than Belgian bluestone).

The environmental optimisation based on energy-related measures resulted for ten of the sixteen analysed dwellings in a reduction in the life cycle financial cost. The majority of these measures were thus justifiable from a financial life cycle cost perspective. Despite this observation, it is important to evaluate all measures carefully because some of the environmental optima resulted in an increase in the life cycle financial cost. The affordability of the environmental optima of the energy-related measures was positively confirmed by observing an average increase of financial investment cost of only 6%. If this is not affordable for the private dwelling owner, it should be through means of support from the government or third party private investments. No straightforward conclusions could be drawn for the non-energy related measures (e.g. material choice). Each single measure therefore requires an assessment based on financial and environmental cost.

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The majority of the optimal dwellings (both based on financial and environmental external costs) proved to be characterised by a yearly net heating demand higher than the low-energy (30 kWh/m² floor) and passive standard (15 kWh/m² floor). However, the low-energy or passive standard may be the optimum for dwellings with an adapted design, layout, glazing area and orientation (which was not investigated in this research). Nevertheless, based on the research results an adaptation of current building practice and layout prescriptions is clearly required to develop low-energy and passive houses in an efficient way.

The inclusion of the quality evaluation confirmed the presumption that dwellings with a higher cost (financial and/or environmental) may be preferred because of their higher quality. This is not experienced as problematic, as long as the dwelling owner/renter is willing to pay for the extra costs (financial and environmental). Moreover, it is obvious that quality is subjective and thus that a certain dwelling is differently appreciated by different persons or at different moments during one's lifetime. An increasing number of singles, an ageing population and a multi-cultural society indicate a strong need for a diversified dwelling stock in Belgium. A mix of high-quality small houses/apartments and large dwellings with a higher degree of flexibility seems to be an important feature of sustainable housing

The **analysis of renovation measures** was based on two case studies from a different construction period and focused on energy-reducing measures. The order of priority of the measures differed for the two case studies (terraced dwelling, built before 1945 and a detached dwelling built between 1971 and 1990). Renovation of both dwellings resulted in lower life cycle environmental external costs. The measures were however most effective for the oldest dwelling because of its lower initial insulation value and older technical services. From a financial point of view, the considered renovation measures were only of interest for the oldest dwelling.

SuFiQuaD - Result

Sustainability, Financial and Quality evaluation of Dwelling types

The **comparison between further use of the non-refurbished dwellings, renovation or new construction** revealed that for the oldest dwelling (built before 1945) further use of the dwelling without refurbishment leads to the highest and renovation to the lowest life cycle costs. The same was true for the more recent dwelling (built between 1971 and 1990) based on environmental costs, but from a financial point of view, further use of the non-refurbished dwelling led in this case to the lowest life cycle cost. However this final conclusion was only true when a remaining service life of 60 years was considered. For a prolonged service life of 120 years, most renovation cases became financially more interesting than the further use of the non-refurbished dwelling.

To date the government invests greatly in energy efficiency measures through tax reduction, green energy certificates and regional and local grants. The **evaluation of current financial incentives** regarding photovoltaic panels and roof insulation, proved that (the order of magnitude of) these are not always justified (e.g. some measures are already financially interesting without subsidies or subsidies exceed the savings in environmental external costs). Each policy incentive should be carefully considered and be based on the analysis of both financial and environmental lifecycle costs.

CONTRIBUTION OF THE PROJECT TO A SUSTAINABLE DEVELOPMENT POLICY

The SuFiQuaD model balances the environmental and economic dimension of sustainable development for dwellings in the Belgian context. It allows quantified evaluation of myriads of building solutions both from the private “self interest” perspective as well as the societal environmental perspective. It thus allows determining the priority of actions for a more sustainable Belgian dwelling stock, the financial consequence of these actions and therefore also the size of justifiable financial incentives from an environmental policy point of view.

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TRANSVERSAL ACTIONS