# Systematic Decision-Making and Design Processes in Social Housing Projects

Antti Kurvinen[1], Juhani Heljo[2], Jaakko Vihola[3], Kalle Kähkönen[4]

In this study the decision-making practices of social housing companies have been analysed. Contextually, the explored decision making addressed suburban residential area development. Methods and models for the design processes in projects which include retrofitting as well as infilling were developed. The aim of the research was to guide suburban housing towards more advantageous, comfortable and, especially, energy-efficient direction. Decision-making was analysed on the basis of a case project, comprising development of a full scale residential building block. Analyses were made by examining the design process of targets there and related decision-making. Decision-making was reviewed specifically from the viewpoint of social housing companies, but the results are broadly applicable to other decision-making environments as well.

Classification of the factors that influenced decision-making revealed that decision-making related to the suburban block development is a quite complicated totality. The most essential factors influencing practical decision-making were divided in six larger groups. Yet, the resulting entities appeared to be closely interconnected. From the analysis it appeared that despite to the global objectives energy efficiency is easily overshadowed in the overall decision making. To lead social housing towards sustainability, and reach national and international energy efficiency goals a new type of planning process management is needed. An essential task in this study was to include energy efficient decision making as a natural part in that process.

Advantageous, comfortable and energy-efficient housing requires that design and decision-making always consider the impacts of solutions and decisions on the whole and not focus too much on individual components. New operational modes are needed in suburban development and improvement of energy-efficiency, and some attitudes must also change. This paper analyses the decision-making in relation to the suburban residential area renovation and infill development, and presents a systematic decision-making process as the concrete model for making energy-efficient selections as part of planning. The suggested method allows systematic comparison of alternative solutions during the planning process and guides selection towards the solution providing best life-cycle economy.

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## 1. Introduction and Background

Typically, building block development projects are expected to achieve successfully many kinds of objectives. In building-level a set of main objectives can incorporate, for example, qualities for improved conditions (e.g. indoor climate), functionality and quality of the building as well as to increase building's energy-efficiency and the occupants' comfort of living. On regional level the building block-level objectives can encapsulate, for instance, particular measures to improve the image and appreciation of a whole residential area. It seems to be widely acknowledged that with the help of suburban development the attraction and desirability of suburban areas can be remarkably increased (Evans 2008; Heljo & Peuhkurinen 2004). The improved degree of attraction can also lead to increased demand for consumer services. Due to its many documented benefits, it can be considered that by putting effort on restoring neighbourhoods, the risk of suburban degeneration can be remarkably reduced (Evans 2008). Traditional examples of suburban development measures are urban infilling and quality improvement of existing buildings in the area (Heljo & Peuhkurinen 2004). Urban infill and higher density of suburban areas have also been found to be effective measures in decreasing the amount of greenhouse gas emissions (Evans 2008; Ewing et al. 2007). Additionally urban infill can seemingly in most cases be considered clearly more profitable from the perspective of overall economy than building completely new residential areas (Nykänen et al. 2012; Evans 2008). Nonetheless, it is not exceptional that the desired benefits of compact urban infill development may not be recognised in the public domain (Lewis & Baldassare 2010).

However, it cannot be taken for granted that the objectives set for building block development projects would automatically be achieved, but the successful execution of this kind of projects requires extensive expertise in many fields. Decision-making in relation to the design phase in building block development projects is challenging and a clear need exists for criteria and tools to support it. Achieving the desired result is more likely if decision-making can be based on research data instead of less factual assumptions. Nonetheless, practice has shown that due to the very limited time available for design, projects are normally able to come up with only a few design alternatives (Welle et al. 2011). In addition, decisions are made in a tight schedule and the comparison of the alternatives is often inadequate. Thus, all the essential impacts will not be discussed before making the final decision. The lack of sufficient indicators can be considered a partial reason to this. At present, it is very common that investment costs have a pronounced role in decision-making. Development of suburban social housing requires remarkable investments, and effective targeting of financial resources is in a prominent role when pursuing the set objectives. However, investment costs alone are not sufficient indicators for decision-making, and thus, their impact must not be emphasized too much. Well-balanced decision-making also requires other indicators, which should have an adequate weight on decisions. The objective of this paper is to provide information on decision-making and design processes in relation to suburban development. Useful methods and information on social housing companies' decision-making are presented for this purpose.

## 2. Research Objectives and Methods

In a recent study completed at Tampere University of Technology (TUT), the decision-making practices of social housing companies have been analysed. Contextually, the explored decision making addressed suburban residential area development. The aim of the research was to guide suburban housing towards more advantageous, comfortable and, especially, energy-efficient direction. Decision-making was analysed on the basis of a case project, comprising development of a full scale residential building block. Analyses were made by examining the design process of targets there and related decision-making. Decision-making was reviewed specifically from the viewpoint of social housing companies, but the results are broadly applicable to other decision-making environments as well. The research project covered also development of methods and models for the design processes in projects which include retrofitting as well as infilling.

Academic scholars and industry professionals were effectively linked together in the research effort behind this paper when the research team members' took also part in the real design process of the case area. This mode of action remarkably enhanced the information flow between research and practice, and can be considered as an effective method in research projects where sufficient amount of resources available.

The already existing methods (e.g. Aalto & Heljo 1984; Abel 2010) and calculation models formed an important point of departure. These methods and models were not only utilized but also developed further within the main research effort. This kind of constructive research was seen as a chance to produce novel decision-making method for the needs of suburban development projects and programmes.

The project had the following five main tasks and objectives:

1. **Analysis and development of the decision-making for suburban social housing projects**
   The objectives of this task were to study practices of social housing companies' decision-making in suburban development projects, and on the basis of made findings to propose potential ways to develop the decision-making towards more favourable direction.

2. **Energy-efficiency and environmental impacts as part of decision-making**
   The objectives of this task were to study how energy consumption and unfavourable environmental impacts can be reduced, and find ways to integrate this to the design process covering both individual buildings and entire suburban blocks.

3. **Life-cycle economy as a criterion**
   The objectives of this task were to find out how life-cycle economy should be taken into account in social housing related suburban development projects covering both individual buildings and entire suburban blocks. In addition to life-cycle costs also value factors were supposed to be covered.

4. **Utilization of building information models to support decision-making**

   The objectives of this task were to study how building information models (BIM) could be utilized in order to develop the design process of suburban social housing.

5. **Comfort of living and airtightness**

   The objectives of this task were to study factors impacting on suburban comfort of living also including research on ways to measure internal airtightness of buildings', and to study the significance of internal airtightness for the comfort of living.

To achieve the objectives of the first task research team members' took part in the design process of the case area and analysed the decision-making within those processes. On the basis of these analyses, a list of factors impacting on the decision-making in practice was compiled. The list was further processed into a form of mind maps for illustrate the relations between different factors. This analysis gave a good basis for developing further the decision-making process.

In the second task, mainly based on the earlier studies executed at TUT, but also on the basis of literature an illustrative profitability model for energy saving measures was presented. The model makes it possible to study impacts of different measures on economy, energy-efficiency and greenhouse gas emissions. It is as well applicable for individual buildings as for larger block-level studies. The overall decision-making process presented in this paper closely integrates the profitability model in the design process.

A starting point for the studies of the third tasks was the results of earlier research and development at TUT. Earlier developed calculation models were utilized and further developed to fulfil the requirements of suburban development projects. In addition to calculating life-cycle costs of new buildings this also requires being able to take into account special features of renovations, demolition, and infill development. Value factors have to be considered as well. The development was accomplished by case analyses and literature.

In the fourth task possibilities of BIM were studied. Building information models were utilized in the architectural design of the case project, which offered great opportunities for the research. The most importantly, the applicability of BIMs created by the case architect was studied for the needs of energy simulations. The expertise of TUT's Virtual Building Laboratory was also exploited in this task.

As energy analyses and defining energy saving potentials were in a very prominent role in this study, energy calculations were made using two different methods. One of them was a straighforward method to calculate the toal sum of monthly used energy. This method has been widely used in Finland during the recent years. It is also included in the Finnish building code. These energy calculations were made using software called DOF-Energy (ver. 2.0.11). The other used method was more sophisticated BIM-based energy simulations. Energy simulations were made using software called IDA-ICE (ver. 4.2) by utilizing the architectural BIMs prepared for the case project.

As a starting point for the studies of the fifth task, the state of comfort of living in the case project was studied with the help of occupant survey. The results of the survey indicate that the smells and noises from neighbour flats were common problems of social housing. It was concluded that a partial reason behind the situation is highly likely the inadequate internal airtightness between apartments. Because of this a clear need was identified for finding a method to measure internal airtightness. The development of an appropriate method was started on the basis of measuring plan drawn up by the research group on building physics at TUT.

## 3. Case Project Description

The case project behind the research comprised development of a multiform social housing block in Tampere Finland. The project included both infill development and renovation of the existing buildings. VTS Homes, which is local social housing company in Tampere, owns all the buildings in the block. The development in the area was planned to be executed in two phases. The first phase was executed during the research project, and the second phase is to be executed after research results and new methods from the first phase are already available and can be applied. In this way, the implementation of new methods is highly effective. An illustration of the case project can be found in Figure 1.

In the first phase of the development, five existing slab form blocks were retrofitted close to the quality level of new buildings. New apartments were built in the first floors, which were earlier mostly used as storerooms. In addition to renovation, the social housing area was also developed by the means of infilling.  An illustration of the case project can be found in Figure 1. The rectangles marked with “wide downward diagonal” fill are new point access blocks and an additional floor on top of a building is marked with “dashed horizontal” fill. The land use was also made more effective by building three new row houses on the same lot. These are marked “large grid” fill in Figure 1.

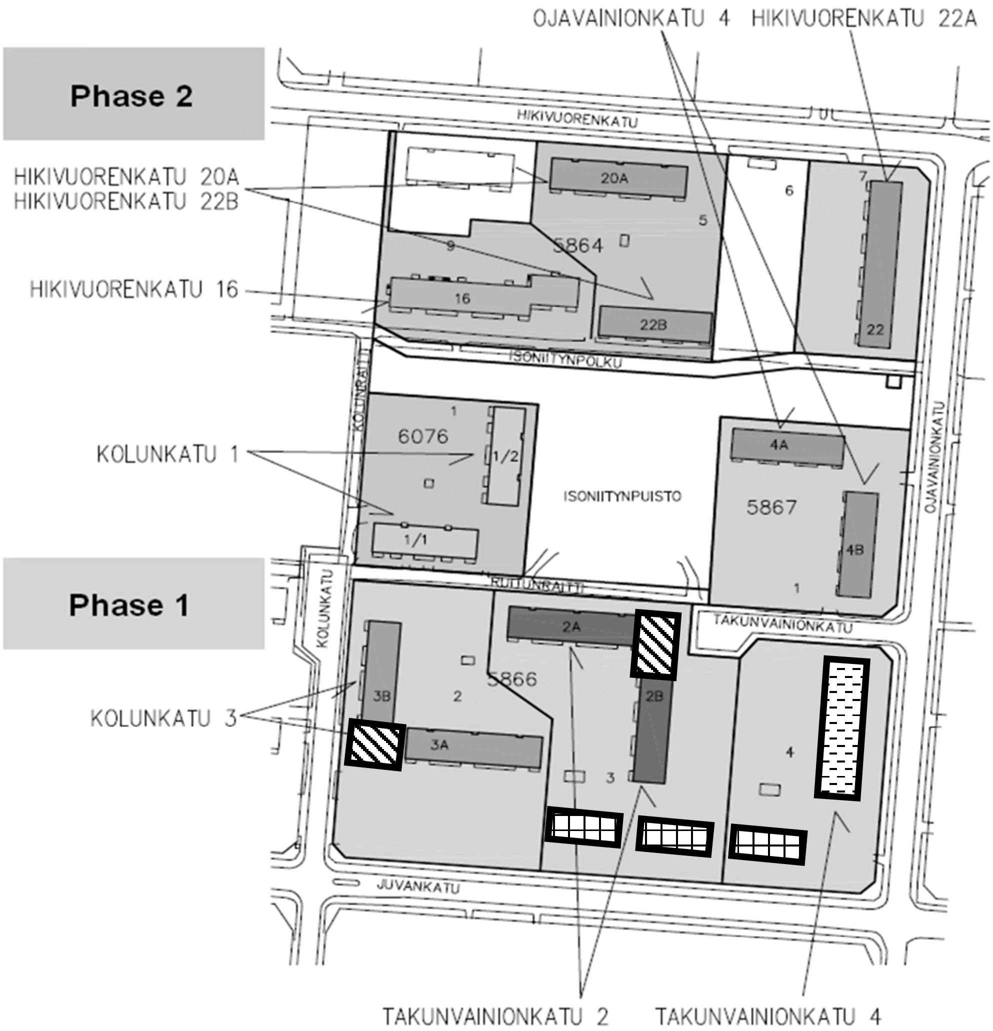


***Figure 1: The case project included housing block development in Tampere Finland.***

Partnering model of contracting formed the basis of construction works carried outin the. This was a very important factor in enhancing the flow of information between project partners. This kind of  cooperation forms are steadily becoming more popular in Finland because of the new kinds of needs arising from the development of residential areas. This can be considered as a very desirable trend, for example, due to its favourable impacts on information flow. To share and receive more reliable information in earlier stages of project life-cycle is very welcome because the decisions defining the big part of final results and costs are already made in that stage. Thus, it is highly likely that utilization of partnering model creates better conditions for decision-making.

Partnering model can be considered quite similar to project alliances, which also emphasize trust between parties, engagement to objectives and cooperation. However, there are also differences between these forms of cooperation like, for instance, that partnering model is juridically based on traditional procurement methods, such as lump sum contract and design and construct contract (Yeung et al. 2007; Ross 2004). However, when utilizing partnering model the project partners usually agree on the common principles as a first step. Thoses are to be obeyed during the project, but this agreement is not a legally binding document. In project alliances juridically binding contracts clearly differ from the traditional ones. (Lahdenperä 2009.)

## 4. Results of the Project: New Models to Facilitate Decision-Making

Classification of the factors that influenced decision-making revealed that decision-making related to the suburban block renovation is a quite complicated whole, where a clear-cut classification of related factors poses a great challenge. The most essential factors influencing practical decision-making were divided in six larger groups. A rough categorization of the factors was discussed in the design meetings (Figure 2). Yet, the resulting entities were not independent, separate entities, but appeared to be closely interconnected. Thus, for example, it is not possible to treat energy-efficiency in decision-making as a separate entity, but it has to be considered as part of a bigger entity. On the basis of the rough categorization a guideline framework for the decision-making of social housing companies was developed (Figure 3). The framework is not all-embracing, but can be utilized as a checklist in decision-making.

With the present energy prices, the share of energy costs is 10–20% of the rent in Finland. If the energy prices rise, energy costs' share of rents increases as does the pressure to raise rents. Although energy costs constitute a significant expense item from the viewpoint of life-cycle economy, and future pressures to raise rents can be restrained by improving energy efficiency, it would appear that energy efficiency nevertheless easily becomes overshadowed by other issues in planning. Thus, a new type of planning process management will be needed to reach national and international energy-efficiency goals.

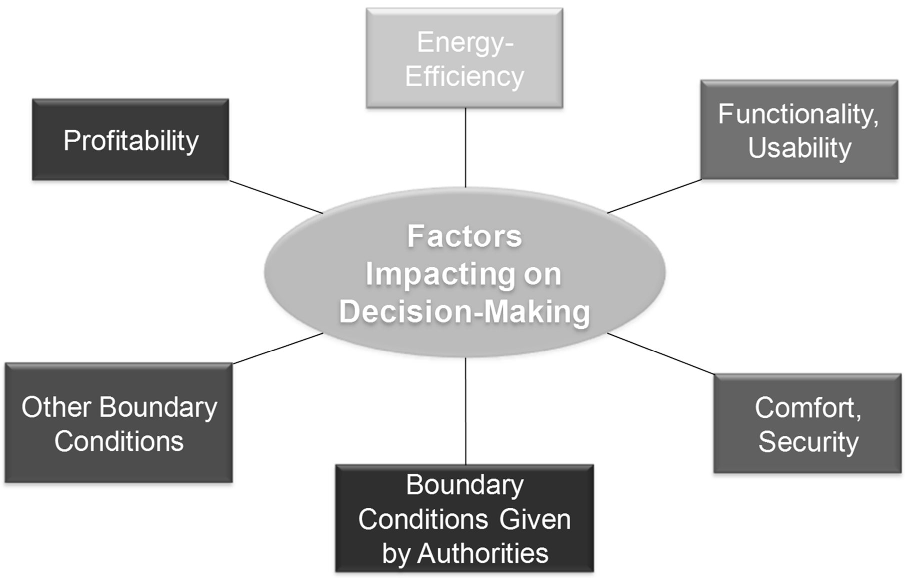


***Figure 2: A categorization of impacting factors that were discussed in the design meetings. (Kurvinen & al. 2012a)***

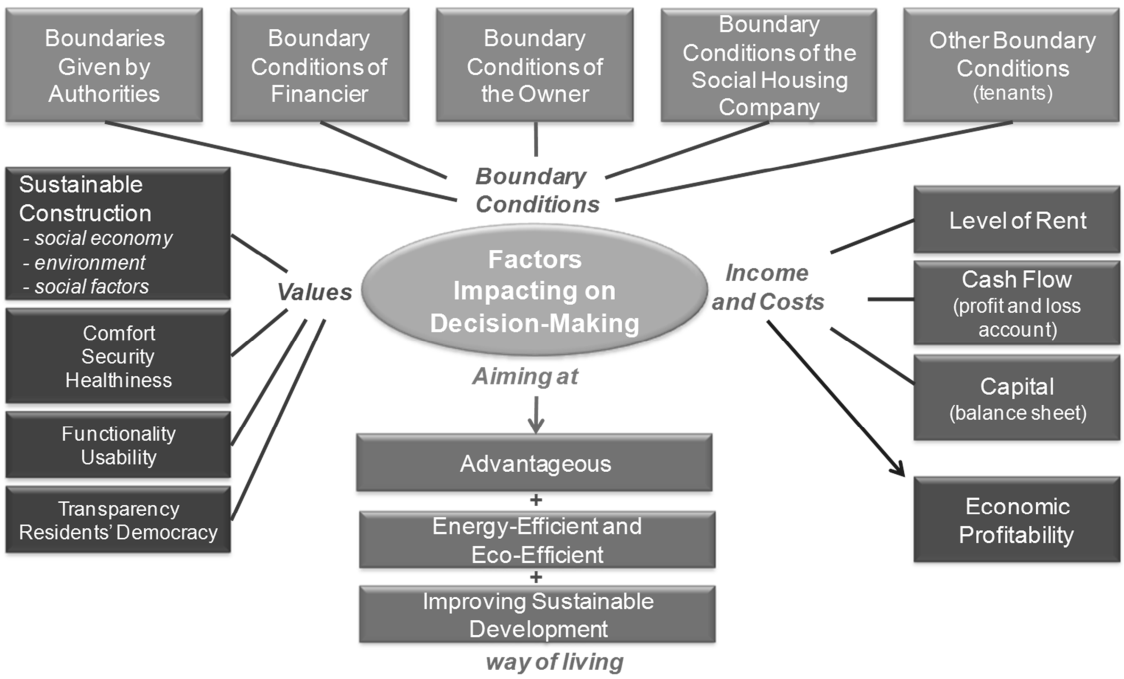


***Figure 3: A framework for the decision-making of social housing companies (Kurvinen & al. 2012a)***

A systematic decision-making process is suggested as the concrete model for making energy-efficient selections as a part of planning process. The suggested method allows a systematic comparison of alternative solutions during the planning process and guides selection towards the solution that is providing best life-cycle economy. Life-cycle economy refers to the relationship between life-time values and costs. The suggested process divides into five stages: definition of factors influencing a project's basic data and selections, planning of the basic solution, selection of system alternatives on the system level, selection of energy-conservation measures on the structural and equipment level (profitability model for energy-conservation measures) and comparison of entities and decision-making. The process chart has been shown as a whole in Annex A.

The development work of stage four of the suggested decision-making process (selection of energy-conservation measures on the structural and equipment level) was of high importance in this project. The profitability model for energy-conservation measures was developed as a tool to support this phase. It allows a graphic comparison of the profitability of energy-conservation measures with different design solutions. The model can be used to determine the measures' impacts on economy, energy consumption and greenhouse gas emissions. The energy-conservation measures of a comprehensive solution can be chosen purely on the basis of economic return requirement or value factors can also be considered. The examination may be expanded from the building level to block level which allows controlling a bigger entity at a time and targeting available financial resources to it. The profitability model enables choosing sensible measures for planning solutions which, again, allows comparison of comprehensive solutions based on life-cycle economy and subsequent selection of the most favourable alternative for implementation. An example of output when profitability model is utilized on block-level is presented in Annex B.

The completed study shows that the profitability of energy-conservation measures is higher in renovation than in new building construction but only under certain conditions. Typically, in a building renovation project the basic level of thermal insulation is significantly lower than in new construction. Such conditions result in a situation where a decision has been made to implement certain renovations in any case. The definition of the basic renovation solution essentially impacts the profitability assessments of energy-conservation measures of renovation projects since they are based on the additional costs from energy-conservation measures and exclude the cost of the chosen basic solution. It is also good to remember that determining the energy savings resulting from measures implemented and the related extra costs is always subject to considerable uncertainty.

It seems that social housing companies are more interested to use the life-cycle cost analysis as a basis of their decision making than is the case today generally in the construction sector. However, it still seems difficult to prepare reliable life-cycle cost analyses for social housing companies –further development is required in that area. An effort must be made to increase understanding of systematic renovation and suburban development further, and tools are needed to support decisions, including calculation models suited for life-cycle cost analyses of buildings applicable to area development projects involving both renovation and new construction. The analysis models which are available at the moment for investment calculations do not appear to be as such suitable for a kind of analyses where the discussed viewpoints are present in a well-balanced manner. Presently, construction costs are emphasised in selections which means that measures that are profitable from the life-cycle economic viewpoint may not be taken. Since rental payments are the key source of revenue for rental housing companies, the impact of measures on the level of rents would appear to outweigh life-cycle costs in decision-making.

It is sometimes necessary to consider the demolition of old buildings as an alternative in connection with life-cycle cost analyses of area development projects. The completed examinations show that in some cases it may be more economical to tear down an old building and build a new one in its stead. Yet, there are no universal truths concerning the profitability of demolishing buildings; each case must be examined separately. Moreover, it must be taken into account that examinations based solely on monetary value may differ from those that also include the ecological viewpoint.

Only relatively limited amount of information about the effects of different solutions is available when decisions that lock costs have to be made. This seems to be a problem of decision-making in the construction and renovation of suburban social-housing blocks. BIM-based design and data transfer could help to solve this problem by producing sufficintlyreliable and representative data in support of the design process at an earlier phase than before. This requires that the various project parties have enough capabilities to exploit information models and BIM-based data transfer. At present, BIM know-how is still quite inadequate in general.

One aim of the project was to guide housing in a more comfortable direction. The conducted resident satisfaction survey showed that smells and sounds caused by neighbours are often considered a problem. The internal airtightness of buildings is at least a partial reason for the transmission of smells and sounds, and it would appear that its impact is not emphasised enough today. Airtightness may be a more complex issue than assumed, and its practical implications are perhaps not understood well enough yet. In addition to its impact on comfort, it is also significant for energy economy.

## 5. Conclusions

Characteristics of energy efficiency in social housing development projects were the main focus of the research effort behind this paper was, The conducted examinations show that certain energy-conservation measures can be profitable when implemented in connection with renovations, but the achievable savings are rather small. Thus, energy efficiency is hardly improved and the savings targets will not be reached if the economic return requirement is set too high. The most effective measures, such as ventilation heat recovery and adding extra insulation to walls, are often omitted in renovation. Although energy efficiency is much talked about, it is only a part of the multiform problem field of decision-making in suburban development.

Advantageous, comfortable and energy-efficient social housing requires that design and decision-making always consider the impacts of solutions and decisions asholistically as possible and do not fall into the trap of local optimization i.e. putting focus too much on individual components. New operational modes are needed in suburban development and improvement of energy efficiency, and some attitudes must also change. The study presented in this paper has been one step towards that direction, and the authors believe that the generated models are useful when put to practice. Although, the research context have been that of social housing the developed methods can be considered to be widely applicable also in other decision-making environments.

There are clear future research needs for developing the pre-design phase of suburban development. More attention should be put in the pre-design phase since decisions that lock costs are made in a quite early phase.  Design processes are complex multi-criteria problems and due to the limited time available the pre-design effort is often inadequate despite of its high its significance. For improving the pre-design process the use of building information models (BIMs) could be beneficial. Such models need to be integrated to different design tasks and cost analysis. A building pre-design tool that enables effective multi-criteria optimization and facilitates decision-making before construction phase could be an object for further studies.

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## Annex A

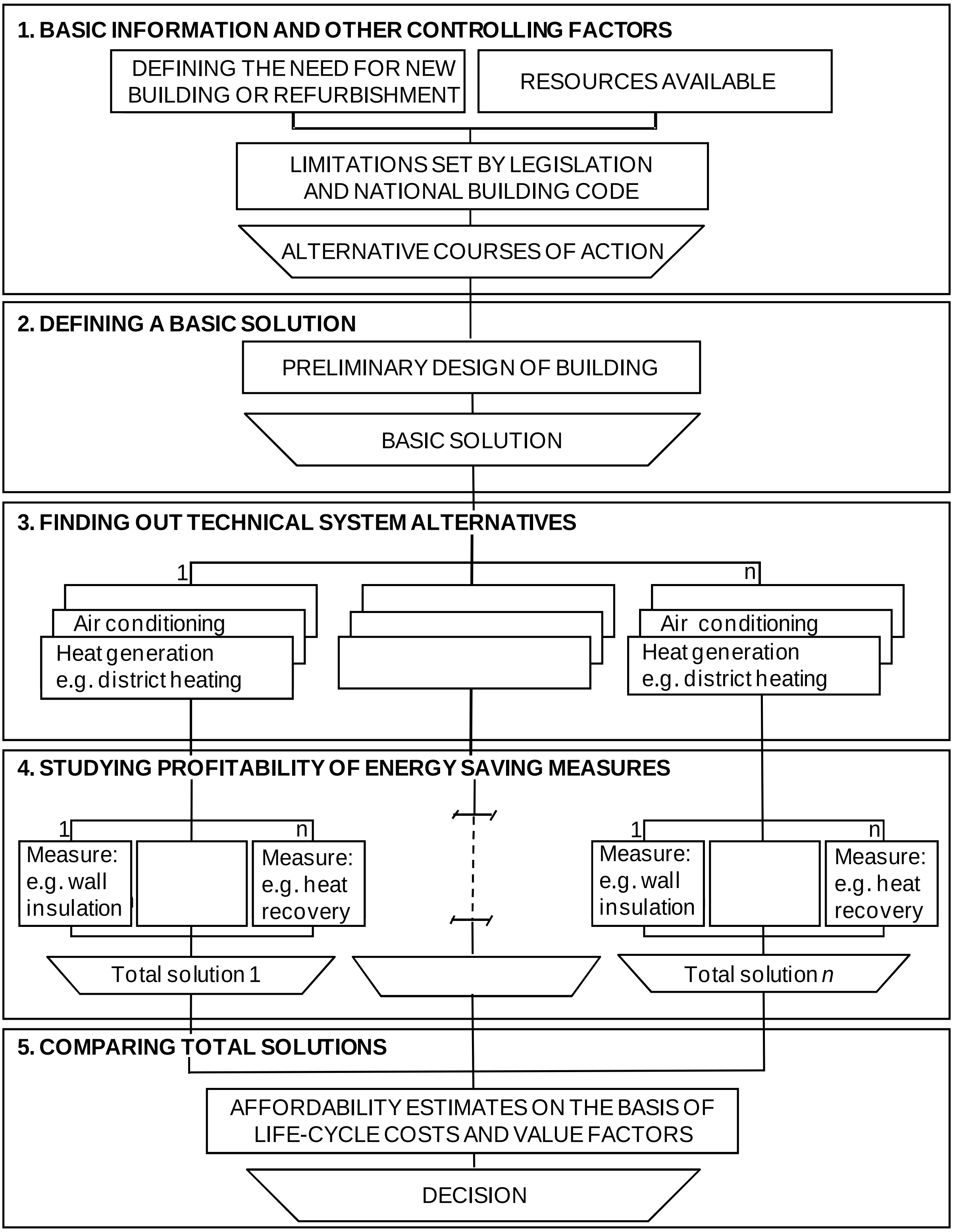


***Figure A: Phases of systematic decision-making (Kurvinen et al. 2012b)***

## Annex B

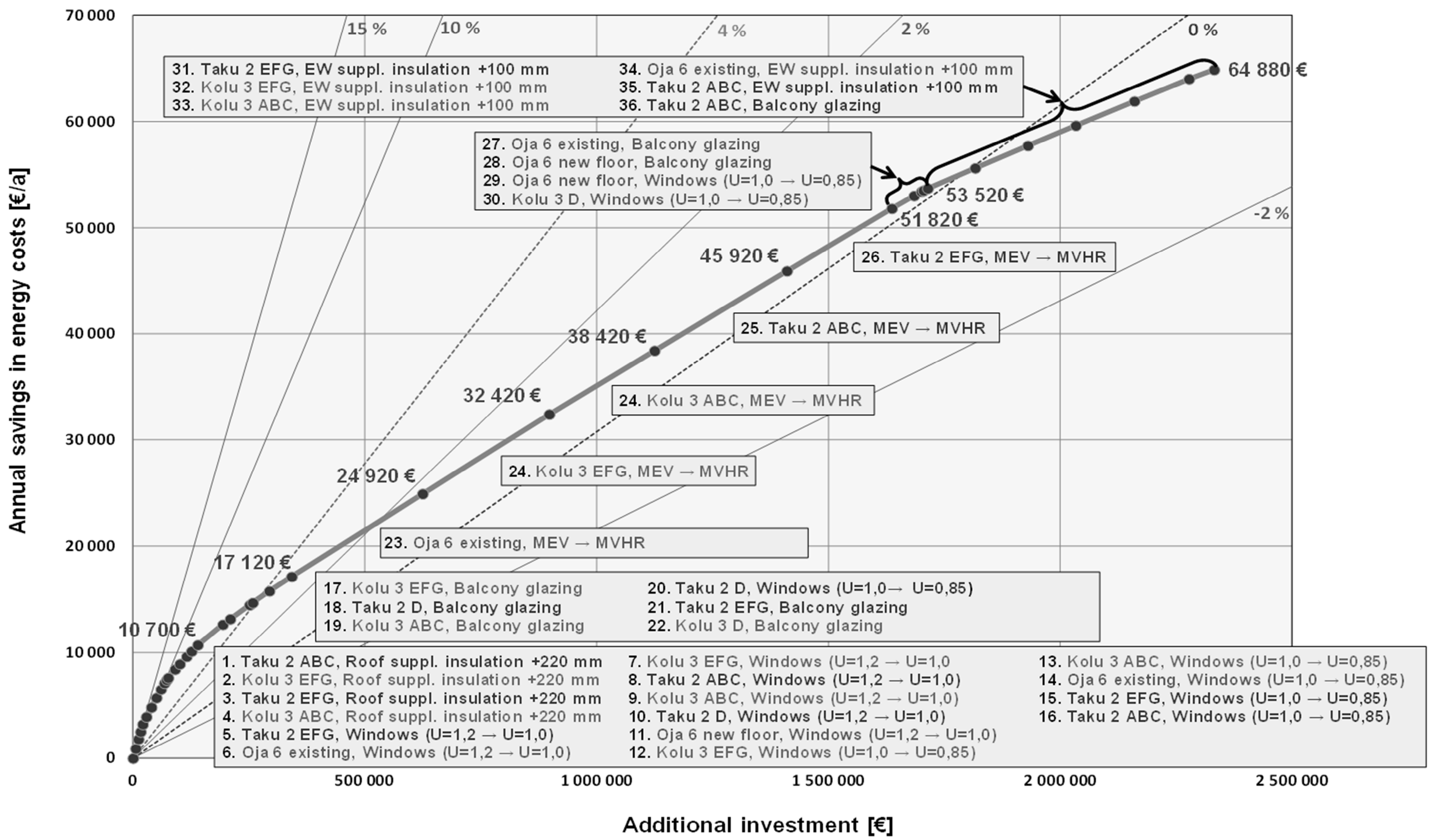


***Figure B: Profitability model, impacts and profitability of energy saving measures in block-level (Kurvinen et al. 2012a).***