



# WORLD

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Environment Conference

# 2017 Hong Kong

Transforming Our Built Environment through  
**Innovation and Integration:**  
Putting Ideas into Action

## Conference Proceedings



Organisers



International Co-owners

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- International Initiative for a Sustainable Built Environment (iiSBE)
- United Nations Environment Programme (UNEP-SBCI, Sustainable Building and Climate Initiative)
- International Federation of Consulting Engineers (IFDIC)
- Global Alliance for Buildings and Construction (Global ABC)

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# WSBE17 Hong Kong: THE MOST INFLUENTIAL GREEN BUILDING MEGA EVENT

The Construction Industry Council and the Hong Kong Green Building Council jointly welcome you to participate at the World Sustainable Built Environment Conference 2017 Hong Kong (WSBE17 Hong Kong).

## Pre-eminent Conference Series

The Sustainable Built Environment (SBE) series began in 2000 and is now the pre-eminent international conference series on sustainable building and construction. The series operates on a three-year cycle with planning in year one, regional conferences in year two and a global conference in year three. Albeit strong competition, Hong Kong won the hosting right of the 2015-2017 cycle global conference, which will conclude the conference cycle by embracing all the top findings from the 20 regional conferences held in 2016.

## About WSBE17 Hong Kong

With the theme of **Transforming Our Built Environment through Innovation and Integration: Putting Ideas into Action**, WSBE17 Hong Kong will bring together **1,800** green building advocates, policy-makers, academics, and industry practitioners from over **55 countries**. The three-day event includes conference sessions with top-notch speakers, and around 100 parallel sessions, with an exhibition alongside.





## Organisers

### Construction Industry Council (CIC)

The Construction Industry Council (CIC) was formed in 2007 under the Construction Industry Council Ordinance (Cap. 587). The CIC consists of a chairman and 24 members representing various sectors of the industry including employers, professionals, academics, contractors, workers, independent persons and Government officials.

The main functions of the CIC are to forge consensus on long-term strategic issues, convey the industry's needs and aspirations to Government, provide training and registration for the construction workforce and serve as a communication channel for Government to solicit advice on all construction-related matters.



### Hong Kong Green Building Council (HKGBC)

The Hong Kong Green Building Council (HKGBC) is a non-profit, member led organisation established in 2009 with the vision to help save the planet and improve the wellbeing of the people of Hong Kong by transforming the city into a greener built environment. The Founding Members of the HKGBC include the Construction Industry Council (CIC), the Business Environment Council (BEC), the BEAM Society Limited (BSL) and the Professional Green Building Council (PGBC). Its mission is to lead market transformation by advocating green policies to the Government; introducing green building practices to all stakeholders; setting design, construction and management standards for the building profession; and promoting green living to the people of Hong Kong.



## Session 7.4: Deep Renovations – Processes & Methodologies

# Towards a Holistic Methodology in Sustainable Retrofitting: Theory, Implementation and Application

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### ABSTRACT

Sustainability paradigm foresees a balance of energy production and consumption with no, or minimal, negative impact on environment (within the environmental tolerance limits). It gives an opportunity to a country to employ its potentiality of the social and economic activities. An overview of recent researches about building renovation context demonstrates the lack of an appropriate methodology and decision support framework -by compounding the typical challenges of sustainable retrofitting from theory to implement stages- that takes into account the retrofitting projects throughout more comprehensive insights and perspectives. It calls, therefore, for a deep building renovation approach. The major difference between a deep building renovation project and an ordinary one is commitment to a holistic approach. From one side, it initially should be able to deal with the society including various stakeholders with different priorities and barriers -on the top of the list is behavioral barriers about energy consumption- in order to improve their learning; to the other side, it has to perform multiple optimization through sustainability development perspective in its full sense. The intent is to identify, manage, and evaluate the renovation objectives through different available retrofitting alternatives during the early design stages. In this framework, the paper considers building renovation as a complex messy/wicked problem and later it gives details on how combinations of methods that are parts of SSM (Soft Systems Methodologies) and MCDM (Multi Criteria Decision Making) may support multiple perspectives of such a problem. The aim is to promote a methodology which is initially able to deal with complexity of the detected problem and subsequently to address building renovation process in order to involve the various stakeholders in the design process [and keep them involved in all design stages]. Doing so leads to more effective and sustainable retrofitting actions within different criteria including functionality, feasibility, and accountability.

**Keywords:** *sustainable retrofitting, deep building renovation, holistic methodology*

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## 1. INTRODUCTION

Enhancing energy efficiency is not the only goal for renovation of the existing buildings. The main objective has to be creating a high-performance building via application of the holistic and integrated design process, to the project during design stages which makes sure all design goals are met. In modern age and so rising complexity, the extent of this potential can be described and made up in several ways and this can happen with focus on climatic interests, security of supplies, environmental impacts, life-cycle cost, indoor climate, building functionality, spatial quality issues and other relevant arguments (Kamari et al., 2016). To achieve overall sustainability in this regard, these factors must be taken into consideration all together in order to gain “sustained prosperity”. But a logical question arises: how can the design team address this complexity among different objectives (?) which itself is methodological issue where the present study as part of a bigger project called RE-VALUE makes effort to deal with. The attempts here is on the development of a holistic methodology to address retrofitting context in order to keep the different stakeholders involved in the process and carrying out a real sustainable retrofitting based on multiple criteria in its totality. Doing so means it deals with the overall objective of the RE-VALUE project (within its macro scale) which is to develop and demonstrate the validity of a generic renovation assessment method within an integrated design schema. For this reason, the present paper primarily (see section 2.1) provides information about the general barriers and challenges in retrofitting context towards formulation of the research problem in section 2.2 that states the main objective of this research project. Later in section 3, it identifies the reasons for the suitability of SSM and MCDM in order to promote a holistic multi-methodology (Mingers et al., 1997) through mixing

certain SSM and MCDM that practically able to implement a sustainable retrofitting and overcome existing barriers in actual situation.

## 2. THE NATURE OF THE PROBLEMS IN SUSTAINABLE RETROFITTING CONTEXT

### 2.1 Barriers and challenges in retrofitting process

Experience over several decades has demonstrated numerous barriers that hinder the uptake of renovation measures. Having overall view over the sustainable retrofitting context reveals the existence of various barriers based on buildings functions and usage, features, environment and society in the bigger scale (BPIE, 2011). Booth et al. (2013) argue the barriers into the most usual ones as “Pre-bound effect” - which is the divergence between modelled and actual energy consumption for the pre-retrofit -, and “Rebound effect” in which the post-retrofit energy consumption is higher than predicted, due to changes in occupant behaviour following the installation of a measure. For the space reason it seems essential to summarize following discussion; therefore, within a more sustainable and holistic vision, the barriers in this context have been examined and classified in a more precise way by BPIE (2011) throughout “Financial”, “Institutional and Administrative”, “Awareness, advice and skills” and “Separation of expenditure and benefit”. In this regard, the challenges were identified as the main risks which need to be addressed for market uptake within Supply chain, Quality of workmanship, Technical failure, and Disturbance.

### 2.2 Problem statement and research objective

This section tries to zoom out and seeks for common patterns in order to formulate and simplify above issues into a few main trends so as to deal with the existing complexity through some of their principles and components. In retrofitting context from one side a common reason for many of existing barriers is the necessity of involvement or dealing with its humane society and so lack of learning. In other side there are different criteria or objective which derives into project based on sustainable perspective [as source of Holism] which need to be optimized within a multiple optimization process. Hence it is looked not just as a technical problem but as a socio-technical problem; in this regard we refer word ‘society’ to the community of different stakeholders who are involved in retrofitting process (see Figure 1), and also word ‘technical’ for sustainable aspects of the retrofitting and its various alternatives (see Figure 2). It also has to be noted that the technical part in this model itself has a holistic insight in connection with three pillars of sustainability.

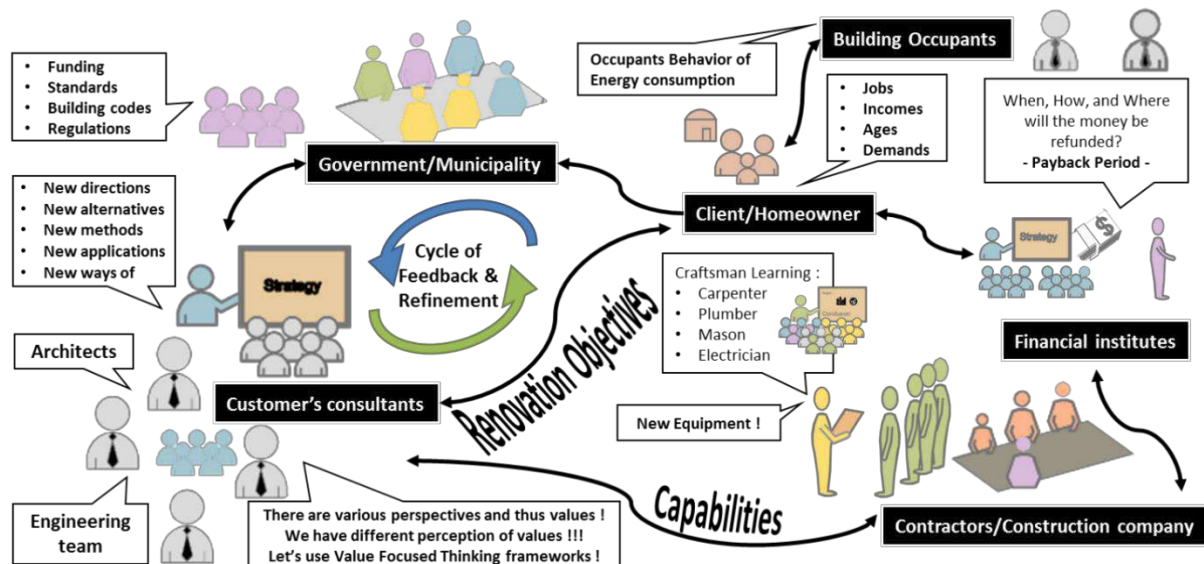


Figure 32: Different stakeholders involved in building renovation context

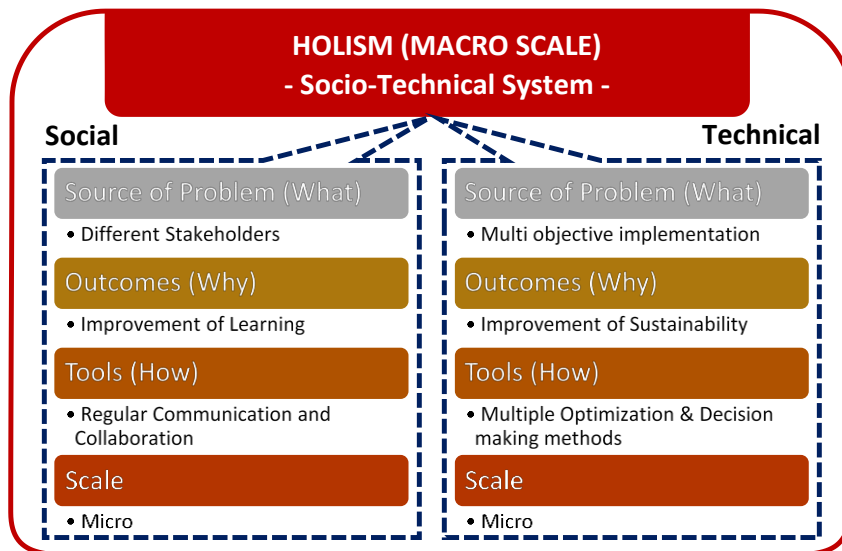


Figure 33: Concept of Holism in retrofitting context

A recent review on existing assessment tools related to building renovation, highlights that 'holism' in relation to building renovation is not an unequivocal quantity. The tools represent a number of different approaches to holism, giving weight to different sustainability indicators (Jensen et al., 2016). The included tools span from process management tools to certification schemes and from a delimited focus to a more evenly weighting of the three sustainability indicators. The major number of the present tools and methodologies are not able to fully address non-technical values alongside quantitative values, especially in relation to social sustainability indicators in aforementioned context.

A retrofitting problem is a complex system because it cannot be fully addressed and evaluated without comprehension of the relationships between its technical objectives and society as well as the influences of its development impact on its environment and world (its neighbors and city in a bigger scale) as whole. Therefore the architects/designer should not only unravel a well technical problem examination, but formulate the problem based on the present circumstances once they begin another. This issue is equivalent from many views to the problems which known as messy/wicked problems. The phrase 'wicked problems' (Churchman, 1967) were originally used in the context of social planning and it used to demonstrate problems that were difficult to overcome, since they address complex social interdependencies. There are at least two attributes of the wicked nature of problems; initially it is difficult to formulate solutions, because of the complexity of a socio-cultural interactions and interdependencies which it happens in; this leads to the inability to foretell long-term effects of decisions since the recognition of the source of the problem is highly complicated. Secondly the definition of objectives due to various circumstances is provisional, and it entails different features, ideas and interests (Estkowski, 2013). Similarly the characteristics of the concern problems in retrofitting discipline involves many qualitative and quantitative factors and criteria that are provisional case to case. In other words, the alternative solutions for an existing building frequently cannot be applied for others due to the changes in environmental circumstances and various decision makers including customers, designers etc. In this perspective its nature is quite similar the problems discussed above as messy/wicked problems. Therefore the practical needs for improvement in this context is calling for new approaches.

In summary then, the decision regarding retrofitting of existing building is initially a highly complex problem subjected to lack of an appropriate methodology and decision support tool to influence its society and technical part simultaneously. It means the methodology should take retrofitting projects into the consideration, initially in order to address its wicked nature resulting by 'Learning Improvement' among the stakeholders and then 'Multiple Optimization' through identify, manage, and evaluate the building objectives among the different renovation criteria and retrofitting alternatives with a holistic vision (subject to the macro scale - see Figure 2) regarding to functionality, feasibility, accountability, or sustainability in its full sense (Kamari et al., 2016). This explanation informs the next section of the present paper in order to detect the existing methodologies which are able to deal with complexity in retrofitting context and hence gives a short description on the suitability of SSM and MCDM towards proposing a qualified methodology which is structured within mix of methods.

### 3. DEVELOPING A HOLISTIC METHODOLOGY IN SUSTAINABLE RETROFITTING

#### 3.3 Appropriateness of soft systems methodology (SSM)

SSM was developed by Peter Checkland in 1970s at Department of Systems, University of Lancaster. The SSM approach stems from the 'systems movement', which Checkland (1999) considers as an effort to give holistic approaches in socio-technical problems. It is a method that in a systematic way attempts to establish and framework a debate regarding actions for enhancing the complex and messy situations. Maqsood et al. (2001) describe it as a framework for iterative enquiry and learning about the organization which provides a well-defined action research approach to help address wicked problems. The concept of SSM has been explained more in details by Checkland (2000); he has referenced SSM in an evolutionary path primarily defined as 'seven stages model (1981)' and being developed through 'two main stream approach (1988)' and finally concluded by 'four main activity research method (1990)'. SSM through the last updated approach (four main activity) encourages group learning and is ideal as a group decision-making approach. It is strengthened by the active participants and stakeholders, and encourages joint ownership of the problem solving process. Eventually, SSM is recommended where an organization is seeking to achieve changes in workplace culture and transformation into a learning organization (Rose, 1997). In this perspective using SSM in building renovation context being able to develop an integrated design process which keeps the society involved in all the design stages. It is able to deal with complexity, capture it and communicate it among the key players. Therefore it enables us to address major part of the problem formulated in section 2.2.

#### 3.4 Appropriateness of multiple criteria decision making (MCDM)

MCDM is a sub-discipline of operations research. It has been developed to help decision makers throughout complex decision analysis. The term 'decision analysis' can be explained as a body of knowledge and professional practice for the logical shining of decision problems. Parnell et al. (2013) discuss it as "a philosophy and a social-technical process to create value for decision makers and stakeholders facing difficult decisions involving multiple stakeholders, multiple (possibly conflicting) objectives, complex alternatives, important uncertainties, and significant consequences. Decision analysis is founded on an axiomatic decision theory and uses insights from the study of decision making". In this regard the term MCDM defines as decision analysis involving multiple criteria. The purpose is to support decision-makers facing complex problems based different aims and objectives. According to the reviewed literatures, MCDM is categorized into two main sub-group, Multi-Objective Decision Making (or MODM) and Multi-Attribute Decision Making (or MADM). MODM studies decision problems in which the decision space is continuous. MCDM can be applied in building renovation (Phdungsilp et al., 2004) context through both MODM and MADM and as such being able to equip the design process to primarily deal with existing complexity and different criteria driven from a sustainable perspective.

#### 2.3 Mixing SSM with MCDM

The utilization of different approaches from different methodologies and domains is not a new concept and there are researchers who have put it into the consideration theoretically and also exploited it practically in the past (Jackson, 2003). It is another way of strengthening the Multiple Perspectives view of the complex problems due to the inefficiency of traditional approaches to confront the actual situation. Similarly, the needs for retrofitting context within different situations was considered diverse and complex and thus could not be served by a single methodology; for this reason present section tries to justify use of mixing methods including SSM and MCDM in retrofitting context. It needs to be addressed primarily through their potential benefits and individual lacks in facing a complex problem and secondarily from the dimension/shape of the formulated problem earlier.

The potential of using methodologies such as SSM or MCDM [in addition to preceding sections 3.1 & 3.2] can be considered from their vast application in other complex domain or over developing more complex products; above all, the availability of the various tools and software in making and implementation of decisions in using SSM or MCDM is the other reason that increases their appeals. However, according to the reviewed literatures the most important weakness regarding to SSM is the lack of support given by it during the Selection and Implementation phases and for MCDM it is in problem exploration and structuring stage which relies for the definition of the model only on brainstorming (Jayaratna, 1994). Petkove et al. (1997) underline that it should not be viewed as a rejection of these techniques as a systems science tool. On the contrary, on the basis of Critical Systems Thinking one can find a common foundation for the complementarist use of MCDM techniques with soft systems approaches

belonging to the field of problem structuring methods. The authors conclude that there is considerable scope for new and fruitful combined application of MCDM method with different strands of systems thinking and the result enriching both. By use of multiple methods [according to sections 3.1, 3.2, and 3.3], the formulated problem in retrofitting context on one side is fitted to be addressed where we need a regular communication, collaboration and brainstorming among the stakeholders in order to promote learning and participation in a bottom up way by using SSM; and on the other side the criteria can be selected, weighted, and balanced in order to choose the most appropriate retrofitting alternative into a sustainable perspective in using MCDM. As a result of this interventions, the stakeholders can concentrate on building a common appreciation about the most essential issues corresponding to the technical, cultural and political aspects of the problems on hand. Moreover it propel better informed management decision related to the particular situation.

#### 4. The proposed holistic step by step methodology in sustainable retrofitting

The preceding discussions provided indications for developing a methodology including mix of methods. The question then arises how techniques are selected and considered suitable for specific tasks. There are assumption of the various methodologies in order to justify choice of the methods (Mingers et al., 1997; Vo et al., 2001; Jackson, 2003; Petkove et al., 2007) and for the space reason we have to just refer to their works. Comprehensive overview of the methods and approaches belonging SSM and MCDM revealed the suitable methodology and methods which can be exploited in retrofitting context. They were identified through the guidelines provided from cited research works, mapping of the selected methods onto the world of building renovation and inclusion of key players in the problem solving frameworks (see Table 1).

<b>Stage 1</b>	<b>Finding out about a problem situation, including culturally/politically</b>	
	Step 1	Problem formulation
	Step 2	Selecting the main design criteria and sub-criteria
	Step 3	Developing measurement scales for the sub-criteria
<i>Proposed methods: Root definition, Rich picture, CATWOE, PQR (What, How, Why), and Delphi method [03,04,20]</i>		
<b>Stage 2</b>	<b>Formulating some relevant purposeful activity models</b>	
	Step 4	Generating alternative solutions
	<i>Proposed methods: Process modeling in SSM [04,15,21]</i>	
<b>Stage 3</b>	<b>Debating the situation, using the models, seeking from that debate both</b>	
	<b>a) changes which would improve the situation and are regarded as both desirable and (culturally) feasible</b> <b>b) the accommodations between conflicting interests which will enable action to improve to be taken</b>	
	Step 5	Weighing the main criteria and sub-criteria
<i>Proposed methods: POT or SAST + Pairwise comparison and/or TOPSIS and/or AHP [12,13,15,19,20]</i>		
<b>Stage 4</b>	<b>Taking action in the situation to bring about improvement</b>	
	Step 6	Predicting performance
	Step 7	Aggregating scores
	Step 8	Analyzing results and making decisions
<i>Proposed methods: AHP and/or TOPSIS [13,20]</i>		

Table 1: Holistic step by step methodology in sustainable retrofitting

The major framework of the above methodology has been developed from “four main activity approach in SSM”; the original methodology can be described as a four main activities process of analysis which uses the concept of a human activity system as a means of getting from “finding out” about a situation to “taking action” and improve the situation (Checkland, 2000). There also eight steps have been outlined that facilitates the avail of the methodology step by step. For each stage the required methods from SSM and MCDM have also been identified; although there is no space in this paper to discuss them one by one but instead the references have been provided to them for further studies.

## 5. CONCLUSION

The significant discrepancy in a deep building renovation and an ordinary one is a commitment to holistic approach. Looking at a project holistically for potential energy savings invariably means using an integrated design process. It is then developing a design process which explores the interdependency between different building systems and renovation goals towards achieving sustained prosperity at the end of the day. This paper explored the nature of the problem in retrofitting context as a highly complex and socio-technical system and subsequently investigated and addressed the concept of Holism. It represented a methodology throughout mixing some certain SSM and MCDM in order to support decision-making process. Following the outlined methodology can overcome the problem formulated in earlier section (see section 2.2) based on the nature and mechanism of the methods which are applied in there. It is initially able to deal with the existing complexity and wicked nature of the problem in building renovation domain and subsequently to address the present issues throughout its society (subjects to improve the building occupants' learning) and technical part (subjects to sustainability in its full sense) simultaneously. However the concept of the using mix of methods in retrofitting context stands on the beginning of its path and to utilize the full potential of this concept it needs to be tested in various circumstances and uses of different methods. "Using a multi-methodology reflects the conflicting nature of the criteria guiding decision makers in complex situations and harness their potential to support learning about the problem and more effective decision support", adopted from Petkov et al. (2007).

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