

# Towards a holistic methodology in sustainable retrofitting: Theory, Implementation and Application

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# Towards a holistic methodology in sustainable retrofitting: Theory, Implementation and Application

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# Agenda

- State of the art
- Retrofitting context (Process of retrofitting)
- Statement of problems (challenges in general)
- Formulation of the problem
- Hypothesis
- Engineering design + Decision making & Management science
- Mixing SSM with MCDM
- Framework of the Methodology
- Conclusion



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# State of the art

- A substantial share of the building stock in Europe is older than 50 years.
- 90% of existing buildings will still be in use by 2050.
- 40-50 % of the total energy consumption today is used in buildings for heating and operating equipment.
- The EPBD Impact Assessment concluded that the potential for cost effective energy savings in the EU building stock is about 30% in the period to 2020.

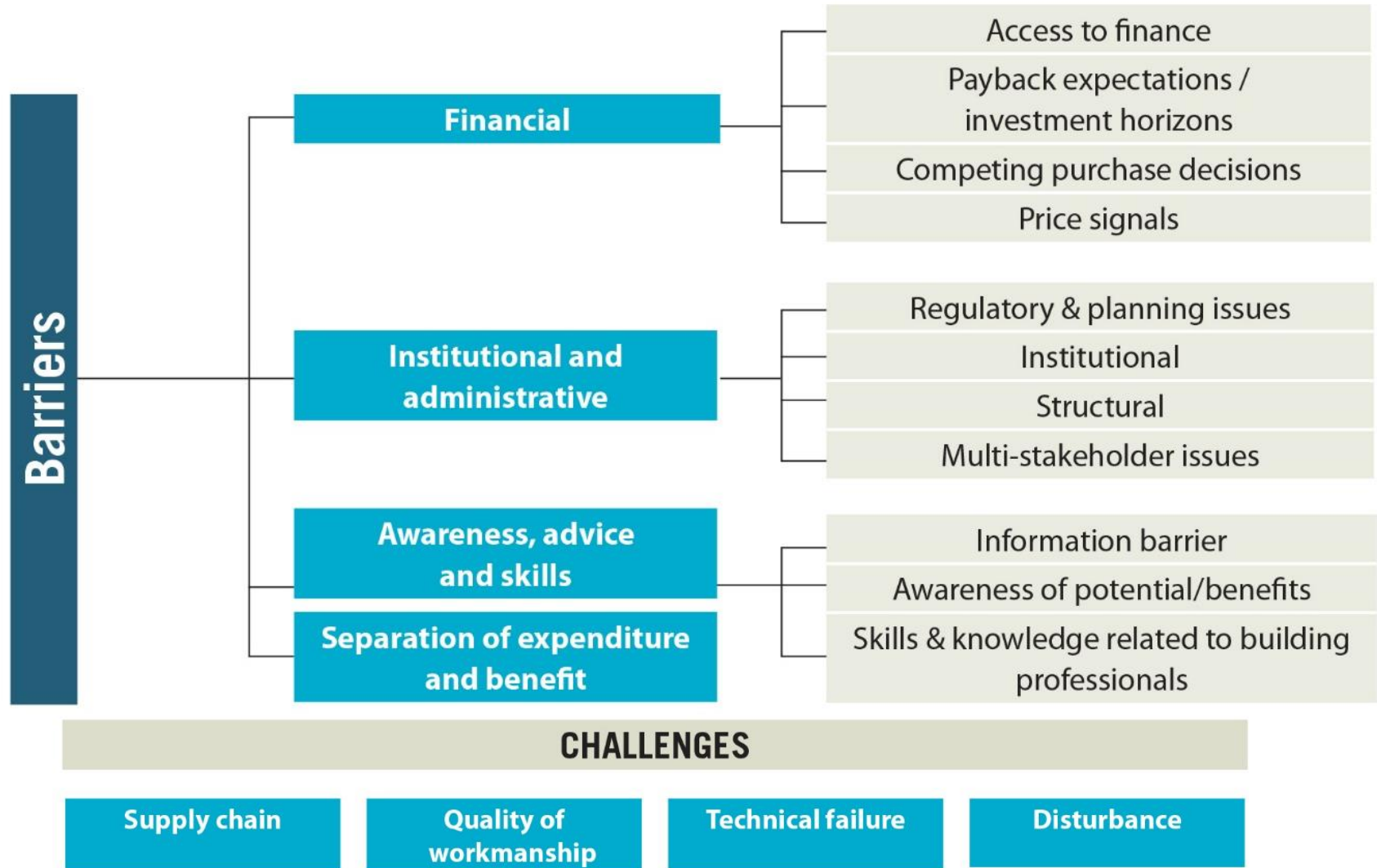


BPIE - Buildings Performance Institute Europe



Energy Performance of Buildings Directive  
European Commission

# Statement of problems (challenges in general)



BPIE - Buildings Performance Institute Europe



# Statement of problems (challenges in general)

- Uncertainties include phenomena such as “pre-bound” effect, the divergence between modelled and actual energy consumption for the pre-retrofit
- Uncertainties about “rebound” effect, in which the post-retrofit energy consumption is higher than predicted, due to changes in occupant behavior
- Financial issues
- Technical & Socio-Technical barriers
- Lack of occupants knowledge of the possibilities
- Lack of knowledge over the state of the art methods and platforms to collaborate and communicate among involved parties in a project



SBi – the Danish Building Research Institute



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# Research problem

## Financing:

- Banks
- Mortgages institutes
- State agents

Architects

Clients

Behavioral barriers

Value chain between actors

...  
Communication  
Collaboration

...  
Integration

...  
Learning

Contractors

**Building Renovation Stakeholders**  
- Artisans/Actors -

Municipality

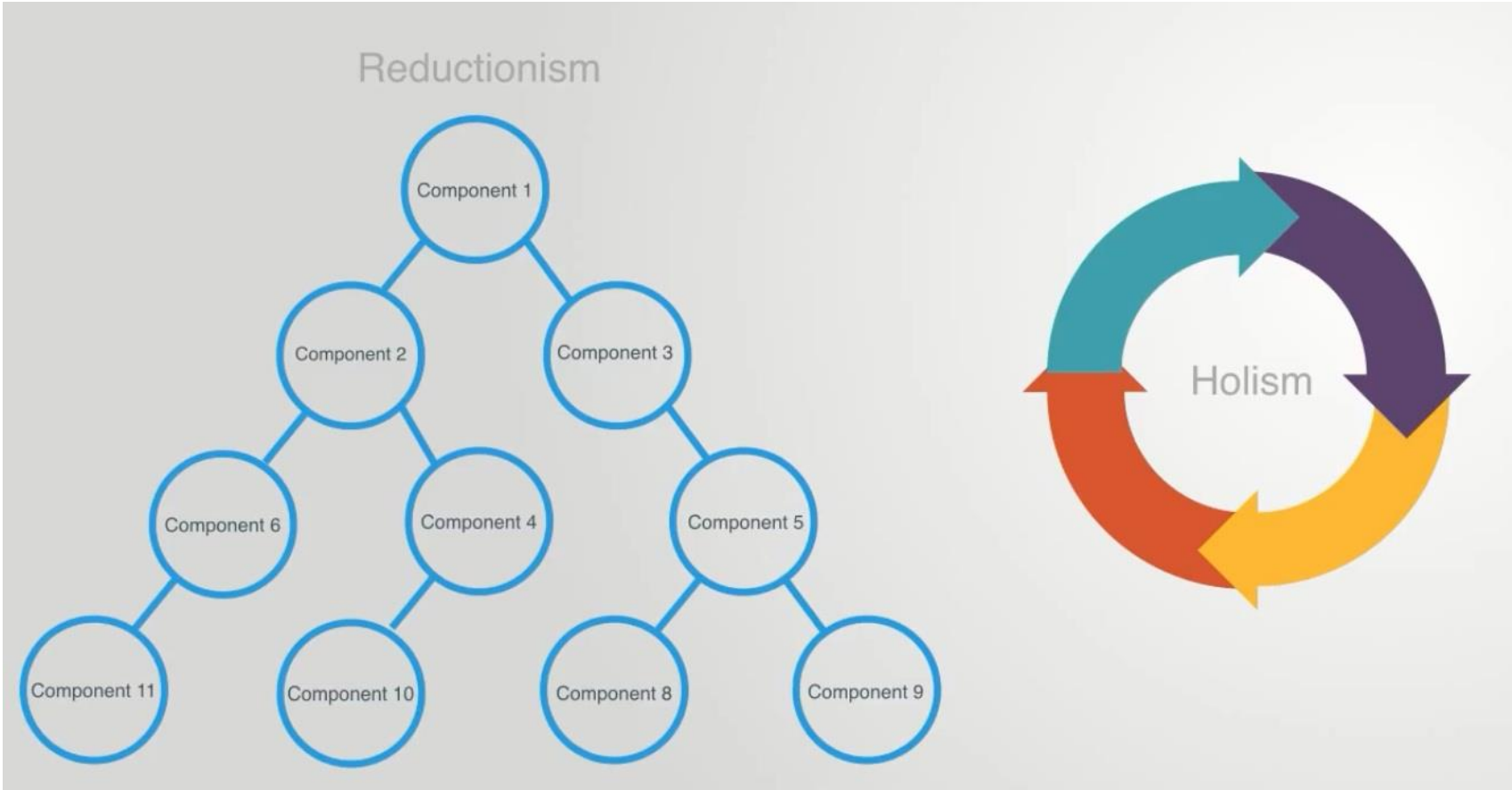
Building occupants

Engineering team: Design engineer,  
Structural & MEP (Mechanical,  
Electrical, Plumbing)

## Craftsmen:

- Carpenters
- Masons
- Plumbers
- Electricians

# Research problem



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# Research problem

Kamari, A., Corrao, R., & Kirkegaard, P. H. (2017). Sustainability focused Decision-making in Building Renovation. *International Journal of Sustainable Built Environment*, Manuscript has been accepted for publication.



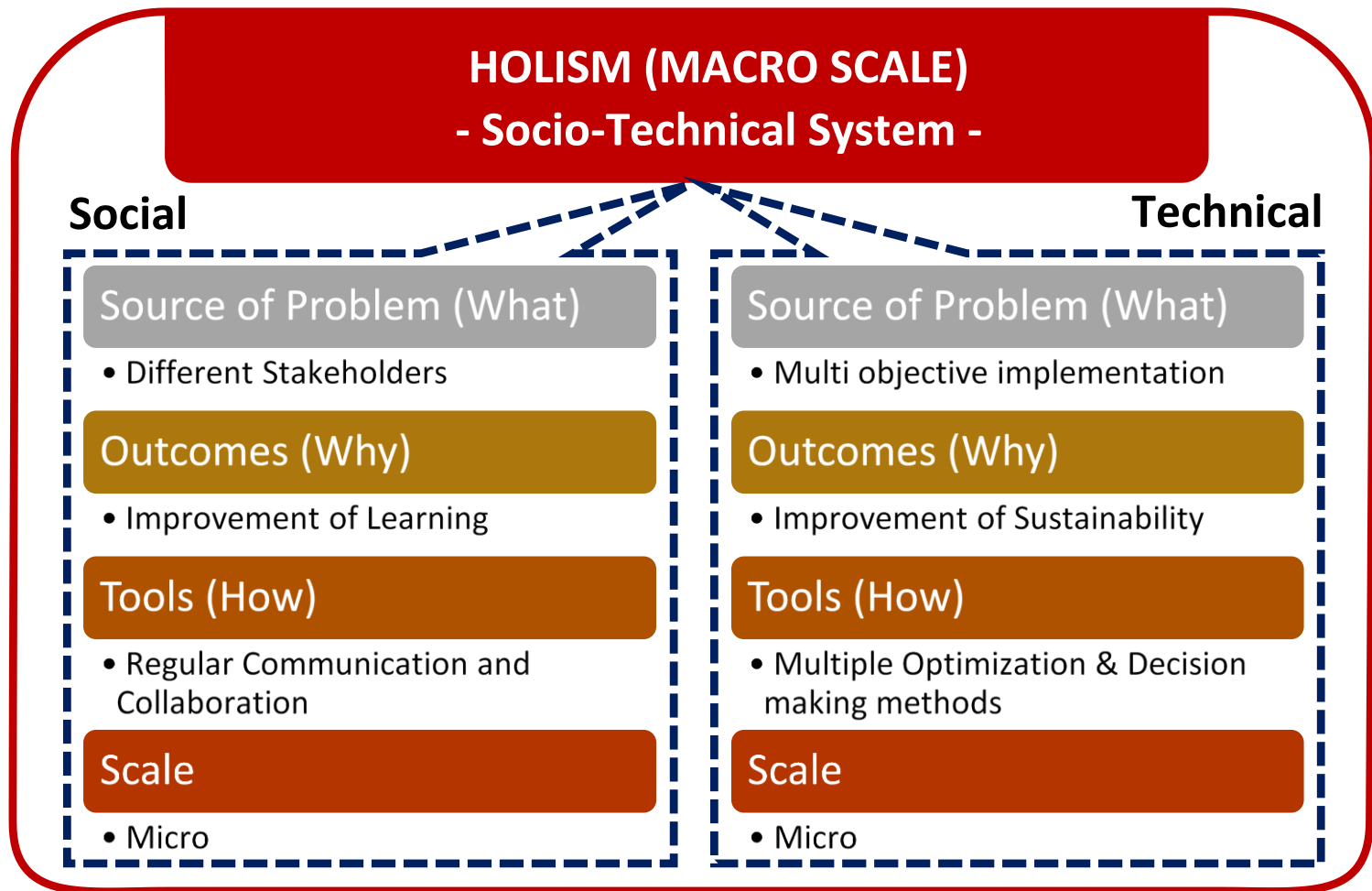
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# Research problem





**Messy Problems**

**Wicked Problems**



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# Hypothesis

**The techniques developed to study and manage engineering change may have positive benefits for retrofitting context.**

Development of an engineering design methodology using SSM and MCDM based on mix methods can harness their potential to support learning about the problem and more effective decision support in the early design stage of retrofitting projects.



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Engineering Design



Systems theory and thinking



Hard and Soft Systems



SSM

Nigel Cross

Design Science

Scientific Design

Decision-Making & Management Science



Operation Research (OR)



MCDM



MADM or MODM

Mixing Multiple Criteria Decision Making with soft systems thinking techniques for decision support in complex situations

Petkov, D., Petkova, O., Andrew, T. and Nepal, T. (2007), Decision Support Systems 43 (2007) 1615–1629

Vo, Huy; Paradise, David; and Courtney, James, "Problem Formulation in Inquiring Organizations: A Multiple Perspectives Approach" (2001). AMCIS 2001 Proceedings. Paper 384.



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By late 1990s Oxford  
dictionaries of current English:  
‘the science of method’

Never imagine that any methodology can itself lead to ‘improvement’. It may, though, help you to achieve better ‘improvement’ than you would without its guidelines. But different users tackling the same situation would achieve different outcomes.

By 1996 Oxford dictionaries of  
current English:  
‘a body of methods used in  
a particular activity’



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# Framework of the Methodology (learning & optimization-based):

**SSM uses “systems thinking” in a cycle of action research, learning and reflection to help understand the various perceptions that exist in the minds of the different people involved in the situation.**

**SSM encourages group learning and is ideal as a group decision-making approach. It is strengthened by the active participation by different participants and stakeholders, and encourages joint ownership of the problem solving process. Finally, SSM is recommended where an organization is seeking to achieve changes in workplace culture and transformation into a learning organization.**

**MCDM can be discussed 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.**



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## SSM including Four Main Activities Methodology (Checkland, 2000)

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” to improve the situation.

Mapping of possible techniques suitable for the problem situations within concept of Holism discussed onto the three worlds of Habermas (1984) for building renovation purpose:

	APPRECIATION		ANALYSIS		ASSESSMENT		ACTION	
<i>Social world</i>	A, B, C, D	-	A, E, F, G	H	F, G	I, J, K	-	I, J, K
<i>Personal world</i>	A, B, C, D	-	C, D, E	H	C, D, E	I, J, K	C, D, E	I, J, K
<i>Technical world</i>	A, B, C, D	-	C, F, G	H	F, G	I, J, K	-	I, J, K
	<i>SSM</i>	<i>MCDM</i>	<i>SSM</i>	<i>MCDM</i>	<i>SSM</i>	<i>MCDM</i>	<i>SSM</i>	<i>MCDM</i>

A) Rich picture B) CATWOE C) Root definition D) Conceptual models E) PQR F) POT G) SAST H) Delphi method I) Pairwise comparison J) AHP K) TOPSIS



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## SSM including Four Main Activities Methodology (Checkland, 2000)

- using Rich picture, CATWOE, and PQR through Giga Mapping
- using POT (Huy et al. 2001) or SAST (Mason et al., 1981)
- using AHP (Saaty, 1980)

<b>Finding out about a problem situation, including culturally/politically</b>	
<b>Stage 1</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</i>
<b>Formulating some relevant purposeful activity models</b>	
<b>Stage 2</b>	Step 4   Generating alternative solutions
	<i>Proposed methods: Process modeling in SSM</i>
<b>Debating the situation, using the models, seeking from that debate both</b>	
<b>Stage 3</b>	a) changes which would improve the situation and are regarded as both desirable and (culturally) feasible
	b) the accommodations between conflicting interests which will enable action to improve to be taken
	Step 5   Weighing the main criteria and sub-criteria
<i>Proposed methods: POT or SAST + Pair wise comparison or TOPSIS or AHP</i>	
<b>Taking action in the situation to bring about improvement</b>	
<b>Stage 4</b>	Step 6   Predicting performance
	Step 7   Aggregating scores
	Step 8   Analyzing results and making decisions
	<i>Proposed methods: AHP or TOPSIS</i>



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# Conclusion

When we deal with increased complexity and multiple stakeholders it is useful to explore the possibilities to combine separate techniques from **soft systems thinking** with **multiple criteria decision making** in order to both reflect 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.



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# Message for the future

- Look into the buildings as the buildings
- Explore the complexity and try to deal with it
- Investigate Sustainability, set the goals from the beginning and address them comprehensively
- The future of solving the problems in our domain should be about adaptation in the process and not just certification of the buildings
- Do not decouple occupants from the design process
- Explore the traditional methodologies and design methodologies and endeavor to equip them with new approaches and methods in order to deal with this level of complexity!



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# Thank you

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