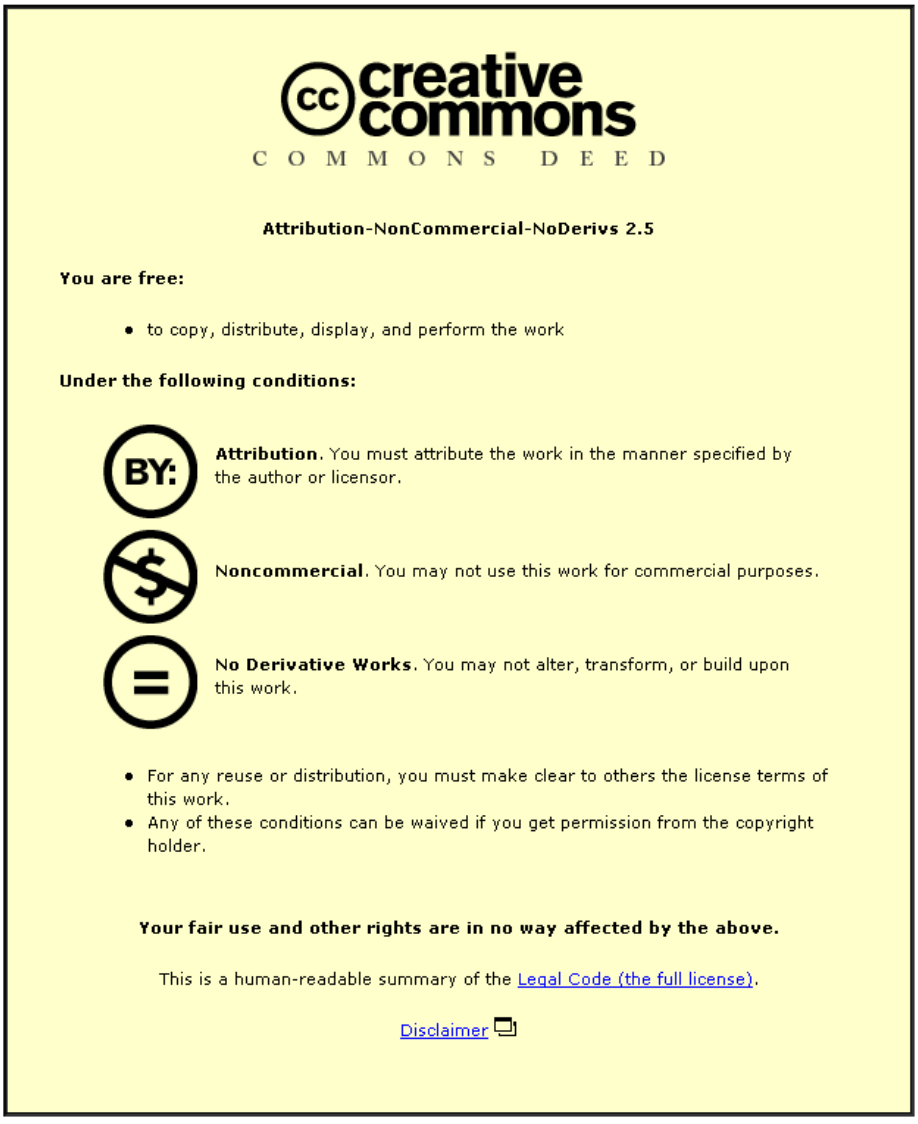

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Building future scenarios using cognitive mapping

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Abstract

A participatory approach for developing future scenarios through cognitive maps as a visual representation of mental models is presented. Applying long-term future visioning techniques in a workshop setting has traditionally been a significant challenge for construction industry practitioners with predominantly short-term, project-based approach to day-to-day operational responsibilities. Six future scenario cognitive maps are presented to illustrate the process. The maps were digitised from A1-sized papers using *Decision Explorer*™ software. Several key characteristics of the resulting cognitive maps and lessons learnt for the organisation of industry-based workshops are discussed. The main benefits are derived from the interaction between participants during the mapping process whereby future issues and their interconnectivities are discussed. Limitations of the findings and further work are presented.

Introduction

In the field of cognitive cartography, a map is a cognitive representation of the world, and knowledge of maps and mapping can help understanding the cognition of individual mapmakers. Maps can contribute to an individual's

inner mental model, and influence their views of the world (Montello 2002). The field of cognitive psychology has equipped cartographers with a greater understanding of how to approach many cognitive map design problems and their interpretations, contributing to the development of cartography as a scientific discipline (Montello 2002).

'Cognitive map' refers to a model of cognitive content (Huff 1990), and is created to represent and communicate human cognition for both geographical and non-geographical information. Cognitive maps do not necessarily represent the actual reality transparently, and therefore are regarded to be 'subjective' and, in some cases, 'unique' to individuals. However, they contribute to our understanding of actions and behaviours of individuals and groups. This subjective aspect can be present in maps containing geographical or non-geographical information. For example, Alexander (2004) found systematic distortion of geographical information of disaster areas by different individuals in scenario exercises. Mapping of non-geographical information is called 'spatialisation' (Skupin and Fabrikant, 2003), which, in cognitive mapping terms, means a diagrammatic representation of constructs (or concepts) and their relationships with each other. Any endeavour to establish cause and effect relationships between constructs is called causal mapping (Laukkanen, 1990), which could be considered as a subset of cognitive mapping.

In this paper, cognitive mapping embraces the wider definition, which can incorporate establishing sequences of events, logical steps in decision making or causality between constructs, representing mental models of cognitive content. Cognitive maps can illustrate these mental models by a simple

graphical representation of a person'(s) thinking, that locates the person(s) in relation to their informational environments (Fiol and Huff, 1992). The cognitive maps exhibit an individual's perception of a network of relationships in a form of nodes and paths (Bryson et al., 2004). Nodes contain future issues, events, exogenous factors or outcomes/goals, whereas paths (arrows) describe relationships between these nodes, that is, a relationship to show that the occurrence of event A may lead to the occurrence of event B, or certain actions may lead to particular outcomes. They are particularly useful when investigating people's perception in groups, where coherent and coordinated behaviours and actions are critical. People need to communicate and negotiate intentions and plans, which in turn will be moderated by the other members of the group. This interaction within organisations for the development of longer-term plans is sometimes called 'strategic conversation' (van der Heijden, 1996). This conversation could be facilitated by explicit representation of mental models of participants. The production of cognitive maps can facilitate the development of future scenarios in which these maps can make explicit the orderly future events within people's mind.

This paper presents several examples of cognitive maps derived from a workshop to develop a range of future scenarios for the UK construction sector. The workshop participants were experienced construction professionals from diverse disciplines and organisational backgrounds. Applying long-term future visioning techniques in a workshop environment has been a significant challenge for construction industry practitioners, particularly because of their predominantly short-term, project-based approach to day-to-day operational responsibilities (Burt and van der Heijden, 2003). In this

context, the paper represents a significant contribution to the application of scenario methodology in the construction sector. The process of developing the cognitive maps is elaborated, and the key benefits and lessons learnt from the process are outlined.

Scenario development using cognitive mapping

A scenario can be simply described as a storyline comprising a range of interconnected and uncertain future events and their possible consequences. This definition reflects the work that is presented in the paper, and is consistent with some of early definitions of scenarios (e.g. Khan and Wiener, 1967; Godet, 2000a). It is not about predicting events or determining the most likely scenario, but developing several plausible stories that describe how the environment in which an entity (e.g. an individual or organisation) lives or operates may develop, given certain future events, trends, and developments, and then to explore possible ‘discontinuities’ and ‘surprises’ (i.e. wild cards) (Hiemstra, 2006).

The usefulness of future scenario building is in empowering organisations to help prepare for an uncertain future by producing a range of plausible futures and identifying associated risks and opportunities in order to inform current strategic decision making (Eden and Ackermann, 1998; Godet, 2000b). Future scenarios make explicit the mental models of managers for the purposes of analysing, sharing, negotiating and reconstructing them. A shared mental model could provide a sound basis for more effective decisions due to a joint

decision making process that encourages buy-in from the key stakeholders (van der Heijden, 1996).

The functions of cognitive maps in scenario development and organisational decision making include: issue structuring (which focuses attention and triggers memory), issue closure (which reveals gaps) and creative problem solving (which highlights key factors and supplies missing information) (Fiol and Huff, 1992). Fiol and Huff (1992) identified three components of cognitive mapping, namely: identity (to identify key actors, events and processes); categorisation (to provide information about the interrelationships of the actors, events and processes); and cause and argument (to provide information about potential interconnections amongst entities of the importance to the organisation through time, i.e. the 'route'). The identity and categorisation components provide the inputs for the causal and argument components. Fiol and Huff (1992) highlighted the significance of managing these interactive components and balancing multiple and often conflicting components and maps of individuals. Individual maps are unlikely to be identical but they may partially overlap. These issues were considered in developing scenarios using the cognitive mapping technique.

Cognitive mapping futures process

The scenario building process used to construct the maps presented here involved a focussed, one-off multi-organisational cognitive mapping workshop with participant verbal plenary sessions in order to produce alternative future scenarios around a particular theme. The main aim of the process was to

encourage a dialogue amongst key stakeholders (of multiple companies and organisations) through building a range of cognitive maps around an issue or theme. This process is designed to empower the participants to investigate the complex interconnections between the different future issues, exogenous factors, events and outcomes/ goals. A cognitive mapping scenario building process was developed and trialled with several industry practitioners in interview sessions before the workshop. This enabled focussed, robust, alternative scenarios on specific topics chosen by participants to be created, debated and critiqued in approximately two to four hours. The cognitive maps were designed to exhibit consequential relationships between issues, exogenous factors, events and outcomes/ goals, set against a rudimentary time line of 10 to 20 years. Twenty-three delegates attended the workshop representing clients, contractors, consultants, manufacturers and trade bodies from the UK construction industry. The research team developed eight predetermined themes and questions which gave a focus to the discussion. The delegates were then asked to choose a theme which they felt comfortable and knowledgeable to discuss and were interested in. The list of themes and questions are presented in Table 1 (columns 1 and 2). Those who chose the same theme were asked to form a group, with six groups of between three and four people in total.

The groups identified desired outcome(s) or goal(s) within the theme under discussion on the right-hand side of the A1 paper (i.e. in the future). Goals are for examples, “to achieve zero carbon for all new built home by 2016”, “to achieve 2050 target to reduce CO2 emission by 60%. They then identified issues which are relevant predecessors to the present situation on the left-

hand side (i.e. today). The space between the envisioned outcome(s) and the current situation provided room for the group to identify and debate issues, such as events, trends, strategies (which are internal to the organisation), and exogenous factors (which are external to the organisation), that might take place within the agreed timescale (usually 10-20 years). The issues were written on Post-It notes which were then located in the A1 paper corresponding to their possible occurrence in the timeline. The participants jointly discussed and established relationships between the Post-It notes, using markers. During this discussion, the timing of the events and their relationships to the others were negotiated, frequently resulting in modifications of the events (or other constructs) and adjustments of the relationships. An example of a cognitive map from the workshop (before digitation) is shown in Figure 1. One participant from each group was required to present their map in a plenary session.

Although the map as shown in Figure 1 presents an authentic depiction of diagrammatic collective cognition, it has limited presentational and further analytical application. Therefore, *Decision Explorer*™ (DE) software was employed to digitise the maps. During the conversion, the approximate 'location' of the Post-It notes was preserved whenever possible for improved clarity. As the main focus is on the 'relationships', the exact 'locations' are not essential. Due to the availability of space and the high number of Post-It notes produced during the discussion, locating the notes in the paper could be somewhat constrained. Therefore, any claim that the location of notes is exactly replicated in the DE map is likely to be invalid, as they only represent indicative 'locations'.

The scenarios developed from this workshop could be classified as normative scenarios as the desired end point was first selected and then events which could lead to the end point were identified (Börjeson et al., 2006). The process was designed to consider engagement with busy industry practitioners with a predominantly short-term, project-based approach to day-to-day operational responsibilities. Therefore, the process needed to be simple, practical, and not time consuming to understand and apply for a short (2-4 hours) workshop session. Compared with fuzzy cognitive mapping (Kok, 2009; van Vliet et al., 2010), the process is considered less demanding - as was observed during the workshop, establishing the relationships between (long-term future) constructs presented a significant challenge to the newly-formed groups of participants, and assigning weights (i.e. strength) to the relationships (as in the fuzzy cognitive mapping) would have proved too complex in the time available. A more detailed description of the process, consideration and review of other frameworks is included in Goodier et al. (2010).

Decision Explorer (DE)

Cognitive maps produced in a workshop environment may be unclear and difficult to read. DE is considered the most advanced computer support for cognitive mapping (Brightman et al, 1999 and Tegarden and Sheetz, 2003). The use of DE has permitted a better presentation of the maps for feedback to the participants, and further analysis. This offers significant benefits in the dissemination of the maps, and in stimulating the minds of other stakeholders, who were not present when the maps were developed.

DE captures ideas as short phrases of text and links them together in order to show their relationship (Figure 2). The most common form of linkage is a consequential (A leads to B) relationship, but DE contains other forms of links that express visually other forms of relationship (e.g. association between issues). It enables the users to explore around a map to obtain a greater understanding of the issues. The users are also free to arrange the linkages as they wish (unlike a ‘fishbone’ or ‘tree’ diagram). A database of relationships can be constructed and then tools within DE can be used to explore and analyse the model in order to develop ones understanding regarding the problem under consideration (Brightman, 2000). This analysis is beyond the scope of the paper, and has been demonstrated in Soetanto et al. (2011).

The maps and their characteristics

Figure 3 depicts a cognitive map which has been digitised using DE software, which corresponds to the map in Figure 1. The other five maps developed within the workshop are presented in Figures 4 to 8. Due to space limitations, it is not possible to describe each scenario in detail, but the theme, question and goal for each scenario are provided in Table 1. Key characteristics of the maps include:

- The cognitive maps as presented provide a good indication on how the topic of future construction resource efficiency can be positively influenced. They also suggest an awareness of the key issues from the industry-based stakeholders which should be considered by policy makers in any future initiatives.

- Observation of the constructs (events, issues, factors) indicates that they tend to be a mere extrapolation of existing trends with predominantly incremental changes toward the goals. There are few ‘wild cards’ events, which may radically change the existing landscape within which the industry operates, for example “the emergent of lightweight buildings” and “architect remuneration based on whole life costing”. Participants felt somewhat constrained by their own sphere of thinking, preventing them to think ‘outside the box’.

- Some of the issues within the maps do have more interconnections than others, providing an indication of the relative importance and influence of that issue. This is because participants tend to talk more about what they think are the important issues (di Gregorio, 2006). These interconnections can be further manipulated and analysed using DE once the data has been collated, using the software’s functions such as domain, central and cluster analyses (as exemplified in Soetanto et al. 2011).

Lessons learnt from the workshop

The workshop allowed the research team to engage with participants and identify and learn lessons for the organisation of industry-oriented workshops in the future, for example:

- As a futuring technique, cognitive mapping is a potentially useful approach for engaging participants in thinking about and discussing the future, identifying and appreciating the interconnectivities of the related issues, and understanding the possible implications of potential future events.

- Feedback from participants suggested that cognitive mapping was a challenging exercise with a significant increase in difficulty from the more common “sticky labels brainstorming” session (where they just identify issues in relation to a particular theme). Here, the process demanded a higher level of intellectual engagement and interaction between those involved, which became easier when participants became more familiar with the process and the other participants. There was however, a strong tendency for participants to establish sequences of fairly generic events rather than more detailed and challenging cause-and-effect relationships.
- This difficulty seems to be exacerbated by the need to consider events in the distant future (e.g. 20 years), which does not align well with the traditionally more short-term, project-based orientation (e.g. 2-3 years) of professionals in the construction sector. The maps reveal that the pathways to the future goals are predominantly an extrapolation of current trends with few ‘wild card’ type events, raising the issue regarding the creative quality of the scenarios (van Vliet et al., 2012). No formal ‘standard’ guidance on organising scenario workshops exists, but the introduction of potential future events and cues, and structured and unstructured balance design of the workshop should be considered.
- The manual representation of cognitive maps using Post-It notes has facilitated a natural, open and productive discussion during the scenario development. However, the majority of the resulting maps are unclear, complex and difficult to read without further computational presentation. The DE software has been beneficial in digitising the available cognitive

information, in terms of better presentation of the cognitive maps and for further analysis.

- The ultimate outcome is not in the resultant scenarios themselves per se, but within the process as experienced by the participants. The process facilitates a better understanding of the main themes and corresponding issues, the context and consequences of possible future events and actions, and of the particular pre-requisites required for certain events and/or desired outcomes to take place. The process also permits the negotiation of diverse perspectives, and encourages buy-in of possible future deliberations. In addition, the cognitive maps may also act as documentary artefacts able to help guide future policies, decisions and actions.

While the findings may be insightful and lessons learnt help in the organisation of industry-based workshops, they do not allow generalisation as they are based on one workshop on one specific subject area, and should ideally be repeated with additional workshops involving different subject areas.

Software

The cognitive maps were digitised using *Decision Explorer*™ (DE) software, available from www.banxia.com.

Acknowledgements

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Table 1 Scenario themes, questions and goals

No.	Scenario theme	Question	Scenario goal(s)	Chosen?
1	Increased demolition of buildings to meet energy efficiency standards	How can the industry cope with increased demolition of buildings given the tighter regulations on waste disposal and higher landfill taxes?	Reduced (and no unnecessary) demolition by 2026. If unavoidable, maximise deconstruction and reuse/recycling of materials towards a zero waste approach.	Yes
2	Increased adaptable and flexible buildings to meet climate change and function requirements	How can the design and construction of adaptable and flexible buildings be encouraged to reduce waste as a consequence of changes of climate and/or use? What are technological, social and business requirements to be considered?	All new buildings designed to be adaptable by 2025. Existing housing upgraded or demolished by 2025. Therefore 2050 target of reducing CO2 from buildings by 60%	Yes
3	Increased emphasis on recycling and reuse on new build	How can recycling and reuse be encouraged? What and how can incentives be given to related parties to realise this?	By 2020 80% of new build waste to be recycled and reused and 30% of new build to be derived from reused/recycled materials.	Yes
4	Increased emphasis on reducing material waste on new build houses	How can reducing material waste be encouraged? What and how can incentives be given to related parties to realise this?	Zero waste to landfill everywhere by 2020.	Yes
5	Increased consideration of whole life costs in the development of built environment	How can whole life principles be applied to improve resource efficiency of materials, products, construction, refurbishment and demolition waste?	A low carbon built environment by 2020.	Yes
6	Increased energy efficiency of buildings and built environment	How can design new buildings and upgrade existing building stocks to improve their energy efficiency?	All new homes/buildings low/zero carbon by 2016/19. 50% reduction in existing housing CO2 emissions.	Yes
(7)	Increased emphasis on zero/ low maintenance buildings	How can zero maintenance building be created? What key factors need to be considered?		No
(8)	Increased emphasis on sustainable land use	How can UK existing land be effectively utilised? What are key factors to be considered (e.g. demography, social, environmental, technological and regulations)		No

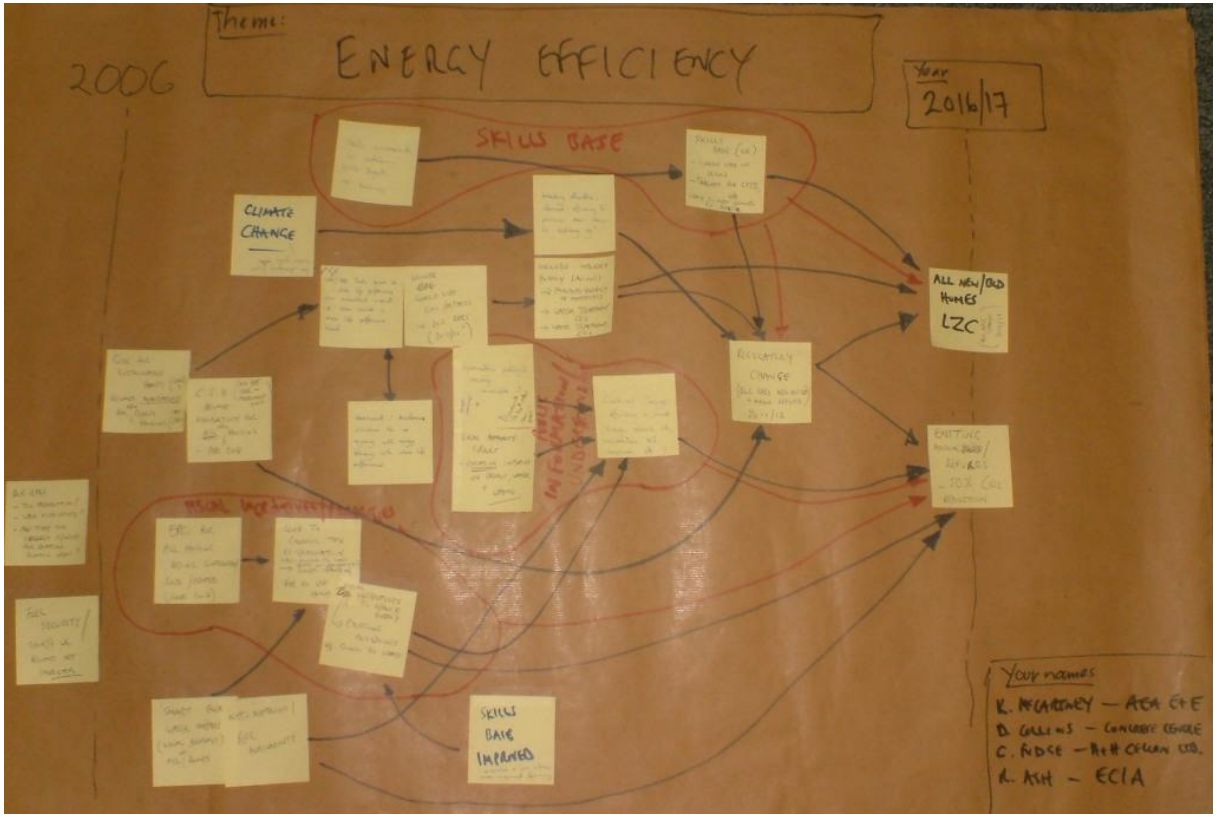

Figure 1: A cognitive map for Scenario 6: “increased energy efficiency of buildings and built environment”

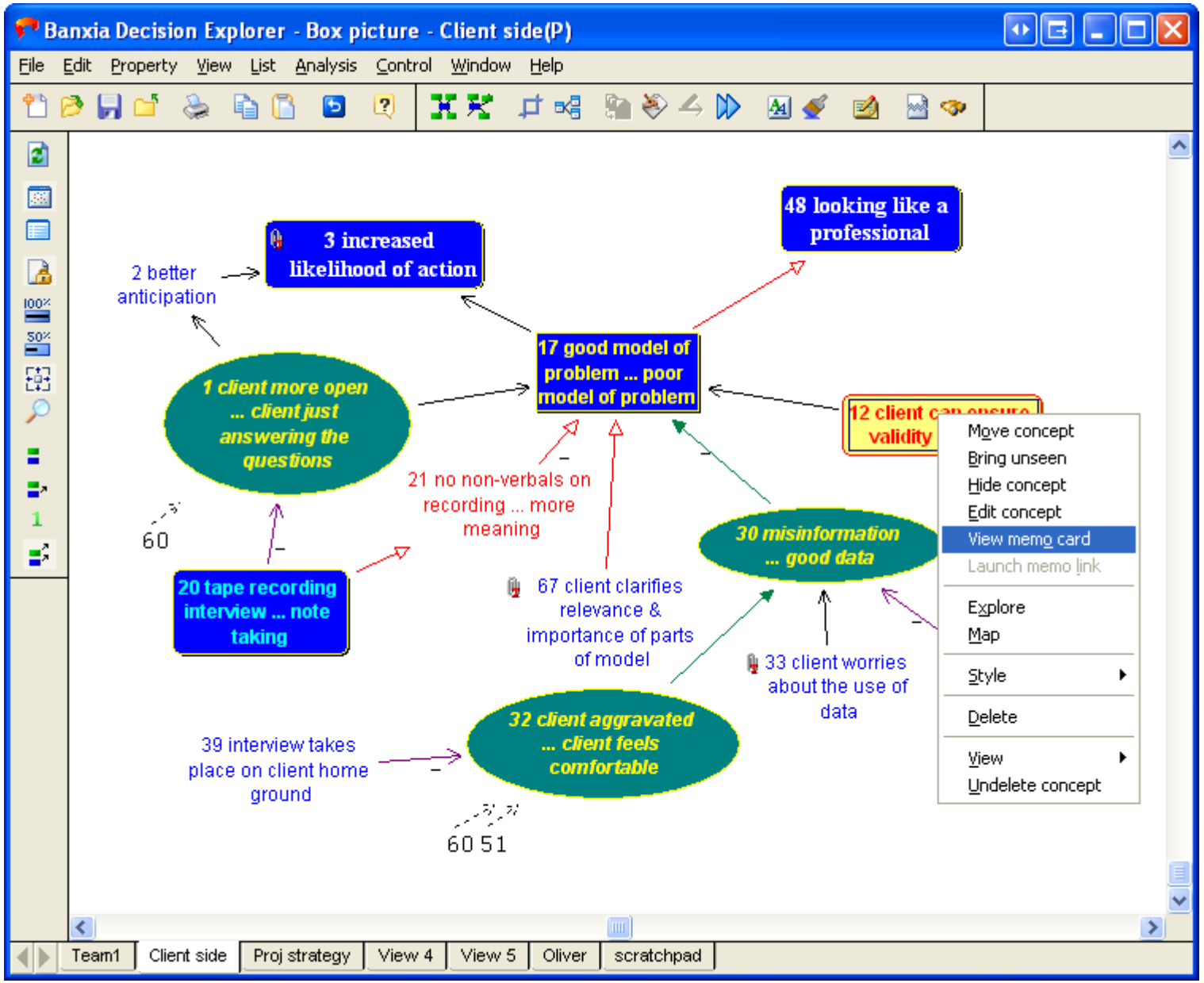

Figure 2: Constructing the cognitive map using Decision Explorer (taken from www.banxia.com)

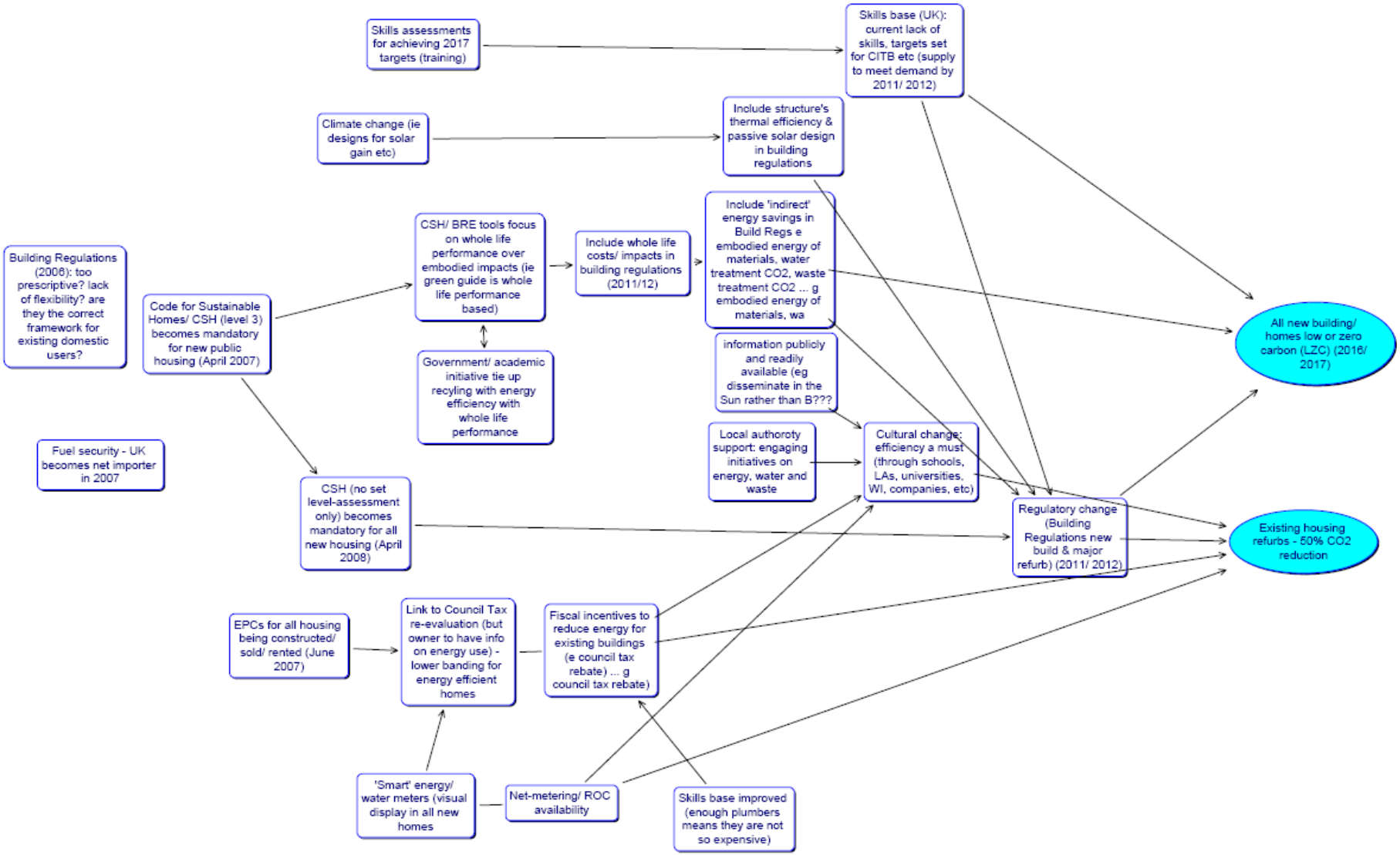

Figure 3: An example of a cognitive map in Decision Explorer (Scenario 6: "Increased energy efficiency of buildings and built environment")

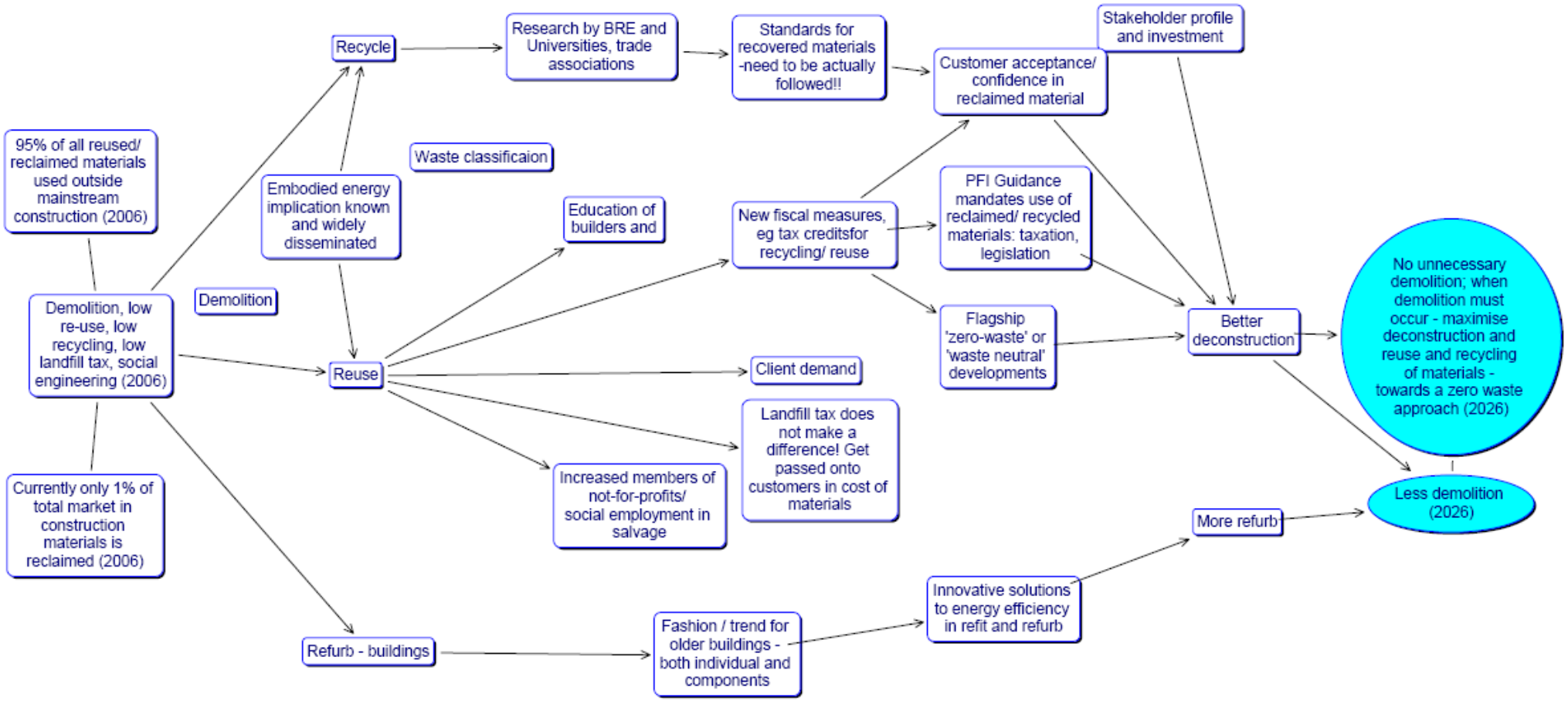

Figure 4: Scenario 1: “Increased demolition of buildings to meet energy efficiency standards”

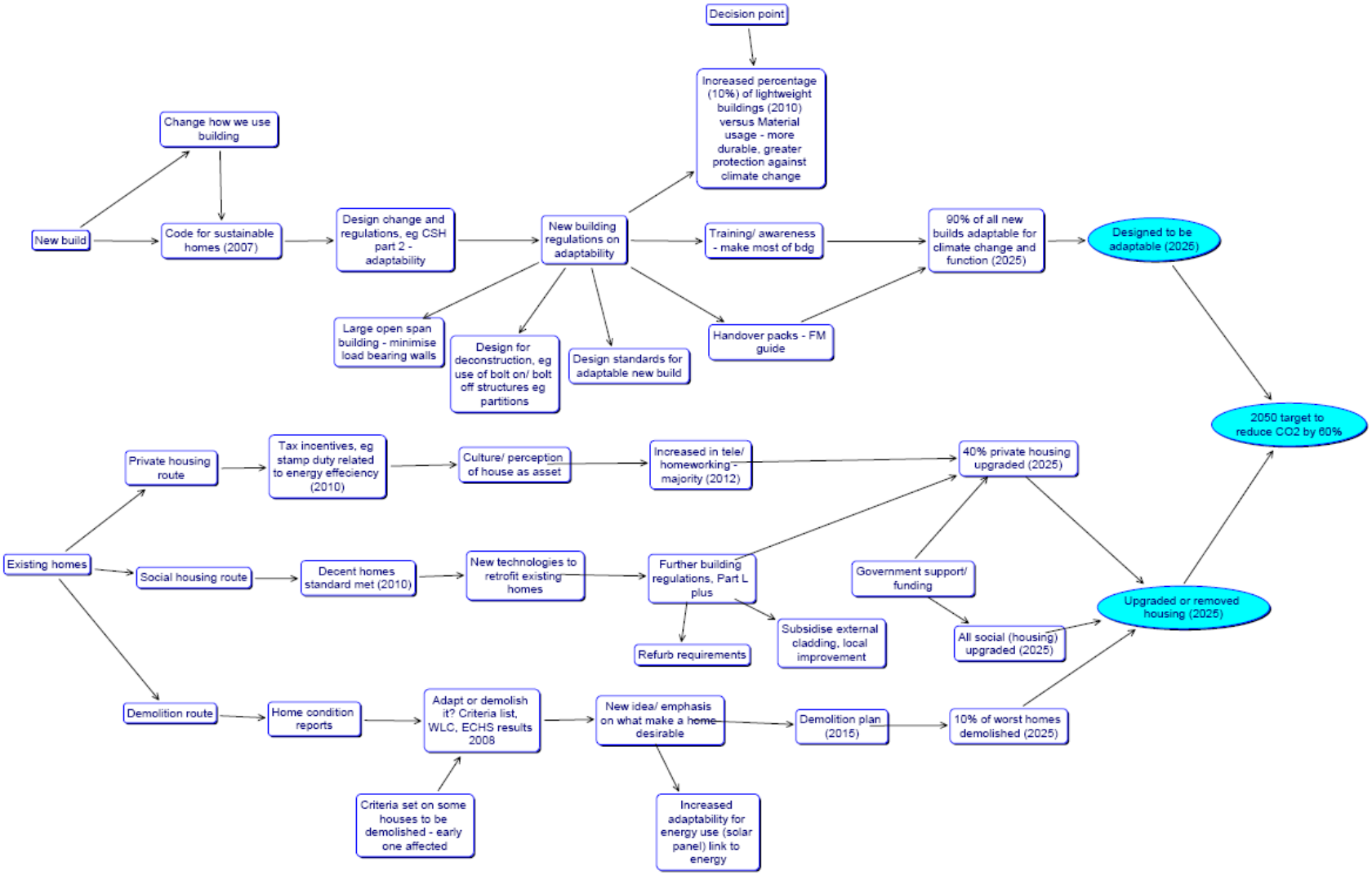

Figure 5: Scenario 2: “Increased adaptable and flexible buildings”

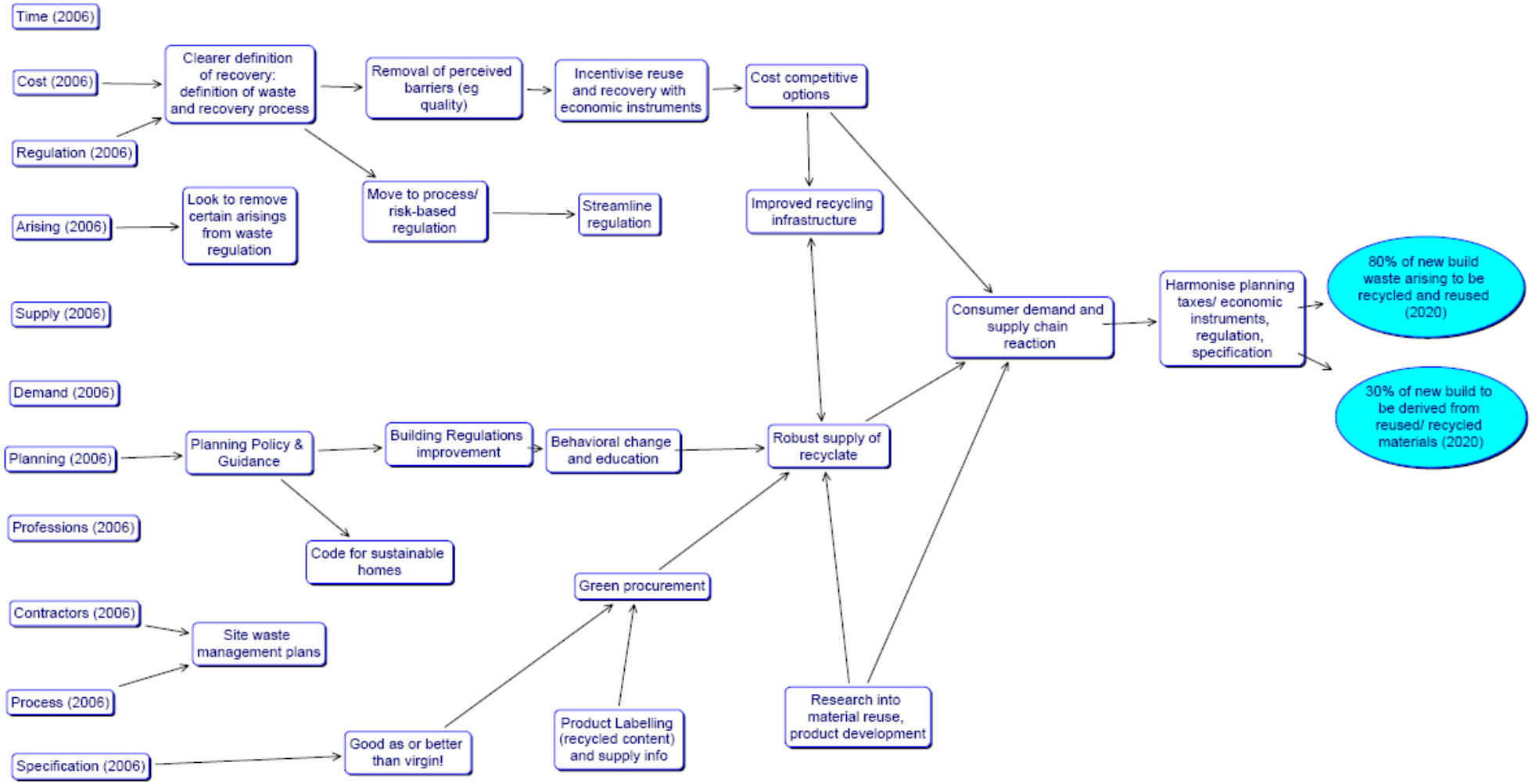

Figure 6: Scenario 3: “Increased emphasis on recycling and reuse on new build”

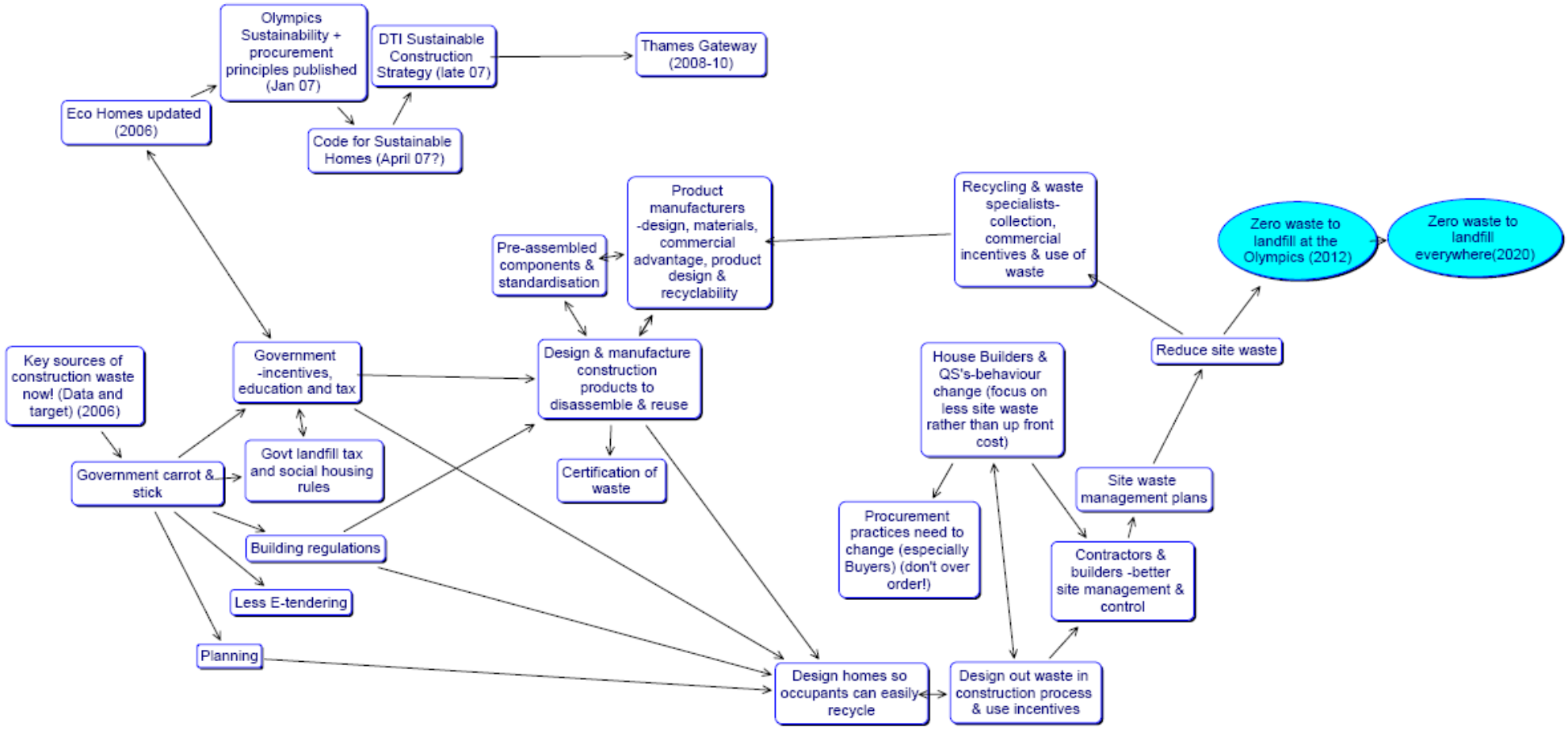

Figure 7: Scenario 4: “Increased emphasis on reducing material waste on new build houses”

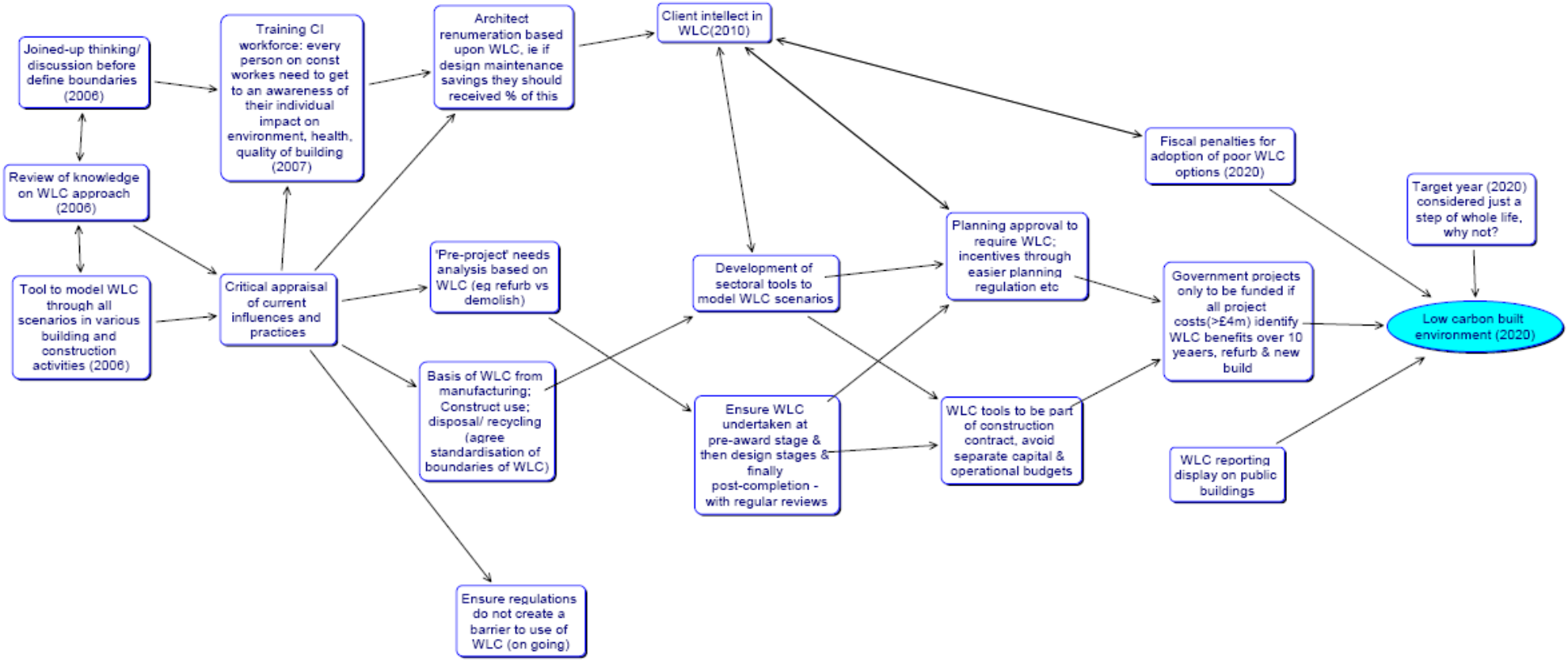

Figure 8: Scenario 5: “Increased consideration of whole life costs in the development of built environment”