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1 **Building future scenarios using cognitive mapping**

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9

10 **Abstract**

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

23

24 **Introduction**

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

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

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

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

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

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

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

82

83 **Scenario development using cognitive mapping**

84 A scenario can be simply described as a storyline comprising a range of
85 interconnected and uncertain future events and their possible consequences.
86 This definition reflects the work that is presented in the paper, and is
87 consistent with some of early definitions of scenarios (e.g. Khan and Wiener,
88 1967; Godet, 2000a). It is not about predicting events or determining the most
89 likely scenario, but developing several plausible stories that describe how the
90 environment in which an entity (e.g. an individual or organisation) lives or
91 operates may develop, given certain future events, trends, and developments,
92 and then to explore possible 'discontinuities' and 'surprises' (i.e. wild cards)
93 (Hiemstra, 2006).

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

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

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

119

120 **Cognitive mapping futures process**

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

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

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

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

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

175 The scenarios developed from this workshop could be classified as normative
176 scenarios as the desired end point was first selected and then events which
177 could lead to the end point were identified (Börjeson et al., 2006). The process
178 was designed to consider engagement with busy industry practitioners with a
179 predominantly short-term, project-based approach to day-to-day operational
180 responsibilities. Therefore, the process needed to be simple, practical, and not
181 time consuming to understand and apply for a short (2-4 hours) workshop
182 session. Compared with fuzzy cognitive mapping (Kok, 2009; van Vliet et al.,
183 2010), the process is considered less demanding - as was observed during
184 the workshop, establishing the relationships between (long-term future)
185 constructs presented a significant challenge to the newly-formed groups of
186 participants, and assigning weights (i.e. strength) to the relationships (as in
187 the fuzzy cognitive mapping) would have proved too complex in the time
188 available. A more detailed description of the process, consideration and
189 review of other frameworks is included in Goodier et al. (2010).

190

191 **Decision Explorer (DE)**

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

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

210

211 **The maps and their characteristics**

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

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

- 223 • Observation of the constructs (events, issues, factors) indicates that they
224 tend to be a mere extrapolation of existing trends with predominantly
225 incremental changes toward the goals. There are few ‘wild cards’ events,
226 which may radically change the existing landscape within which the
227 industry operates, for example “the emergent of lightweight buildings” and
228 “architect remuneration based on whole life costing”. Participants felt
229 somewhat constrained by their own sphere of thinking, preventing them to
230 think ‘outside the box’.
- 231 • Some of the issues within the maps do have more interconnections than
232 others, providing an indication of the relative importance and influence of
233 that issue. This is because participants tend to talk more about what they
234 think are the important issues (di Gregorio, 2006). These interconnections
235 can be further manipulated and analysed using DE once the data has
236 been collated, using the software’s functions such as domain, central and
237 cluster analyses (as exemplified in Soetanto et al. 2011).

238

239 **Lessons learnt from the workshop**

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

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

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

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

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

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

287

288 **Software**

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

291

292 **Acknowledgements**

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294 *competitiveness in the UK construction sector: a fresh perspective*', or the '*Big*

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296 the Innovative Manufacturing Research Centres at the universities of
297 Loughborough, Reading and Salford. The workshop was a joint initiative
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299 involved in the project and workshop.

300

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- 352

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

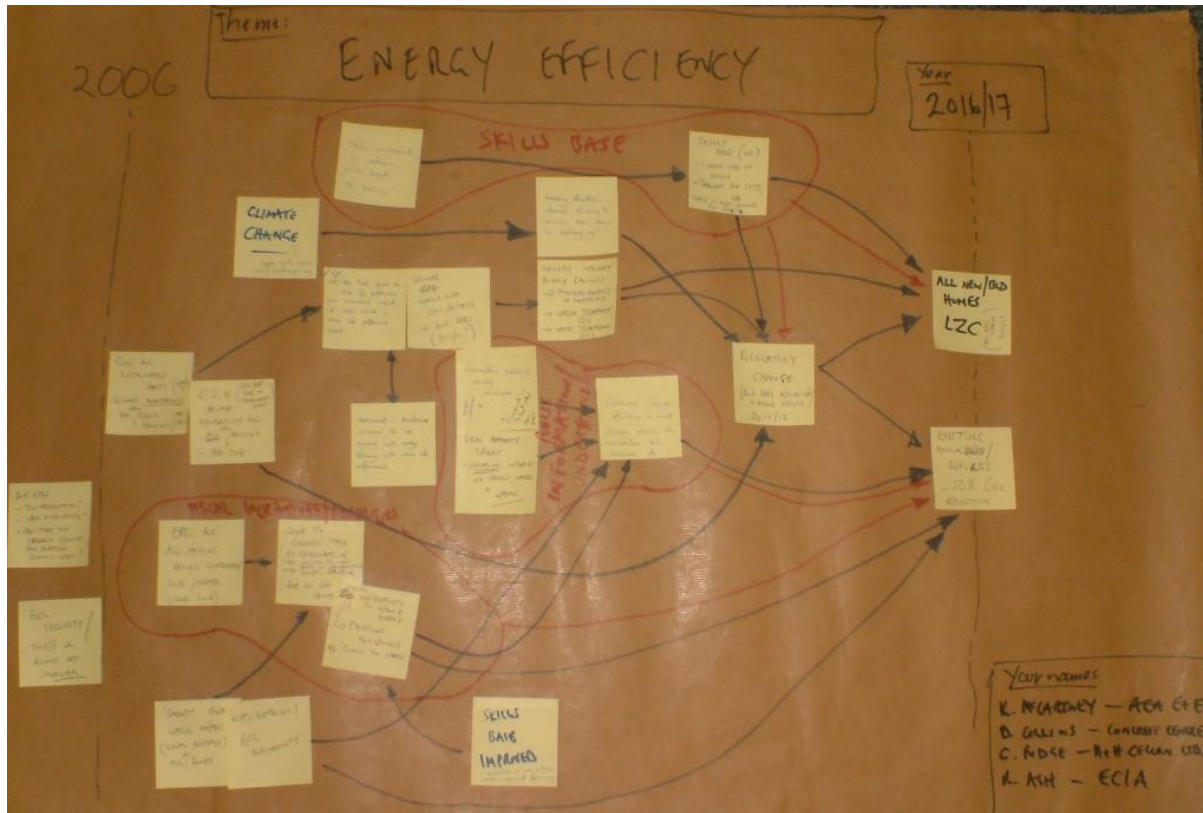


Figure 1: A cognitive map for Scenario 6: “increased energy efficiency of buildings and built environment”

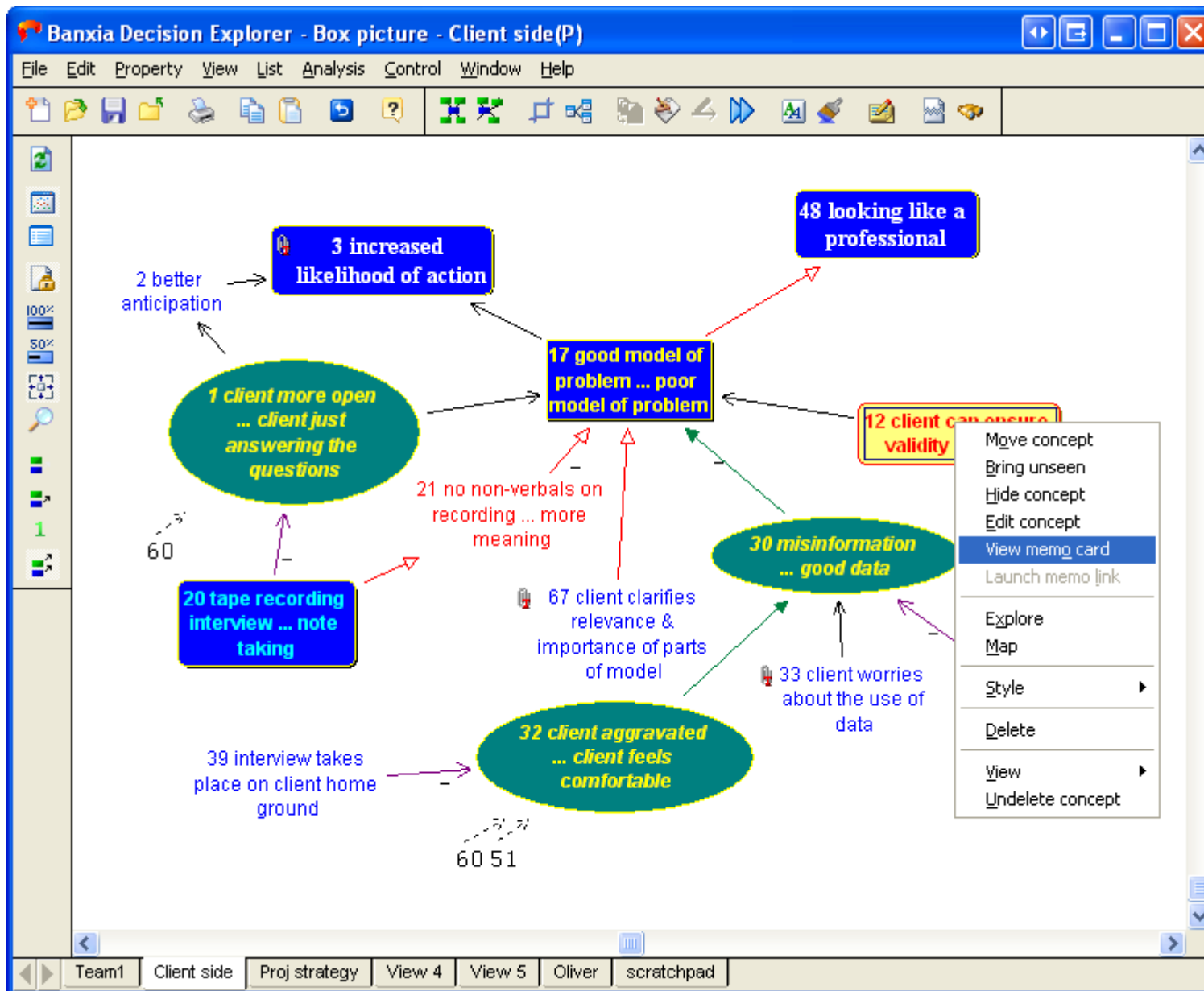


Figure 2: Constructing the cognitive map using Decision Explorer (taken from www.banxia.com)

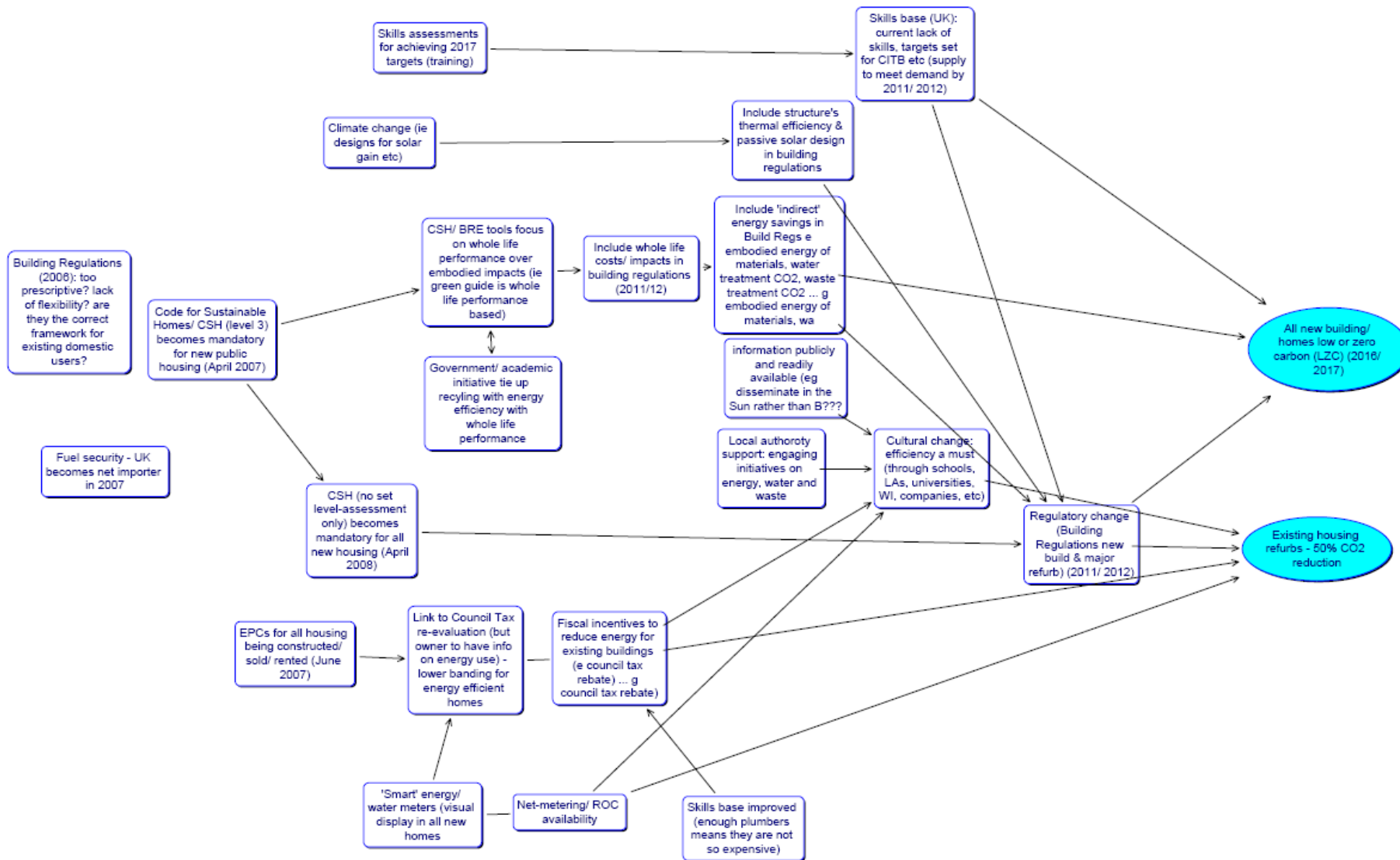


Figure 3: An example of a cognitive map in Decision Explorer (Scenario 6: “Increased energy efficiency of buildings and built environment”)

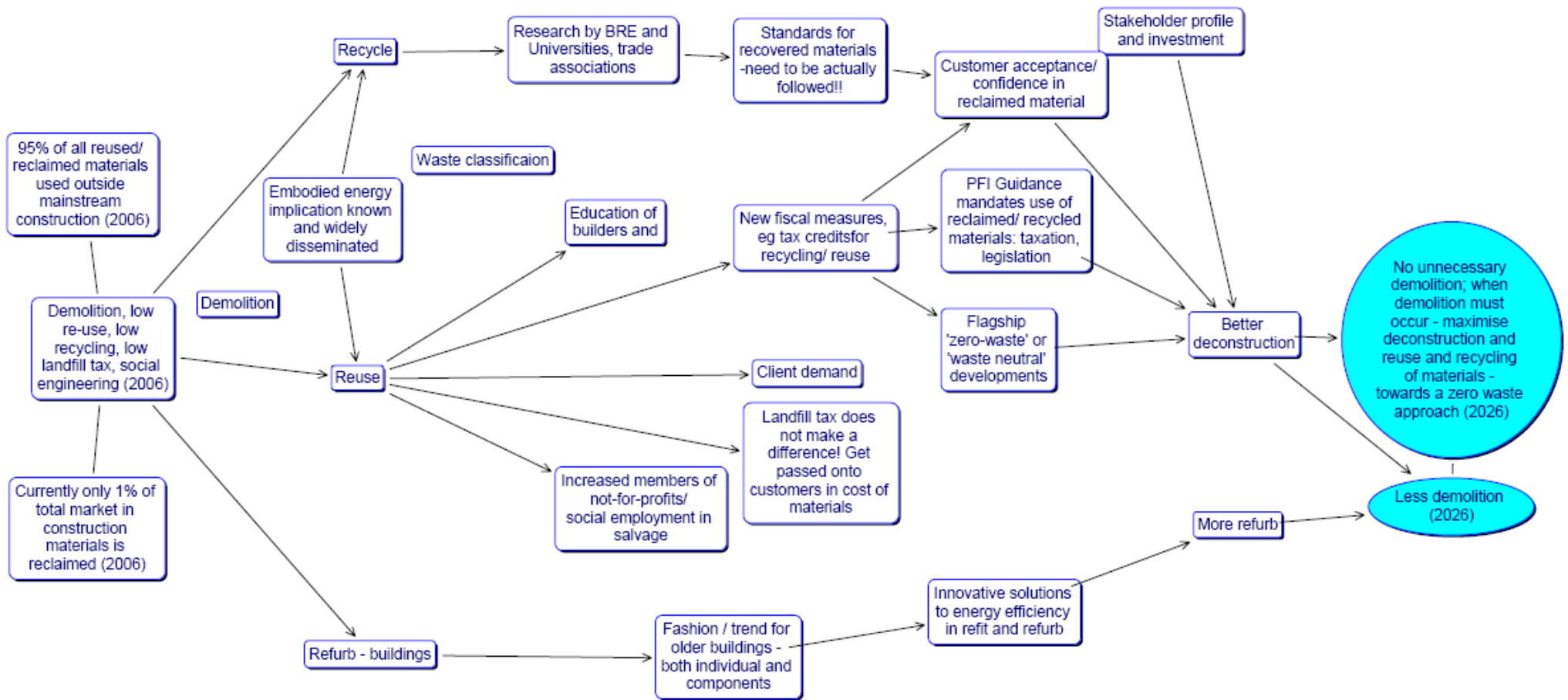


Figure 4: Scenario 1: “Increased demolition of buildings to meet energy efficiency standards”

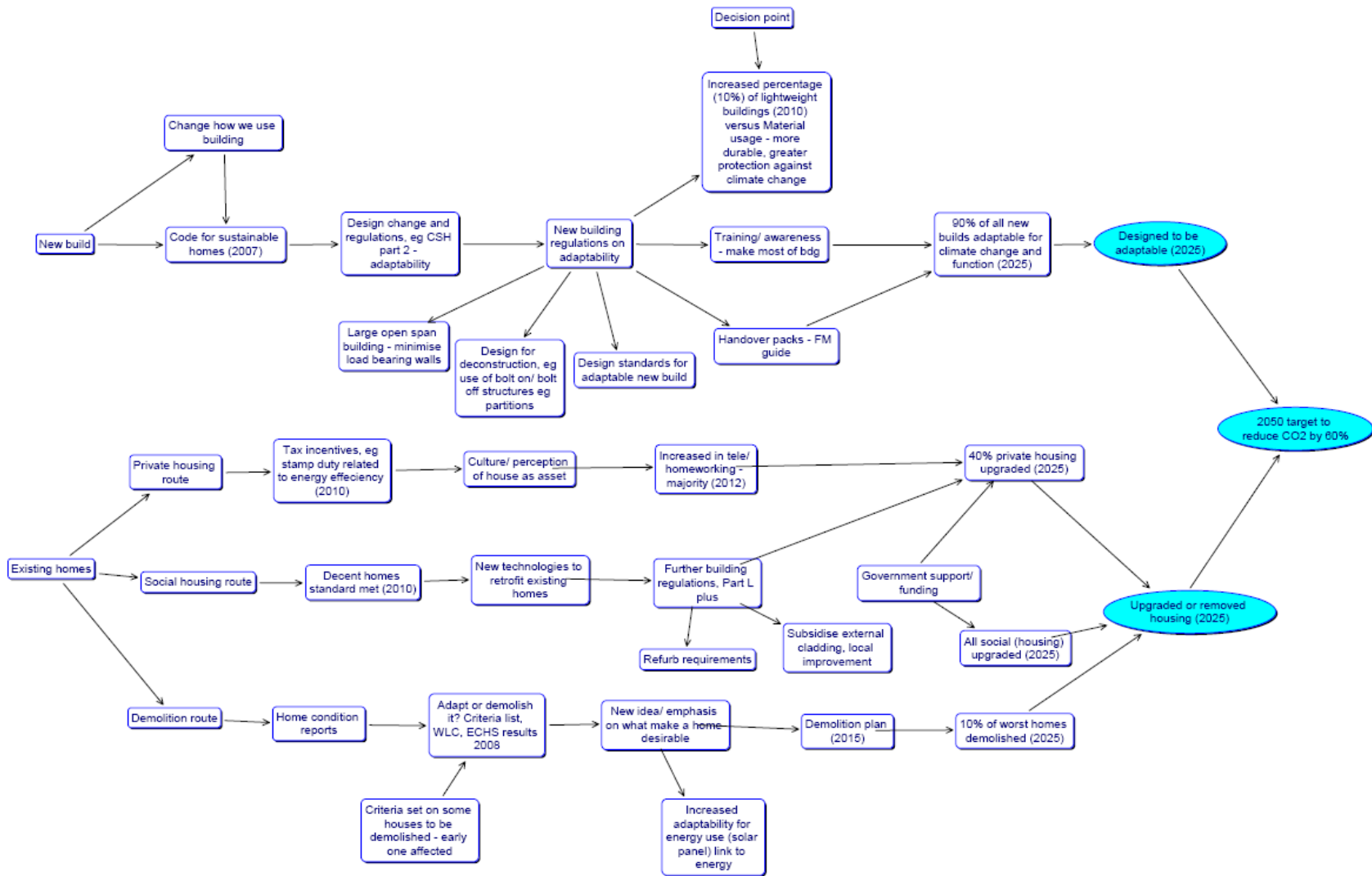


Figure 5: Scenario 2: “Increased adaptable and flexible buildings”

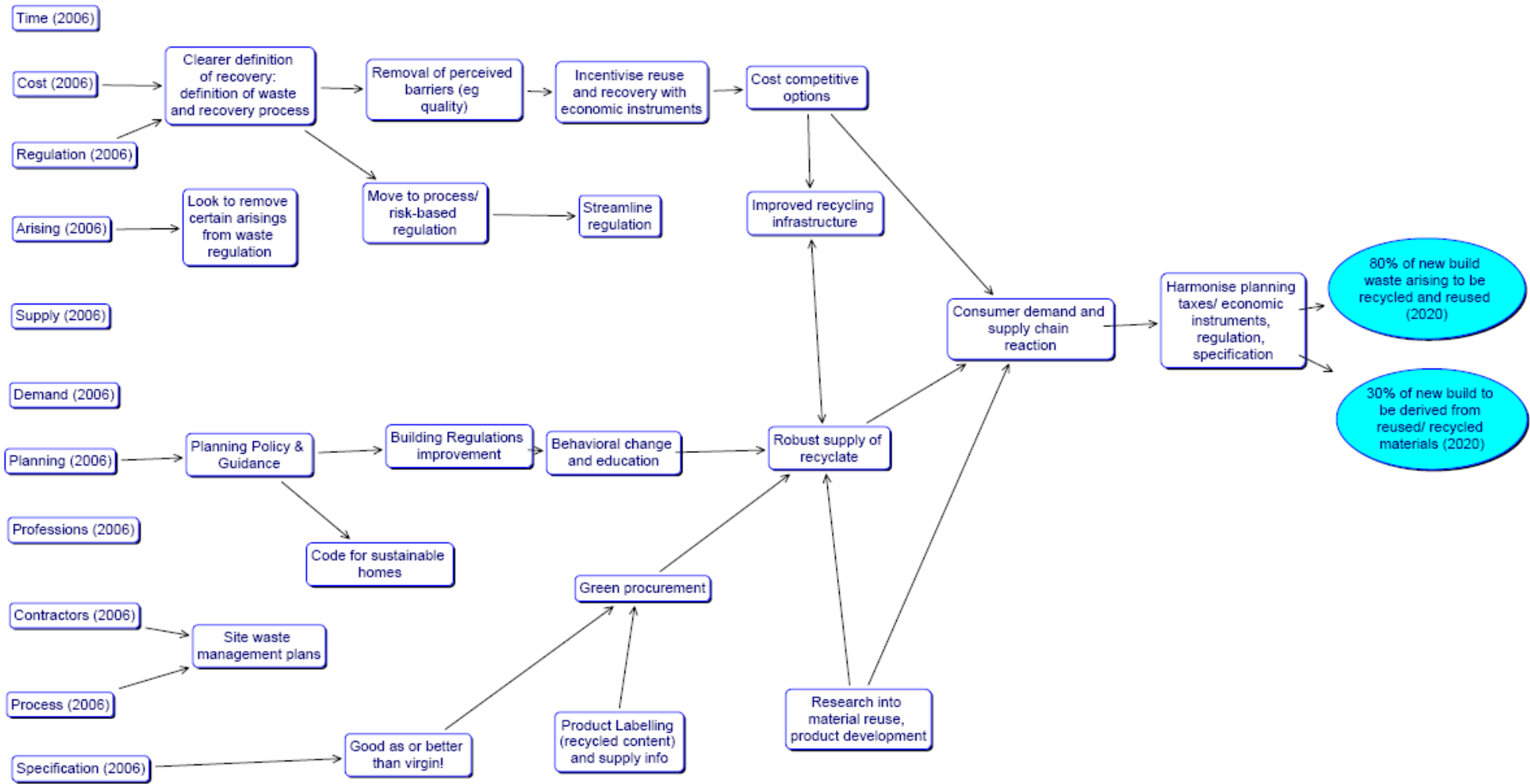


Figure 6: Scenario 3: “Increased emphasis on recycling and reuse on new build”

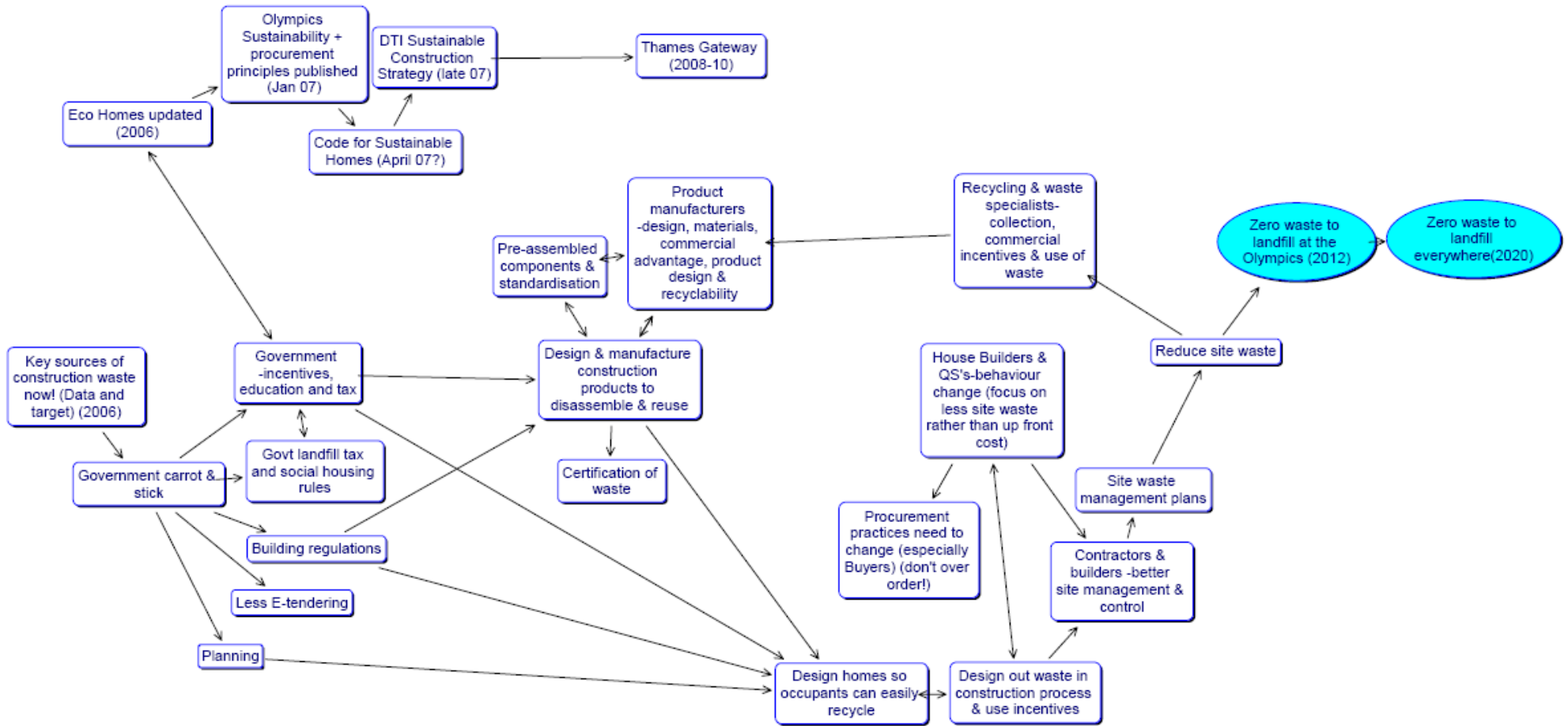


Figure 7: Scenario 4: “Increased emphasis on reducing material waste on new build houses”

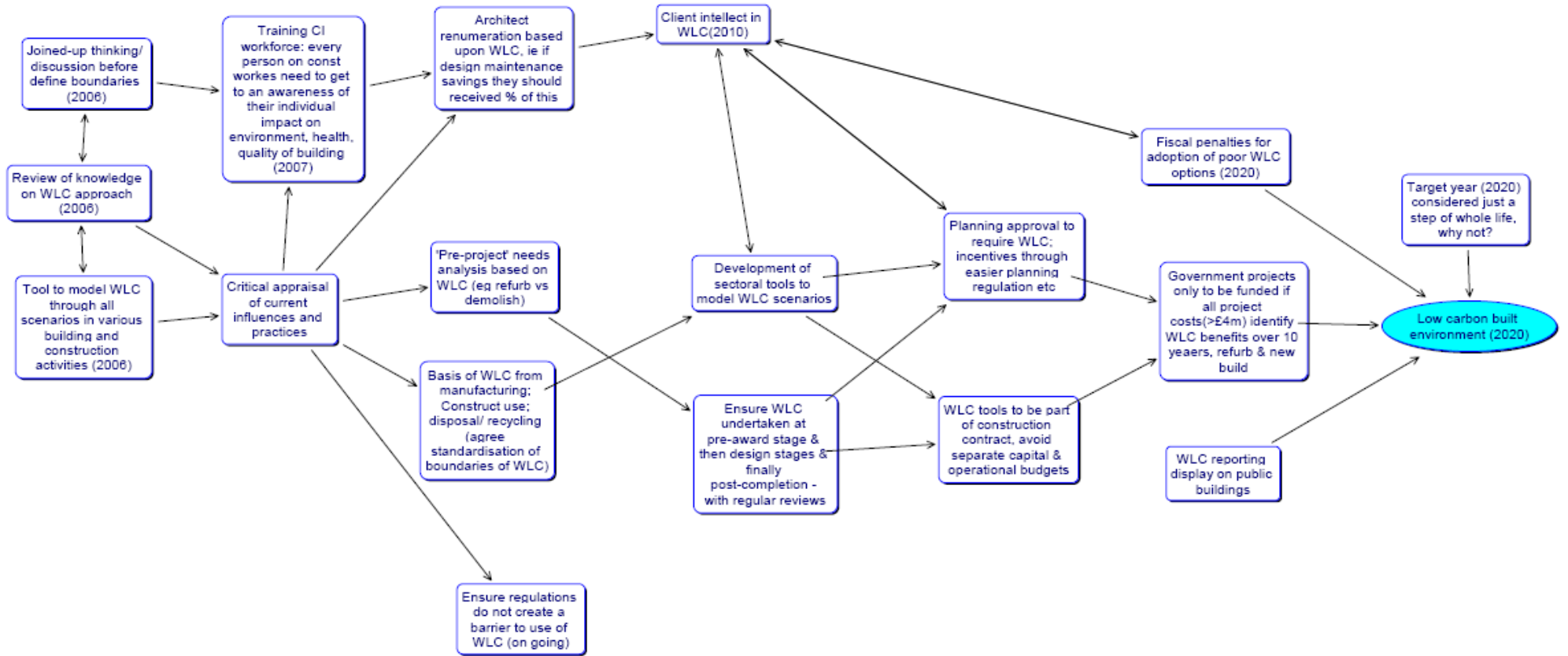


Figure 8: Scenario 5: “Increased consideration of whole life costs in the development of built environment”