Employing back casting principles for the formation of long term built asset management strategies - A theoretical approach

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ABSTRACT

Purpose: Facilities managers have traditionally relied on forecasting approaches using the stock condition survey to predict maintenance and refurbishment needs against changing user requirements. However, the authors have previously shown that such an approach, whilst effective for short term planning, is unable to cope with the uncertainty and complex data sets required to develop long term plans (> 10 years), in particular the impact of future climate change (physical and legislative). This paper will present back casting as an alternative approach to support long term built asset management planning.

Background: Back casting has been applied to sustainable transport management, energy planning and community climate change adaptation projects. The process in principle envisions a future state (end-point) set by stakeholders. Alternative 'paths of approach' are identified by looking backwards from the future state to the present. Each path is examined in turn to identify interventions (physical and/or operational) required in order for that path to achieve the end-goal. The stakeholder's review each path and select the most appropriate for achieving the desired (end-point). This path is then integrated into the facilities (built asset) management strategy.

Approach: The researchers worked with various stakeholders as part of an action research team to identify climate change adaptations that may be required to ensure the continued performance of the building and integrate these into a 60 year facilities management plan.

Results: The paper superimposes back casting theory onto the adaptation process and explains how the theory supported long term facilities management planning. The paper also explains how the approach was used to provide confidence for the building owner to invest in the planned refurbishment of their built asset to improve its future performance and sustainability.

Practical implications: The paper demonstrates the application of this approach through a case study example of a newly constructed £75 m educational building. A similar approach could be applied to other building types.

Research limitations: This paper presents a theoretical model which needs to be validated using longitudinal data sets.

Originality/value: This is the first paper to suggest the potential of back casting to inform long term built asset management strategies.

Keywords

Climate change, back casting, facilities management, built asset management,

1 INTRODUCTION

This paper presents an alternative theoretical approach to facilities and built asset management in which back casting is used to identify potential adaptations that may be required to improve a building's resilience to future climate change, specifically increased flooding and overheating. The focus of the project was a new £75m educational building which, at the time of this research project, was at the detailed design stage (RIBA Stage D). The building will occupy a 0.65 hectar brown field site located within a world heritage site. The building will be bounded by transport infrastructure on two sides and residential/commercial building on two sides. The building will have an internal area of 15,267m². The building will house Academic Departments, a University Library and provide a series of shop fronts onto the main street. The building has been designed to achieve BREEAM excellence. The aim of the research project was to examine the potential impact that future climate change could have on the performance of this building in-use and develop a 60 year adaptation strategy to address any potential negative impacts. An action research approach was used in this project.

The impacts that climate change could have on built assets is well documented (Sanders and Phillipson, 2000; Camilleri .et.al, 2001; Liso .et.al, 2003; Levermoore et.al, 2004); as is the suitability of alternative adaptation strategies to address these impacts (Gavin et.al, 2005; Hacker et al, 2005; DCLG, 2010; Tillsona et al 2013). What is less clear from literature is how adaptation strategies can be integrated into long term built asset planning (Desai and Jones, 2010). Desai and Jones (2010) argued that the uncertainty associated with climate change; the long term nature of future climate projections; and the short term operational demands placed on buildings make it difficult for facilities managers to prioritise climate change adaptations over other interventions that have a more immediate benefit. However, failure to address climate change in a timely fashion could render many buildings prematurely obsolete. Desai and Jones further argue that current forecasting tools used by facilities managers to set built asset management plans could exacerbate the problem by restricting the scope of possible long term 'futures' to an extrapolation of current experiences and performance trajectories. Such an approach will limit the inclusion of step change scenarios that may be required to address the impacts that future climate change could have on many buildings.

This paper presents an alternative approach to developing long term 'futures' based on back casting. The paper reviews the theory of back casting against the backdrop of a new £75m educational building. The paper outlines the action research approach that was used to develop a 60 years climate change adaptation strategy for the building and presents a theoretical model by which the learning from the action research project could be applied more generally as a part of the strategic built asset management process. The paper concludes that back casting could provide the theoretical base to support the step change in thinking about built asset management performance that is required to address future climate change. The paper also identifies the need for new life cycle analysis tools to support a back casting approach.

2 STATE OF THE ART

Future studies have been used for policy planning; in depicting economic and market trends; and for setting organisational strategies. In this context Chatterjee and Gordon (2006) identified a 'futures' spectrum and described a range of approaches to deal with uncertainty and ambiguity at one end of the spectrum (e.g. behavioural simulations, scenario planning and modelling etc.) and certainty at the other end of the spectrum (e.g. forecasting, exploration etc.). Banister and Stead (2004) and Miola (2008) also examined the role that scenario planning played in future studies and mapped the different types of scenario to different types of futures (Table 1).

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Table 1: Future studies and respective scenarios

Future Studies	Questions	Scenario
Probable	What is likely to happen	Precautionary /Predictive scenarios
Possible	What might happen	Explorative/ Projective scenario
Preferable	What we would prefer to happen	Visionary/Normative Prospective scenario

'Probable' and 'Possible' future studies are described as forecasting approaches which use predictive and exploratory scenarios based on quantitative data generated from surveys, past and current trend monitoring and explanatory modelling to develop views of the future. 'Preferable' future studies are described as back casting approaches which use visionary and prospective scenarios based on a mix of quantitative and qualitative data generated through workshops, focus groups and Delphi techniques to develop views of the future. In all cases the future views provide the criteria against which success or failure of alternative solutions can be evaluated.

The term back cast is widely attributed to Robinson (1982, 1990) who defined it as a normative method in which a desired long-term end-point is set and then used as the reference point to 'look back' to the current day position to identify the various stages at which actions are required to achieve a successful journey from the current day position to the preferred future position. In a review of back casting Dreborg (1996) concluded that the approach was most applicable to situations where:

- the problem being addressed is complex and a change in the existing trend is required;
- time frames are long and deliberate choice (interventions) need to be made;
- dominant trends are part of problem; and
- the problem scope is wide and externalities are crucial.

The author's contend that these criteria map well to the problems associated with integrating climate change into future facilities and built asset management decision making models where:

- climate change scenarios are complex and riven with uncertainty;
- facilities and built asset management time scales are long, typically 30-60 years;
- short-term thinking tends to dominate over long-term objectives;
- where potential solutions involve multiple stakeholders and external agencies.

Indeed, these issues are not dissimilar to those addressed in back casting studies that examined energy (Robinson et al, 2011) and sustainability (Miola, 2008) futures. Of particular relevance to this project is Robinson's work (ibid) in which a modified version of back casting, participatory back casting, was used to gain input from a broad range of stakeholders to collectively develop future scenarios. In the current project action research was used to engage a wide range of stakeholders in the development of the future scenarios. Although not designed as part of the original action research model, the process of developing the future scenarios mirrored very closely the 5 stage model suggested by Quist et. al (2006). This is discussed in more detail later in the paper.

Stage 1: Strategic problem orientation;
Stage 2: Specification of external variables;
Stage 3: Construction of future visions or scenarios;
Stage 4: Back casting: backwards-looking analyses;
Stage 5: Elaboration and defining follow-up and an action agenda;

Finally, whilst most research studies have treated back casting and forecasting as separate, distinct approaches, Hojer and Mattsson (2000) suggest that they can be combined in situations where forecasting alone suggests the future end-point is unlikely to be reached. In this case back casting provides the futures vision whilst forecasting can be used to quantify the ability of interventions to bring about the desired future. Such an approach emerged as the most suitable model for integrating climate change adaptation into built asset management in the current research project.

3 THEORETICAL APPROACH AND RESEARCH METHODOLOGY

3.1 Theoretical approach

The subject of the research project was a £75m new educational building. As part of the initial design the client requested their Facilities Management department to work with the design team to undertake a review of the potential impact that climate change could have on the building and develop a long term facilities and built asset management strategy to ensure that the building continued to perform at an acceptable level over a 60 year period. Researchers from the University of Greenwich were part of the project team.

3.2 Action Research Process

The action research project commenced in October 2010 and was completed in June 2011. The action research team comprised representatives from the Architects; Building Services Engineers; Structural Engineers; Quantity Surveyors; the Client (represented by the Facilities

Management Department); and members of the Sustainable Built Environment Research Group at the University of Greenwich. In addition, specialist input to the project was provided by a climate change expert who developed the climate impact models. The action research team met formally on 4 occasions. Each of these meetings was in the form of a 1 day workshop. Between workshops members of the team worked in small groups to develop, test and refine their inputs. The first meeting established the focus for the project; developed a set of questions for the partners to investigate; agreed procedures for data gathering/analysis; and outlined a set of deliverables for the second meeting, which was mainly concerned with an assessment of the antecedent climate threats and the identification of future climate change risks.

At the second meeting the action research team received a climate change risk report that identified current and expected risks aligned to the predicted first and second refit of the building (2020 and 2040) and design life (2080). The risk reports were generated using the UKCP09 (median prediction emissions scenarios) to produce likely weather scenarios and associated building impacts on: Internal Comfort & Building Façade; External Comfort; Structural Stability; Infrastructure; Water Supply; Drainage & Flooding; Landscaping; and the Construction Process. Although a wide range of extreme weather events were examined, due to limitations in national data sets the final analysis was limited to issues of thermal performance, where 3.8-4.8^{o}C rise in annual mean temperature above the control period was predicted by 2080 and pluvial flooding, where an increased risk was identified to the basement areas and attenuation tank capacity.

Once the weather data had been presented, the facilities management members of the action research team developed performance specifications, in terms of operational expectations of the building for 2020, 2040 and 2080, and the design members analysed how their design solutions would perform against each specification (Prospective scenarios in Table 1). In particular 4 questions were considered: 1) Would rooms overheat in the future? 2) What will be the impact on the annual energy loads? 3) Can the chiller specification cope with the increased load? 4) How will solar gain change in the future? These analyses were presented to the whole action research team at the third workshop. As this project was solely concerned with the impact of climate change no account was taken of other future scenarios (e.g. economic, political etc.).

The third Workshop examined the design implications of the questions outlined above. The performance specifications provided the 'operational targets' (end-points) from which costed adaptation solutions were 'back-cast' to ensure that the building would meet its targets over its life-cycle. This process identified twenty five adaptation measures which were tagged as ‘do now’, ‘2020’, ‘2040’ or ‘2080’. Each adaptation was evaluated against the following principles:

1. Measures that required structural alteration were recommended to be undertaken immediately irrespective of their actual required implementation date.
2. Measures that required changes to system or component capacity were only to be implemented when required but consequential structural and space planning issues were implemented as 1) above.
3. Each measure was considered in terms of its impact on the current design and modifications introduced to facilitate a future retrofit.

4. Those measures that were identified, but for which the UKCP09 weather data provided no firm direction, were assessed on their merits. This particularly applied to the risk of flooding where preparation was undertaken even though the likelihood of future events was uncertain.

At the final workshop each of the detailed adaptations were considered and either adopted or rejected by the client team. Of the 25 detailed adaptations developed through this process, seven were adopted immediately and included in the final detailed design. The remainder formed part of the future facilities and built asset management plan. The full list of adaptation measures can be seen in Table 2.

Table 2: Adaptation measures and implementation schedule

Risk	Adaptation/ Comment	Implementation			
		Now	2020	2040	2080
Overheating	Alter the current glazing system to allow for openable windows to be easily installed in future			•	•
	Install additional chillers on the roof		•	•	
	Future thermal design modifications should be based on an adaptive comfort model		•	•	•
Overheating and Energy Use	Introduce a ‘siesta’. Behavioural adaptations were seen as benefitial and could limit the predicted thermal issues. However it would impact on the usability of the building.		•	•	•
Reduced Heating Load	Replace boilers with an increased number of smaller sized units			•	
Insufficient comfortable external areas	Allow all building users to access the roof areas Introduce shading to external spaces Introduce external water features	•			
Increase in cooling load	Allow for an increase in plant and riser space	•			
Infrastructure failure (electric)	Add access control to the standby generator	•			
Infrastructure failure (gas)	Include for an electric back-up form of heating (GSHP)			•	
	Increase hot water storage			•	
Infrastructure failure (water)	Increase the cold water storage			•	
Infrastructure failure (drainage)	Increase size of Attenuation tank				•
Increase in storm activity	Increase capacity of rainwater pipes & drainage Increase roof capacity to store rainwater				•
	Permanent flood protection measures to basement areas	•			

	Include adaptable door frames for door dams Increase the height of the retaining walls				
Failure of drainage system	Connect drainage system to the BMS	•			
Increase in groundwater level	Provide adequate build-up above the tank to avoid flotation	•			
Increase in water costs	Introduce waterless urinals Add a rainwater recycling system			•	
Waste from refurbishments	Upgrade facade systems with recyclable materials	•			
Insufficient cycle storage spaces	Increase the cycle store capacity	•			

5. DISCUSSION AND PRACTICAL IMPLICATIONS

The approach that emerged from this project used back casting as a primary method for evaluating the future needs of the building and for assessing the possible adaption paths by which the performance of the building (against climate change) could be ensured over a 60 year time span. An action research approach, incorporating a series of brain storming workshops and group consultation was used to develop future climate impact scenarios against which a range of potential adaptations were assessed. From this study a generic 6 stage approach to the application of back casting to facilities and built asset management was developed.

The first task for the action research team was to establish the desired outcome (in terms of building performance criteria) that any adaptation solution would need to satisfy. This process involved establishing the future context within which the building would have to operate. To do this, existing corporate documents were examined and reviewed. These documents included the organisation's mission statement and long term strategic plans. Following a brainstorming session involving all the project stakeholders' a facilities management problem orientation statement was developed. The statement said that any adaptation strategy should seek to ensure that "the performance of the new built facility in terms of its future resilience to climate change, and ability to fulfil mitigation targets, should be achieved without compromising user comfort and future operational demands".

Once the future building expectations had been articulated, specific performance criteria were established against which specific adaptation options could be evaluated. In the case of this project the key criteria were future CO_2 reduction, energy efficiency improvements and resilience of the building to the impacts of flooding (identified as a consequence of increased storm intensity and the inability of the local drainage system to cope with the expected volume of water). Wherever possible quantitative performance targets were set (e.g. future overheating thresholds) against which adaptations to future climate change projections could be evaluated. Where this wasn't possible (e.g. behavioural responses to overheating) qualitative performance targets were set as a guide to future expectations.

Setting the expected 'end-point' or 'target' of future adaptations provided a focus for the development of alternative paths that could be taken to achieve the end-point. This process again involved a brainstorming exercise to establish a range of future paths (technical and operational) that could form the basis of alternative adaptation strategies. As a starting point the team established a business as usual scenario which gave a point of reference for visioning alternative future scenarios by reflecting on shared knowledge of the organisation. Five future scenarios were developed.

- Scenario1 (business as usual path) – For this base scenario the energy load due to heating and cooling was presumed to increase whilst the energy supply source remained the same (i.e. energy supplied using a mix of gas and electricity). The resulting CO_2 levels would be offset by buying carbon credits to ensure the organisation hit expected UK government targets for their sector. No additional adaptation measures for flooding resilience were considered with cost and disruption of any future flooding event being dealt with through existing disaster recovery and business continuity plans.

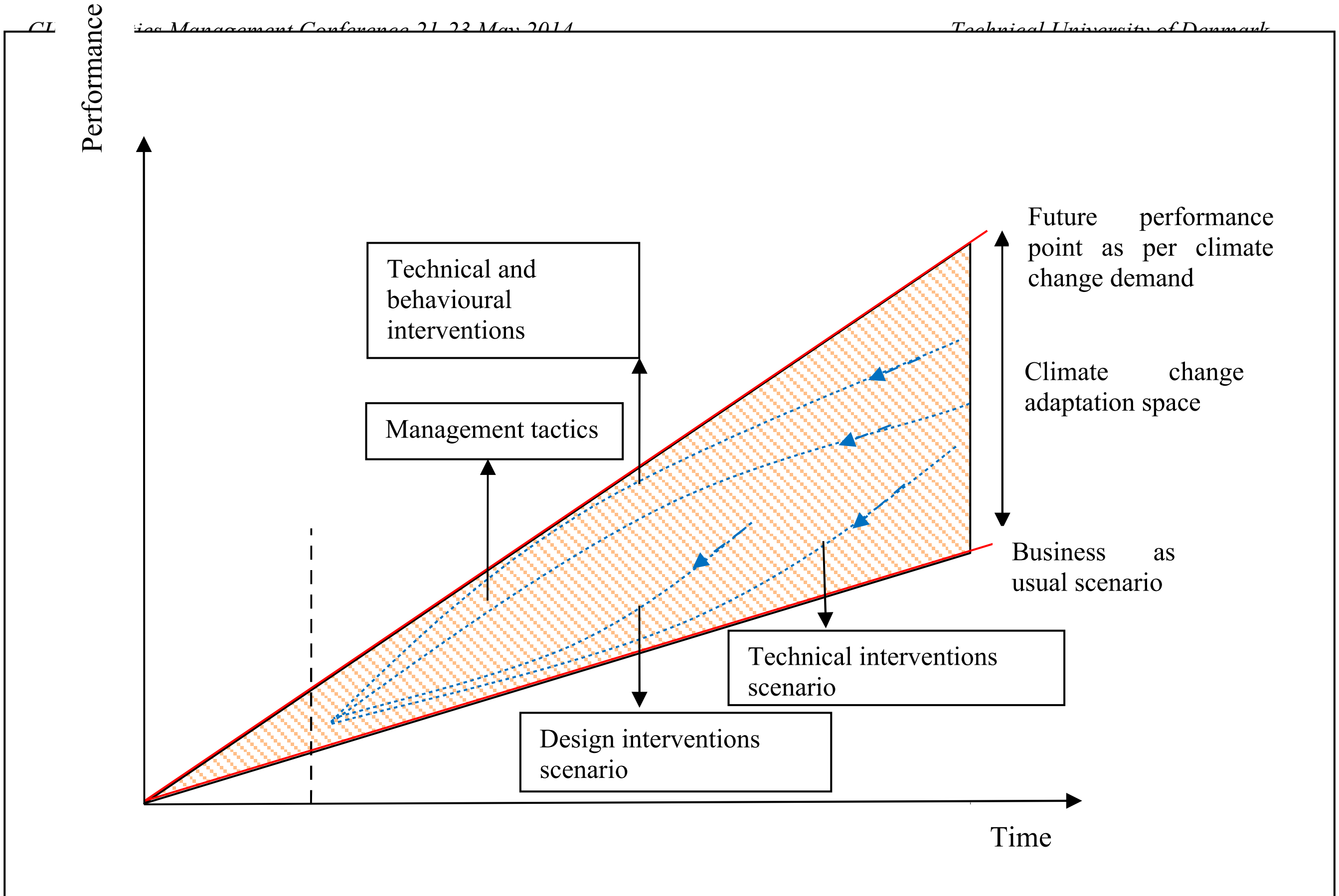
- Scenario 2 (management path) – Considering the UK Government drive for renewable energy, this scenario envisioned new procurement contracts for renewable energy supply. The scenario also envisaged new workplace strategies to encourage energy efficient behaviour (e.g. incentives and acknowledgements for energy efficient departments and employees). A new disaster recovery plan using a flood warning system to trigger a flood management strategy is also envisaged.

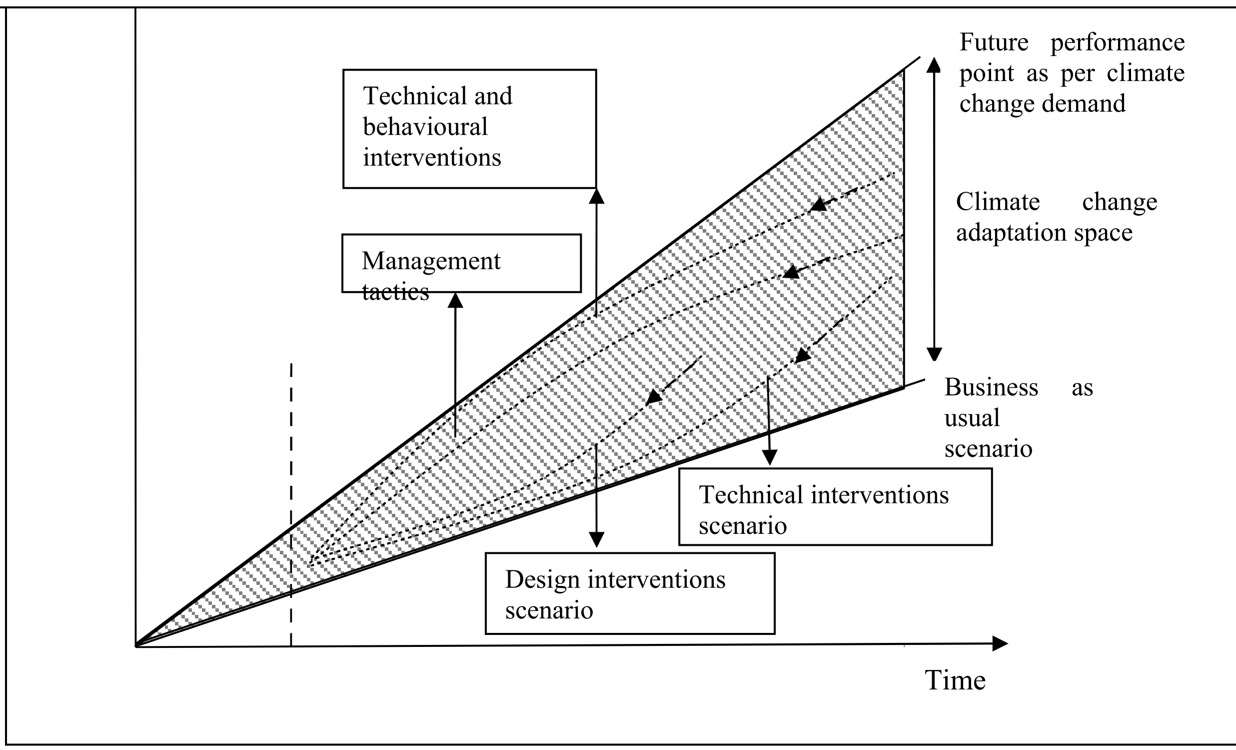
- Scenario 3 (design path) – This vision outlined use of landscaping and natural ventilation systems to reduce cooling loads in the event of an increase in overheating in the future. Building users would also be encouraged to make use of external spaces, particularly the roof gardens. The landscape would be designed using SUDS (sustainable urban drainage systems) principles and this would also make the site more resilient to flood events.

- Scenario 4 (technical path) – This scenario assumed a range of technical adaptations would be retrofitted to the building as and when they were needed. The difference between this approach and a tradition refurbishment model is that the building would be designed with specific retrofit upgrades in mind. This would include initial preparatory works being undertaken during the original construction phase to allow subsequent retrofit in the future. Measures for flood resistance such as flood gates are put in place; the electrical sockets are placed above flood level; and the basement would have resilient fixtures and fittings. No services would be placed at basement level and flood kits would be provided for after flood cleaning process.

- Scenario 5 (combined technical/management path) – This scenario outlined the use of a combination of technical (e.g. additional air condition units or portable fans during overheating events) and management (e.g. staff encouraged to adopt a casual dress code and make use of outdoor spaces during breaks) adaptations similar to those described above.

These scenarios are shown graphically in Figure 1. Whilst the scenarios were not developed with back casting in mind they do demonstrate back casting principles. The figure shows the expected performance of the building over time. The dashed line represents the ‘present time’ where the





In order to work out the operational and financial feasibility of the scenarios a building simulation modelling exercise was undertaken. Each scenario was considered against 8 principle design criteria: Internal Comfort & Building Façade; External Comfort; Structural Stability; Infrastructure; Water Supply; Drainage & Flooding; Landscaping; and the Construction Process

Each scenario was considered against 2020, 2040 and 2080 time frame. The feasibility studies identified 42 possible adaptations, the majority of which were technical in nature. The fact that technical adaptations dominated discussions was not surprising as the majority of the action research team were engineers and architects who were familiar with undertaking technical assessments. Indeed, the lack of an approach for considering management strategies for climate change adaptation was one of the key findings to emerge from this part of the study.

In Phase 5 of the process the facilities management team reviewed the adaptation options to identify when in the building time line each would need to be enacted. The review process included an assessment of the cost and benefits that each adaptation would have on the building's performance. The adaptations generally fell into three categories; immediate implementation of the adaptation solution as part of the original build; implementation of preparatory work as part of the immediate build to allow for a planned future upgrade; or future operational changes to the building. An example of an immediate implementation was the inclusion of a backup generator to run essential services in the event of a flood. Although the building was not currently at risk of flooding, the future flood risk assessment had identified a potential risk to the critical power infrastructure that supplies the building. This risk, whilst unquantifiable during the project, was nevertheless considered serious enough for the facilities management team to advise the client of the need to build in a contingency against this possibility as part of the initial design solution. An example of preparatory work was to increase the plant and riser space within the building to accommodate future increase in chiller capacity for cooling (circa 2020) and support a change to a modular based boiler installation to allow for a reduction in installed heating capacity as demand reduces from 2040 onwards. Examples of operational changes were adopting a relaxed dress code (staff) and not programming classes for the middle of the day to encourage behavioural adaptations to the thermal environment within the building. The changes were expected from 2020 onwards.

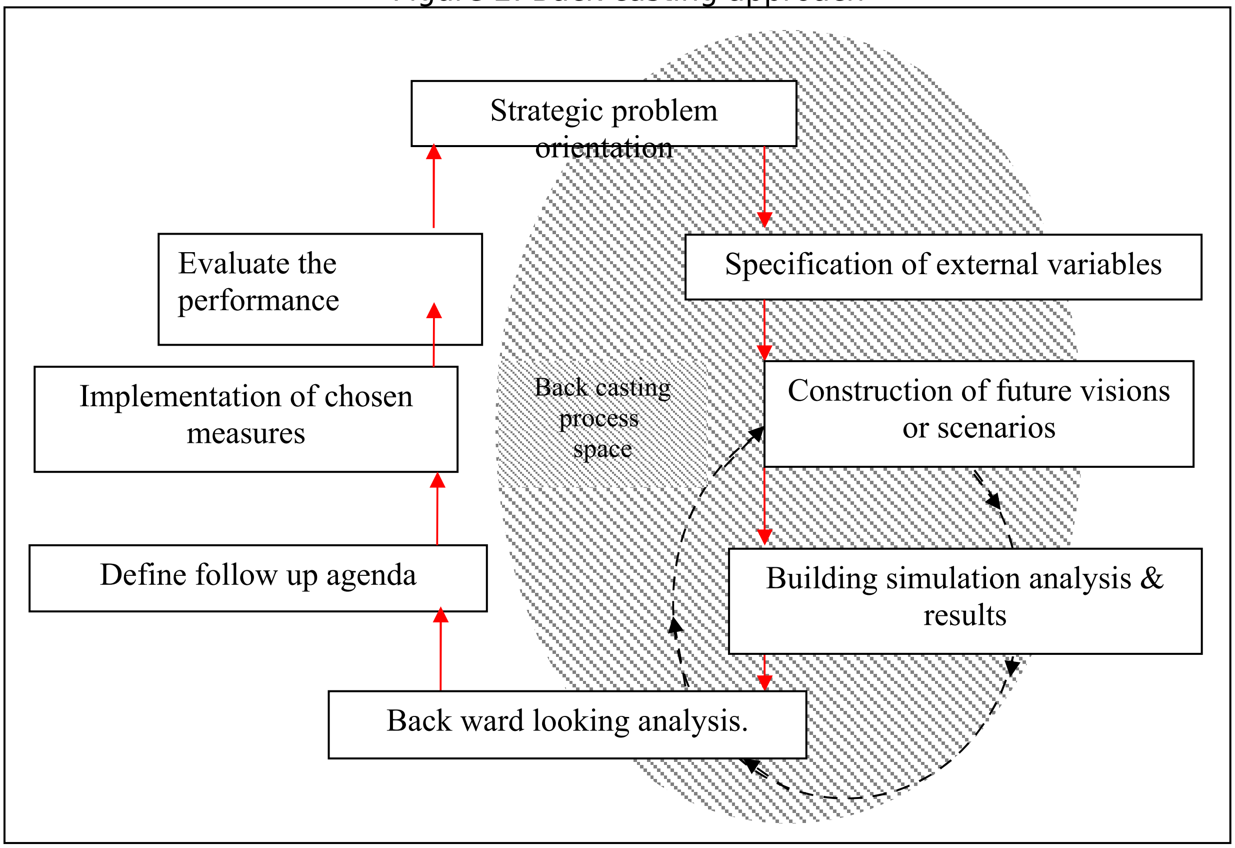
The final stage involved implementing the various adaptations. Those adaptations identified for immediate application, or where preparatory work was required at the design stage to support their later application, were included as changes to the original building design. These changes were estimated to cost the client an additional 0.4% of total project cost. Those adaptations that were required in the future were programmed into the building's long term built asset management plan. The cost of these changes is estimated at 2.2% of total project cost.

An explanatory model outlining the general approach of back casting application to facilities and built asset management is shown in Figure 2.

CONCLUSIONS

This paper outlined a back casting approach which was derived from developing building adaptation plans that address future climate change. The back casting approach emerged from an action research project of a £75m new educational building. Whilst back casting wasn't explicitly addressed in the action research project, subsequent analyses mapped the processes used in the action research project to back casting theory. This analysis confirmed the applicability of the back casting as an alternative to forecasting to develop future visions against which facilities and built asset management adaptations could be evaluated. This said, the adaptation solutions developed through the project tended to be biased towards technical retrofit solutions, which most likely reflected the balance of the action research team and the lack of an accepted approach for quantifying the cost benefit of management strategies for climate change adaptation. This latter point will need to be addressed if the back casting approach to built asset climate change is to be more widely adopted. The authors recommend the development of such tools as part of facilities and built asset management life cycle analysis.

Figure 2: Back casting approach



REFERENCES

Banister, D, and Stead, D. (2004), "The Impact of ICT on Transport", Transport Reviews, vol. 24, issue 5, pg. 611-632.

Camilleri, M., Jaques, R. and Issacs, N. (2001), "Impacts of climate change on building performance in New Zealand", Building Research Information, vol. 29, issue 6, pg. 440–450.

Chatterjee, K., and Gordon, A. (2006), "Planning for an unpredictable future: Transport in Great Britain in 2030". Transport Policy, vol 13, pg. 254-264.

DCLG (2010), "Guidance and standards for drying flood damaged buildings - Signposting current guidance – BD2760", Department of communities and local government (DCLG), UK.

Desai, A. and Jones, K. (2010), "Examination of existing facilities management approaches to climate change and future directions". Proceedings of the São Paulo 2010 CIB W070 International Conference. CIB Proceedings, Department of Construction Engineering, Escola Politécnica, University of São Paulo, São Paul, Brazil, pg. 585-596.

Dreborg, K. H. (1996), "Essence of Back casting", "Futures", vol.28, issue 9, pg.813-828.

Garvin, S., Reid, J. and Scott, M. (2005), "Standards for the repair of buildings following flooding", Construction industry research and information association (CIRIA), UK.

Hacker, J., Belcher, S. & Connell, R. (2005), "Beating the Heat: keeping UK buildings cool in a warming climate". UKCIP Briefing Report. UK Climate Impact Program, Oxford, UK.

Hojer, M. and Mattsson, L. (2000), "Historical determinism and back casting in future studies", Futures, vol 32, issue 7,pg. 613 -634.

Levermore, G., Chow, D., Jones, P. and Lister, D. (2004), "Accuracy of modelled extremes of temperature and climate change and its implications for the built environment in the UK", Technical Report 14, Tyndall Centre for Climate Change Research, UK.

Liso, K., Aandahl, G., Eriksen, S. and Alfesen, K. (2003), "Preparing for climate change in Norway's built environment", Building Research and Information, vol. 31, issue 3–4, pg. 200–209.

Miola,A. (2008), "Back casting approach for sustainable mobility", Joint Research Centre – Institute for Environment and Sustainability, ISBN 978-92-79-09189-6.

Robinson, J., (1982), "Energy back casting – A proposed method of policy analysis". *Energy policy*, vol 12, pg. 337-344.

Robinson, J., (1990), "Futures under glass: a recipe for people who hate to predict", Futures, vol 22, issue 8, pp.820-842.

Robinson, J., Burch, S., Talwar, S., O'shea, M. and Walsh, M. (2011), 'Envisioning sustainability: Recent progress in the use of participatory back casting approaches for sustainability research', Technological Forecasting & Social Change, vol 78, issue 5, pg. 756-768.

Sanders, C., H. and Phillipson, M., C. (2003), "UK adaptation strategy and technical measures: the impacts of climate change on buildings", Building Research & Information, vol 31, issue 3-4, pg. 200-221.

Tillsona, A., Oreszczyna, T. and Palmerbet, J. (2013), "Assessing impacts of summertime overheating – some adaptation strategies", Building Research & Information, vol 41, Issue 6, pg.652-661.

Quist, J. and Vergragt, P. (2006), " Past and future of backcasting: the shift to stakeholder participation and proposal for a methodological framework". Futures, vol 38, issue 9, pg. 1027-1045.