

Multi Objective Decision Making: a guidebook approach
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Abstract

The paper describes one recently-completed and one ongoing research project. The first project, the Reference Sustainability System, is a network model that investigated new technological and resource management strategies to enhance urban sustainability. Based on data for the domestic sector in London, it developed modules relating to energy, paper and waste paper, piped water and bottled water. This research demonstrated the potential value of going beyond modelling, to the development of decision supporting tools/frameworks that take into account user needs and stakeholder perspectives. The second part of the paper describes the current project, which develops a 'guidebook' approach to multi objective decision making by water authorities. The guidebook will offer a framework that aids the incorporation of sustainability assessment in decision making. It will provide guides to the selection and use of a range of environmental, social, technical and economic criteria, as well as to the tools and assessment methodologies that can assemble or generate appropriate data. Then, through two case studies, the use of the guidebook to aid decision making will be demonstrated.



**Multi Objective Decision Making:
a guidebook approach**

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The Structure of the Paper

- The paper describes one recently-completed and one ongoing collaborative research project.
- The first project – the Reference Sustainability System – is a network model that investigates new technology & resource management strategies to enhance urban sustainability.
- The second project relates to the development of a ‘guidebook’ approach to water authority decision-making.
- Both projects have received support from the UK Engineering & Physical Sciences Research Council



Background: The Reference Sustainability System

- A network model constructed by Imperial College with the London Research Centre
- The model investigated technology & resource management strategies to enhance urban sustainability
- Four related modules:
 - energy; piped water; bottled water; paper & waste paper
- Allowing for:
 - waste management, recycling & re-use
 - emissions of air, water & solid wastes
- Addressed domestic/household sector in London
- Conventional & novel technologies and varying efficiencies



The Modules

- The modules were used to assess the system-wide impacts of new technologies or resource management strategies applied at different stages in the life-cycle:
- the energy module assesses supply-side technologies and end-use efficiency measures
- the piped water module assesses demand management measures; and
- the bottled water and paper modules focus on options at the waste management stage.

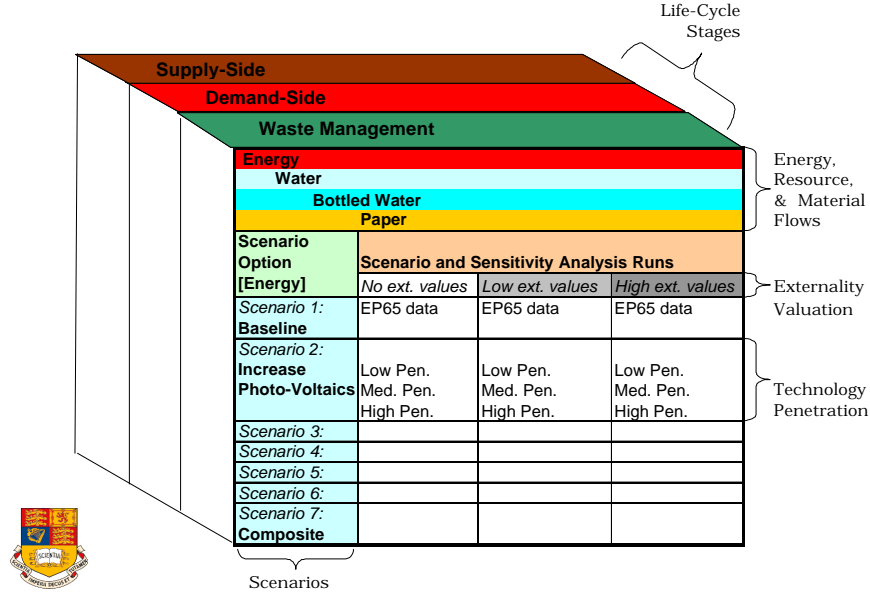


Scenario Outline (Figure 1)

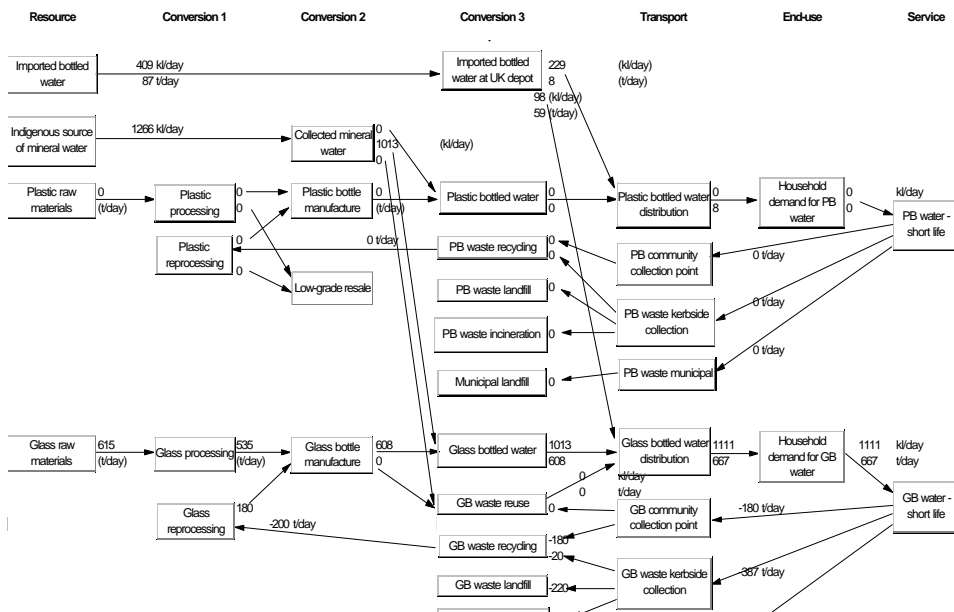
- Scenarios were created for the introduction of new technologies and resource management practices at different life-cycle stages
- Baseline and alternative scenarios were compared, at a point in time and/or over time
- Sensitivities to different rates of penetration of new technologies and resource management practices were explored
- As were sensitivities to different estimates of environmental externality valuation



Figure 1: The Reference Sustainability System: Scenario Outline



Reference Sustainability System: The bottled mineral water module



RSS contribution

- Extended RES & enhanced LCA approach by applying it in a dynamic system flow context - to London
- Applied sustainability criteria and showed:
 - Conceptual & practical complexities of indicators & valuation
 - how assessment depends on decision-maker & stakeholder perspectives

Next stages?

- Build on RSS-type models to develop useful decision-supporting tools/frameworks?
- What do users need to help sustainability assessment?
- Led to collaborative project, with decision support tools a key focus



Decision-support Project

- The development of a decision-support tool to assess the relative sustainability of water/wastewater systems
- Supported by the UK Engineering and Physical Sciences Research Council *WITE* Programme:
 - Imperial College, University of Abertay, Dundee, Heriot-Watt University
 - North, East, West of Scotland Water Authorities, Severn-Trent Water



Ways forward for sustainability

- Formulating environmental, social and economic criteria: stakeholder input
- Analysis of options: systems modelling tools and social impact assessment
- Assessment of relative sustainability: multi-criteria analysis
- Decision-support system/guide

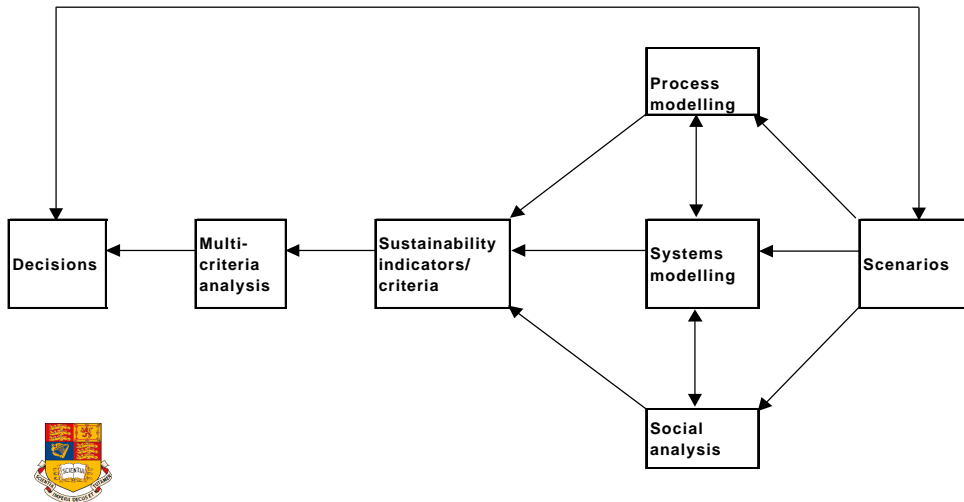


Project process

- Learn about how water utilities currently make decisions
- Focus groups with water authority/company managers
- Decision mapping exercises:
 - map information flows and criteria used
 - identify decision nodes
- Specification of criteria
- Development of the Guidebook



Framework for decision-support



Guidebook: framework for incorporating sustainability assessment into decision making

- Guide to criteria
- Guide to tools and assessment methodologies
- Guide to appropriate data
- Demonstration projects



Selection of criteria

- Formulation of generic criteria: environmental, social, economic, technical
 - developed in collaboration with water industry & stakeholders
- End-user may select appropriate criteria for evaluation of decision options



Economic and environmental criteria

- **Economic**
 - Life-cycle costs
 - Willingness to pay/price responsiveness
 - Affordability
 - Financial risk exposure
- **Environmental**
 - Resource utilisation
 - Service provision
 - Environmental impact



Social and technical criteria

- Social
 - Acceptability to stakeholders
 - Participation and responsibility
 - Public awareness and understanding
 - Social inclusion
- Technical
 - Performance of the system
 - Reliability
 - Durability
 - Flexibility and adaptability



Components of economic life-cycle costs

- **Life Cycle Costs -stages**
 - Resource extraction
 - Production
 - End-use
 - End of life/ Decommissioning (inc. 'Green costs')
 - o **Cost components:**
 - Capital
 - Operation (O)
 - Maintenance (M)
 - **Cost categories**
 - Marginal; Average; Total



Components of willingness-to-pay/ price responsiveness

- **Attributes**
 - Product
 - Environmental
 - Safety
 - Health
 - Other



Tools for analysis of options by Guidebook users

- Systems modelling tools for economic and environmental impact
- Social impact assessment: stakeholder workshops, etc.
- Technical assessment (generation of data for technical criteria)



Assessment of sustainability

- Scoring options according to criteria
- *Either:* compare with indicators of sustainability
- *Or:* use Multi-Criteria Analysis to assess trade-offs between different criteria
- Different stakeholders may assign different weights to criteria
- Implications of these weightings

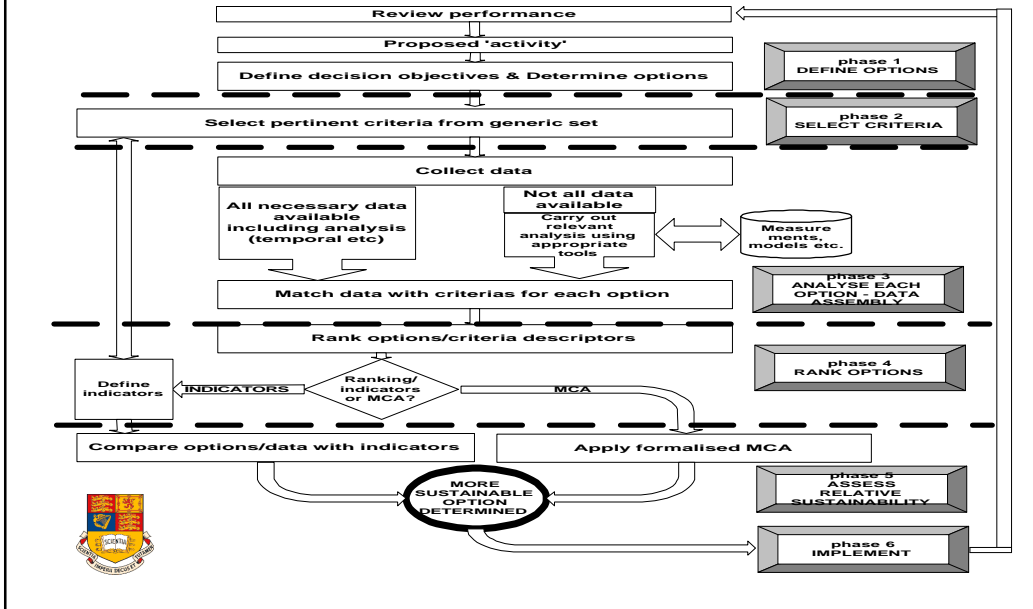


Post-decision phase

- Implement decision
- Monitor and evaluate option chosen
- Feedback refined criteria and evaluation of process into decision-support procedure
- Open and transparent process



The Guidebook Process



Further Reading

- Leach MA, Bauen A and Lucas NJD (1997). 'A Systems Approach to Materials Flow in Sustainable Cities. Case study of paper'. *Journal of Environmental Planning and Management*, 40(6), 705-723.
- Foxon TJ and Leach MA, with Butler D, Dawes J, Hutchinson D, Pearson PJ and Rose D (1999). 'Useful indicators of urban sustainability: some methodological questions', *Local Environment*, 4(2), 137-149.
- Foxon, T J, Butler, D, Dawes, J, Hutchinson, D, Leach, M, Pearson, P and Rose, D (2000, forthcoming), 'An assessment of water demand management options from a systems approach', *Journal of Chartered Institute of Water and Environmental Management*.
- Francois Bouchart, Tim Foxon, Nicki Souter, Richard Ashley, David Butler and Paul Jowitt (1999): 'Decision mapping for the development of multi-criteria analysis tools to assess the relative sustainability of water/wastewater systems', CHAINET (European network on chain analysis for environmental decision support): <http://www.leidenuniv.nl/interfac/cml/chainet/absfoxon.rtf>

