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Strategic Infrastructure System Investment Analysis

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Valuing and financing the Infrastructure of Cities, Regions and Nations

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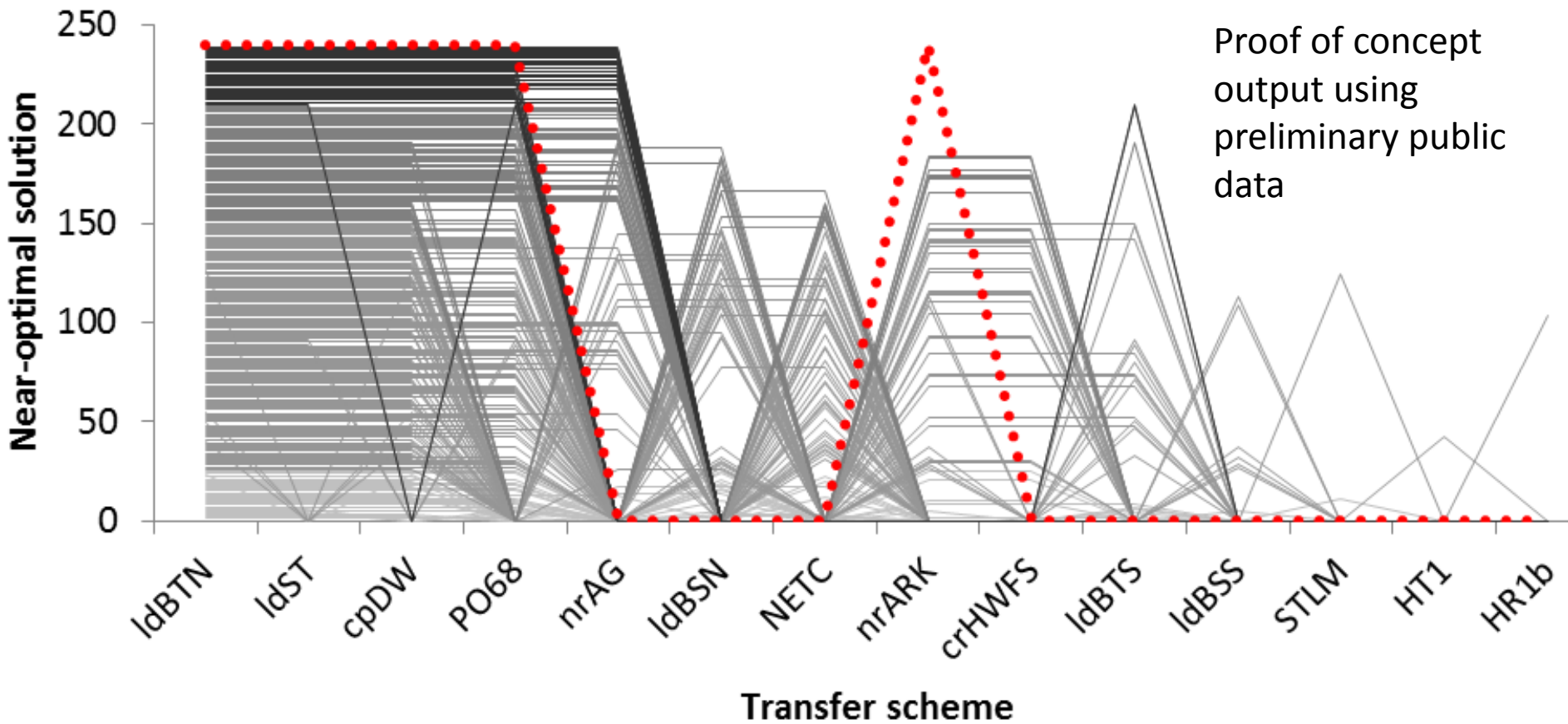
Limitations of current least-cost water planning approach

- **Monetised benefits only**: must monetise all societal goals if they are to be considered
- **Conservative**: seeks to prevent worst supply-demand annual imbalance, rather than work well across a range of plausible futures
- **Potentially inaccurate**: non-linear interactions between schemes not considered
- **Many similar solutions**: many different portfolios are nearly least-cost

Diversity in the frequency of WRSE **transfer** scheme selection amongst the 240 near-optimal solutions within 10% of the optimum



- Each line is one of the 240 near-optimal solutions
- Darkest lines are closest to least cost
- Densely colored transfers: selected in all or most 240 near-optimal solutions

Investment analysis framework

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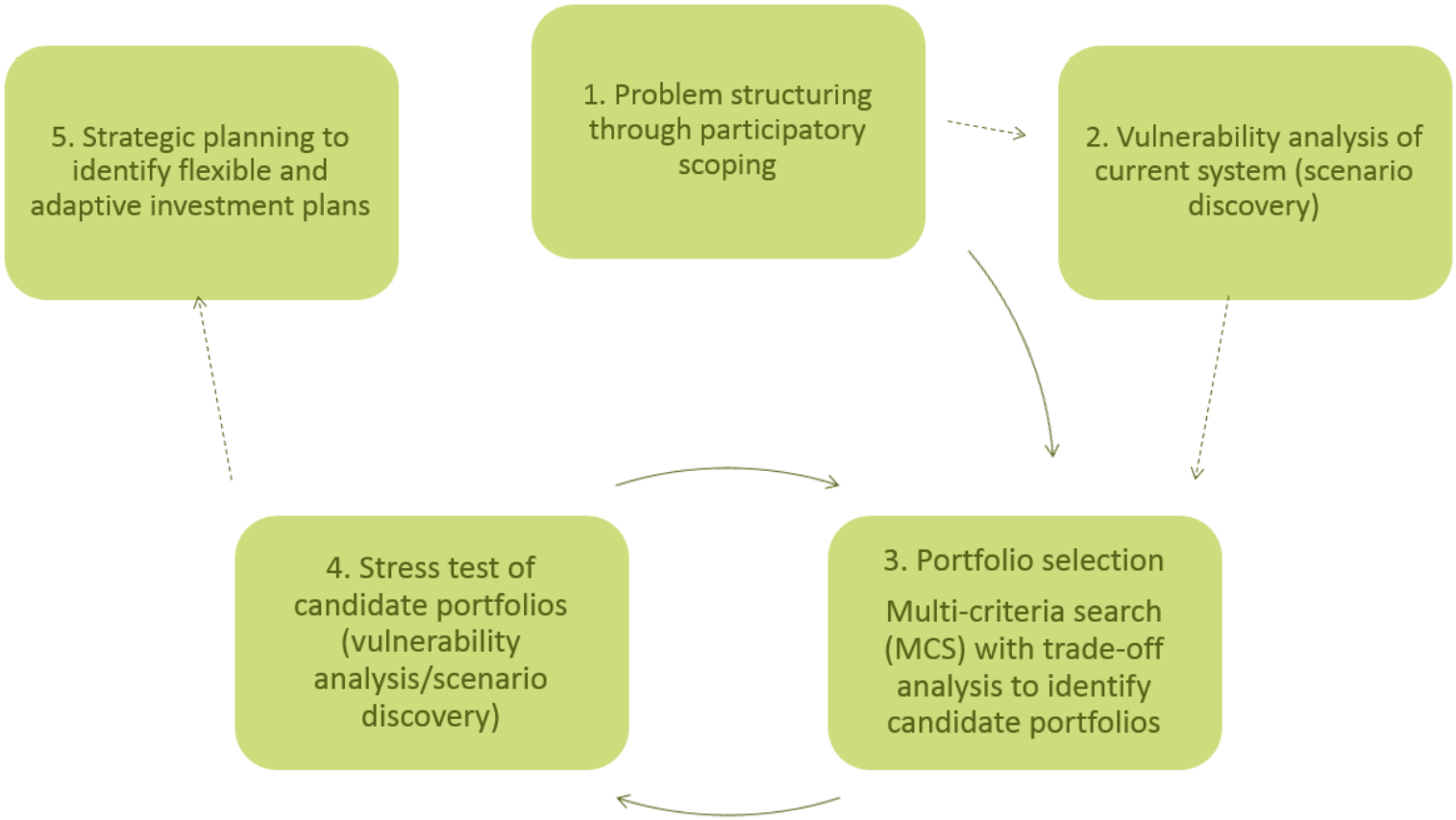
- **Problem framing**:
  - credible stakeholder informed system simulation model,
  - metrics of system performance,
  - sources of uncertainty,
  - interventions (policies, infrastructure investments)

- **Automated filtering** through the large number of combinations of interventions ("search process"): identify robust & efficient combinations of assets

- Stakeholder **interaction, deliberation and negotiation** via visual & interactive assessment of trade-offs, to select a preferred strategy(ies)

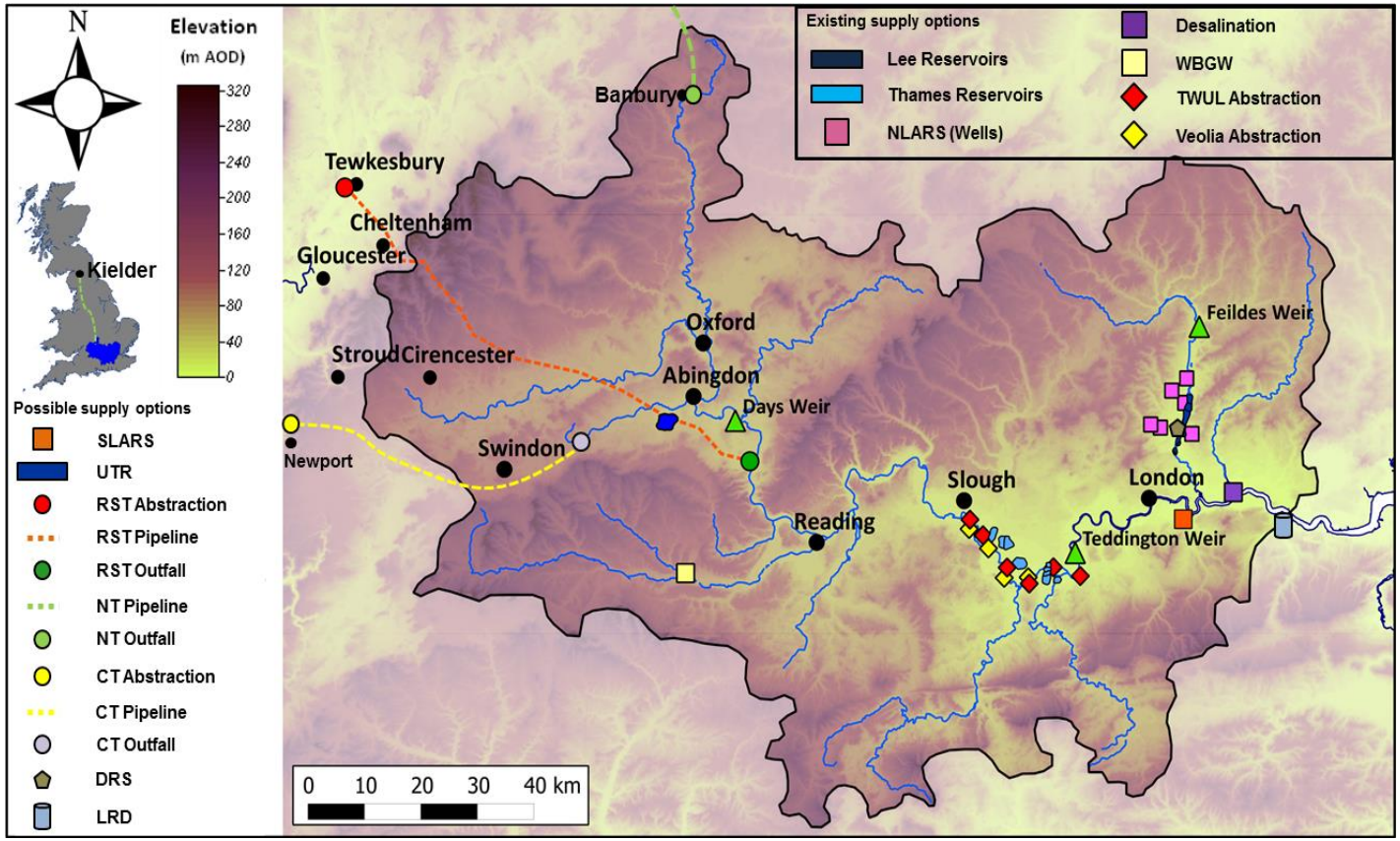
- **Stress testing**: use Robust Decision Making (RDM) methods (e.g. statistical clustering) to identify conditions under which strategy is vulnerable

Investment analysis framework



Case study – Thames Basin, UK

Stressed water resource system with population over 13 million including London



Demand management options
Active Leakage Control
Pipe repair campaign
Enhanced Efficiency Improvements
Installation of Smart Meters
Seasonal Tariffs

What mix of supply and demand interventions (portfolio)? At what capacity?

What are we searching for?

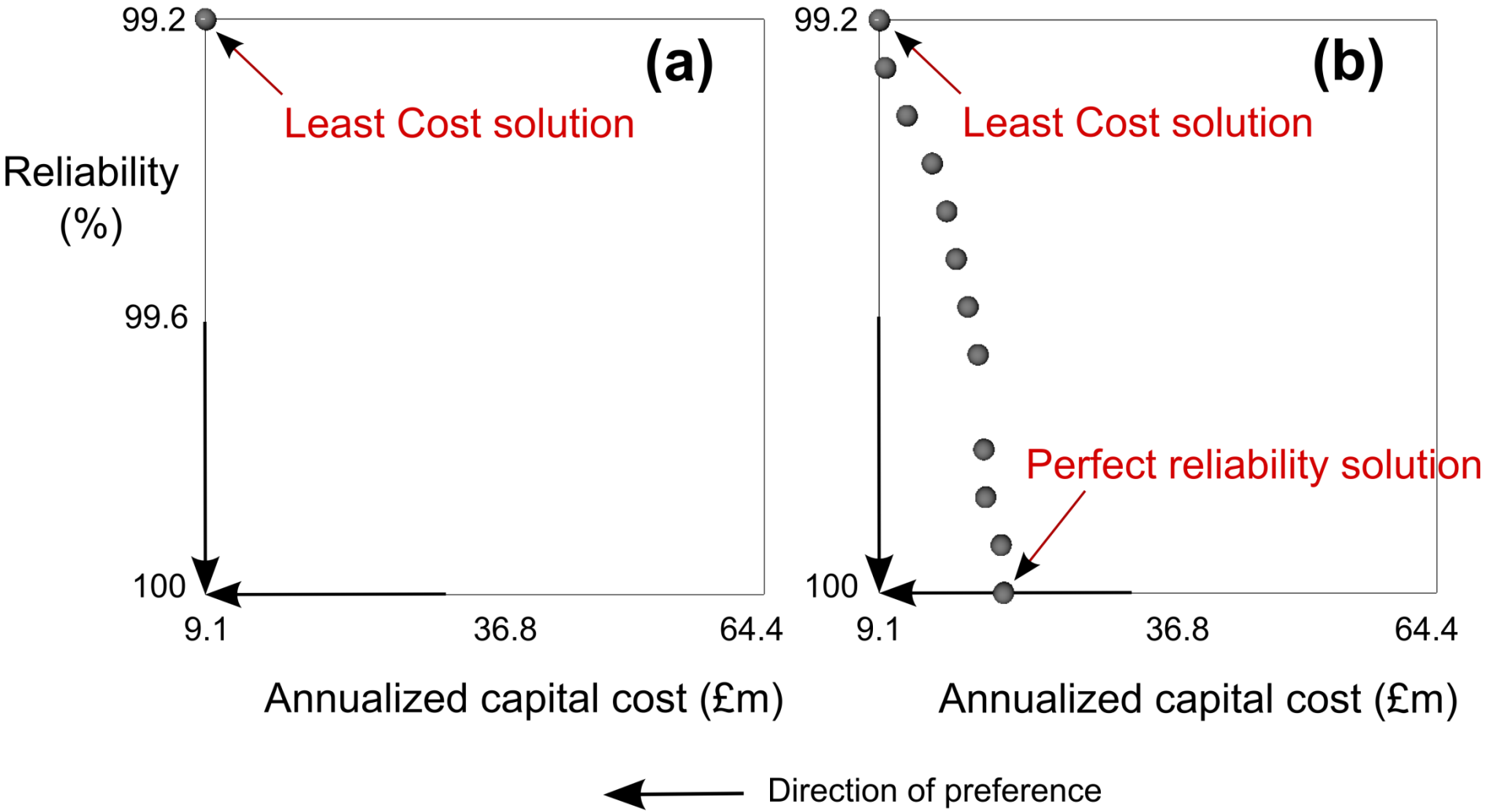
Objectives

- **Capital costs**
- **Supply deficit**
- **Supply resilience**
- **Supply reliability**
- **Ecological deficits**
- **Energy cost**

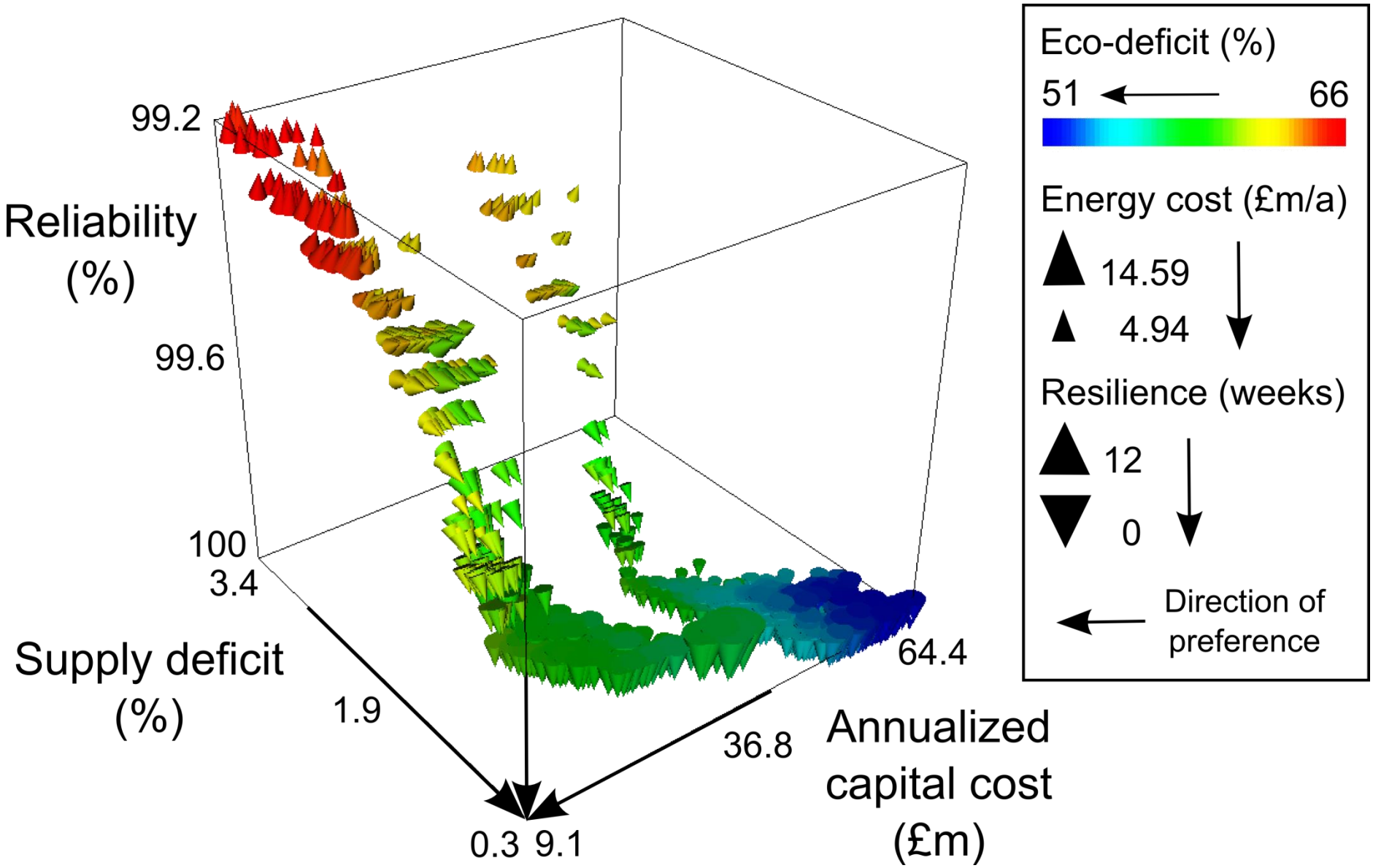
Constraints

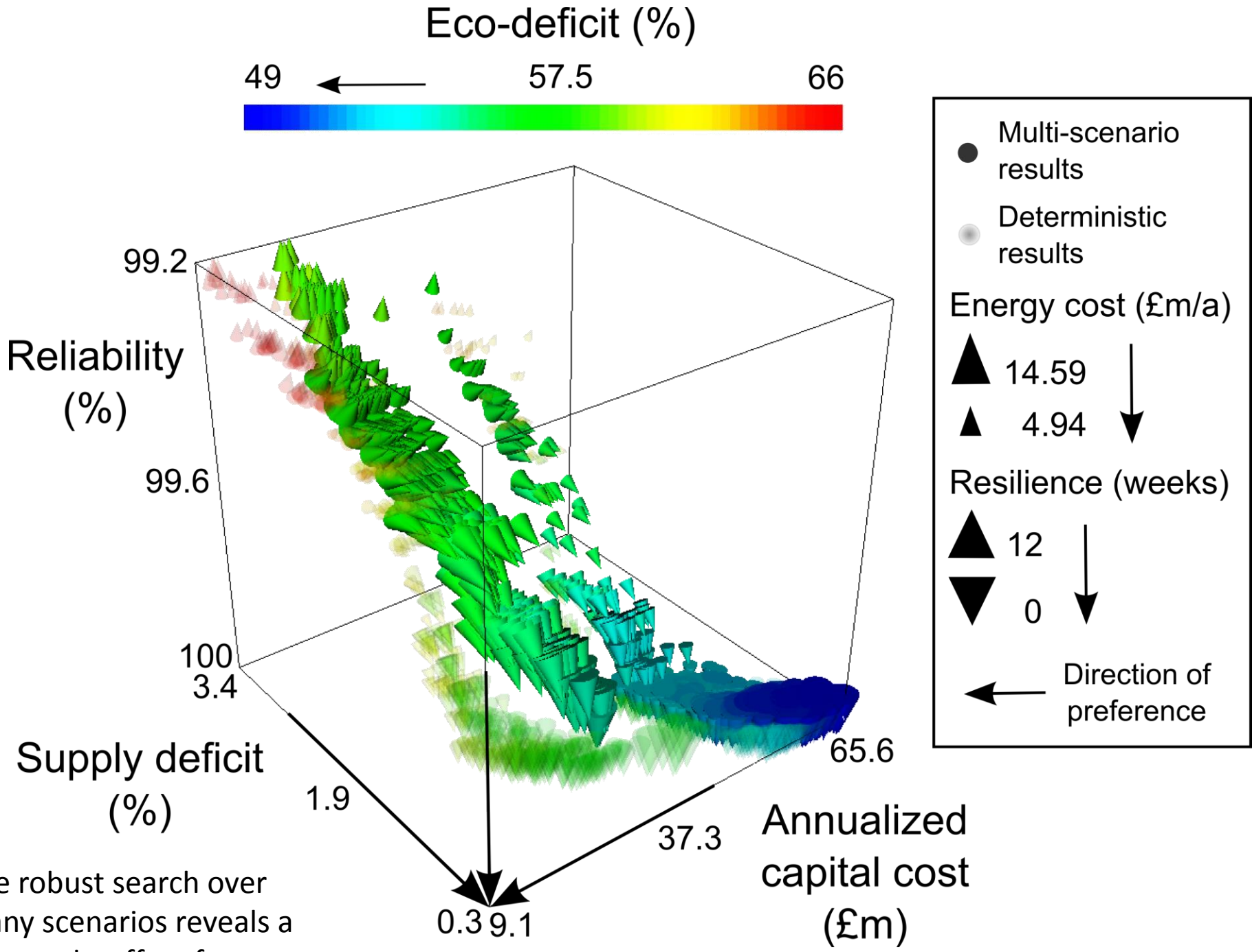
- **Levels of Service**
- **Mutual exclusivity of some supply options**

Single and two objective optimization; Currently UK utilities find a) they should consider b)



Six objective trade-offs

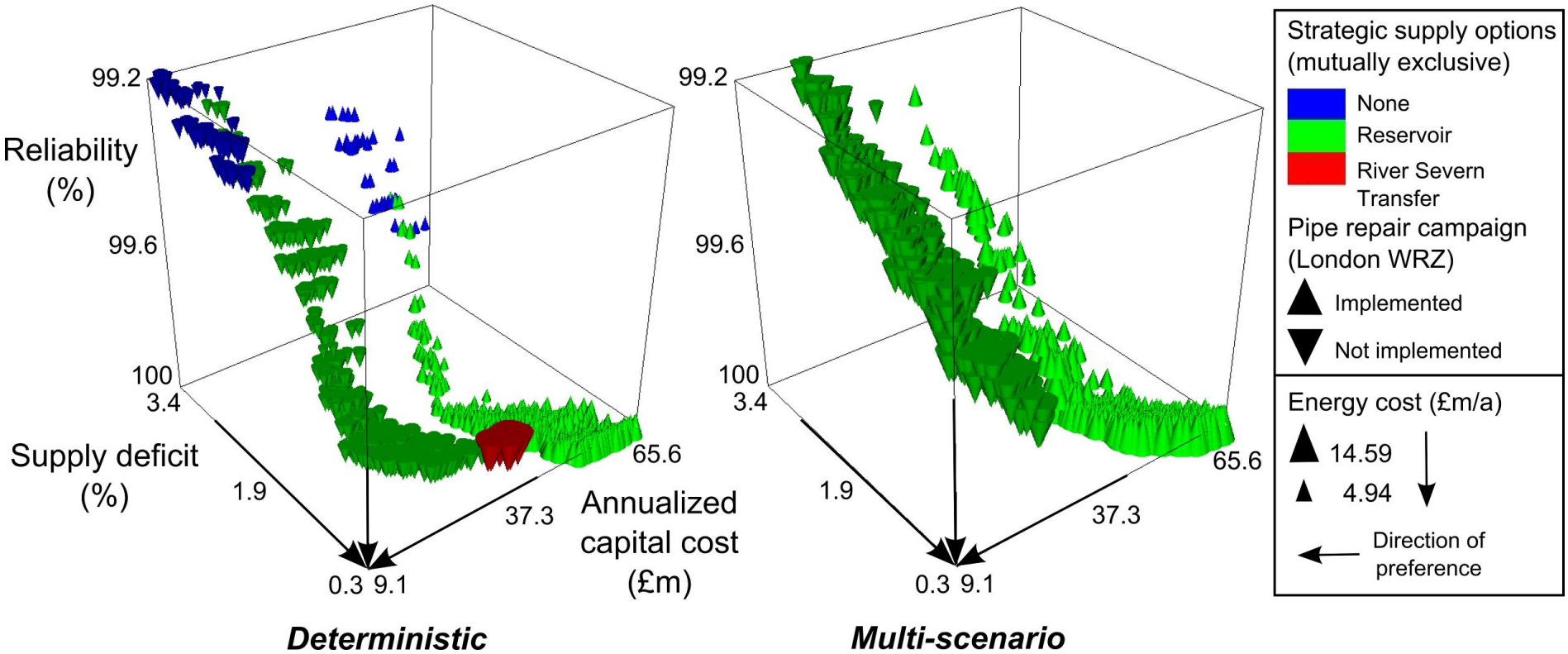




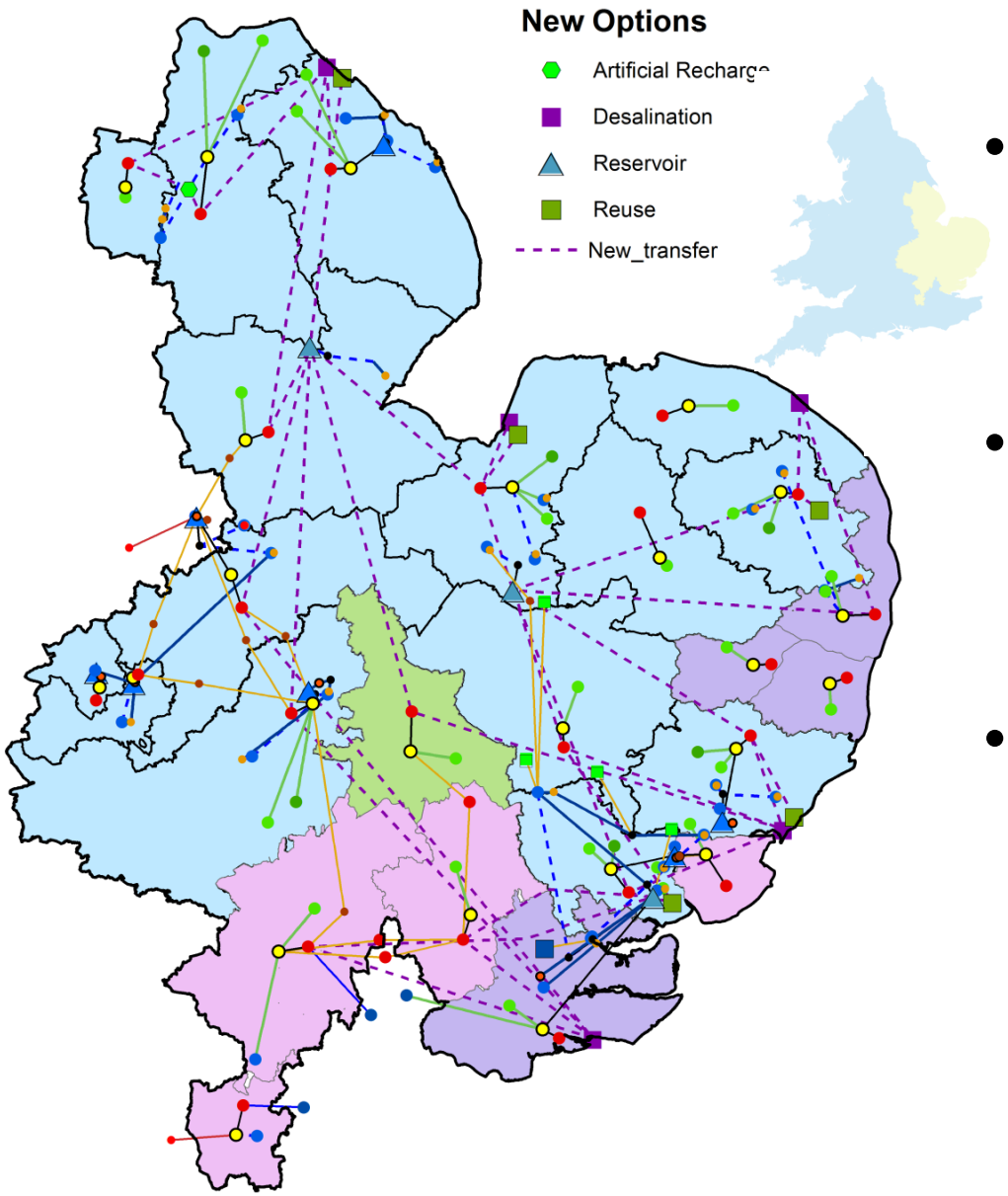
The robust search over many scenarios reveals a new trade-off surface

How do investments map to the trade-offs?

Automated filtering was performed under historical (left panel) and multiple future scenarios (right panel)

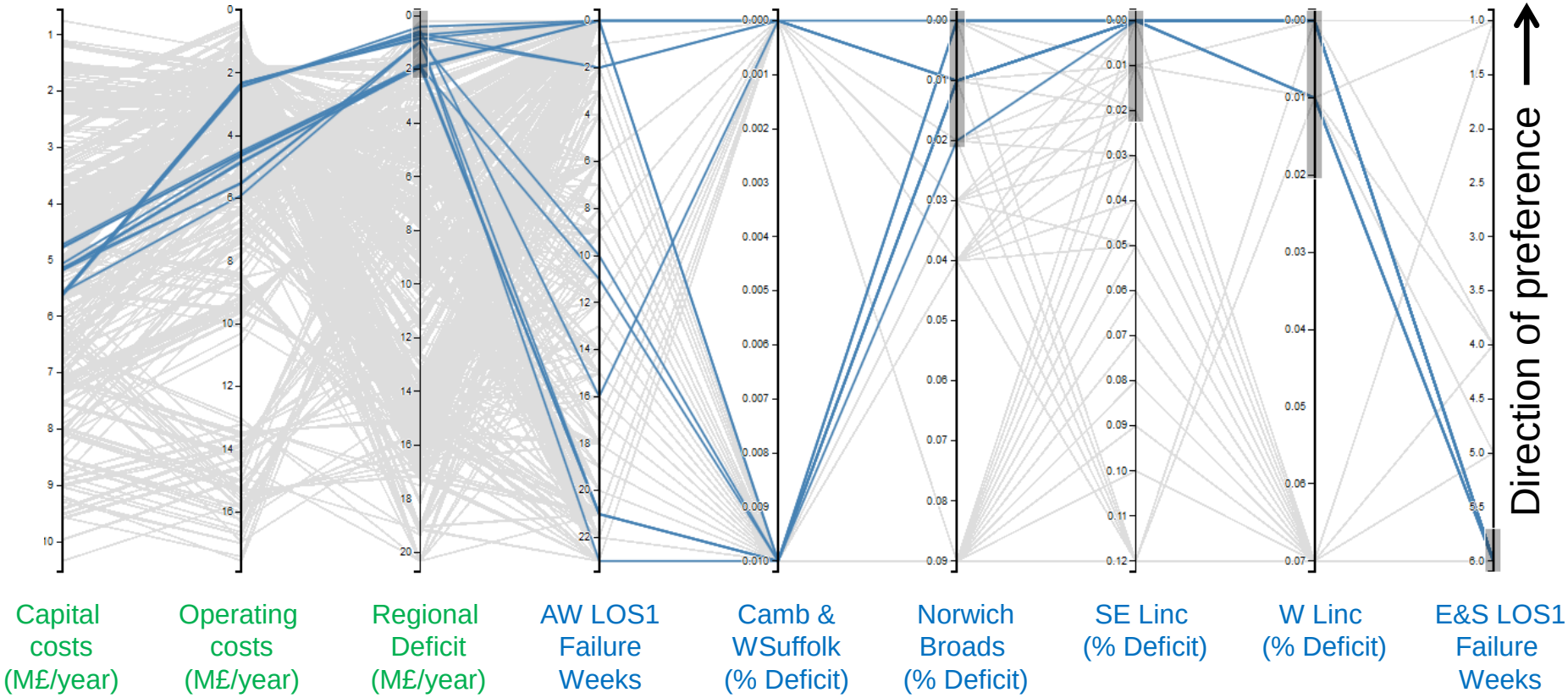


Case study – East England



- Large regional system with 4 utilities serving 9.4 million customers
- Challenges include climate change and rapid growth
- Utilities considering infrastructure expansion, demand management, and increased interconnectivity

Interactively negotiating and selecting a preferred portfolio



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Strategic Infrastructure Investment analysis process

- Problem framing
- Automated filtering
- Visual & interactive trade-off analysis
- Stress testing

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Further reading

- Huskova, I., E. S. Matrosov, J. J. Harou, J. R. Kasprzyk and C. Lambert (2016). "Screening robust water infrastructure investments and their trade-offs under global change: A London example." Global Environmental Change 41: 216-227, http://dx.doi.org/10.1016/j.gloenvcha.2016.10.007
- Matrosov, E. S., Huskova, I., Kasprzyk, J. R., Harou, J. J., Lambert, C., & Reed, P. M., (2015), Many-objective optimization and visual analytics reveal key trade-offs for London's water supply. *Journal of Hydrology*. 531(3): 1040–1053, http://dx.doi.org/10.1016/j.jhydrol.2015.11.003
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- Matrosov, E. S., Woods, A. M., and Harou, J. J. (2013). "Robust Decision Making and Info-Gap Decision Theory for water resource system planning." Journal of Hydrology, 494, 43-58. http://dx.doi.org/10.1016/j.jhydrol.2013.03.006