Forecasting and Backcasting For Sustainable Urban Water Futures

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ABSTRACT

The Australian and international water industry is on the verge of significant change, and a significant opportunity to embrace sustainability in its operations. The paper shows how a combination of forecasting and backcasting is necessary for predicting a water service provision model of the future. Using some real examples, we demonstrate how actions that pick the low hanging fruit result from forecasting and how actions that challenge existing assumptions result from backcasting. We show how the application of these two tools can pay dividends for residential, commercial, and industrial water users.

INTRODUCTION

The water industry in Australia and internationally is on the verge of a significant move from commodity supply to service provision. The drivers behind this change include

- Total annual water sales much lower than forecasted, leading to stagnating utility revenues;,
- Increasing interest in holistic thinking;
- Increasingly limited access to adequate and affordable water resources;
- Aging infrastructure;
- Increasingly expensive maintenance of highly centralised systems;
- Increasing treatment costs;
- Increasingly stringent discharge licences;
- Increasing recognition of potential resources in stormwater and sewage nutrients;
- Regulatory requirements for more cost-reflective water system pricing;
- New approaches to infrastructure provision; and
- Privatisation and competition

In this paper we outline how the methods of forecasting and backcasting can be harmonized to provide a framework for taking actions to meet these challenges. By way of a series of examples, we show how such an approach is already contributing to changing practices.

LIVING WITHIN OUR MEANS

If sustainability is about preserving and conserving the resources for future generations then managing for sustainability is about 'living within our means'. When this simple principle of 'living within our means' is applied to water resources, we can appreciate the significance and value in moving from 'supply-side thinking' to the approach of 'water service provision The fundamental difference in the two approaches is that the former views managing the demand for water as a commodity supply business whereas the latter approach is focused on providing a broader range of services to meet the water demand. For a discussion of integrated resource planning as a means of providing water related services and the comparison with supply side planning see Howe and White (1999), White and Fane (2001). In the following sections, forecasting and backcasting are introduced as two tools that can be used to complement one another to take appropriate actions on the above strategies.

Guiding strategies for urban water systems that would be consistent with 'living within our means' include:
- Recognising the limits of a catchment and the water that is available within it;
- Ensuring water use is efficient *i.e.* use the lowest volume of water necessary to provide a service or to meet a demand;
- Ensuring water use is effective *i.e.* use the lowest quality of water necessary to provide a service;
- Ensuring sufficient and appropriate quality flows to our local ecosystems;
- Maximising the efficiency of the use of energy and materials to deliver a service;
- Investing in new and existing infrastructure consistent with these principles; and
- Investing in institutional structures and arrangements which facilitate these principles

PREDICTING THE FUTURE AND TAKING ACTION

Planning for the future is a core activity of all water businesses. Whilst predicting the future is impossible, there are a wide range of techniques for thinking about what might happen, and how we can influence that. In very general terms, these methods can be categorised as either forecasting or backcasting.

Forecasting methods are based on current dominant trends, and therefore tend to describe futures that look similar to the present. Forecasting methods struggle to anticipate surprises and discontinuities. Backcasting, on the other hand, begins by defining a societally preferred future, and then works backwards to determine alternative feasible physical and behavioural paths connecting the societally preferred future with the present. Thus, the solutions generated by backcasting are independent of current dominant trends. A desirable water service provision model of the future therefore requires the application of both forecasting and backcasting.

Forecasting and backcasting are complementary in planning for the future. When thinking about a future incorporating sustainable urban water service provision, forecasting can help identify the actions that produce results in the short term, and deliver needed marginal changes in how water is used. In other words, forecasting can help pick the low hanging fruits. Having identified short-term measures, it is also important to simultaneously develop scenarios for a societally preferred future, which is not limited by assumptions of the present. In other words, a future that challenges existing assumptions. Backcasting is a technique that can help in this process because it provides a focus on a longer timeframe and delivering step changes in the water business.

Thus, together the two techniques are necessary and sufficient conditions for sustainable urban water systems. Our view, illustrated in Figure 1, is that these two processes inform each other, and so both are necessary, and best implemented in an ongoing iterative approach. Challenging existing assumptions will generate different perspectives, and with a different perspective, we might identify different low hanging fruit. Identifying and acting on different low hanging fruits changes our current position, so the path from our current position to the preferred future changes, and so forth.

To make this explicit, think about Australiaville Water, a large urban water utility. Australiaville Water's forecasts show that the security of supply of the existing system will be reduced due to the expected rise in population, long-term rainfall trends, and the need to increase environmental flows. Options that may be proposed include new water supply storages, transferring water from neighbouring catchments or even desalination. At the same time, Australiaville Water might engage in backcasting and challenge its existing assumption that more supply is the only option for meeting the demand. It might do this by evaluating the costs and benefits to the community of investing directly in the improvement of water efficiency by its customers and through reducing system losses. This process, known as least cost planning or integrated resource planning, begins with end-use analysis, and asks whether there are opportunities for reducing demand which have a lower cost per unit volume than equivalent supply augmentation options. In most cases, reducing demand by installing water efficient showerheads, taps, toilets, washing machines, cooling towers and urinals is the cheapest, fastest, and most sustainable way to obtain new water for increasing population or environmental needs.

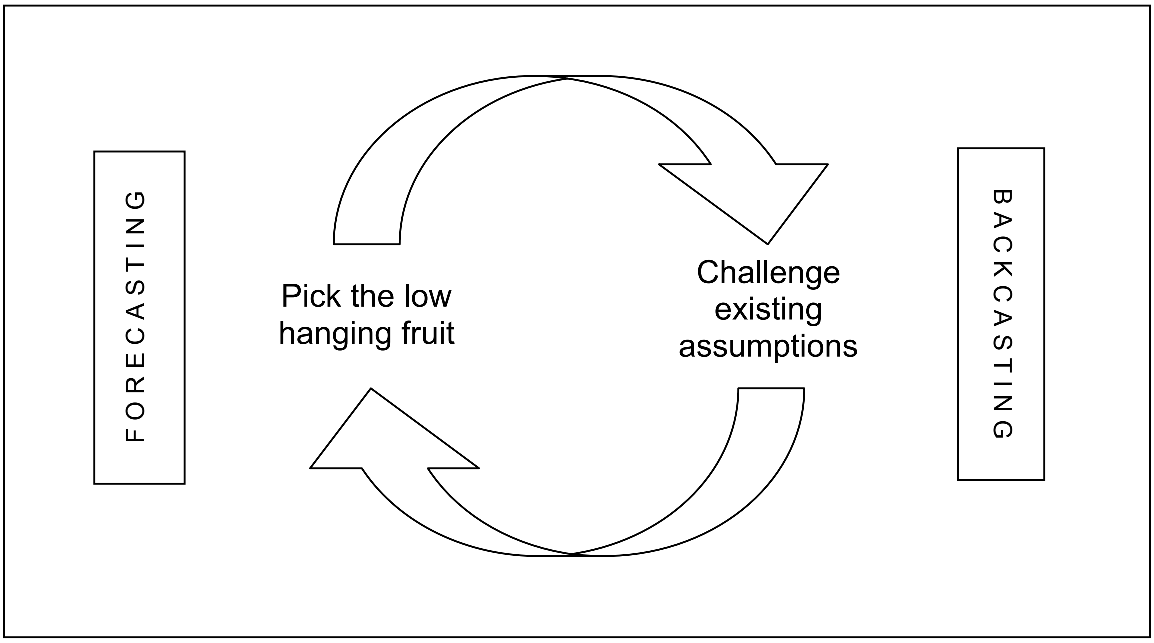

Figure 1 The relationship between forecasting, backcasting, and maxims for action

In the sections that follow, we demonstrate the kinds of actions that result from forecasting and backcasting techniques.

SHORT-TERM ACTIONS FROM FORECASTING

Forecasting helps in identifying actions that pick the low hanging fruit. These actions are easy to do now, more or less within the existing urban water system, and will pay sustainability dividends in both the short and long term. These actions are aimed at making the most of the system as it stands, and include a focus on, for example, water efficiency. Improved water efficiency is often associated with reduced energy consumption and greenhouse gas emissions as well as reduced costs for water treatment, sewage transport and treatment, and re-distribution or discharge.

We see a hierarchy within low hanging opportunities:

1. Demand management: Maximise water efficiency and implement source control
2. Water quality cascade: Match required water quality with water quality supplied

Demand management means looking at what our customers use water for (end uses) and determining whether the same service could be provided using less water. The classic example here is the installation of water efficient showerheads and tap regulators that can save between 23 and 35 kL/hh/year in large scale programs. The USA, for example has had mandatory performance standards for showerheads and many other water using fixtures, since 1994. Australian initiatives in this area have led to moves for mandatory labelling (Day and White 2002, Sarac, Day, and White 2002).

Implementing demand management first, opens up more opportunities for better matches between the quality of water required for specific end uses, and the level of treatment needed and therefore quality of water supplied. For example, a concept study carried out by the Institute for Sustainable Futures for Sydney Water's new corporate headquarters showed that the building could, in principle, have accommodated up to 1 000 people using only rainwater captured on site as the water source. This was possible through significant efficiency improvements by low water use dual flush toilets, waterless urinals, sensor-operated high efficiency taps in hand-basins, and water efficient showerheads, and, most significantly, treatment and reuse of effluent and the use of ground source heat pumps rather than cooling towers (Chanan *et al* 2003).

In its new building sustainability rating tool, BASIX, PlanningNSW will provide a performance based scoring system based on the reduction of demand for water through implementing water efficiency and through applying the water quality cascade and implementing source substitution (see http://www.planning.nsw.gov.au/ for details). The most useful features of this tool are firstly that it gives developers, builders, plumbers, home renovators, and consent authorities a consistent set of figures to work from, and secondly, it enables consistent ranking of different water saving opportunities.

Similarly, a new residential, commercial, and public space development at Kogarah Town Square in Sydney implemented the principles of demand management and the water quality cascade. With the objective of improving stormwater management and reducing water use, rainwater from the site is collected and used for toilet flushing and landscape water use (Jha *et al.*, 2001).

An example of the potential for improved water efficiency within the industrial sector is provided by our recent experience in central Queensland. In this region, large industrial customers have historically been subject to long term contracts with little, if any, incentive to improve water efficiency. Recent droughts have meant that allocations have been reduced and restrictions brought into force. Most industries met 10% restrictions with minor changes in practice, very little or no capital investment, and often reductions in operating costs. Reductions in demand of up to 50% are being achieved with capital investment in improved processes.

LONG TERM ACTIONS FROM BACKCASTING

Backcasting with its longer-term approach results in actions that challenge existing assumptions. Existing assumptions must first be identified before they can be challenged. Identifying assumptions behind business-as-usual requires us to step back a little, and see what it is we are taking for granted in our decisions.

A starting point here could be the assumption that having a single pipe supplying one quality of water for all end uses is the best option. We could start by asking the question 'what do we mean by 'best'?'. Do we mean 'cheapest'? And by cheapest, do we mean ‘lowest capital cost’? And by lowest capital cost, do we mean ‘lowest capital cost for the portion of the system for which we have to pay’?

In a recent study for Sydney Water, we developed a series of conceptual servicing plans for a greenfield estate in Sydney’s southwest with approximately 12 000 lots. The plans varied from business as usual (dependence on highly centralised off-estate water supply, wastewater treatment and discharge) through estate and neighbourhood scale technologies, to allotment scale technologies. Costs were assumed to include everything necessary to supply the service. All off-estate infrastructure was appropriately pro-rated, and on-estate costs included distribution and supply to the house, rather than to the property boundary. In this joint project of the Institute for Sustainable Futures and CSIRO Urban Water, we showed that the system boundary used to assess the costs significantly influences the comparative capital costs for vastly differing systems. Instead of breaking up the capital costs for servicing a new subdivisions according to who normally pays (*e.g.* the water utility is responsible for delivering bulk water and removing bulk sewage and charges the developer a headworks contribution, the developer is responsible for all infrastructure from the boundary of the estate to the boundary of an individual property, and the home buyer is responsible for the infrastructure within their property), we included all the pro-rated costs of all the infrastructure necessary to supply the service, regardless of the location of the infrastructure. On this basis, annualised capitalised costs for all options varied by less than 10% (*i.e.* less than the likely error in the cost estimates).

Another common assumption is that water, sewage, and stormwater systems should be considered and planned for separately. Thinking in terms of a total water cycle can enable quite different solutions. For example, in a greenfield residential development in Melbourne’s northern outskirts, water efficiency assumptions have reduced projected demand of internal residential use by 45 L/p/d. Further reductions through source substitution enabled by water cycle thinking include using rainwater for the hot water supply (44 L/p/d) and reclaimed water for toilet flushing (23 L/p/d) and garden watering (33 L/p/d). Overall, this gives a 70% reduction on demand from the reticulated water system.

One of the most influential applications of the water quality cascade that also involves challenging existing assumptions is to replace a high quality water stream with no water stream at all. In other words, to think in terms of providing a service rather than providing water. For example, in our central Queensland study, approximately 80% of the raw water demand comes from industry and approximately 80% of industry’s demand is for cooling. More than half of this cooling demand is from coal-fired base-load power stations in a different catchment. Like the new power station at Milmerran in Queensland, these power stations could instead be air-cooled. Taking a total resource cost approach, the levelised cost (Howe and White, (1999), Fane, Robinson, and White (2002)) of converting to air cooling, and making the limited raw water available for uses for which there is no feasible substitute, appears to be roughly similar to the cost of augmenting supply by either desalination or a pipeline from another catchment.

CONCLUSION

The Australian and international water industry is on the verge of significant change, and a significant opportunity to embrace sustainability in its operations. We have shown how a combination of forecasting and backcasting is necessary for predicting a water service provision model of the future. These two processes inform each other, and so both are necessary, and best implemented in an ongoing iterative approach to make progress towards sustainable water service provision.

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The Institute for Sustainable Futures (ISF) is a flagship research centre at the University of Technology, Sydney. In designing workable solutions to real world problems, we consider the economic, environmental and social dimensions, we select projects based on their ability to create change towards sustainability in the areas encompassing urban infrastructure namely - water, energy, building design, urban forms and transport. The Institute is known nationally and internationally for its work on water conservation and least cost planning in the water industry. Some of our recent achievements include.

- A Banksia Award for *Your Home*, a comprehensive national guide to sustainable home design that was written by ISF for the Australian Greenhouse Office.
- A lead role to Efficient 2003, an international conference on the efficient use and management of water for urban supply held in Spain from 2-4 April 2003

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