DEMAND MANAGEMENT AND INTEGRATED RESOURCE PLANNING IN AUSTRALIA

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ABSTRACT

In Australia, some urban water utilities have invested significant funds in programs designed to reduce the demand for water. The reasons for such investment include: the high costs of water supply and distribution; licence conditions required by government; the benefits of deferral of capital works; and the benefits of downsizing sewage treatment plant upgrades.

This paper will present the background to these activities in three case study areas: Sydney, Australia's largest city; Kalgoorlie-Boulder, a mining city in Western Australia; also a rapidly growing rural area in northern New South Wales. Sydney is unique in that the water utility, Sydney Water Corporation (Australia's largest, serving nearly 4 million people) has a regulatory requirement to reduce demand by 25% in 2001 and 35% by 2011, from the 1991 levels of 503 litres per person per day.

The programs that have been implemented have been based on a low cost end-use analysis technique, in which an understanding of where and how water is used is determined from demand data, surveys, equipment sales data and direct estimation. The methodology of integrated resource planning is used to determine the best mix of options to invest in, based on the cost of the options to the utility and the customers, and the benefits that are obtained from avoided supply costs, reduced capital expenditure, reduced energy costs and many other benefits. Options are ranked and compared to supply costs, and also considered in the light of a range of other parameters, such as equity, risk and uncertainty, and the timeframe for implementation.

Options include: leakage detection and repair; pricing reform; water restrictions; regulation of the performance of water using appliances; audits and support for commercial-institutional-industrial customers; retrofitting of water efficient equipment in customers premises; and comprehensive education programs.

Recently obtained results showing the actual savings achieved through programs, based on a paired comparison between participating customers and a control group, will be provided.

1. INTRODUCTION

This paper describes recent Australian experience with the use of integrated resource planning and how it can be used to determine the most effective means of providing water services to customers, rather than the means of supplying water at the lowest cost, which is often the basis for utility planning. This approach requires a detailed analysis of how water is actually used by customers (end-use analysis) which provides a much more rigorous basis for demand forecasting, and allows the development and evaluation of demand management, or water efficiency options, which can often permanently and reliably reduce the demand for water in a way that provides significant financial, operational and ecological benefits.

Section 2 outlines the history, principles and process of integrated resource planning and end use analysis. Section 3 describes a number of demand management or water efficiency options. Section 4 describes a number of case studies in Australia where the principles of integrated resource planning have been applied with actual demand management programs.

Section 5 summarises the results of monitoring and assessment that has been undertaken on two programs in Australia.

Section 6 describes the potential for improved regulations for water efficiency in Australia.

2. INTEGRATED RESOURCE PLANNING

Integrated resource planning, or least cost planning for utilities, has it's origins in the electricity industry in the 1980's (Mieir, Wright and Rosenfeld 1983). The principle of integrated resource planning is that customers do not actually need electricity or water (kWh or m^3), instead they require the services that are provided by these commodities. In the case of electricity, these services include warm houses and preserved foodstuffs; in the case of water, examples are showers, sanitation and landscapes. This approach recognises that these services, often called end uses, can be met either by increasing the supply of water through new dams, water or wastewater treatment plant capacity and reuse plants, or it can be provided by increasing the efficiency of water use, for example, by replacing water using equipment with more efficient types of equipment, or by finding and repairing leaks in the distribution system (Beecher 1996).

The process of carrying out integrated resource planning has been described in detail elsewhere (White 1998). However, one of the key steps involved is end use analysis, an investigation into the ways that customers use water, to as great a level of disaggregation as possible. This can be achieved by the use of low cost customer surveys of water using appliances (toilets, showers, taps) and water using practices (frequency of bath and shower use, frequency of clothes washing), through analysis of market research data for large appliances (eg clothes washers) or through industry sales statistics provided by manufacturers. Modelling the data, including bulk water production data, metered customer data by sector. These sectors include residential single family dwellings, residential multi-family dwellings, and the commercial, industrial and institutional sectors. Demographic and land use data is also important, as this can have a very strong influence on demand, including most obviously population data, but also household occupancy (number of persons per dwelling) and the proportion of residential buildings that are multi-family, compared to single-family.

The importance of end use analysis is illustrated by an example of the decrease in water demand due to toilets in residential dwellings in Sydney, Australia. The average flush volume of flushing cisterns in Australia has decreased significantly from about 11-13 litres in 1980 to less than 4 today, due to an innovative development of the dual flush toilet. All toilets manufactured in Australia are now 6 litre/ 3 litre dual flush (White 1998,1999). As older toilets are replaced and new houses are built, the stock of toilets in use changes, and less water is used in toilets per person. Between the mid-1980's and today, these changes in toilet efficiency will reduce the per capita demand for water for residential customers by nearly 20 litres per person per day, a total of 24,000 ML/a saving for the city as a whole by 2000. By the year 2020 this will have resulted in a halving of the per capita demand for water in toilets.

The second stage of integrated resource planning involves developing and analysing a range of demand management options. A number of examples of demand management or water efficiency options are described in the following section. Having developed these options, the costs and benefits can be calculated and compared to the available supply options. This cost-benefit analysis should be undertaken from the combined perspective of the utility and the customers, that is, from an economic rather than a financial perspective (White and Howe 1998).

Following implementation of the selected water efficiency options, there are a range of techniques available for assessment of the options, some of which are described in Section 5.

3. DEMAND MANAGEMENT

Demand management options can include the following:

- reduction in system losses, including leakage detection and repair;
- operational changes, including pressure reduction and reduced mains flushing or reservoir cleaning;
- metering, pricing and billing reforms, including the use of universal metering, a volume-based water price set at or above the marginal cost, and at least quarterly billing;

- detailed feedback systems for customers which provide information on water use;
- comprehensive information, education, training and advisory services which assist customers who wish to take action to reduce their water use;
- detailed water use analysis (audits) for water customers in the various sectors;
- minimum performance standards for the efficiency of equipment and appliance installed in new premises or as replacement;
- financial incentives for the purchase and installation of efficient water using equipment;
- programs to retrofit efficient water using equipment in buildings;
- programs designed to facilitate treatment and reuse of wastewater or stormwater by customers.

Detailed descriptions of the various options are provided by White (1998).

4. PROGRAMS IN PRACTICE - CASE STUDIES

Three case study programs are described in this section. The first two have been described previously and in more detail in White (1994, 1997, 1998). The third case study has been described in more detail, along with other Sydney case studies, by Howe and White (1999).

4.1 Kalgoorlie-Boulder Water Efficiency Program

Water is supplied to the City of Kalgoorlie-Boulder in Western Australia from the coastal surface water storages near Perth, over 500 km away, as well as to many towns and rural uses along the way.

The demand at Kalgoorlie-Boulder is of particular interest for two reasons. Firstly, at 7,000 ML/a, it is the largest single demand on the pipeline, and the number of customers in Kalgoorlie-Boulder has been steadily growing with the growth in the mining industry. Secondly, it is at the end of the pipeline and therefore the operating and capital costs associated with supplying this demand are amongst the highest in Western Australia.

The objectives of the Kalgoorlie-Boulder Water Efficiency Study were to find ways to permanently reduce the demand in Kalgoorlie-Boulder in order to reduce the cost of pumping water through the pipeline, and also to defer the need to increase the capacity of the pipeline and the source in the future.

The study recommendations (White, 1994) were that a major water demand side management program be implemented, with the objective of reducing demand by at least 700 ML/a in the residential, commercial and industrial sectors.

Water use restrictions had been in place over the previous two summers, and surveys had shown that the community in general support them as a means of conserving water. However it is clear that restrictions do not permanently reduce the demand for water, and restrictions on watering times often merely shift the peak of water use, rather than reducing the overall demand.

Providing permanent and measurable reductions in demand requires changes to the efficiency of water using equipment, such as the toilets, shower heads, evaporative air conditioners and irrigation systems, as well as changes in the type of landscaping. In addition it requires an education and advisory component to provide information on watering times and patterns, on pool operation and other day to day water using behaviour. The emphasis was on measures that would provide the same or even an improved level of customer service.

The specific options that have been implemented as part of the Kalgoorlie-Boulder Water Efficiency Program include the following:

- retrofitting 6/3 litre dual flush toilets - free of charge;
- AAA-rated (9 litres per minute or less) water efficient shower heads - installed free of charge;
- fitting of flow restrictors/aerators to tap spouts in internal sinks and basins - free of charge;
- leaking taps repaired - free of charge;
- air-conditioner bleed valves fitted - free of charge;
- garden reticulation systems checked and adjusted plus minor repairs - free of charge;
- tap timers discounted from $AUS20 to $AUS8;

- the supply of free WaterWise (drought tolerant species) plants up to the value of $AUS80; garden mulch up to the value of $AUS200 in exchange for lawn reduction and new garden establishment in the WaterWise theme;
- WaterWise garden assessment and information brochures **-** free of charge;
- free water audits for the premises of 150 commercial and institutional customers with annual demand greater than about 1,000 kL/a;
- two WaterWise demonstration gardens which incorporate information on low maintenance and low cost landscaping.

Of the 8,200 domestic customers in Kalgoorlie/Boulder, around 5,200 households participated in the free plumbing and retrofitting of toilets offer and approximately 3,200 houses have taken up the external reticulation and gardens offer. The financial analysis of the program suggests that the financial benefits in reduced operating and capital costs will more than make up for the costs. There will also be a major financial benefit to customers in reduced water bills and also energy bills due to reduced hot water usage. Based on the original budget, the projected savings to the Water Corporation are $AUS3.5m, and $AUS2.8m to the customer over a 2.5 year period (Botica and White, 1996).

It has been estimated that annual energy savings of 3,000 MWh will result from reduced water pumping and reduced water heating costs. A comparative analysis of the energy savings of 1,000 households who participated in the water efficient shower head retrofitting component of the program, with a control group who did not, indicated an average 1.1 kWh/day saving in electricity from hot water savings, which is consistent with the estimated water demand reduction of 25 kL/a per household (White 1998).

4.2 Rous Regional Demand Management Strategy

The Rous Regional Demand Management Strategy was commenced in 1996, with the aim of reducing the demand for water in a region of high population growth. Rous County Council is the bulk water supply authority to four local councils in the north coast region of New South Wales, Australia , supplying a population of about 70,000 people.

This strategy, which resulted in a comprehensive water efficiency program outlined below, provides an example of the benefits of deferring capital works. In this case deferral of the adopted schedule of capital works (with a present value in 1996 of $AUS30m) by one year, results in a financial benefit of $AUS1.4m. This means that any measure which reliably reduces demand by 1 ML/a provides a financial benefit of more than $AUS3,500. During the Rous Regional Demand Management Strategy many options were identified and implemented that had a cost significantly lower than this.

The program developed included the following components:

- pricing and billing reform, highlighting the benefits of a simple two-part tariff structure with a single price for all water used, accompanied by quarterly meter reading and billing and sewerage volume charges for non-residential customers;
- a major program of reduction of unaccounted-for-water, including leakage detection and repair;
- the promotion and distribution of high quality water efficient shower heads at reduced cost ($AUS1 and $AUS10);
- the offer of a $AUS150 rebate on the sale of front loading washing machines at point of sale;
- the offer of a reduced cost assessment of the water efficiency of houses, including a free shower head, tap flow regulators, repair of leaking toilets and taps and adjustment of toilet flush volume;
- the offer of free water audits for non-residential customers, including the production of a detailed and costed water saving action plan;
- the design and construction of a water efficient demonstration house and garden and accompanying educational materials in association with a display home builder;
- the development of a strategy for increasing the reuse of effluent in ways that offset the demand for water from the supply system, including investigation of direct potable reuse in a new village subdivision and a household greywater treatment system;
- a comprehensive school education program including visits by teachers to most primary schools in the region and distribution of educational materials;

- the preparation of information materials on rainwater tanks and greywater treatment systems (White 1998).

Support for components of the program that reduce hot water use has been provided by the Sustainable Energy Development Authority of New South Wales, which has an objective of reducing greenhouse gas emissions in a cost effective ways. The local electricity retailer, NorthPower, also contributes to the washing machine program (White, 1997).

4.3 Sydney Water Demand Management Program

In 1997, Sydney Water Corporation, the largest water service provider in Australia, commissioned the Institute for Sustainable Futures to undertake a major end use analysis and least cost planning study. The study considered over 40 different options to reduce demand, covering all water use sectors (residential, commercial, industrial, institutional, unaccounted and non-metered water) and all end uses (e.g. toilets, showers, taps, washing machines, garden and lawn watering). The options also covered the range of possible means of implementing water efficiency measures, including regulation, pricing, education and advisory services, loans, incentives and retrofitting. A number of reuse options were also modelled including industrial, potable, greywater, rainwater tanks and golf course irrigation. The options were modelled by estimating the potential demand reduction that would be achieved at different levels of investment in each option. Options were selected on a range of criteria including the cost to the community to implement the option and the ability to provide timely reduction in demand.

The selected program is summarised in Table 1, from Howe and White (1999).

Table 1. Demand management program designed to meet Sydney Water's Operating Licence targets.

Option	Estimated demand reduction in 2001 and 2011 (litres per person per day)	Levelised cost (AUS$/kL)
1. Shower head performance standard	8.6	0.0014
2. Price increase (AUS$0.10/kL over two years)	1.9	0.0018
3. Clothes washer performance standard	3.5	0.041
4. Permanent low-level outdoor water use restrictions	1.8	0.063
5. Shower head rebate (AUS$10)	0.7	0.14
6. Residential indoor audit & retrofitting (AUS$15 fee)	3.4	0.19
7. As for 6 (free for low-income households)	1.5	0.25
8. Active leakage control	7.2	0.30
9. Industrial & commercial audits	2.9	0.42
10. Hotel audits	1.3	0.42
11. Outdoor water use promotion/ advisory program	0.2	0.49
12. Industrial reuse project 1	2.3	0.53
13. Industrial reuse project 2	1.8	0.65
14. Outdoor irrigation system audits	0.3	0.67
15. Washing machine rebate (AUS$150)	0.4	0.70
TOTAL DEMAND REDUCTION IN 2001and (2011)	26 (38)	

All options except for numbers 1 and 3 are being implemented in order to meet the 25% water consumption reduction target, now pro-rated to 2004-5. Numbers 1 and 3 are scheduled for implementation in 2003 for achievement of the 2011 – 35% water consumption reduction target. The program is ranked in order of levelised cost (i.e. the present value of the cost of the option to the community divided by the present value of the annual reduction in demand for water resulting from that option). The levelised cost does not include those costs and benefits that are transfer payments between Sydney Water and its customers, such as: foregone revenue; reduced customer bills (water, wastewater); or proceeds from sales of reclaimed effluent. It represents the cost to the community to achieve a certain level of water saving by means of reducing demand (water efficiency), reducing losses (leakage control) or substituting reclaimed effluent (reuse). In these calculations "cost to the community" means costs incurred by both Sydney Water and its customers. The marginal cost of supplying water for the Sydney region, not accounting for local variations due to infrastructure augmentation, or other factors that apply in the following two case studies, is approximately AUS$0.13/kL (Howe and White 1999).

In 1999 Sydney Water began implementing the majority of the programs, costing over AUS$50m, and requiring the participation of more than 10% out of the 1.4 million domestic residences supplied by Sydney Water. The response by customers to the residential program in particular has been dramatic. In a southern Sydney suburb of Shellharbour, where the residential assessment and retrofitting program was piloted, a 25% uptake rate was experienced compared with a 10% estimate. It appears that other programs such as the industrial and hotel audits and the shower head rebate program are under performing. A first year analysis of the program is currently being conducted to evaluate the performance against assumptions and to assess the actual costs and benefits of each program component. This analysis includes statistical comparison of participants versus control groups to assess actual customer demand reduction (Howe and White 1999).

5. ASSESSMENT OF PROGRAMS

As part of the assessment of the Sydney Water Demand Management Program described in Section 4.3, statistical analysis has been undertaken of the residential retrofit program, initially (as a pilot) implemented in Shellharbour, south of Sydney. The methodology used is described in Dziegielewski et al. (1993). Comparison group analysis using winter period demand data shows that the Program resulted in a demand reduction of 18 ± 7 kL/a at the 95% confidence level. Using demand data for spring, the average reduction in demand is 23 ± 5.5 kL/a for each participating household. The Sydney Water Least Cost Planning Study resulted in an estimate of the savings from a residential retrofit program of 27 kL/a for participating households (ISF 2000a).

This equates to an average saving of 74 ML/a (39 - 88 ML/a, or 62 - 100 ML/a for the whole pilot program with 3,517 participating households, based on the winter and spring data respectively), which is consistent with the modelled reduction of 95 ML/a.

An analysis has also been carried out on a program undertaken by Rous County Council and described in Section 4.2, which involved the same retrofitting components as the Shellharbour Residential Retrofit Program. The results of this analysis were that the average reduction in water demand per participating household was approximately 35 ± 26 kL/a at the 95% confidence level, consistent with the estimated savings for participating households of 43 kL/a (ISF 2000b). In the Rous County Council program, data for the flow rates of existing showerheads, knowledge of occupancy rates and other key household attributes made prediction of savings feasible.

6. REGULATION – THE FUTURE

The regulatory framework for water utilities in Australia is highly fragmented, with each of the 8 states and territories having different requirements. The recent reforms in the industry to separate the roles of supplier and regulator, and to encourage a more commercial perspective had led to confusion in the industry about the role of water efficiency. This confusion is solved in the unique case of Sydney Water with the operating licence requirement and a regulator (the NSW Independent Pricing and Regulatory Tribunal) that has explicitly recognised the need to adopt a Total Resource Cost test approach in evaluating water efficiency options. An appropriate framework would be to use price regulation oversight to ensure that investment in water efficiency options was optimised in terms of the costs and benefits from the perspective of both the utility and customers. This would require all capital works and infrastructure proposals to be evaluated in comparison with demand management options prior to approval. This applies not only to major water supply storages or headworks which are effected by growing annual average demand or declining reliable yield. Many of the most costly capital works in are for sewage treatment plants which are facing a hydraulic flow constraint, or water treatment plants that have a peak day constraint that is amenable to a strategy that targets outdoor water use. Similarly drought response strategies should be evaluated to determine whether the use of a targeted demand management strategy can reduce the risk of requiring restrictions.

The other important regulatory measure is the use of water efficiency performance standards for water using appliances and for buildings. Australia regulated for toilet efficiency standards (dual flush toilets) in most states by 1993, but other appliances have proved more difficult. There is currently considerable activity to implement regulation for showerheads, which would provide significant and low cost water and greenhouse gas reductions.

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