WATER EFFICIENCY AND REUSE: A LEAST COST PLANNING APPROACH

S.B. WHITE, Institute for Sustainable Futures
C. HOWE, Sydney Water Corporation

ABSTRACT

Effluent reuse has an important role to play in sustainable water resource management, particularly in reducing the potential impact of the discharge of nutrients and other pollutants in effluent, and reducing the demand on potable water supplies. It is therefore appropriate that increased consideration is being given to effluent reuse by water service providers and regulatory authorities. This paper puts forward a framework for the economic evaluation of effluent reuse options that integrates them with water efficiency options, in order to ensure that objectives are met at the least cost to the community. This framework, called least cost planning or integrated resource planning, means asking the question "how can we meet water related needs at least cost?". Generally speaking, a range of available water efficiency options have a lower unit cost than increasing supply, whether such increase is achieved by augmentation of surface or groundwater supplies, effluent reuse or rainwater tanks. Such options include providing financial incentives for the purchase and installation of water efficient shower heads, taps, toilets and front loading washing machines, as well as providing support for the use of water efficient equipment and processes for commercial, industrial and institutional customers. While there are often compelling reasons to implement effluent reuse options other than the need to decrease demand for water, due consideration should be given to implementing water efficiency options as part of an integrated strategy. Results of two Sydney Water Corporation case studies are described, in which both water efficiency options and reuse options have been considered as part of a least cost planning strategy.

KEY WORDS

Effluent reuse, least cost planning, integrated resource planning, water efficiency, demand management, water conservation

INTRODUCTION

There is an increasing interest in effluent reuse. Some of the objectives that effluent reuse can satisfy include:

- reduction of effluent discharge to waterways;
- reduction in average dry weather flow to sewage treatment plants;
- reducing the ecological impact of nutrients or other pollutants;
- licence conditions or other regulatory requirements;
- community expectations;
- reduction in water demand.

Despite this, the objectives for specific effluent reuse projects around Australia have often not been clear, or clearly specified. Effluent reuse has often been an alternative means of disposing of effluent, hence the dominance of land disposal and irrigation activities. While this option often has the lowest costs and requires the least additional treatment it introduces other constraints, notably:

- market constraints, in that customers must be found who are willing to accept treated effluent for reuse;
- climatic constraints, in that irrigation is rarely required all year and either the reuse potential is limited at times or large storages must be constructed for wet weather;
- there can be environmental and public health risks associated with effluent irrigation schemes unless application rates are carefully monitored, due to the generally low level of treatment.

There has been more interest recently in the potential for effluent reuse to offset the demand for potable water supplies, and it is this objective that is of most interest in this paper. In the following section we outline a methodology for economic evaluation of effluent reuse, and other supply options with water efficiency options.

LEAST COST PLANNING

Least cost planning, also called integrated resource planning, means evaluating the costs and benefits of a range of means of meeting water customers' demand for water related services. Customers need the service that water provides (sanitation, showers, landscapes) rather than the water itself. If the same service (e.g. showers, toilets) can be provided at lower cost to the community by improving efficiency (e.g. installing water efficient shower heads or toilets), then this represents better value than supplying more water. In other words, if the producer and consumer surplus is increased by the water service provider installing water efficient equipment, then this is the economically most appropriate action.

In practice, this means calculating the *levelised unit cost* and *reliable yield* of all supply and demand-side options (see Appendix One) and investing in those options with the lowest cost. This is no different to the process that would be followed when supply options of various kinds are being assessed, except in this case the means of reducing the demand for water are included, in addition to methods for increasing supply.

Least cost planning can, and indeed should, be used as a tool to determine the best mix of resource options to meet customer need. However, as an economic decision-making tool, it presupposes that all the relevant factors can be expressed in economic terms, that is, as a financial cost or benefit. This is difficult at best for ecosystem constraints, and so other methods are required to attribute values to these externalities, or to determine a community consensus of n the best course of action. These issues are beyond the scope of this paper, which is concerned with a framework to compare efficiency measures with supply measures. Consideration of the environmental costs of water supply will act as a driver to invest further in efficiency or reuse.

Least cost planning has been used in the design of many water efficiency programs in the U.S. in particular (Beecher 1996). Examples of programs that have been developed include retrofitting of water efficient toilets, free water audits and financial rebates for non-residential customers, sub-metering programs and shower head retrofitting programs. New York City Council spent $US250m retrofitting toilets and other measures to defer the augmentation of waste water treatment capacity in that city. Similar examples exist in Australia, such as in Kalgoorlie-Boulder in W.A. and on the north coast of NSW (Botica and White 1996; White 1998).

As an example, water from a new major storage and associated water treatment plant with a reliable yield of 24 GL/a supplying at full capacity from 2001 onwards and costing $300m to construct (in 2001) and $3m a year to operate, would have a levelised cost of approximately $1.25/kL, assuming a 30 year analysis period and a 9% discount rate. The variable cost of sewage pumping and treatment could add a further 5-10¢/kL to the cost of water used indoors and discharged to sewer.

On the same basis, water saved by undertaking a program in the current year which results in the installation of water efficient shower heads will cost approximately 13¢/kL. Each water efficient shower head is equivalent to a source of water with a reliable yield of about 25 kL/a, and a capital cost of $40. Similarly each 6/3 litre dual flush toilet that replaces an 11 litre single flush toilet will have a levelised cost of approximately 68¢/kL, being a 35 kL/a source with a $270 cost.

Where a water service provider has no immediate plans for augmentation of the water supply system, the variable cost of the current water supply and sewerage system should be considered for the purpose of determining the least cost means of meeting customers needs. For example, for groundwater sources or areas supplied from considerable distances, pumping costs can be in the order of 10-15¢/kL, while variable treatment costs can be similar, giving total operating costs of 20-30¢/kL, before adding sewage treatment costs.

The levelised cost of effluent reuse options depends on a range of factors, particularly whether the cost of secondary treatment is considered as free. Costs vary from less than 80¢/kL for effluent pumped direct from sewage treatment plants to typical nearby customers, to well over $2/kL for dual reticulation. On average, the cost would be over $1/kL. This is also a typical minimum cost for desalination. A comparison of typical levelised costs for various water efficiency and supply options is provided in Table 1.

Option type	Typical levelised cost to community (¢/kL)
Pricing	0-2
Restrictions	5-10
Shower head giveaway	10-20
Residential indoor assessment/ retrofit	20-30
Active leakage control	20-50
Tap timers/ education	20-50
Non residential efficiency	40-60
Residential outdoor assessment (retic systems)	50-70
Toilet retrofit	70-80
Typical augmentation	80-100
Typical reuse	90-150

TABLE 1 Typical levelised costs for various demand and supply side options.

Having calculated the levelised cost and reliable yield for all the possible supply and demand-side options, including the current variable operating cost of supplying water and treating sewage, a ranking can be made which provides an order of implementation. The reliable yield for water efficiency options will depend on the method used for their implementation. For example, in most cases, education programs designed to influence outdoor water use behaviour will have a more uncertain yield than replacement of water using equipment with more efficient models.

COST RECOVERY FOR WATER EFFICIENCY PROGRAMS

An issue that is often raised in relation to investment in water efficiency options is the cost of foregone revenue and foregone profit due to reduced water sales. The level of foregone revenue is directly related to the marginal price of water. The level of foregone profit relates to the difference between the marginal price and the marginal cost (also called the avoided cost). In many areas, this difference is large, particularly where water service providers use average cost pricing or have inclining block tariffs.

However, when assessed from the perspective of the costs and benefits to the community as a whole, that is, using the Total Resource Cost test (Planning and Management Consultants 1993), foregone revenue is seen as a transfer payment between customers and the water service provider, and has no relevance in a rational evaluation of the cost effectiveness of a supply or demand side option. This is illustrated in Table 2, where it can be seen that the key issue is the relative magnitude of the avoided costs and the combined program costs (or, in the case of a supply side option such as reuse, the capital and operating costs). Where the present value of the avoided costs is higher than the combined program costs the option is cost effective, regardless of the magnitude of foregone revenue.

Parameter	Water Service Provider	Customers	Total Resource Cost test
Costs	program costs (PC) foregone revenue (FR)	customer costs (CC)	-PC-FR-CC
Benefits	avoided cost (AC)	reduced bills (RB)	+AC+RB
Net benefit	+AC-PC-FR	+RB-CC	+AC+~~RB~~-PC-~~FR~~-CC

TABLE 2 Illustration of the method of cost benefit analysis for least cost planning, using the Total Resource Cost test.

Price regulators need to be aware of this, and to allow water service providers to pass through the cost of cost effective water efficiency programs, including the cost of foregone revenue, to customers through increases in variable or fixed charges. The NSW Independent and Regulatory Tribunal (1996) has recognised this methodology as the most appropriate to use when assessing water efficiency options. The methodology has been developed in the 1980's for the U.S. electricity industry, at a time when changes in the regulation of electricity utilities (many of which were and are privately owned) meant that utilities were allowed to pass on the costs of investing in efficiency programs. Subsequently, the methods have also been employed by the water industry in the U.S., particularly by water service providers and regulators in California.

The introduction of competition at the retail level in the electricity industry in the U.K., the U.S. and eastern Australia has curtailed many efficiency programs and led to price competition, which has meant that there has been, from an economic viewpoint, a sub-optimal investment in efficiency. Some re-regulation may occur through the use of tradeable emission credits or targets (EPA 1998). Despite recent discussions on the question of third party access rights in the water industry (NCC 1997), all water service providers currently have a monopoly in their service area, and are likely to continue to do so, and therefore this issue of retail competition has not arisen.

CASE STUDIES – SYDNEY WATER CORPORATION

In this section, two case studies are described in which a least cost planning analysis has been employed.

Sydney Water Least Cost Planning Study

Sydney Water holds an Operating Licence granted by the NSW Government to provide water services. The Licence outlines performance standards for Sydney Water. An audit of compliance with the licence is carried out annually, or at the request of the Minister by independent auditors. It contains a number of requirements regarding water conservation, including a requirement to prepare a demand management strategy (Sydney Water 1996). A section of the Operating Licence relevant to the use of least cost planning states that “Sydney Water must aim over the term of relevant licenses to reduce the quantity of water drawn from all storages on a per capita basis by a least 25% between 1990-91 and the year 2000-01, and by at least 35% between 1990-91 and 2010-11”. (Sydney Water Corporation Operating Licence clause l.5.14). Therefore the objective of the least cost planning process was to determine what options could reduce the demand for water at least cost to the community.

Summary results of the least cost planning study are provided in Table 3. The options shown are ranked in order of *levelised cost* as described in Appendix One. These options are cumulative in the sense that the effect of possible double counting has been removed. For example, the impact of restrictions has been reduced by the estimated savings that would be expected due to the increase in the price of water and the purchase of tap timer kits.

Option	Estimated demand reduction in 2001 (litres per person per day)	Levelised cost (¢/kL)
Pricing	1.95	0.18
Restrictions	1.79	6.3
Smart Showerhead Program	0.72	14
Residential indoor assessment and retrofit	3.41	19
Community residential assessment and retrofit	1.47	25
Active leakage control	7.18	30
Non Residential Program	2.94	42
Hospitality Industry (Olympics 2000) Program	1.26	42
Tap timer kit	0.22	49
Wollongong industrial reuse	2.28	53
Kurnell industrial reuse	1.82	65
Residential outdoor assessment	0.29	67
Washing machine rebate (with energy agencies)	0.44	70

TABLE 3 A proposed least cost program for reducing demand from Sydney Water storages by approximately 25 litres per capita per day in 2001. Note that the two industrial reuse schemes have a low cost due to their large scale and proximity to the reuse opportunity.

Table 4 shows a comparison of the estimated levelised cost of a selection of reuse and rainwater tanks supply options.

Option	Demand reduction (litres per person per day)	Levelised cost (¢/kL)
Wollongong industrial reuse	2.28	53
Kurnell industrial reuse	1.82	65
Potable reuse (116ML/d)	27.6	77
Bondi STP reuse	0.14	93
Golf courses (7) reuse	0.29	147
Rainwater tanks (80% of houses)	12.7	211
Greywater reuse systems (80% of houses)	9.93	244

TABLE 4 A comparison of the levelised cost of a selection of reuse and rainwater supply options..

Upper Blue Mountains Waste Water Strategy

In the Upper Blue Mountains area, served by Sydney Water Corporation, a least cost planning study has been undertaken as part of a waste water management strategy. The objective of the study has been to determine what economic benefits can be provided by improvements in the efficiency of water use and in particular, to determine the impact of such options on the proposed augmentation of the sewage treatment plants (STPs) through the reduction of sewage flows. The potential costs and benefits of dual reticulation of reclaimed effluent was also estimated. Preliminary results indicate that a program of retrofitting water efficient taps and toilets provides net economic benefits to the community as a whole. Economic benefits accrue from water saving, from capital and some operating cost savings from reducing the required ultimate capacity of the STPs. Environmental benefits arise from reduced abstraction of water, and reduced discharge to waterways, including a reduction in nutrient mass loading. Dual reticulation had a levelised cost greater than $5/kL in this situation, compared with an average of approximately 70¢/kL for the efficiency options.

CONCLUSIONS

Water efficiency options and effluent reuse options can often complement each other as part of a program to reduce the environmental impact and the total costs of water service provision. Least cost planning provides a sound framework with which to determine the best mix of options to implement.

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APPENDIX ONE – LEVELISED UNIT COST

There are a number of ways of calculating the cost of water from a supply or from a demand side option. In the context of least cost planning we are interested in ways of comparing different means of satisfying the need for water service, including increasing supply (such as from storages, groundwater sources, pumping stations, effluent reuse and rainwater tanks) and reducing demand (increased efficiency).

The levelised cost means the unit cost of water, levelised over the period of consideration, and taking into account all capital and operating expenditure by the water service provider (WSP) or the customers, and the amount of water saved or supplied.

It is defined here as:

$$L = \frac{PV(coststo\ WSP) + PV(coststocustomers)}{PV(water\ saved\ orsupplied)}$$

where:

L=levelised cost in $/kL

PV(costs)=present value of costs ($) over a given period and at a given real discount rate

PV(water saved or supplied)=present value of the water actually supplied by a source or saved by a demand side or water efficiency option over the same period and using the same discount rate (kL)

Note that some authors do not include the customer costs in the calculation of levelised cost.