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Desalination for Urban Water: Changing Perceptions and Future Scenarios in Australia

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In response to prolonged drought, large desalination plants have been built in Australia's major cities over the last decade. This paper identifies those plants and focuses on the context surrounding the decision to build the plant in Sydney. Whilst a portfolio approach allowed lower cost options for secure supply to be identified – including an innovative 'desalination-readiness option' – perceived uncertainty and political decisions led the state government to build the desalination plant before the carefully considered planning triggers dictated and without revisiting the decision when the drought broke. Media analysis is used to construct a timeline of reported headlines relating to the pre- and post-construction periods including events surrounding heavy rain, overflowing dams and dialogue on desalination being unnecessary and expensive. The paper highlights a disconnect between the planning processes, stakeholder and community engagement and political decision-making. Given desalination is now an embedded feature of water supply in most major Australian cities, scenarios are used to assess the potential role of desalination in the future urban water landscape and broader economy.

1. Introduction

Australia has a population of 23 million. Over 85 % of the population live in coastal, urbanised areas served by a combination of major sources such as dams, groundwater, river abstraction and now desalination. The desalination plants were designed and constructed during one of the worst droughts in Australian recorded history, the millennium drought, which varied across the country but lasted for over a decade, only finally officially ending in 2012. Whilst the majority of water in Australia is used in rural agriculture, cities are often part of separate catchments where residential demand is approximately two-thirds. Commercial and industrial use, as well as system leakage, comprise the remaining one-third. In this context, desalination provides a reliable, rain-independent source of water in coastal urban areas.

2. Contemporary context for desalination: Australian overview

Key statistics for the main reverse osmosis (RO) desalination plants in Australia are shown in Table 1. Since the construction of these desalination plants, heavy rains have filled many dams. Hence, most of the plants are (or are about to be) put on standby, which in many cases will take several months and further investment to reverse. This reflects a significant capital investment (now sunk costs), which lies idle. As a major capital investment across the country, well in excess of 10^9 US$ ($10x10^9$ AUD), desalination is recognized as being a significant contributor to the rapid rise in water supply costs and therefore water price increases in recent years. In 2005 desalination only contributed $1x10^6$ m^3/a. Now the capacity is well over $500x10^6$ m^3/a, over a third of the current demand of the major cities in Australia. This significant increase in desalination has caused an increase in the unit cost (over figures quoted by the International Desalination Association) due to high demand and labour shortages (ATSE, 2012). From an operational perspective desalination is also recognized to have significantly contributed to increasing the energy intensity of the water supply systems despite recent advances in increased efficiency (Cook et al, 2012). For example in the case of Perth, energy intensity of water supply almost doubled from 0.56 to 0.98 kWh/m^3 with the introduction of the first major desalination plant in Australia (Kenway et al., 2008). The

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energy intensity of RO desalination of seawater is typically in the range of 3 to 6 kWh/m^3, with the Gold Coast plant being closer to 3 kWh/m^3, one of the most efficient in the world. (ATSE, 2012). Of course desalination alone is not the only contributor to increases in the capital and operational costs of water with other contributors being major works to transfer desalinated water to the network, inter-catchment transfers, water recycling and water grids each with their own associated high capital and energy costs. Australia's urban water sector consumes <2 % of electricity production (ATSE, 2012) and the energy required to produce water from desalination for a household is the equivalent of running a domestic fridge. However, since the global financial crisis hit Australia in 2009 the public have little tolerance for additional demands on their household incomes and for Australia there is now a significant shift in the water industry to understand customer needs and minimize the impact of rising utility costs.

Table 1: Key statistics for main desalination plants in Australia (source ATSE, 2012)

	Built	Initial capacity ($1x10^6$ m^3/a)	Capacity as a % of annual demand in 2009/10	Cost ($1x10^6$ AUD)
Perth I (Kwinana)	2006	45	18	387
Gold Coast (Tugun)*	2009	49	25	1,200
Sydney (Kurnell)*	2010	90	18	1,890
Melbourne (Wonthaggi)*	2012	150	43	3,500
Adelaide (Port Stanvac)**	2012	100	80	1,830
Perth II (Binningup)***	2012	100	40	1,400

*Standby as at May 2013; **planned standby 2015, ***currently being expanded

3. Sustainable urban water management: an evolving landscape

Historically, water supply systems in Australia have been dominated by 'big dam' and 'big pipe' engineering solutions, that is, the tendency to build large infrastructure to meet growing population needs rather than considering demand management, fit for purpose source substitution or smaller incremental supply options. In the mid 1990s, integrated resource planning (also known as least cost planning) gained traction in Australia as an approach to consider both demand- and supply-side options and seek the lowest cost means of providing water services (Turner et al., 2010). For example, in Sydney, the utility justified major investment in the largest demand management program in Australia. Also during this time significant effort was made to encapsulate the broader social and environmental costs and benefits of options in decision-making. More recently adaptive management and portfolio planning in the face of a changing climate and other uncertainties has been highlighted in planning documents, such as Sydney's Metropolitan Water Plan (NSW Office of Water, 2010).

The future of water service provision is moving towards 'climate resilience' and 'water sensitive cities' and integrated water cycle management is being considered across multiple spatial scales within cities. However, ensuring water supply security for a city, at least cost to customers, within an adaptive management framework and utilizing both centralized and distributed infrastructure, remains a significant challenge for advocates of such a future.

Further issues pertinent to the evolving sustainable urban water landscape (White et al., 2008), including the potential for: scarcity pricing (requiring individual metering of multi-unit dwellings); rural-urban water trading (where relevant); competition in the urban water industry (currently mostly state or local government owned); and community engagement and broader use of integrated resources planning.

With this evolving landscape as a back drop, the following section explores the story of desalination in Sydney. Notwithstanding sophisticated water planning concepts emerging in the water industry over the last decade – and in the planning for Sydney – there has been a disconnect between planning processes, stakeholder and community engagement and political decision-making resulting in over investment of public funds, as in the case of the Sydney desalination plant, as recognized by the Productivity Commission, Australia's independent economic research and advisory board (PC, 2011).

4. Desalination planning, practices and perceptions: the case of Sydney

The story of how desalination was implemented in Sydney has been explored as part of an international comparison (Tal, 2010), an Australian review of desalination plants with a focus on technical and operational aspects (Saliby et al., 2009) and inquiry into Australia's urban water sector (PC, 2011). The context leading up to the construction of the desalination plant in Sydney has also been described in detail as part of a broader discussion on the implications for climate change adaptation and sustainability of drought proofing Australian cities using technologies such as desalination (Isler et al. 2010). The distinct

focus of this paper is to track the perceptions of desalination in Sydney through a combination of a time series analysis of media headlines and the authors' knowledge of the adaptive governance model used.

4.1 Timeline of key milestones for desalination in Sydney

A timeline of key desalination events in Sydney is shown in Figure 1 overlaid on historical dam levels.

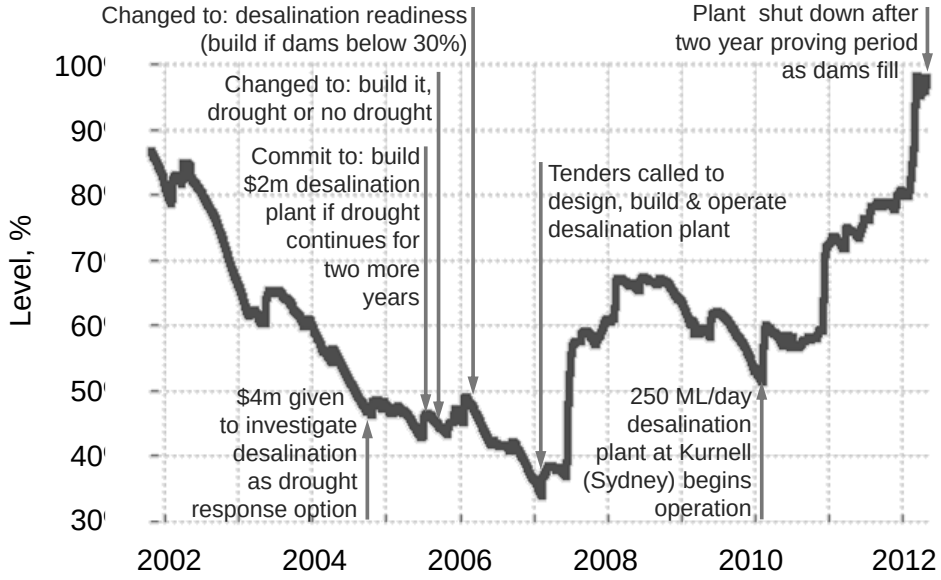

Figure 1: Dam levels in Sydney from 2002-2012 with key desalination decisions/events overlaid

4.2 Changing perceptions of desalination over time in Sydney: media headlines analysis

The method used for the media content analysis was based on charting the top six headlines retrieved in Google news [accessed 10 May 2013] with a search term "desalination Sydney" for pages from Australia. It was undertaken for yearly intervals from 2004 to 2012 inclusive. Headlines were classified as portraying desalination 'positively', 'neutrally', or 'negatively' and each year assigned a defining theme to help relate the changing story. The results are shown in Table 2. In 2004, the beginning of the Sydney desalination story, the then government commits 4 $x10^6$ AUD to investigate the potential for desalination. Both positive and negative headlines were found. In 2005, the focus moves to the detailed 'examination' of the technology, how it compared to other options such as recycling and where it would be built (namely, the seaside location of Kurnell). It provides a mix of positive, neutral and negative stories, particularly relating to cost (more than environmental impact). Later in the year, the planning for the plant to be built is confirmed by the then Premier, Morris Iemma. The potential role of water efficiency does not feature in the headlines. Moving forward to 2006, the plant is put on hold when the government adopts a 'readiness strategy', to build only when dam levels fall below 30 %, that is, with the right approvals in place sufficient time to build the plant before reaching dead storage. Whilst formally adopted, the readiness strategy (part of a real options process) is overtaken by political imperative. In early 2007 dam levels are dropping 0.5 % per week [note the main dam for Sydney holds approximately four years of storage when full to cover infrequent, but prolonged droughts]. Prompted, in part, by concern of storage levels continuing to fall too close to the trigger level of 30 % storage within the caretaker period, between when the state election was to be called and the date of election, a decision was made to tender for the design, construction and operation of the desalination plant. Had the decision been taken to split the call to tender for (i) design from the (ii) construct and (iii) operate – more of the 'readiness' strategy could have been preserved without the cost of the pre-emptive build. In addition, not signing the full contract when the dam levels were at 57 % would have avoided over commitment (PC, 2011). The 2008 headlines of 'wind; rain; residents' refers firstly to the commitment of the plant to be powered by wind power at Bungendore ($140x10^3$ kW). Soon after the announcement to proceed with the desalination plant, it rained and by the end of 2008 dam levels had risen to above 60 %. Finally the local residents featured in the headlines as preparations for constructing the plant progressed. In 2010, the desalination plant was switched on and operated safely. Some headlines during this period are shown in italics, which means whilst they mention desalination in the main article, they are actually focused on other headline issues (often public infrastructure spends e.g. 2011). In 2012, the desalination plant output is reduced as rain causes dam levels to spill.

Table 2: Headlines from 2004–2012 regarding desalination in Sydney (N.B. key to sources of headlines SMH = Sydney Morning Herald; ABC = Australian Broadcasting Corporation)

Year:Theme	Positive	Neutral	Negative
2004: 'Proposed'	Government looks at desalination to alleviate water crisis (*Oct 18, ABC*)		
2005: 'Examined, committed'	Recycling more expensive than desal-ination: Carr (*June 29, SMH*); Desal-ination plant 'too important to debate' (*July 12, SMH*)	NSW desalination plant would be built at Kurnell (*July 11, ABC*); Iemma (Premier) confirms Kurnell desalination plant planning (*Aug 10, ABC*)	Desalination to fill state coffers, not dams (*June 4, SMH*); Sydney desalination plans criticised (*July 10, SMH*)
2006: 'On hold'	PM ponders wish list for saving water (*Sep 30, News*)	Desalination plant put on hold (*Feb 8, ABC*); Sydney desalination plant gets planning OK (*Nov 16, SMH*); NSW Lottery sale proposal 'a gamble' (*Dec 11, The Australian*)	Water plant 'workshop' walkout (*Jan 18, SMH*); Recycling embraced as Sydney's water woes worsen: Water (*May 8, ABC*)
2007: 'Costly to build'		Sydney Desalination plant to double in size (*Jun 25, ABC*) Veolia wins 570 million euro Sydney desalination deal (*Jul 18, Reuters*); Desal plant to cost $1m a week (*Sep 17, ABC*)	Desalination plant energy plans don't help:Greens (*Oct 15, Brisbane Times*) State wants second opinion on water (*Apr 16, The Australian;* Desal plant costings misleading (*Dec 8, SMH*)
2008: 'Wind; rain; residents'		Wind to fuel Sydney's desal plant (*May 13, ABC*); Kurnell residents to be 'compensated' (*Apr 24, SMH*); Hosing the car legal as water rules relaxed (*Jun 20, Stockland Land*)	Water plant branded a bungle (*Jul 17, SMH*); Sydneysiders to pay $126 more for water (*Jun 16, Telegraph*); Kurnell residents protest pipeline, test drilling (*April 22, ABC*)
2009: 'Security= desal+ recycling'	Recycled water secures Sydney's supply 'for 50 years' (*May 7, ABC*)	Water restrictions eased as dam levels rise (*Jun 22, SMH*); Desal dominates discourse on dam decision (*Nov 12, ABC*)	*Rees urged to scrap Sydney Metrorail plan (Oct 16, SMH);* State sues water firm for millions (*Sep 1, The Australian*); *New blow to household bills: electricity up (Mar 12, SMH)*
2010: 'It works; it's safe'	Water plant: wind power to come on line this week (*Jan 22, Cumberland Courier*)	NSW premier switches on Sydney desalination plant (*1 Feb, de-salination.biz*); NSW Premier brings $1.9bn desal plant on line (*Jan 29, The Australian*); Sydney's drinking water is 'completely safe' Minister says (*Nov 6, BusinessWeek*)	O'Farrell pledges $5bn infrastructure spend (*June 10, ABC*)
2011: 'Government infrastructure management'	Boom in renewable energy (Jun 12, Waste Management World)	After the election the hardest sell (*Mar 2, The Australian*); infra-structure attack on NSW opposition (*Feb 24, ABC*); NSW Libs release election costings (*Mar 24, ABC*)	Keneally (Premier) should come out fighting (*Feb 7, SMH*); First home buyers' sting in state budget (*Sep 6, News*)
2012: 'More rain, less desal'		Sydney desalination will halve output due to rain (*Feb 29, News*); $700m pipeline added to desalination sell-off plan (*Apr 5, ABC*); Final run for Sydney desal frenzy (*Apr 27, Intl. Fin. Review*); Minor flood warning as Sydney dam spills (*Apr 20, ABC*)	Barry O'Farrell's year of living cautiously *(Mar 24, The Australian);* Breakfast deals: Casino standoff *(Mar 29, Business Spectator)*

4.3 Proposing adaptive planning practices and a comment on drought restrictions

Whilst the media analysis has highlighted the changing profile of publicly reported issues, innovative adaptive planning approaches were being developed as part of the Metropolitan Water Plans, which now oversee a diverse portfolio of supply and efficiency options to ensure water security. In a system with diverse supply sources (dams, desalination, recycling, rainwater tanks) the established rules relating to temporary drought restrictions and even cultural norms are up for revision. Temporary drought restrictions to mandatorily reduce demand secure supply without the need to invest in new infrastructure. Given that desalination has been introduced – are they still relevant under future scenarios? From a customer perspective: mild restrictions are popular amongst a predominantly water-wise public; only severe restrictions for extended periods are unpopular; and desalination can help avoid these severe restrictions or at least limit their application. In effect, the consumer is paying a higher price on their water bill annually for a more secure supply where deep drought restrictions are less likely. The availability of desalination, also means less water needs to be taken from the Shoalhaven River south of Sydney.

5. Scenarios to explore possible futures for desalination in the urban water landscape

Given the Sydney case study, future scenarios are now explored to ensure the right questions are asked regarding desalination in Australia. The costs and energy intensity of desalination are reducing and its global deployment is rising rapidly. This is occurring at a time when constraints in fresh water continue to grow. The following discussion explores plausible trajectories for desalination and future considerations for Australia – both as part of local urban water landscapes, as well as a sector. The Sydney case study highlights the need to strategize under future scenarios. Three global water scenarios for 2025 (Gallopín and Rijsberman, 2000) are intended as thought-starters for exploring plausible futures for desalination in Australia with respect to (i) the Australian urban water landscape and (ii) economic potential of desalination for Australia. Scenario summaries from Gallopín and Rijsberman (2000) are quoted, drawing on major forces impacting water including economics, demographics, technology, social, environmental, and governance factors.

“The alternative scenarios are: Business-as-Usual (BAU), representing the future trajectory in case those who don’t believe in the crisis prevail, and no major policy or lifestyle changes take place; Economics, Technology and Private Sector (TEC), which could result from policies favoured by those who rely on the market, the involvement of the private sector and mainly technological solutions, and largely national/local or basin-level action; and Values and Lifestyles (VAL), that could materialize through a revival of human values, strengthened international cooperation, heavy emphasis on education, international mechanisms, international rules, increased solidarity and changes in lifestyles and behaviour.” (Gallopín and Rijsberman, 2000)

Table 3 (overleaf) positions some of these issues for Australia within the three future water scenarios. Whilst the scenarios are illustrative of plausible futures rather than predictive, they highlight contrasts, both in the ends achieved and the means to achieve them. These may be in terms of technology and governance and the differences in benefits and risks when looking at desalination as a component within the local urban water landscape and within the Australian economy in the Asian century.

6. Conclusions

This paper has provided a brief overview of the rapid rise of desalination in Australia, alongside the changing urban water landscape and sophisticated discussions in Australia relating to the need to move towards diverse water portfolios that provide ‘climate resilience’ and ‘water sensitive cities’. It also highlights the complexity involved in adaptive management and governments implementing new desalination technology, using Sydney as a case study. And how despite good process involving multiple stakeholders and community engagement there can be a disconnect between such processes and political decision-making. This is at odds with the urban water planning dialogue and can result in significant over investment of public funds and sharp shifts in the perception of the value of desalination over relatively short periods, exacerbated by the media. These insights are used to position future issues and possibilities for desalination in Australia with respect to local urban water futures and the economic potential of the technology. The scenarios highlight a wide range of plausible futures for the role of desalination in Australia’s urban water landscapes and the Australian economy. They also highlight that while some aspect of the scenarios could be policy driven, such as increased completion and privatisation in the water sector or increased citizen voices in deliberative governance, other drivers, such as the impacts of climate change on existing supplies or future (global) energy prices, are outside water policy-makers control.

Table 3: Water scenarios (Column 1); Australian implications added in this paper (Columns 2 and 3)

Water scenario (from Gallopín and Rijsberman (2000) global scenarios)	Urban water landscape implications in Australia	Desalination sector's role in the Australian economy
1. Business as Usual Lower energy costs and improvements in technology sharply reduce the cost of desalination, it becomes a local solution in a number of cases for municipal and industrial water supply. Desalination, however, does not make a dent in the overall water problem, mostly accounted for by agricultural water demand.	- desalination continues as part of diverse portfolio of water supply - as utilities seek to recoup the costs of (often idle) desalination by selling more water, the focus on water efficiency championed during drought and embraced by the community fades	- after a period of intense activity to build desalination in major cities across the country, activity remains static – both in building new plants and in future research - money (and political will) not available to invest in additional desalination development; Australia's position as global player declines
2. Economics, Technology and Private Sector Desalination rapidly becomes the technology of choice (as prices fall sharply), for domestic & industrial use in water scarce areas where brackish or salt water is close by. The same membrane technologies also replace chemical treatment for drinking water purposes.	- desalination dominates urban water landscape over recycling, coupled to clean energy it gains a green image as a technology of the future despite high energy requirements. Desal. underpins development of water grids which can be sold to private operators	- Australia privatises utilities in technology-led revolution in urban water, including using smart meters - economic value of desal. sector grows strongly; exports of know-how and technology globally - development of water grid linked to increasing food exports to Asia, despite increased environ. impacts
3. Values and Lifestyle Cheap and effective solar powered desalination is used in many arid and semiarid countries for domestic water supply and is increasingly affordable even for irrigation. Water supply and sanitation are de-coupled… Municipal water supply is supplemented by extensive use of reclaimed urban wastewater for non-potable uses.	- cheap, smaller scale desal. supports move to distributed systems - citizens have strong voice in deliberative governance of a resource efficient sector - urban water-energy-food nexus integrated with recovery of nutrients from wastewater including phosphorous	- there are pockets of excellence in desalination in Australia, but the cost reductions and innovations have been imported from overseas; exports are low - cheap and effective solar desalination sees increased use for irrigation of crops for domestic self-sufficiency

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