Innovative water features at Zhangjiawo (near Tianjin), China.

Conserving urban water resources cuts greenhouse gas emissions

Jerry Yudelson
Author and founder of Green Buildings Consultancy Practice
Yudelson Associates

Urban water supply, treatment and sewage disposal consume significant amounts of electricity and fossil fuels, almost unnoticed. Without acting to reduce urban water consumption, planners can overlook a significant means of reducing carbon emissions. Fortunately, there are effective water conservation tools available to policymakers such as pricing, regulation, education and incentives. Green buildings and sustainability expert, Jerry Yudelson, proposes a 10-step programme for preventing urban water crises, while at the same time cutting carbon emissions from the water cycle.

Electricity generation requires significant water supplies in most situations, whether in a thermal power plant fuelled by coal, oil, natural gas (methane) and nuclear, or in concentrating solar power (currently the most cost-effective form of solar power generation). For plants located along coastlines, seawater can be used for cooling but, for power plants located inland, massive fresh water withdrawals are required. In fact, in the US, nearly half of all freshwater withdrawals are for cooling thermal power plants.

Water supply, however, is also a large consumer of electricity, primarily for pumping, conveyance, water treatment, distribution and sewage treatment processes. When water is transported long distances or withdrawn from ever deeper groundwater sources, significant electricity is needed for pumping. Electricity and/or fossil fuels are also consumed in great quantities in thermal and distillation processes used for seawater and brackish water desalination.

So, there's no escaping this conundrum: Growing populations worldwide will consume ever-greater quantities of water, with greater problems as urban populations grow ever more dominant. In turn, these urban areas will require ever-greater quantities of energy, which will require ever-larger quantities of water for thermal power production.

The Water/Energy Nexus

Water and energy are inextricably linked, now and forever. Without a reliable energy supply, there can be little water supply; without a reliable water supply, there can be only limited energy production. This intimate relationship is called 'the water/energy nexus'. Even a rapid growth in renewable energy supply will not soon solve this problem.

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A centre of excellence for the water/energy nexus in the US is Sandia National Laboratories in New Mexico. One engineer Michael Hightower, who leads many studies of water and energy, says, "In the next five to 10 years, we will see significant changes in energy systems and their need and use of water. The reason behind (this renewed interest in water use and consumption in electric power generation) is a combination of older infrastructure needing to be replaced and new power infrastructure needing to be built that could significantly impact water use and consumption in the next decade and beyond."

He concludes that there is no 'magic bullet' that is going to provide energy supply for growing water demands and water supply for growing energy demands. This situation requires an integrated planning effort that considers future water and energy needs together, one that develops different solutions for different regions within a country, and which relies heavily on water conservation investments and integrated planning of water and energy infrastructure.

The water/energy nexus in California

Studies by the California Energy Commission have calculated the energy intensity of the water use cycle in the state, shown in Table 1. Energy use for the water cycle in southern California, where most water comes from hundreds of miles away, is dominated by conveyance (transportation), because of both the distances involved and lifting water more than 900 metres. In northern California, most of the water supply flows by gravity from the Sierra Nevada Mountains to the urban centres.

In California, water supply and wastewater treatment accounted for almost a fifth of statewide electricity use and 32 per cent of all natural gas use, generating 106 million tonnes of carbon dioxide-equivalent emissions per year. This intensive energy use makes water conservation the single most cost-effective means of greenhouse gas (GHG) reduction in California!

While California might be an extreme case of the energy cost of water supply and treatment, this example illustrates how future energy and water supplies have to be jointly considered.

Table 1. California (US) State water supply energy requirements

Water Use	California	
	(Northern) kWh/million gallons (kWh/ML)	(Southern) kWh/million gallons (kWh/ML)
Conveyance	150 (40)	8,900 (2,351)
Water Treatment	100 (26)	100 (26)
Distribution	1,200 (317)	1,200 (317)
Wastewater Treatment	2,500 (661)	2,500 (661)
Regional Total	**3,950 (1,044)**	**12,700 (3,355)**

The effect of climate change on water supplies

Without concerted action, growing urban populations will require considerably more freshwater than is being produced by most countries today and far more than is widely considered available. In addition, global climate change will have adverse effects on current water supplies.

> *"Water supplies will be diminished because of warmer temperatures, greater seasonal and annual fluctuations in rainfall, and reduced summer stream flows."*

Most climate change analyses show that water supplies will be diminished because of glacier melt, warmer temperatures, greater seasonal and annual fluctuations in rainfall, and reduced summer stream flows. Therefore climate change will adversely affect our ability to deliver adequate water supplies to meet the demands of growing populations, not only the direct demands for urban water supplies, but also significant demands for agricultural use, energy production and electricity generation, and biofuels production. Climate change will likely decrease our surface water supply capacity and, because of the over-pumping and drawdown of aquifers worldwide, available groundwater supplies will also decrease.

Carbon-neutral water suppliers

Western Water, an Australian water supplier serving parts of suburban and rural Victoria, a state northwest of Melbourne, developed a plan to become carbon neutral by 2017. They plan to do this by increasing the energy-efficiency of their pumps, using solar-powered (photovoltaic) mechanical aerators at sewage treatment plants and buying green power (from solar, wind and biomass resources) from outside suppliers. The net annual reduction in carbon emissions is estimated at 23,000 tonnes. This is a programme that most water suppliers and sewage treatment operators could easily emulate. Based on ratepayer surveys, Western Water found that consumers were willing to pay up to AUS$30 per year – about US$2.50 per household per month – to achieve these reductions.

The range of possible solutions

In researching the prevention of urban water crises, I developed a programme that any country, province or city can employ to reduce urban water consumption, increase green jobs and promote social equity in access to clean water. Many countries have already acted to reduce urban water consumption. In the case of extreme drought,

Table 2. The 10-step programme for preventing urban water crises

Measure	Potential savings*
1. Reduce water use in non-residential buildings through pricing and process changes, as well as fixture/appliance retrofits	20 to 40 per cent
2. Reduce home water use through behaviour change and fixture retrofits	20 to 40 per cent
3. Recycle and reuse site-generated greywater, rainwater and blackwater (sewage)	10 to 30 per cent
4. Reduce landscaping water use, both residential and non-residential applications, through use of weather-based irrigation controllers	20 to 40 per cent
5. Create water conservation pricing in rate structures, to penalise high-volume and/or wasteful users	20 to 35 per cent
6. Water utilities provide rebates and incentives for conservation retrofits	5 to 15 per cent
7. Change building codes to allow onsite water recycling	5 to 30 per cent
8. Train green plumbers to identify and install water efficiency measures	N/A
9. Promote water-efficiency labelled homes, fixtures and appliances	5 to 20 per cent
10. Meter and measure water use, eliminate waste, use only water required by plants in each climate zone	5 to 30 per cent

** Not all savings are cumulative, as each reduces demand from a lower baseline.*

Australian urban areas have successfully reduced water use below 150 litres per person per day, as has a concerted effort in heavily urbanised Singapore. By contrast, water use in the relatively water-rich US averages 150 gallons (567 litres) per person per day. The contrast demonstrates the considerable room for improvement that can take place without affecting urban lifestyles.

The 10-step programme

Preventing the next urban water crisis will take a combination of measures that include: introducing new technology, changes in water pricing, environmental considerations, financing infrastructure upgrades, new institutional arrangements and inducing behavioural changes in residents who use the water. In this context, consider this 10-step group (Table 2) of measures behind which water planners and citizens can unite, from the immediately possible to long-term fixes that will depend on the water issues in a specific region, as well as local politics.

“Preventing the next urban water crisis will take a combination of measures.”

Many of these measures will lead to ‘green jobs’ in the water industry, from performing home and building water audits and renovations to installing rainwater and greywater harvesting systems, etc. Each action leads to both water savings and reduced GHG emissions.

Implementing the 10-step programme

1. The first step is to construct, renovate and operate non-residential buildings to reduce water use, including reducing energy use (in large buildings, this measure also reduces water use in cooling towers). In new building design, one can mandate use of an accepted third-party rating and certification system, such as LEED, BREEAM, Green Star, CASBEE, etc. In existing buildings, retrofit fixtures to reduce usage by 30 per cent.
2. Reduce water use in the home, starting with water audits, installing efficient technologies and inducing changes in behaviour through education, better real-time information and pricing.
3. Recycle, capture and reuse water more than once, the basic principle behind greywater, rainwater and blackwater (sewage) recycling technology and practice.

Figure 1: A 6-Star Green Star-rated building, Council House 2 in Melbourne, Australia, pioneered an urban innovation, ‘sewer mining’ of blackwater for treatment and reuse in buildings.

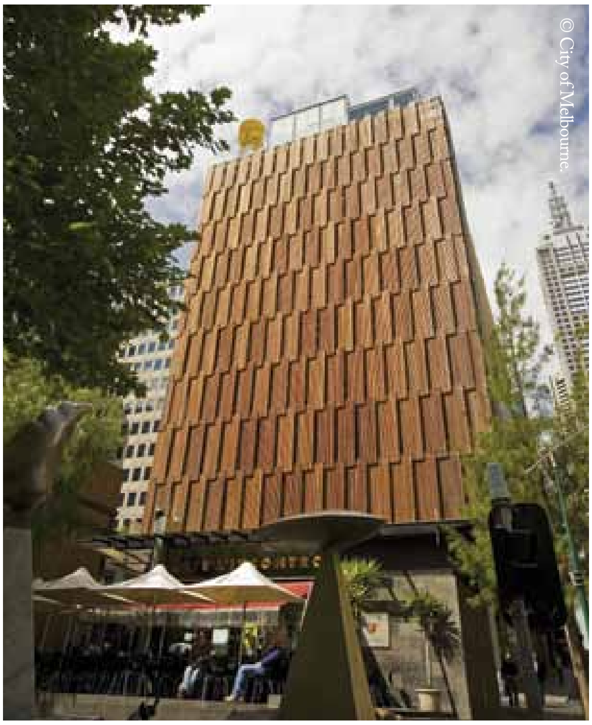
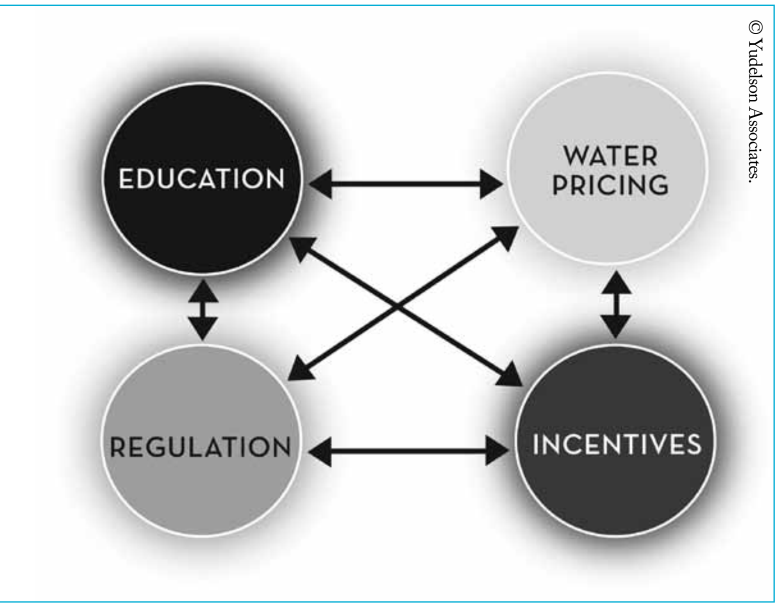


Figure 2: Four basic water demand management/conservation tools are regulation, education, water pricing and financial incentives.



The key is to match water quality of the supply source with required water quality at the point of demand. Figure 1 shows a creative use of blackwater in cities.

4. Reduce water use in landscaping on building sites, with effective irrigation technology and revised plant choices, emphasising native and adapted vegetation (called 'xeriscaping').
5. Water pricing should be structured so that rates are steeply tiered, rising with increasing use, with at least three tiers – preferably five or more – resulting in significant economic penalties for water waste and excessive water use. This brings market incentives effectively into the picture without harming the poor.
6. Water agencies should focus on conservation measures first; these usually reduce water use by 15 per cent or more. Most urban systems have the potential to reduce their total demand anywhere from 25 to 45 per cent today with relatively straightforward approaches such as reducing infrastructure leakage and imposing outdoor watering restrictions. Figure 2 shows four basic demand management tools for urban water managers.
7. To accommodate new water technologies, codes such as the International Plumbing Code need to be changed to allow for much more on-site treatment and reuse, without losing their essential focus on protecting public health and safety.
8. The entire plumbing industry, including for example more than 40,000 plumbers in the US, needs to be trained in green plumbing practices. By working with water agencies, vocational schools, labour unions and local colleges, many new jobs can be created by retrofitting millions of inefficient fixtures across a country and introducing new efficiency technologies.
9. Rapid adoption of new water efficiency labelling schemes, (such as those found in Australia, Singapore and the US), for new and existing homes, along with other green building and energy performance labels will directly and indirectly reduce water use.
10. Meter and measure all aspects of water uses (this could even be Step 1): 'What gets measured, gets managed.' With today's technology, people can use the internet to get real-time data about their water use. Knowing daily, even hourly, water use in a simple, readable and understandable format can affect behaviour and reduce water consumption.

> *"The key to reducing urban water consumption is to work on all fronts at once, in a coordinated manner."*

To prevent an urban water crisis and to reduce carbon emissions from the water cycle in your country or region, begin by getting cities and water agencies to embrace the 10-step programme outlined above. Individuals can start at home with a water audit, a series of low-cost and no-cost measures that can reduce water use by 15 per cent right away and installing water-efficiency-labelled appliances as they come available. The key to reducing urban water consumption is to work on all fronts at once, in a coordinated manner, with retrofit incentives, technological and process changes, rate structures, code modifications, public education and technical assistance.

Jerry Yudelson *is founder and CEO of the green building and sustainability consulting practice, Yudelson Associates. He is a professional engineer with more than 25 years' experience in water conservation, environmental planning and green building design. He is a keynote speaker at conferences worldwide and the author of 12 books on green building, green homes, green development and water issues.*

Yudelson Associates *provides consulting services in green building, green development, sustainability planning and technology research for corporate, governmental, utility and institutional clients in North America. The firm provides project management services for LEED green building certification and advises companies on market introduction of green technologies. The firm's research services focus on new energy technologies and markets, largely for corporate and institutional clients.*

Yudelson Associates
P.O. Box 18138
Tucson, AZ, 85731, USA
Tel: +1 (520) 207 9759
Fax: +1 (520) 844 6944
Email: jerry@greenbuildconsult.com
Website: www.greenbuildconsult.com