Urban Water Security Research Alliance

Indirect Energy Impacts of Urban Water Choices

Steven Kenway

Life Cycle Analysis and Integrated Modelling Project

Urban Metabolism and the Water-Energy Nexus PhD

18 August 2009

Queensland Government

CSIRO

Griffith UNIVERSITY

THE UNIVERSITY OF QUEENSLAND AUSTRALIA

Key Messages

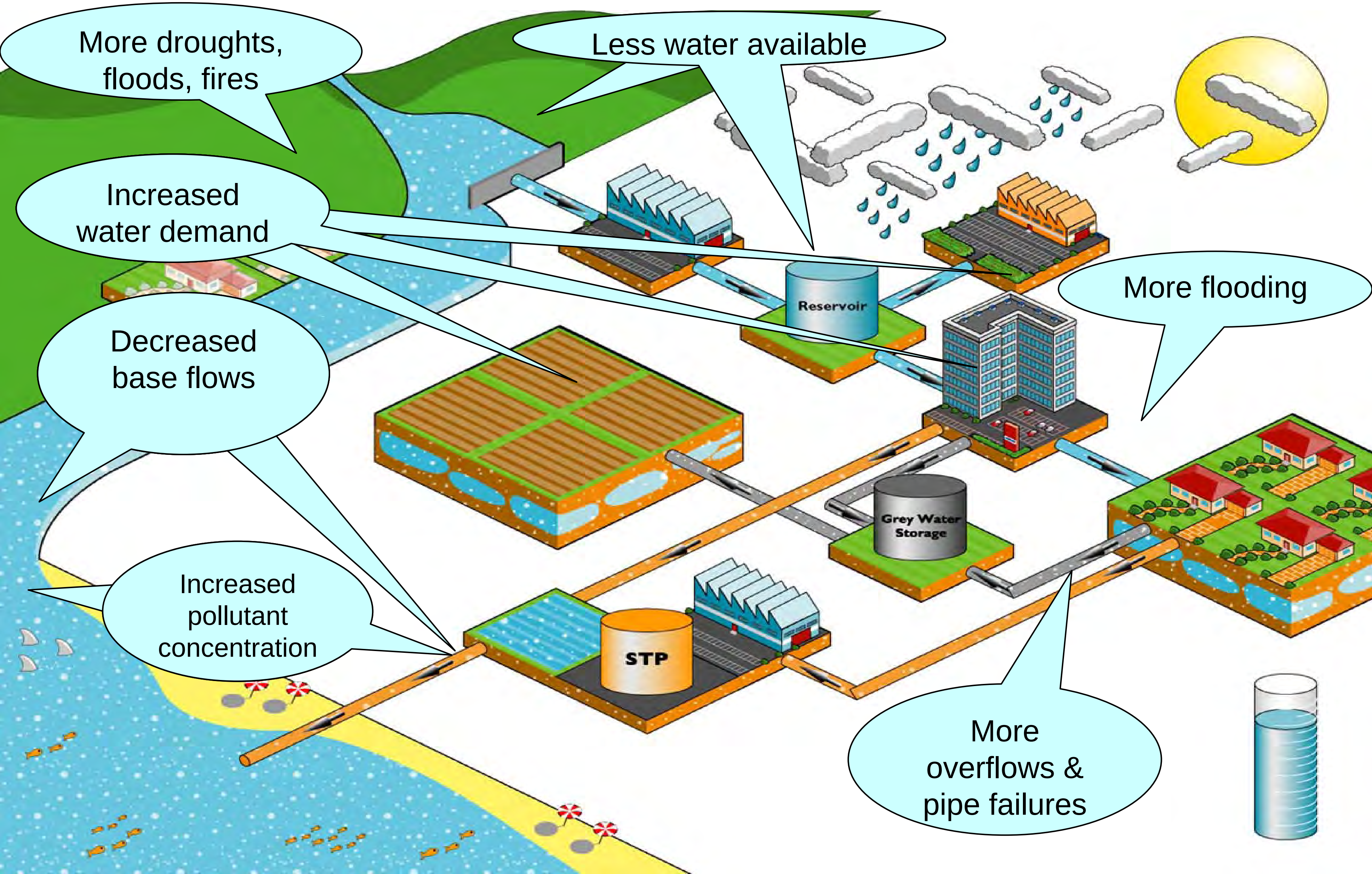
A 15% saving in residential hot water could completely offset all energy use by water utilities in 2006-2007

Utility energy use set to triple by 2030 assuming current water sources continue to yield at existing rates

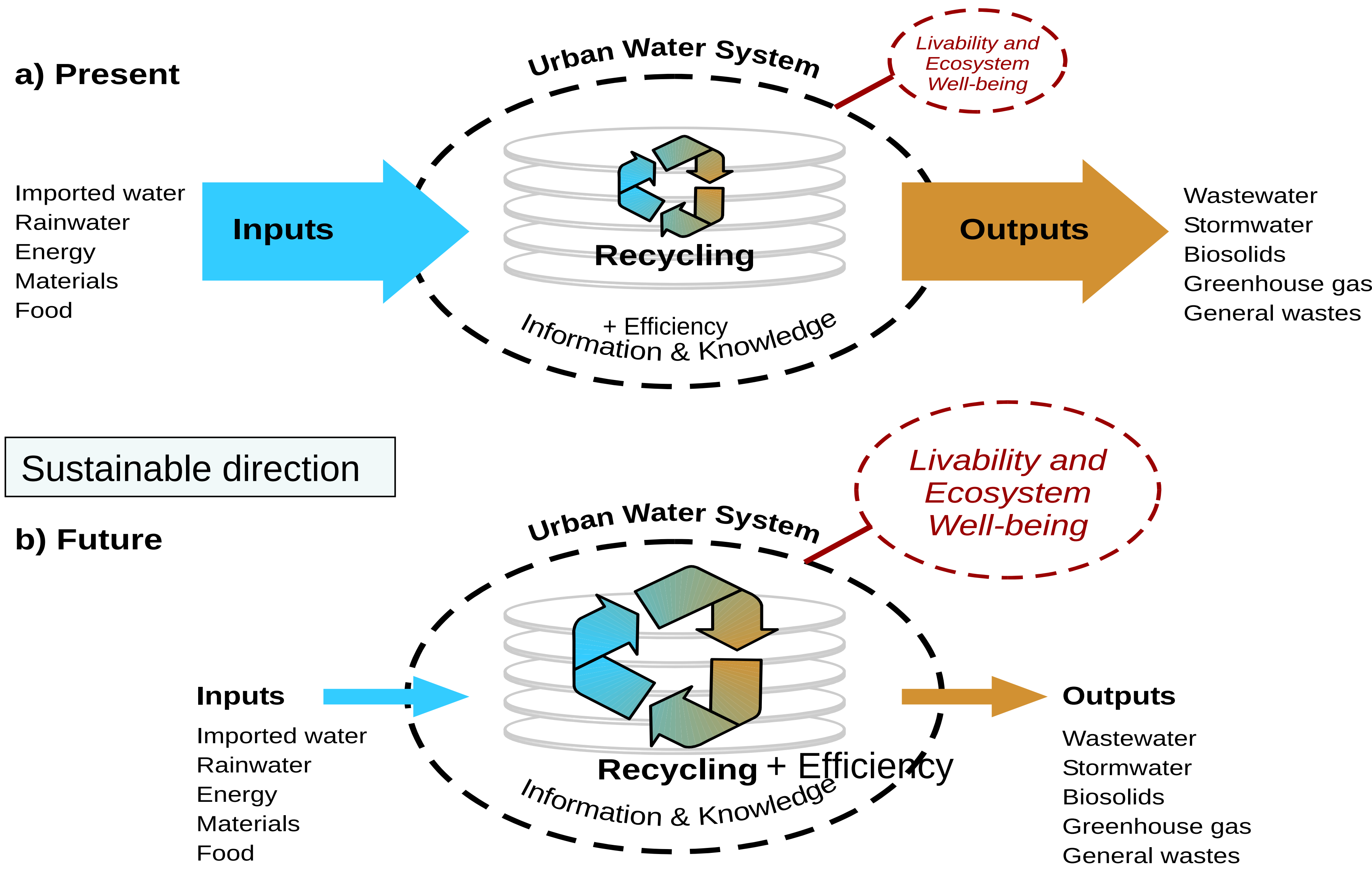
Looking outside our typical “system boundaries” will help identify opportunities for energy and water savings.....many opportunities exist

Urban metabolism principles will help identify solutions

What does climate change mean for urban water?



Urban metabolism and water



Energy use in water provision, consumption and "total urban system" for 2006-07

	Energy Use (PJ/a)			Energy (% of urban system)		Utility energy use as % of hot water energy use
City	Water Utility (W)	Res Hot Water (R)	Urban system (T)	Water utility =W/T	Res hot water =R/T	
Sydney	2.7	14	949	0.3%	1.5%	19%
Melbourne	1.3	15	1045	0.1%	1.4%	9%
Brisbane	0.5	3	561	0.1%	0.5%	15%
Gold Coast	0.2	2	157	0.1%	1.3%	11%
Perth	1.1	6	597	0.2%	1.0%	19%
Adelaide	1.3	6	242	0.5%	2.5%	21%
TOTAL	**7.1**	**46**	**3552**	**0.2%**	**1.3%**	**15%**

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By 2030, with 25% population growth…and existing supplies

26-36PJ	(300 L/cap/d)	= 260-400% increase
16-41PJ	(225 L/cap/d)	= 130-200% increase
7PJ	(150 L/cap/d)	= 0% increase

A problem

Energy use by utilities is set to grow 300-500% by 2030. Simultaneously, investment in urban water security is at unprecedented levels. The national aim is to reduce ghg emissions by at least 5-15%, other countries are targeting 80% reduction.

An opportunity

The water sector has low direct (0.2%), but large indirect (3-6%), influence on total urban energy use.

Literature review excerpts

- To find sustainable solutions we mush ensure that [water, energy and climate change] we address all three in a holistic way. It is not practical to look at them in isolation…. When you have an energy problem, you have a water problem and vice versa. *(World Business Council on Sustainable Development March 2009).*

- The US Water-Energy Nexus Roadmap articulates $250M US research over 5 years (for Group 3 of 7 alone) to develop 1/ consistent frameworks and standards, 2/ policy and economic models, long-term scenarios, water rights models, integrated infrastructure planning and co-locating. *(Sandia National Laboratories 2008).*

- "The literature on water use contains little information on energy use integral to water end use beyond domestic fixtures and appliances…… This is an area of great significance for future research and energy and water policy." *(Cohen et al. 2004, Energy Down the Drain p. 18).*

Water-Energy Nexus Studies

Objective of study	Dimension of Study: Technology	Environmental	Economic	Social	Political / Legal	Scale of study: Appliance	Building/Facility	Water system	City	Catchment	State	Nation	Globe
Water/wastewater infrastructure impacts on energy use	a,b,c,d,k, o,w,t,v,x, y	a,b,c,o,w ,t,x	o,x		o,t,x	w	k,v	a,b,d,v,x	t,y	c,	o,x		
Residential water use impacts on energy use	g,h,p,q,r, v,x,y	g,h,p,q,v ,x	m,s,x	s,		p,q,r,v	p,v	m,v	s,v	h,	x,y	g,	
Agricultural water use impacts on energy use	g,h,l,x	g,h,l,	i,j,	l,						c,h,j	l,x	g,i	
Industrial/commercial water use impacts on energy use	l,x						l,				x		
Energy infrastructure impacts on water use or flow	o,e,f,x	o,e,f	o		o,e						o,e,f,x		

a/ Stokes and Horvath 2006 (San Francisco, LCA/Input-Output)	k/ Nowak 2003 (Austria,	
b/ Lundie et al 2004 (Sydney, LCA)	l/ De Monsabert 1998 (US Fed. Facilities, Numerical Model)	
c/ Cohen et al 2004 (Columbia, Numerical Model)	m/ Hansen 1996 (Denmark,	w/Gleick 2009 (Bottled water)
d/ Cohen et al (San Diego, Scenario Analysis)	o/ Marsh 2008 (NSW, Input-Output)	x/ Californial Energy Commission 2005
e/ Antipova 2002 (Kyrgyzstan, Optimisation)	p/ Flower 2007 (Melbourne, Numerical)	y/ Cohen et al 2004
f/ Nunn 2002 (NSW, LCA)	q/ Mithrane and Vale 2006 (New Zealand, LCA)	
g/ Leavesly 1996 (USA)	r/ Retamal 2009 (Sydney, Numerical)	
h/ Cohen 2004 (Westlands Water, USA, Numerical Model)	s/ Lenzen 2004 (Input-Output)	
i/ Kumar 2003 (Western India)	t/ Kenway 2008a (Melbourne, Systems Dynamic)	
J/ Shuck et al 2002 (Kern County Califronia)	v/ Kenway 2008b (Australia, Numerical)	

Substantial data drawn from Marsh 2008, Retamal (2009) and also Cammerman (2009)

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Residential water use impacts on energy use	g,h,p,q,r, v,x,y	g,h,p,q,v ,x	m,s,x	s,		p,q,r,v	p,v	m,v	s,v	h,	x,y	g,	
Agricultural water use impacts on energy use	g,h,l,x	g,h,l	i,j,	l,						c,h,j	l,x	g,i	
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Energy infrastructure impacts on water use or flow	o,e,f,x	o,e,f	o		o,e						o,e,f,x		

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Examples of the links
For a conceptual city of 12 million people

Use of the water "product"

- 46 PJ (1.2%) in residential water heating (showers, baths, taps, appliances) is influenced by water conservation programs, efficient appliance rebates and customer information programs
- 60 PJ (1.4%) in non-residential water heating (steam production, air-conditioning blow down and commercial water heating for varying purposes) influenced by the technology, appliance and industry mix in cities

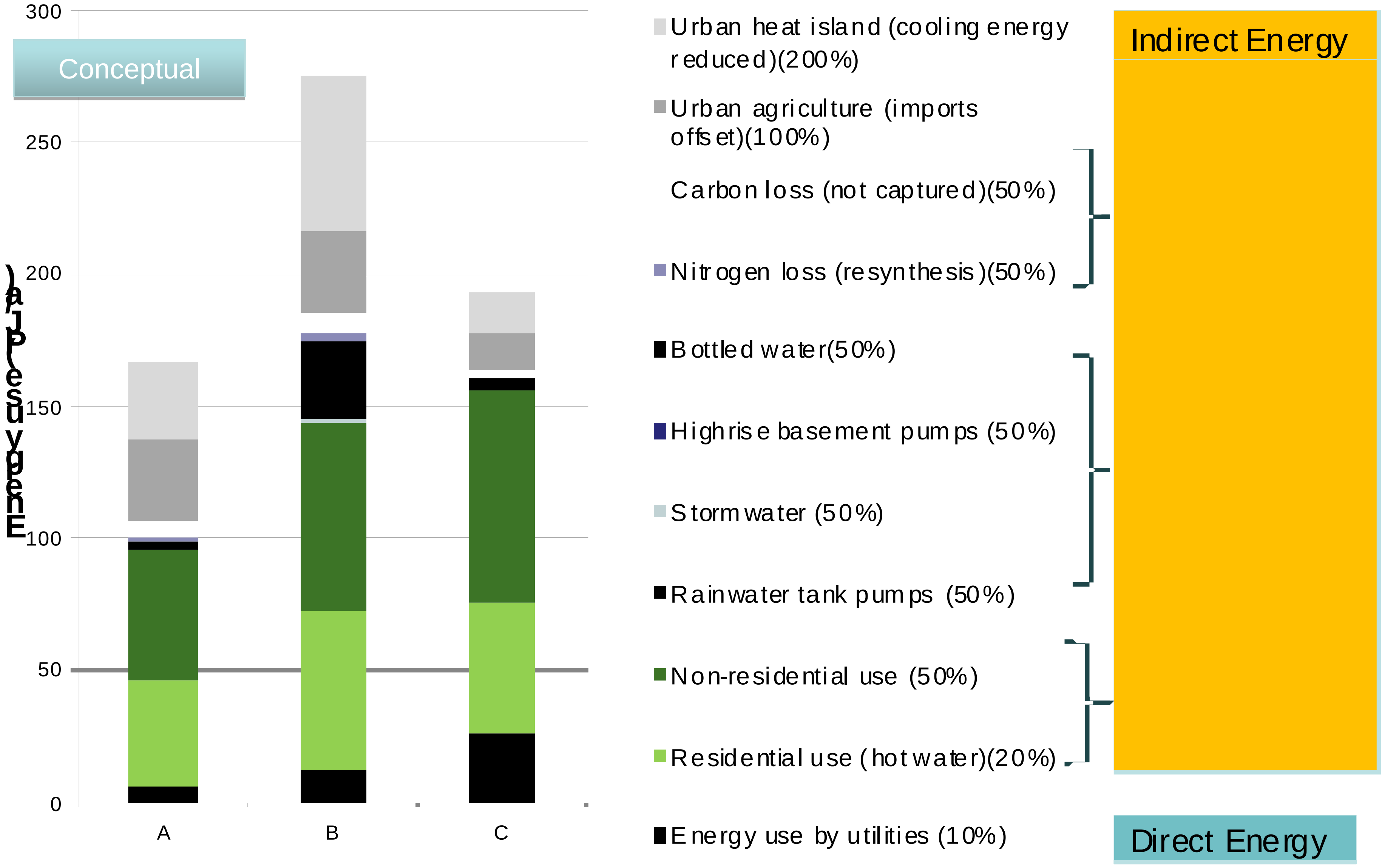
Energy demand associated with alternative or competing supplies (2-30 PJ)

- energy demand of alternative water supplies such as decentralized water sources (private bores and rainwater tanks which can be of high energy intensity due to the small system components and motors)
- bottled water production (has around 1000 times the energy density of public water supplies)

Other indirect influences

- nutrient loss and resynthesis, renewable energy harvesting (methane) (3-8 PJ)
- additional air conditioning or cooling tower energy use in cities associated with the urban heat island effect (15-60 PJ)

Direct and indirect influence of water management on energy use



Research questions - examples

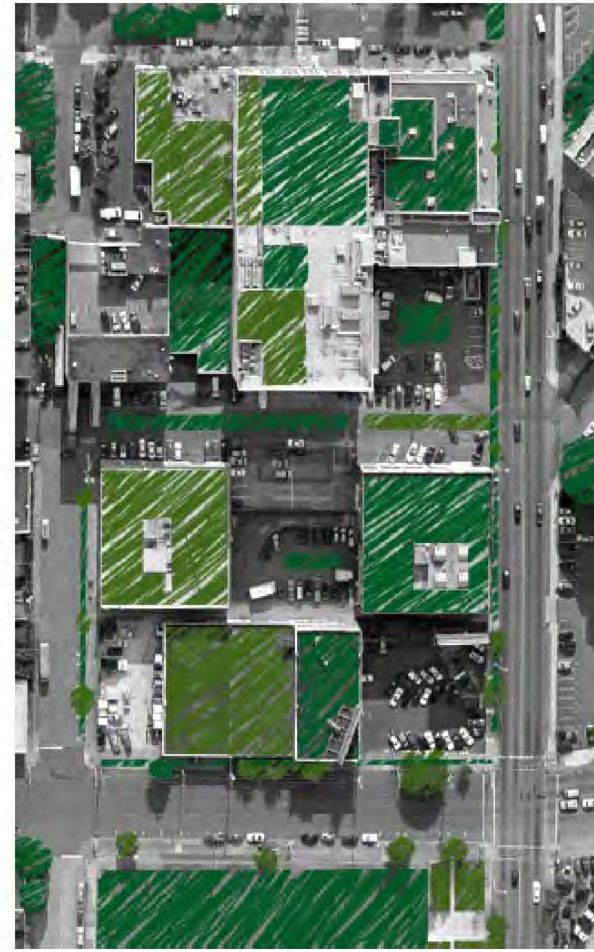
- *How does urban water management affect urban systems energy use - directly and indirectly?*
- *Can water-related energy use be correlated with other input variables? (e.g. total or indoor water use, appliance stock, industry mix, etc).*
- *How would energy and water use change with technology ? (e.g. change in industry processes, implementing water-efficient savings programs targeting hot water, urban greening)*
- *How confidently can we estimate water-related energy use for arbitrary cities given rudimentary data?*

Green Factor Landscape Code – Seattle, US

Pre-Settlement Conditions

Historical Urban Development

Source: Steve Moddemeyer 2009



Urban Greening

Source: MKA

Putting it all together

SKYSCRAPERCITY.COM RESIDENCE ANTILIA IN MUMBAI RELIANCE INDUSTRIIES ARCHITECTS PERKINS + WILL

Source: Steve Moddemeyer 2009

Conclusions

- Direct energy use in urban water is a small proportion of total urban energy use (0.2%). But growing rapidly.

- When we consider indirect influences, water sector policy has an influence on a much greater pool of energy use and ghg emissions (3-6% estimated).

- System boundary is critical. What are we comparing and what are we optimising?

Reference basis

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Thank you

www.urbanwateralliance.org.au