Unclassified **ENV/EPOC/GSP(2008)21/FINAL**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development

11-Mar-2009

English - Or. English

ENVIRONMENT DIRECTORATE
ENVIRONMENT POLICY COMMITTEE

Working Party on Global and Structural Policies

ALTERNATIVE WAYS OF PROVIDING WATER: EMERGING OPTIONS AND THEIR POLICY IMPLICATIONS

JT03260941

Document complet disponible sur OLIS dans son format d'origine
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ENV/EPOC/GSP(2008)21/FINAL
Unclassified
English - Or. English

FOREWORD

Reused water (either reclaimed water or grey water reuse) is increasingly considered a sustainable source for some uses of water. It is regarded as one option to address the increasing mismatch between available water resources and rising demand, in both OECD and developing countries. Reused water can be supplied from either centralized or decentralized systems.

This report reviews the pros and cons of alternative sources of water (reused water and rainwater) and of decentralized systems to collect, produce and use them. It assesses lessons learned and the main policy issues which have to be addressed before such alternative ways of providing water can be widely applied; the focus is on urban areas in OECD countries. The report builds on the analyses developed in the context of the OECD project on Infrastructure to 2030 (OECD, 2007a, b), on a literature review and on a series of discussions with experts.

This report is part of the wider OECD Horizontal Water Programme on "Sustainable Financing to Ensure Affordable Access to Water Supply and Sanitation". The main conclusions of the OECD Horizontal Water Programme are synthesized in a synthesis report (OECD, 2009) and in a series of analytical reports (available at *www.oecd.org/water*).

The report was written by Xavier Leflaive, Principal Administrator, OECD, Environment Directorate, Environment and Globalisation Division. It has benefited from discussions during the SIWI – GWP – EUWI Workshop on Progress in Financing Water Services at the Stockholm Water Week (August 2007) and the OECD Expert Meeting "Sustainable Financing for Affordable Water Services: From Theory to Practice" (November 2007).

The contributions of following experts who have taken time to answer questions and share ideas in the course of this and related projects are gratefully acknowledged: Jeff Ball (Orenco Systems), J. Freedman and James W. Hotchkies (General Electric), Peter Gleick and Meena Palaniappan (Pacific Institute), Hans G. Huber (Huber Technologies), Michel Le Sommer (Le Sommer Environnement), David Lloyd Owen (Envisager), Dominique Lorrain (EHESS), Jack Moss (Aquafed), Peter Shanaghan (USEPA), James Winpenny (Wychwood Consult).

The report benefited from comments from the team of the OECD Horizontal Water Programme, under the supervision of Brendan Gillespie, in particular Peter Börkey, Céline Kaufman, Roberto Martin-Hurtado, Monica Scatasta. All errors and inconsistencies remain the author's responsibility.

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EXECUTIVE SUMMARY

Populations in most OECD countries enjoy high levels of access to networked systems of water supply and sanitation. However, the maintenance of these systems is becoming more difficult because of the major investments required to repair and replace ageing infrastructure and the costs associated with meeting more stringent environmental requirements. It is expected that half of OECD countries will have to increase the level of expenditure on water infrastructure as percentage of GDP (OECD, 2007a).

In addition, questions arise about the articulation of such services with water management issues. Water scarcity, the benefits of adjusting water quality to needs, the concern for making a better use of available resources, all argue that water supply services should be adaptable, resilient and flexible.

In this context, the traditional economies of scale attached to piped water supply, single water use, and water-borne sewage treatment in centralized systems are being questioned. There are diseconomies of scale attached to large municipal systems for supplying water, in particular in megacities where high costs are attached to water transport and network maintenance, including work on roads to repair underground infrastructure. The strong technical path dependency of existing infrastructures generates rigidities which may be problematic in the context characterized above.

Some governments and the private sector are examining alternative ways of providing water. In particular, reuse of (treated or not treated) grey or reclaimed water attracts a lot of attention, as it provides an alternative source of water. Reuse can be organised at different scales and, as noted by Yang and Abbaspour (2007), one key question from a policy perspective is to determine the optimal scale of wastewater reuse, from a technical, socio-economic, environmental and institutional perspective.

Alternative water systems differ from prevailing ones in at least one of two dimensions: i) they reclaim and reuse water for a variety of uses; ii) they can be based on decentralized infrastructures, producing water where it is consumed. Markets for water reuse are booming. Experience with decentralized water accumulates in emerging economies and in rural areas; experience is more limited in OECD urban areas. Australia, Spain, some states in the US are pioneering these new technologies, spurred by serious constraints on water resources.

There are debates about the pros and cons of alternative water systems, and about the contexts where they might be viable. This paper sheds some light on these debates, by reviewing the literature and available case studies. It identifies contexts where alternative water systems might be considered as an option for OECD governments and municipalities. It identifies a number of policy issues which have to be addressed before these systems can be deployed and contribute to tackling the challenges OECD countries face regarding water supply. This is a preliminary exploration and more work is needed to collect evidence and bring more light on these and related issues.

Pros and cons of alternative water systems

Alternative systems have pros and cons. The discussion focuses on selected issues, namely:

- the investment and operating costs. Available data indicate that there is no absolute ranking of water systems based on costs. Regulation is one of the main drivers of costs for decentralised systems and for water reuse. Alternative systems may be cost effective, even in cases where central infrastructure is already in place;

- the capacity to internalize some externalities attached to improved water supply (e.g. capturing land and property value) and to harness new sources of private capital. Investment in decentralised water supply can be included in property development plans, thus taking some pressure off local public finance.

From an environmental perspective, water reuse can reduce demand for fresh water resources, diversify water sources and enhance reliability of access to resource; it can reduce volume of wastewater discharged into the environment. Decentralized systems can reduce energy required to transport water from the point of production to the point of use; and reduce greenhouse gas emissions (due to energy savings).

Alternative water systems have financial benefits as well: constructing fewer infrastructures and deferring and reducing costs for the construction of networks; relieving public finance from part of the financial pressure, as new players are incited to invest their own money in the (decentralized) infrastructure. Alternative systems are flexible and adaptable to changes in population and consumption, land use, and technologies.

Alternative water systems have a number of drawbacks. They can generate additional costs, in particular when not integrated in the initial plans for service provision and building construction. From a revenue side, their financial attractiveness is limited by the fact that revenues do not reflect the positive externalities for the society at large (this is also true of conventional systems). Typically, revenue streams from non-potable reused water are limited and willingness to pay is low. This is so in part because the price of water does not reflect its full cost.

These systems generate a number of risks, associated with public health and the economy of water services at the municipal level; for instance, they preclude cross subsidies and financial solidarity between rich and poor, especially if they are not operated in a coordinated way. Other concerns that apply to decentralized water systems are: how can decentralised systems constitute cohesive networks? What happens if the service provider goes bankrupt? How are tariffs set, revised, and approved? Who will undertake water quality testing at the customers' taps?

It follows that alternative systems can only be considered in particular contexts, and their most appropriate scale will depend on specific conditions.

Where alternative water systems are viable

Alternative water systems have been used in rural areas for decades. They obviously are an option in new urban areas where no central infrastructures pre-exist, and in extra-urban urban areas.

In addition, alternative water systems might be considered in city centres with decaying water infrastructures or with infrastructures meeting diseconomies of scale or capacity constraints, and in projects of urban renewal. They are more competitive in unstable contexts, where flexibility, resilience and adaptation are valuable (i.e. a context created by climate change in many places). They are even more relevant where property developers operate the buildings they invest in.

In any case, the most appropriate infrastructure may very much depend on policy orientations, as no single system's performance is systematically superior for, e.g., water conservation, recycling nutrients, *and* keeping construction costs low. One size does not fit all the different functions of urban water services (e.g. supplying potable water, non-potable water uses, rain water management, sanitation) and the most appropriate scales for each function have to be combined and articulated. A combination of centrally-provided and alternative water systems is probably the most practical approach in many cases. Limited experience is available on the best ways to combine both approaches. More work is needed on the technical, regulatory, economic and financial aspects of this issue.

Policy issues

Alternative water systems fit in the variety of options OECD governments have to address challenges associated with water supply and sanitation. However, they can only be deployed when water-related institutions and regulations are transformed into technology neutral enabling frameworks. Such frameworks would address the issues highlighted below.

Public involvement, and transparency are critical when alternative ways of providing water are considered, because public acceptance is topical, especially in cases of water reuse for (direct or indirect) potable uses.

There is a risk that responsibilities are blurred between municipalities (who generally are responsible for water provision), property owners (who may invest in decentralized systems), technology suppliers (who provide the equipment), and service providers (who operate and maintain these equipments). It follows that accountability and responsibilities have to be clearly defined.

The regulatory framework has to be adjusted, to allow exploring the benefits of alternative water systems. While a variety of technical options exist to provide water, options in use are limited by planning regulation, norms for the quality of the product or service, standards for grey water reuse and for the techniques to be used. Recent initiatives at sub sovereign, national and supra national level indicate that regulatory frameworks can be reformed.

In addition, water sector regulators need to be prepared to monitor water quality from a variety of different sources (e.g. fresh water abstraction, harvested rainwater and water treated) in multiple settings (in central plants, commercial and industrial buildings, and private houses). This requires capacity, financial and human resources.

Setting the prices right for water is the first step towards stimulating markets for alternative water systems when they are needed.

An increasing array of experience accumulates, from which governments, municipalities, the private sector, consumers and citizens at large can identify the best ways of combining existing infrastructure with alternative water systems. An informed policy dialogue on the available options, in a context that favours innovation and adaptation, is the best way forward.

INTRODUCTION

Recent work by the OECD (OECD 2007 a, b) confirms that OECD countries face major challenges regarding the construction and the maintenance of water related infrastructure. It suggests that prevailing ways of providing water (essentially based on centralized infrastructure and single water use) may not be able to face these challenges. Alternative water systems may be part of the portfolio of options governments have to consider to achieve their water policy objectives.

In this report, alternative water systems are defined by one or two of the following features: i) they recycle and reuse water for a variety of uses; ii) they can be based on decentralized infrastructures, producing water where it is consumed.

Water reuse attracts a lot of attention. Markets are booming and a variety of technologies and systems are available to meet an increasing demand in OECD and emerging economies. The situation regarding decentralized ways of providing water is less clear: there are debates about the benefits and the costs of such options; there are questions about their relevance in an OECD context, especially in urban areas where centralized infrastructure is already in place.

The objective of this report is to shed some light on the pros and cons of alternative water systems in OECD countries, in particular in urban areas. The paper identifies a number of policy issues which have to be considered before such options can effectively be considered and deployed in OECD urban areas.

The paper has three chapters. The first one sets the scene. It recalls a number of challenges OECD countries face regarding water supply and sanitation and explains why prevailing ways of providing water may not be able to cope with them. Alternative water systems are described, and data is presented on their development.

In the second chapter, the pros and cons of alternative water systems are assessed. The chapter builds on the available literature and on selected case studies in a variety of contexts. Some questions remain, as there is no comprehensive set of facts and data that systematically address all the facets of the issue.

The last chapter identifies the main policy issues which have to be addressed to harness the full benefit of alternative water systems. In particular, governance regimes, regulatory frameworks and capacities have to be reformed, to adequately plan, design, construct, operate, and monitor such systems, should they be part of the portfolio of options governments implement in OECD countries.

OPPORTUNITIES FOR ALTERNATIVE WATER SYSTEMS

The chapter explains why alternative water systems attract attention in the current context. Recent work confirms that OECD countries face daunting challenges as regards water supply and sanitation. It suggests that prevailing approaches, based on central infrastructure and single water use, may not be able to meet these challenges.

In this context, alternative water systems are considered by a number of national and local authorities. They include water reuse and decentralized systems for water supply. Recent trends and data on related markets are compiled.

Challenges that prevailing approaches face in OECD countries

OECD countries face daunting challenges regarding water supply and sanitation, including in urban areas. It is unclear how prevailing approaches, based in single water uses and centralized, piped systems can cope with these challenges. These uncertainties stimulate research on alternative ways of providing water and sanitation.

Alternative water systems are based on the so-called soft path, an approach which is not technology driven and suggests that a variety of ways of providing water and sanitation should be explored and/or combined.

Current challenges related to water supply and sanitation in OECD countries

According to Ashley and Cashman (2006), the key drivers likely to impact on the long-term demand for infrastructure in the water sector can be grouped under four broad headings: socio-economic, technological, environmental and political.

Socio-economic changes are expected to increase total and unit costs of water service infrastructure into the foreseeable future due to: population growth; population profile changes (e.g. ageing and more sophisticated life styles); demand for increased service quality; extended coverage and access to services; increasing share of the risks and functions (e.g. coping with rain water) associated with providing water services being borne by the private sector.

Technological change is expected to attenuate the overall increasing costs of water services. This will be due to: new techniques (e.g. sensor and information and communication technology) and better ways of managing information and hence performance, resulting in smarter ways of operating new and current systems; greater energy and resource efficiency. Green infrastructure technologies (e.g. natural or engineered systems which use soils and vegetation to capture, cleanse and reduce storm water and other excess flows[1]) and methods (e.g. integrated water resource management, payments for ecosystem services) can avoid additional infrastructures and treatments and save major costs (for instance, good management of watersheds draining into drinking water reservoirs can avoid artificial water filtration). Technological change also presents an opportunity to challenge some but not all of the ways in which water services are provided. The key question is: to what extent can technology bring about the closing of the water cycle such that the requirement to abstract new resources is

[1] Common approaches include green roofs, trees and tree boxes, rain gardens, vegetated swales, pocket wetlands, infiltration planters, vegetated median strips, reforestation, and protection and enhancement of riparian buffers and floodplains. See the position of USEPA on this issue

minimised? This would require technologies that are reliable, cost effective, appropriate for those who must use them and capable of widespread adoption.

Environmental/external stresses will be main change drivers. Shortages today very often result from rising abstraction levels and from mismanagement and unsustainable actions. But climate is likely to compound the problem of competition for water use. In Australia for example, droughts and water stress in the main cities have forced the adoption of a whole new range of approaches to managing water, based much more on the concepts of reuse, recovery and matching water quality to what the water is used for, and also to education of users (CSIRO, 2004). Such stresses can generate additional demand for security of access to resources. The degradation of watershed ecosystem services may result in shifts to engineered water filtration, thus increasing cost of water. Responses include new infrastructures and management techniques which build redundancy in the systems (to make sure that water will be supplied) and which ensure contaminant control to protect health and ecosystems. A report by Marsden Jacob Associates (2006) notes that differences in the way climate uncertainty and risk have been treated correlate with recent levels of expenditure on water supply infrastructure: the city of Perth has incorporated an unfavourable scenario on climate into planning, for many years; over the past five years, per capita expenditure in Perth, has been twice or more the level of water supply investment in Sydney, Melbourne, Brisbane and Adelaide, which have not adopted scenario planning approaches or have only done so very recently.

Political changes are expected to increase the relative costs of future water service delivery, principally due to: land use and urbanisation control processes; effectiveness of governance up and down the process, at national and/or local levels; the forms and needs of revenue collection (which may not improve due to political will); increasing service levels driving infrastructure performance up; for instance, in Europe, the lowering of lead content from 50 to 10 µg/l (as required by the EU Drinking Water Directive adopted in 1999) will cost up to 35 billion $ while, according to Barraqué (2003), there is no evidence that the former level provokes lead poisoning.

Projections illustrate the scale of the challenges that face those responsible for planning and providing for water service needs (see OECD 2007a): most OECD countries will have to increase the share of their GDP allocated to the water and sanitation sector over the next twenty years.

This can be illustrated by a number of instances. Coverage is not comprehensive: in Europe, more than 20 million people lack safe sanitary facilities. When the infrastructure exists, it can be too old and ill-adapted to the current challenges: London’s sewerage collector system overflows in case of heavy rains and pours into the Thames. The existing infrastructure can also create environmental problems (e.g. Baltic sea pollution from wastewater).

Although the benefits of investments are likely to outweigh the costs, it does not follow that the projected expenditures will be realised. Indeed, over the last two decades, investment rate has been falling in water, in most OECD countries (OECD, forthcoming). The evolution of capital stock in the water sector relative of GDP tends to decline in countries with higher levels of provision (Austria, the Netherlands, or the U.S.).

Limitations of prevailing approaches to water supply

In OECD countries, prevailing ways of providing water and sanitation are based on piped water supply and water-borne sewage treatment in centralized systems using a series of accepted technologies.

It is not clear how these approaches will be able to adjust to the challenges identified above. Indeed, some observers claim that "we have invested a lot of money in building infrastructure, but we have not developed sustainable infrastructures through this investment" (Michael Deane, Associate Assistant Administrator for Water, USEPA). In Rees et al.'s words, "the 1980s Water Decade provides lessons for the future: plenty of infrastructure was created but, in many cases, it was badly chosen, poorly maintained, and lacked supporting institutions. Consequently, the investments did not realise the expected benefits and did not adequately address the service deficit" (Rees et al., 2008).

The city of Mexico illustrates this observation. According to Tortajada and Castelan (2003), "Construction of infrastructural projects *ad infinitum* to bring more and more water to the metropolitan area is neither sustainable, nor economically feasible, nor is it environmentally and socially desirable. With the existing poor-management practices, investment costs would skyrocket to transport more and more water from increasingly distant and expensive sources, higher operating costs would be incurred for energy, land subsidence will accelerate due to increasing groundwater withdrawals, the quality of groundwater abstracted will decline, higher subsidies and higher investments would be necessary to cover operation and maintenance costs, etc. This represents a never ending vicious circle. The quality of life is likely to improve for the rich, but continue to worsen for the poor."

Because there are negative externalities and diseconomies attached to large-scale, centralized infrastructure, the "soft path" for water emphasizes improving the productivity of water use rather than seeking endless sources of new supply. It delivers water services and qualities matched to users' needs, rather than just delivering quantities of water. It applies economic tools such as markets and pricing, but with the goal of encouraging efficient use, equitable distribution of the resource, and sustainable system operation over time. It includes local communities in decisions about water management, allocation, and use. The soft path opens new avenues for accessing capital. The soft path explores four opportunities (Gleick et al., quoted in OECD, 2007b).

The first opportunity is <u>changes of scale</u>. Planning water supply and sanitation at alternative scales can increase cost-effectiveness of water services, increase revenues, and introduce new models to meet capital needs. On the one hand, regionalization of water services has improved efficiency, cost-effectiveness and watershed management in key areas in France, Canada, Portugal, and the United States. Expanding the scope of service can improve a water system's ability to finance needed investments. On the other hand, decentralized systems are changing who is responsible and paying for water infrastructure. Engineering firms are building water systems using private capital, and maintaining ongoing service contracts to finance this capital. And home and land owners are investing their own capital (or servicing the debt on needed capital) in order to build onsite systems for single-family or multi-family complexes.

It is important to acknowledge that water and sanitation services cover a range of services which can be organised at different scales: potable water supply, supply of water for non potable uses, rain water harvesting and flood mitigation, wastewater collection, treatment, etc.

The second opportunity to meet infrastructure needs is through <u>demand management</u>. Demand management changes the nature of needs for infrastructure. Increasing water productivity and efficiency, and improving conservation can reduce the need for new and expensive water supply or wastewater treatment projects. As new water supply projects become more expensive to source water from further distances, the cheapest new source of water has often been water gained through conservation, efficiency, and improved management. Many OECD countries have successfully reduced water use per capita and in total in recent years - indicating that the right policies, along which pricing plays a prominent part, can lead to a decoupling of water use from economic and population growth. This is reflected in the ongoing OECD Horizontal Programme on Water which investigates how pricing strategies can address policy questions related to water supply and sanitation (see OECD, 2009).

Competition is a key opportunity to reduce ongoing financing needs and improve the capacity of utilities to access financing. Competition that increases efficiency and improves water system management will reduce costs and can also have a significant impact on the utility's credit worthiness, thus providing access to (cheaper) private capital and public bonds. However, competition and decentralisation require a strong capacity on the part of governments and regulators to monitor water abstraction, service quality and management practices. The capacities needed by governments to monitor and manage a variety of private actors are analysed in a distinct section of the OECD Horizontal Programme on Water.

The fourth opportunity is public involvement. In the end, the public, whether as ratepayers, taxpayers, or stockholders, will finance whatever debt is incurred to build new infrastructure. Ultimately, water utilities must convince ratepayers, taxpayers, and/or stockholders of the need for new infrastructure investments and the utility's ability to manage those infrastructure improvements effectively. Public involvement can facilitate larger investments in the water sector, or help identify the need and opportunities for smaller investments. It is a requisite to improve demand management and to encourage efficient use and equitable distribution of the resource. This again is being explored in the OECD Horizontal Programme of Water which reports how policy dialogue supports the design of sustainable financing strategies for water-related investment.

Trends in the provision of water supply

This section proposes a classification of different ways for supplying water. It reports on a number of experiences based on alternative water systems and monitors trends in the development of related markets.

Alternative ways of supplying water

Ways of supplying water can be characterized along two axes. One deals with the infrastructure, which can be centralized or decentralized. The other deals with the water which is used: either freshwater only, for a single use; or alternative sources of water.

Alternative sources of water include:

- rainwater, which can be harvested and treated locally;
- grey water, i.e. non-industrial wastewater generated from domestic processes; it is distinct from black water, which contains more and more polluting chemical and biological contaminants; USEPA defines grey water as non-drinkable water that can be reused for irrigation, flushing toilets, and other purposes; grey water can be used immediately or treated and stored; and
- reclaimed water, i.e. former wastewater that has been treated to remove solids and certain impurities. It is only intended to be used for non potable uses (e.g. irrigation, dust control, fire suppression); with more advanced treatment, it can be used for indirect potable reuse (i.e. discharged into a water body before being used in the potable water system).

Table 1. A typology of ways of supplying water

	Freshwater only	Alternative sources of water
Central infrastructure	*Prevailing in OECD countries* Single quality water is provided by central infrastructures. Waterborne sewerage is centrally collected and treated in a plant usually located at the outskirt of the urban area	*In use in some contexts* Treated or untreated rain and grey water is sent back to the city where it is used again. The system requires an additional network and energy is used to transport wastewater and reclaimed water
Decentralized infrastructure	*Not common in OECD urban areas* Relies on point of use resources (wells). Connections to central infrastructure may be needed to ensure reliable sourcing	*Widespread in specific contexts* Water is produced and treated locally (on the point of use). Treated or untreated rain and grey water is used for (usually non potable) uses

Central versus decentralized infrastructure

Water can be supplied by decentralised systems. This is the case when the source of water is local (wells). This is also the case when water is treated locally: rain water can be harvested at any scale. This is also the case when grey water is collected, treated and used locally. Similarly, reclaimed water can be used where it has been treated.

Decentralised systems for wastewater reclamation are increasingly in use in collective buildings (hotels, hospitals, schools) or industrial facilities. In Japan, in 2003, more than 1,000 on-site individual buildings and block-wide wastewater recycling systems generated water for non-potable urban applications (toilet flushing in commercial buildings and apartment complexes) (Funamizu et al., 2008).

Centralized and decentralized approaches do not need to be exclusive. First, it is more appropriate to speak of degrees of de/centralization. Second, communities can combine both approaches.

Freshwater versus alternative sources of water

As defined above, alternative sources of water include rain and storm water, grey and reclaimed water.

Treatment of alternative sources of water is adjusted to the quality standards of different applications. There are two broad categories of applications: potable and non potable ones. Non potable uses include irrigation (for crops, parks and golf courses), some industrial applications, some uses for households, including outdoor uses (such as gardening) and indoor applications (e.g. flushing toilets or washing machines). Alternative sources of water can be used for direct or indirect potable reuse (water is discharged into a water body before being used in the potable water system).

The California Local Government Commission makes a distinction between reuse and recycling (see www.lgc.org). Reuse involves using untreated, uncontaminated wastewater – from bathtubs, showers, bathroom washbasins, clothes washing machines and laundry tubs – a second time around, for an appropriate purpose. Recycling means the use of treated wastewater for appropriate purposes.

Rainwater harvesting requires that tanks be installed, in existing or new homes, to collect the runoff from the roof area; these tanks would be connected to indoor end uses (such as toilet flushing and washing machines) and outdoor (watering the garden). Wastewater reuse requires retrofitting systems in houses so that grey water from the house can be collected, treated and reused (for the same end uses). In the case of new homes, grey water systems can be integrated in the initial planning, saving investment costs.

Reuse can be combined with either central or decentralized infrastructure.

This report discusses the pros and cons of harnessing alternative sources of water (rainwater, grey water, reclaimed water) and of the systems which are required to do this in an efficient and cost effective way (onsite systems to harvest and treat rainwater; decentralized systems to collect, treat and reuse grey water, or to reclaim wastewater). The focus is on urban areas in OECD countries. While a lot of experience has been gained on water reuse (see below), it is less clear how decentralized systems can adjust to OECD urban areas, which are already equipped with centralized infrastructures.

Sharing experiences that work and their limitations

An increasing number of applications illustrate how alternative water systems can be implemented in urban areas in developed economies. They indicate that alternative water systems are not limited to rural areas (where land is abundant and density is low) and to developing countries (where infrastructures have to be built or extended).

In old Europe, where cities are equipped with central infrastructure to supply water and to collect and treat wastewater, experiments with alternative water systems are burgeoning. ARENE (2005) reports on a number of them which share common water-related features: i) rainwater is harvested in tanks (in-house or underground) and used for flushing toilets, washing machines and gardens; ii) run offs are collected and treated so as to replenish aquifers; iii) some experiments reuse water for indoor or outdoor non potable applications:

- In BedZED (UK), renewable sources of water (rainwater, reclaimed water) supply 18% of the daily consumption of water. Wastewater is treated in a "Living Machine" (Green Water Treatment Plant): water is treated biologically and through ultraviolet light to a level that complies with requirements for toilet flushing and gardens.

- In Vauban-Fribourg (Germany) rainwater is harvested and used for toilet flushing, washing machines and gardens; in a pilot building, grey water is collected, treated and reused (for indoor and outdoor non potable applications); biogas is produced out of wastewater, which feeds gas appliances in the homes.

- In Hammarby Sjörstad-Stockholm (Sweden), the initial target was to reduce water consumption by 50%, by a variety of techniques, including reclaiming wastewater and installing filters in all taps that mix air into the water; the target to 2015 is even more ambitious.

Singapore has developed one of the world's most advanced water reuse programmes. The reuse programme, called NEWater, relies on advanced microfiltration, reverse osmosis and ultraviolet exposure to clean and treat wastewater for potable consumption. NEWater has been recognized as an international model for innovation in water management, most recently winning the Environmental Contribution of the Year award from the London-based group Global Water Intelligence. Namibia's capital city, Windhoek, is the only supported instance of reclaimed wastewater used for direct potable use; one third of the population (250,000 people) are served this way.

In China, a number of developments treat water at the level of a house, or of a commercial building. In Beijing, it is required that newly developed residential buildings with construction area over 30,000 m2 build on-site wastewater reuse facilities (Yang, Abbaspour, 2007). The 2008 Olympic Games have been an opportunity to demonstrate savoir-faire in this area (see Box 1).

Box 1. Water Reuse at the Olympics: Beijing Bei Xiao He

Beijing BeiXiaoHe water treatment plant is located at the North of Beijing, China. It is responsible for the water supply of the Olympic Park. Water reuse is part of a solution where potable water is conserved, wastewater discharge is reduced, and a reliable and verifiable quality of water is ensured. According to the CSR Newswire, the sewage water reuse facility in BeiXiaoHe Wastewater Treatment Plant constitutes one of the world's argest membrane bioreactor plants; it is designed to produce 15,000 m(3)/day of filtered water for landscape care.

The Reclaimed Water Reuse for Beijing Capital International Airport, with capacity of 10,000 m(3)/day, will recycle municipal wastewater for the daily water consumptions of the airport and to help meet the needs of approximately 20,000 visitors per day. The treated water from the Reclaimed Water Reuse for Beijing Economic-Technological Development Area (BDA), with capacity of 20,000 m(3)/day, will be supplied as industrial water to the companies in BDA. Combined, these three facilities will provide 45,000 m(3)/day of water.

Source : CSR Newswire and others

In Hong Kong, the Total Water Management aims at meeting long-term water needs, while supporting future population and economic growth. It integrates reclamation (defined as lower quality water used to replace high quality water for non-potable purposes), new sources of water, water conservation and demand management (see Box 2). Alternative ways have been systematically assessed and a number of pilot projects are under way. The issue of public acceptance is explicitly being addressed.

Box 2. Water reclamation, Hong Kong

The Government has conducted pilot schemes in Ngong Ping and Shek Wu Hui. These schemes, commissioned in 2006, use reclaimed water for toilet flushing and gardening.

Both pilot schemes were expected to be completed by the end of 2008. They are being monitored in respect of operating conditions, reclaimed water quality and public acceptance of using reclaimed water. The interim results of surveys on public acceptance to the use of reclaimed water under the two pilot schemes are favourable. Subject to the final results of the two pilot schemes, reclaimed water from Shek Wu Hui Sewage Treatment Works could be provided to consumers in Sheung Shui / Fanling for toilet flushing and other non-potable uses.

These schemes take place in a wider review of options, which also cover rain water harvesting and grey water reuse: demonstration projects are considered to create markets (see chapter 3). The review also covered expansion of water gathering grounds and reservoir storage and desalination. The review concluded that expanding water gathering grounds and reservoir storage is of very low priority for Hong Kong. Seawater desalination by reverse osmosis can yield the largest quantity of new water supply in Hong Kong. The pilot tests were completed in 2007 and confirmed that this technology is viable for Hong Kong.

Source: ACQWS (2008), Total Water Management Strategy in Hong Kong, Paper No. 20 (http://www.wsd.gov.hk/acqws/doc/p20.pdf)

The global market for water reuse

Water is already reused in a number of OECD and developed countries. According to a survey by Jimenez and Asano (2008), water is primarily reused for irrigation in Southern Europe, the US and Canada; this includes landscape and golf course irrigation. Industrial uses are prevalent in Northern Europe and Asia. Municipal reuse of water also exists in Asia (e.g. Korea, Singapore), for activities requiring low quality water.

The markets for reused water are potentially large. According to market insights from Global Water Intelligence (see GWI, 2005), half of the world's major industrial companies and one quarter of major cities will consider water reuse in the decade from 2005 to 2015.

While desalination is a bigger market, reuse is expected to grow at a faster pace. The overall water reuse capacity is projected to rise from 19.4 million m3/d in 2005 to 54.4 million m3/d in 2015. GWI notes that a large proportion of this capacity will involve secondary water treatment only, thus not complying with standards for potable water. Siemens anticipates that desalination and reuse markets will grow together from 48 million m^3/d in 2006 to 158 million in 2016 (see Siemens, 2008).

In the OECD area, Japan, Australia, the US (California, Florida) already have experience in using reclaimed water, in particular in regions living under water stress. In these regions, reclaimed water has been used for a number of purposes, including groundwater recharge programmes. Western Europe has not fully used this alternative resource yet, although the potential is high in regions where water in scarce (Spain), or where water resources are overexploited (Belgium, the Netherlands, parts of Germany and the UK; see OECD, 2008). Spain has a plan to triple the volume of wastewater reuse by 2015; up to 1.5 km^3 of wastewater could be reused annually within the next few years.

Among non OECD countries, China will be a major market, with the development of wastewater treatment capacity and water shortages in the North East. Market prospects in the Middle East and South Asia depend on the extension of wastewater collection and treatment infrastructure.

GWI identifies five market drivers for water reuse: increased demand for water; reduced availability of water supply; affordability due to falling costs for membrane technologies; practicality of water reuse as a local solution; public policy (for instance, stringent standards for wastewater discharge in Europe are an incentive to recycle water).

The most promising trends for wastewater reuse are (municipal) irrigation or industrial use. In a number of projects (completed or ongoing), treated wastewater is stored in aquifers. The figures below show how reclaimed water is used in California (source: www.lcg.org):

- Agricultural Irrigation: 46%
- Landscape Irrigation: 21%
- Groundwater Recharge: 14%
- All Other Uses: 19%

One application of reclaimed water is dual reticulation systems in new build residential areas providing separate pipes for potable and non-potable water. Here comes a dilemma: either treat reclaimed water so that it is potable, or build secondary networks.

PROS AND CONS OF ALTERNATIVE WATER SYSTEMS

This chapter presents available information on the pros and cons of alternative ways of providing water, compared to centralized services. It builds on the general literature and on available case studies.

The discussion focuses on selected issues:

1. the investment and operating costs. Scarce data indicate that there is no absolute ranking of water systems based on costs. Regulation is one of the main drivers of costs for decentralised systems and for water reuse. Alternative water systems may be cost effective, even in cases where central infrastructure is already in place;

2. the capacity to internalize some externalities attached to improved water supply (e.g. capturing land and property value) and to harness new sources of private capital.

These considerations point at the contexts where alternative ways of supplying water can be viable. Such contexts include, but are not limited to, new urban areas where no central infrastructures pre-exist; extra-urban, or low-impact urban areas. Additional contexts where alternative water systems might be considered include city centres with decaying water infrastructures or with infrastructures meeting diseconomies of scale or capacity constraints, instances of urban renewal. Moreover, alternative water systems are more competitive in unstable contexts, where flexibility and adaptation are valuable. They are even more relevant where property developers operate the buildings they invest in.

In any case, the most appropriate infrastructure may depend on policy orientations, as no single system performs best for water conservation, recycling nutrients, *and* keeping construction costs low at the same time. A combination of central and alternative water systems may be an answer.

Cost factors for water reuse and decentralized systems

This section identifies some costs drivers for water reuse and for decentralized systems, taking account of both investment and operation and maintenance costs. It indicates that alternative water systems can be cost effective in certain situations, especially when central infrastructures meet diseconomies of scale or capacity constraints. It indicates that the length of the payback period is essentially regulation-driven. It presents a case study where central systems and alternative ways have been systematically assessed.

The section can only scratch the surface as systematic analyses based on public, comparable information are lacking.

Assessing the cost effectiveness of alternative water systems

Marsden Jacob Associates (2006) analyses the costs of major supply and demand options available to Australian cities. The conclusions emphasise that, all things being equal, contextual features determine the cost advantage of any option:

- most options have very low cost in favourable locations and situations;

- many options have very high cost (>$3.00/kl) in unfavourable locations and situations;
- the costs of pipelines and pumping have a dominating influence where water needs to be transported over distance.

It follows that there is no simple universal cost ranking which can be simply applied to each and every situation. However, in most cases, there is some advantage at cutting the costs related to pipelines and pumping to transport water over long distance. This explains why urban services are meeting diseconomies of scale when the last urbanites are finally connected (Barraqué, 2003); similarly, wastewater reclamation will be more cost effective when treatment facilities are located close to potential users, be they industrial, agricultural, or municipal.

As noted by the Rocky Mountain Institute, if decentralized systems lose the advantages of economies of scale that are possible in capital and operation and maintenance costs, they also avoid diseconomies of scale that are inherent in centralised water systems. In the case of wastewater collection and treatment: "Given that collection system costs can be 80 percent or more of total systems costs, collection diseconomies of scale can overwhelm treatment economies of scale, resulting in decentralized systems being the more economical choice" (Rocky Mountain Institute, 2004).

The dominating influence of transport costs also explains why reuse is more expensive when water is treated at a central location (typically a central wastewater treatment plant away from the city) and reclaimed water is transported back into secondary networks and plumbing in the buildings where it will be used. According to Marsden Jacob Associates (2006), major new water reuse initiatives are frequently comparable with, or more expensive than, desalination due to long transportation distances and/or the need for third pipe systems. This is where decentralised systems have an advantage, saving on (investment and operation and maintenance) transport costs for both wastewater and reclaimed water, using *less* infrastructure.

Other factors have to be accounted for, when assessing the cost effectiveness of alternative water systems. The Rocky Mountain Institute (2004) has systematically compared the costs and benefits of decentralized wastewater treatment, relative to centralized systems. As regards financial planning and financial risk, the Institute notes that "the small unit size of decentralized system allows closer matching of capacity to actual growth in demand. Decentralized capacity can be built house-by-house, or cluster-by-cluster, in a "just in time" fashion. This provides a number of important benefits. It moves capital costs of capacity to the future. The result is often a more economical approach than building centralized treatment capacity or extending sewers (depending on many other factors). Spreading out capital costs also typically means that a community needs to incur less debt, compared to the borrowing requirements of a large up-front capital investment in capacity. This can reduce the financing costs for the community.

[…] Some potential financial disadvantages of decentralized systems are that the large number of systems can increase design, permitting, financial, and other transaction costs of a wastewater service strategy. Also, lenders may perceive individual and small wastewater system debt as riskier investments compared to municipal borrowing, so the unit costs of debt may be higher. Decentralization also concentrates the financial risks of individual system failures on individuals or clusters of residents, in contrast to the insurance-like spreading of risks of failure across large numbers of users that centralized systems can provide" (Rocky Mountain Institute, 2004). It remains to be seen whether similar arguments apply to decentralised water supply.

Regulatory drivers of the payback period for alternative water systems

Regulation drives investment and operation and maintenance costs of alternative water systems.

All over the world, reclaimed water must be channelled through separate infrastructure and plumbing, which adds to investment costs. In France, an estimate for such up-front investment is around 20 k€ for a public building. This can be considered as marginal compared to the overall construction costs. This is less so for private houses.

Reuse systems bear specific operation costs, such as the maintenance of the system, the coloration of non-potable reused water (depending on regulation) and the monitoring of water quality. On the other hand, they allow to buying less water from the central service and to discharge less wastewater into the main sewer or the environment.

Savings in operation and maintenance can compensate the initial up-front investment, when the party who pays for the investment operates the building/house[2]. When the investor operates the building, the main financial criterion to compare central and decentralized systems will be the payback period: how many years does it take for the savings on operation and maintenance to compensate for the initial higher up-front costs? Michel Le Sommer (personal communication) indicates that, in the case of France, where the average price of water is roughly 3€ per m3, the payback period of such systems is between 15 and 20 years.

Regulation is a major driver of the payback period. The payback period depends essentially on the standards set by the regulatory agencies, environment and/or health authorities, for reused water (what water can be harvested, quality standards of reused water for specific applications, building standards, etc.). It also depends on how water supplied by the central system is priced (are investment and operation and maintenance costs fully recovered?) and how the environmental externality of discharging (treated) water to the environment is reflected into taxes/levies for wastewater discharge.

The Rocky Mountain Institute notes that high effluent standards "tend to favor centralization, although it is possible to produce high quality effluent with some decentralized technologies. Some of these technologies, such as small-scale constructed treatment wetlands, may be more land-intensive" (Rocky Mountain Institute, 2004).

Sustainability of water reuse in two German cities[3]

Hiessl (2005) has systematically assessed and compared the costs of providing water to two German cities using either central or alternative water systems.

Three scenarios were developed, for two German cities, with a long-term perspective up to 2050: "Continuation", "Municipal Water Reuse", and "Local Recycling". Technological, organizational, and institutional innovations were integrated into coherent urban water systems with improved eco-efficiency with respect to water, nutrients, and water polluting materials.

[2] Note that this is not always the case. There are cases of split incentives, i.e. when the landlord bears the costs related to investment in water efficiency, while the benefits accrue to the tenant. Split incentives are common in energy efficiency, and lessons can be learned from experience of policies to address them (e.g. UK's *Landlord's Energy Saving Allowance*).

[3] This section is adapted from Hiessl et al., 2005

In the "Continuation" scenario, water and sanitation are provided through central infrastructure. Major improvements in eco-efficiency accrue from a more systematic separation of rainfall runoff and wastewater and through innovative technologies such as membrane technology for wastewater treatment. The "Municipal Water Reuse" scenario takes a decentralized approach for rainwater management and introduces a closed loop system to provide non-potable water uses in industry, households, and municipal purposes. The "Local Recycling" scenario abandons the central water supply and wastewater systems altogether and uses completely decentralized systems to provide potable water from rainwater and water for non-potable uses through reclaiming various grades of wastewater.

The scenarios are assessed and evaluated with respect to their sustainability, defined along a set of 44 criteria, grouped into economic, social, and ecological dimensions. Preliminary results indicate that the "Local Recycling" scenario prevails with regard to most of the criteria. However, the other scenarios succeed in various single criteria. The "Municipal Water Reuse" scenario, for example, has advantages in terms of water conservation, reduction of discharge of treated wastewater to receiving water bodies, recycling nutrients, and the energy production. The "Continuation" scenario is advantageous with respect of acceptance and construction expense.

Harnessing new sources of finance: capturing some of the rent attached to water services

Peterson (2006) notes that urban land values are created in part by public investment and other services made possible by municipal investment. It is economically appropriate therefore for municipalities to capture part of the land-value increment they create through their investment.

Land value capture as a means to finance municipal infrastructure

More attention has been brought to bear recently on the potential of land value tax, whereby a proportion of the increased value that accrues to landowners benefiting from new or improved infrastructure in the proximity is captured and used to fund the infrastructure provided. Successfully conceived and implemented, it shows interesting possibilities for integrated financial, land-use and infrastructure planning. In Shanghai, landowners and property developers already contribute to water-related investment. Half of financing for fixed assets over the period 1995-2003 came from self-raised funds, i.e. financial resources raised by public developers in urban development projects. The rent that these institutions create in developing industrial, commercial or housing zones is invested back into financing infrastructures, including water and sanitation (Lorrain, 2008).

Where infrastructures are being put in place in already densely populated, built-up areas, land value capture is limited. But where relatively undeveloped areas benefit from new infrastructures, it has considerably more potential. An interesting recent illustration, although not in the water sector, is the Copenhagen metro in Denmark (see Box 3).

Building on experience in China, Hong Kong, Ethiopia and the US, Peterson (2006) notes that, under specific conditions, exchanging landholding for infrastructures can contribute to infrastructure financing. Now, land leasing can only be a transitional infrastructure-financing strategy: at some point in time, the supply of land available for lease or sale will run out and cities will have to rely more on revenues from services provided by the infrastructures to recover capital costs. Moreover, such financing strategy generates risks, which are particularly acute in the current period, where real estate prices are highly volatile.

Box 3. Land value capture and new infrastructure: the Copenhagen metro, Denmark

The Copenhagen metro, completed in 2007, is one of Scandinavia's most ambitious transport infrastructure projects. The Ørestad Development Corporation (ODC) was established with the dual task to build the metro in Copenhagen and to develop the Ørestad area. It is owned 45% by the government and 55% by the municipality of Copenhagen. The area to be developed is about 600 metres wide and 5 kilometres long, and is situated about 2 kilometres from the city centre of Copenhagen. The project is characterised by a close interconnection of infrastructure, land use development and financing. By putting infrastructure in place, this facilitated the sale of land to private investors to help finance the metro system.

The ODC has carried out the following actions: took over the Ørestad land covering around 310 hectares from the owners, *i.e.* the municipality of Copenhagen and the Danish government; raised loans on commercial market terms, but with joint liability with the Danish government and the municipality of Copenhagen; designed, built and initiated the operation of the new Copenhagen metro. At the same time, the corporation continued the planning and construction of other infrastructure projects; sold/sells the land to developers and investors. The corporation used/uses the surplus from the proceeds of the sales to repay the loans.

The total cost of the project – building the metro and preparing the Ørestad area for development – is estimated at EUR 1.7 billion. It should be met by selling the land (50%), direct payments from the owners not contributing land themselves (10%), in lieu payments of real estate taxes (10%), and profit from the metro (30%).

Source : OECD (2007b)

Capturing the value added by decentralized water systems

Experience of such financing strategies for water and sanitation are scarce. Peterson (2006) notes that, in a context where local property taxes are frozen, and local tax increases and municipal borrowing are restricted, California's localities turned to land assets as a way to finance infrastructure: new intergovernmental rules were adopted that allowed developers to issue land-based bonds to finance roads, sewer and water systems and other basic infrastructure that no longer could be financed by the public budget. Land became the collateral for a good deal of new infrastructure financing.

Decentralized water systems can connect the value created by the infrastructure and the investment. This is because they are typically owned by property developers, homeowners, or other private entities, whereas centralised systems usually are publicly owned. Hence, the investor has a direct incentive to invest in the (decentralized) infrastructure, as this investment can enhance the value of the property, or generate cash flows by saving on the operation and maintenance costs of the water systems.

Harnessing private finance to invest in alternative water systems

Engineering firms are building water systems using private capital, and maintaining ongoing service contracts to finance this capital. And home and land owners are investing their own capital (or servicing the debt on needed capital) in order to build decentralized systems for single-family or multi-family complexes (see Box 5 on Brisbane, Australia). In Mexico, the largest source of investment funding for water supply and sanitation, besides the Federal Government, is housing developers (22 percent), which construct water and sewerage systems within their developments and which increased their investments substantially as part of large subsidized housing programs initiated in 2001 (World Bank, 2005).

Housing/property developers deserve a particular attention as, in certain contexts, there are incentives for them to invest in decentralized systems to raise the value of their property. Australia probably paves the way. Research by Australia's biggest property website www.realestate.com.au has revealed more vendors are seeing green credentials as selling points, and buyers are responding with one in ten people prepared to pay up to 20 per cent more for a 'green' home. As water supplies and sustainability move up the agenda, properties that are environment friendly are becoming more popular; water tanks rank as *the* feature most likely to add value to a property. In France, rainwater harvesting is the second highest feature regarded by the public as a positive feature of green building, after renewable energy and before renewable materials (although this does not translate in the property value: owners of private houses in France cannot reflect the investment cost into the sale value of the property).

Moreover, innovative institutional arrangements may generate additional incentives for private investment in decentralized systems. In England, inset appointments generate opportunities to organise decentralized water systems in the context of a central infrastructure. There is reference to neither water reuse nor self-treatment of wastewater, but the stage might be set for further developments (see Box 4). Franceys (2007) signals some of the difficulties associated with inset appointments. We turn to them in the concluding section of this report, as they are relevant for decentralized ways of providing water.

Box 4. Inset appointments in England

In England, "inset appointments" are an important means of introducing more competition to the water and sewerage industry: they allow some customers, particularly large ones, to choose who provides their water supply and sewerage services (for more information, see OFWAT). Inset appointments were initially allowed for large consumers, typically commercial users such as steel makers and breweries.

In 2007, Ofwat has granted Independent Water Networks Limited an inset appointment to supply a 950 home development in Corby, Northamptonshire. IWNL will serve its customers by buying water from Anglian Water and discharging sewerage to Anglian Water's network. IWNL has said its 2007-08 volumetric charge will be 5% lower than that of Anglian Water. Ofwat is considering other inset appointments.

Source : Franceys, 2007

The capacity of decentralized water systems to attract (private) investment from parties which will benefit from the rent accrued by improved water services is particularly relevant in a context where public finance is scarce. As Rees et al. (2008) make clear, given limited government budgets and funds from donors, it is important that those functions and services which can raise capital or revenue from users or beneficiaries do so. The opportunity costs involved in continuing to use public funds to provide private goods to those able to pay for them are high. This requires that the governance structure and finance strategies be mutually adjusted: from this perspective, water governance should provide the capacity to make the best use of available water and financial resources.

Contextual features

Technologies are available to meet all types of constraints. Both centralized and decentralized approaches may be desirable, in specific contexts. The general opinion is that the centralized option may be preferred for large urban areas, where municipally managed recycling is possible. For extra-urban, for low-impact urban infill, or for many industrial applications, onsite, decentralized water management may be the preferred option (see Freedman and Hotchkies, 2007). It may be worth recalling that one out of two city dweller lives in a city which has less than 500,000 inhabitants.

Some observers claim that alternative water systems are more readily competitive in new urban areas, where no central infrastructures pre-exist. Indeed, as Hiessl and his colleagues argue, the water infrastructure, organized around centralized, piped systems for water supply and sanitation has a very high technological path dependency (Hiessl et al., 2005) and this may lead to further investment in, and extension of, the existing infrastructure.

It does not follow that alternative ways of providing water should only be considered in cases of urban expansion, where large infrastructures (especially centralized water supply and wastewater collection) meet diseconomies of scale. There are a number of contexts where they might be considered as a viable option.

Firstly, major parts of the existing infrastructures in OECD countries need heavy repair and/or replacement; in the case of the US, most pipelines need to be replaced in the next two decades (CBO, 2002, quoted in OECD, forthcoming). This may be an opportunity to revisit the technological trajectory and to explore alternative paths. Secondly, the urban landscape is continuously being renewed. In OECD countries, city centres in particular bear considerable attention and extensive renewal. It used to take more than a century to rebuild a city on its own foundations. The pace of renewal is likely to accelerate, with consideration given to the energy efficiency of buildings and to sustainability issues at the city level. These are opportunities to consider alternative water systems in existing urban areas.

Other contextual features have an impact on the relevance of alternative water systems. Such systems may be more competitive where property developers operate the buildings they invest in.

Alternative systems are more competitive in unstable contexts, where flexibility, resilience and adaptation are valuable. Maintaining and extending existing infrastructures cannot account for rapid shifts in population location and demand for water; it is trapped in a technological trajectory and cannot easily absorb innovation. As noted by Hans-Gert Pöttering, President of the European Parliament, large scale infrastructures, with a life-span of decades, provide few opportunities for learning and easily lead to lock-in situations. Experience in Eastern Europe, Caucasus and Central Asia suggests that existing infrastructures may become oversized and, hence, too expensive to be properly operated and maintained (see OECD, 2009). Decentralized systems are more flexible to adapt to climate change (e.g. floods), migrations and changing land uses. This is a positive externality that is not readily reflected is cost analyses.

In addition, Hiessl's analyses suggest that the most appropriate infrastructure may depend on policy orientations; no single system performs best for, at once, water conservation, recycling nutrients, *and* keeping construction costs low.

POLICY CONCLUSIONS

Alternative water systems use complementary, renewable sources of water, such as rainwater and reused water. They can be designed at a decentralized level, close to the place where water is consumed or wastewater is produced.

These systems can be part of the solution needed by OECD governments to address the daunting challenges they face as regards water supply and sanitation. They may be considered in a variety of contexts, including urban areas already equipped with (decaying) centralized infrastructures for water supply and sanitation.

Table 2. Some pros and cons of a variety of ways of providing water

	Freshwater only	Alternative sources of water
Central infrastructure	Pros • Scale effects • Provides consistent services • Financial solidarity at municipal level Cons: • A number of negative externalities (environmental, financial) • Capital intensive and fails to attract private capital	Pros • Positive environmental externalities (resource, wastewater discharge) • Financial solidarity at municipal level Cons • Costly (several networks) • Energy intensive
Decentralized infrastructure	Pros • Less water leakage in mains and less energy used to transport water • Reduced energy use • Flexible and resilient • Deferred and reduced investment costs Cons • Additional connections are needed for reliable sourcing • Unequal service provision in the municipality • Inadequate monitoring systems	Pros • Positive environmental externalities (resource, wastewater discharge) • Reduced energy use • Flexible and resilient • Deferred and reduced investment costs • May harness new sources of finance Cons • Health issues related to potable reuse • Questions about relevance when central infrastructure is in place • Scale effect • Unequal service provision in the municipality • Inadequate monitoring and regulatory systems

Note: alternative ways of supplying water appear in grey

There are a number of potential benefits from alternative water systems:

- reduced demand for fresh water resources, diversified water sources and enhanced reliability of access to resource;
- reduced volume of wastewater discharged into the environment;
- reduced energy to transport water from the point of production to the point of use; reduced greenhouse gas emissions (due to energy savings);
- less infrastructure and deferred and reduced costs for the construction of networks;
- relieving public finance from part of the investment burden, as new players are incited to invest their own money in the (decentralized) infrastructure;
- flexibility and adaptation to changes in population and consumption, land use, and technology.

Alternative water systems also have a number of drawbacks:

- They can generate additional costs, in particular when not initially integrated in the plan for service provision and building construction;
- They generate a number of risks, associated with the economy of water services at the municipal level. From a social and economic perspective, decentralised systems forbid cross subsidies and financial solidarity between rich and poor;
- It is not sure how decentralised water systems will contribute to a sustainable network. In particular, the combination of decentralised systems with existing, central infrastructures has to be reflected. Experience in this area is scarce; Australia (see Box 5), Paris (see Box 7) and Calcutta (where wastewater treated locally can either be reused by the inhabitants or discharged into the municipal sewer) provide some references;
- A number of concerns raised by Franceys (2007) regarding inset appointments apply to decentralized systems: what happens if the service provider goes bankrupt? How are tariffs set, revised, and approved? Who will undertake water quality testing at the customers' taps?

From a revenue side, the financial attractiveness of alternative water systems is limited by the fact that revenues come from water tariffs and other charges and do not reflect the positive externalities for the society at large. Typically, revenue streams from non-potable reused water are limited: only a few applications qualify, and the willingness to pay for them is low (see Yang, Abbaspour, 2007, for the case of Beijing). This is so for two reasons: first, the price of potable water does not reflect its full cost and second, non-potable uses are valued less by the community and the customers than drinking water.

This illustrates a market failure which is typical for environmental policy and which can legitimate policy interventions. It follows that alternative water systems can only be deployed when water-related institutions and regulations are transformed into enabling frameworks. Such frameworks need to be technology neutral. They would rely on a consistent set of policies: address public concerns; adjust governance; reform institutions; adjust the regulatory framework; create opportunities. These policies are briefly considered below. More work is certainly needed to explore them further.

Box 5. Innovation in a Greenfield Site: the Gap, Brisbane

The Payne Road residential subdivision in The Gap, Brisbane, is a Greenfield, 20-lot subdivision being undertaken by a property developer with an interest in achieving sustainable water management. This particular developer has other projects with similar planned features.

The developer has planned the site to have minimal water transfer in or out. This is achieved through rainwater tanks at each house connected to three large communal tanks. These communal tanks can be topped up from the town water supply in the rare event of insufficient rainfall. Only blackwater is discharged to the existing sewer network. Grey water is used for subsurface irrigation at each property.

The system architecture combines on-site systems and central infrastructure. This can be consequential for the operation of central wastewater systems: in Australia, water utilities report up to 40% reductions of wastewater collection flows due to, among other things, increasing on-site recycling; less water in the system can generate blockages and higher concentrations of contaminants (see the Water Services Association of Australia Report Card 2007-08).

In the Payne Road operation, the developer has kept local and state government stakeholders informed, and these parties maintain an ongoing interest in the project for monitoring purposes. Responsibility for ongoing management of the communal components of the system will be through a body corporate. This project, though small and insignificant in terms of Australia's overall urban water balance, is at the leading edge of decentralised approaches to sustainable urban water management. The water cycle is, to a great extent, localised and "closed loop", resembling much more closely the original natural water cycle than the intervention of conventional centralised systems.

A limitation on replication of this project is the large land areas required (each lot is 1,000 m2). There are also several unresolved questions such as how water will be supplied during power outages, potential health consequences and social acceptance and amenity over time. In addition, this project does not address the need to close nutrient cycles.

Source : quoted from Linvingston et al. (2005)

Address public concerns

Acceptability by the social communities or households is a requisite for the deployment of alternative water systems. The main challenge regards potable reuse.

In Australia, research has shown how public perceptions of alternative sources of water (including reclaimed water) have changed over the last five years, from public health hazard to less resistance for garden watering and cleaning uses. Dolnicar and Schäfer (2009) have identified opinion leader groups and the media mixes that can reach them.

Indirect potable reuse (IPR) – where purified recycled water is discharged into a water body before being used in the potable water system – has successfully been implemented in Australia, Europe, Singapore and the United States. As noted by Marsden Jacob Associates (2006), "the key issue is not whether the science or the engineering are feasible, but the extent to which IPR will be accepted by the public".

Direct reuse is more sensitive. Singapore, which produces new water complying with the most stringent requirements for industrial uses, finds it difficult to sell extra-safe water to consumers (even if it is promoted as bottled water in a number of events). Trust in standards and in the processes that prevailed to their definition contributes to (but does not guarantee) acceptance.

In addition, the public is not comfortable with the increased cost and intrusiveness of inspections and maintenance required by decentralized services.

This suggests that reform of the governance and the institutional framework for water supply is a requisite for the public opinion to consider alternative ways of providing water. Livingston and his colleagues claim that changing patterns of water use is a process of long-term institutional transformation. They argue that "future policy directions should focus on facilitating stable predictable arrangements for making policy decisions in civic groups. This will involve long-term institutions for continuous negotiation among diverse stakeholders about meanings, values and relationships" (Livingston et al., 2004). The way public dialogue is structured in San Diego, California, illustrates a way forward (Box 6).

Box 6. Structuring policy dialogue on water reuse. The case of San Diego California

Facing challenges of ensuring reliable and sustainable water supplies, the City of San Diego, California, has identified the importance of recycled water in the City's overall water supply portfolio. A water reuse study was commissioned to examine water recycling opportunities. The Preface identifies the crucial points that have to be addressed in a public policy dialogue:

"Understanding the value and uses of recycled water is of critical importance in making informed choices and decisions. In developing recycled water uses, the City has several choices. Evaluating these choices requires considering more than just costs. Values, such as those listed below, will be at the heart of the public dialogue answering two critical questions: 1) what water recycling opportunities should be pursued?; and, 2) depending on the opportunity, how much water should be recycled?

Recycled water brings value to San Diego because it enhances the reliability of our water supply; promotes a sustainable balance with our environment; is a locally controlled resource; reduces water diversions from other California ecosystems; and, is an investment in San Diego's future."

Source : *The City of San Diego's Water Reuse Study*, March 2006

Adjust governance

Water governance should be adjusted to financing strategies (a point made by Rees and her colleagues in another context; see Rees et al., 2008).

Public involvement, and transparency are even more critical in the case of alternative ways of providing water, because public acceptance is critical, especially in cases of water reuse for (direct or indirect) potable uses.

Alternative water systems need to coordinate a number of players, including new comers into the sector (technology suppliers, property developers, etc.). The relationships between actors will change: the typical bilateral relationship between the municipality and the service provider (be it public or private) will have to give way to more complex relations between a nexus of players, with a variety of competences and *savoir-faire*. There is a risk that responsibilities are blurred between municipalities who generally are responsible for water provision, property owners who may invest in decentralized systems, technology suppliers who provide the equipment, and service providers who operate and maintain these equipments. It follows that accountability and responsibilities have to be clearly defined. The contractual arrangements will have to adapt, to specify the responsibilities and risks born by each player.

The difficulties Australian wastewater utilities face because of successful recycling schemes upfront (see Box 5 below) indicate that planning is critical, especially when centralised and alternative systems are designed in combination.

Decentralised systems fail to benefit from the economies of scale associated with the management of water supply services. However, they can be centrally managed, if roles and responsibilities are clearly defined. That may contribute to the emergence of a consistent network, based on aggreated decentralised water systems.

There is a risk that water tariffs for decentralized systems fluctuate on a case by case basis and are set in an opaque way at a decentralized level. Procedures to approve tariffs have to be designed and enforced.

Reform institutions

Alternative water systems generate risks which have to be properly addressed and mitigated. Institutional reform can contribute to this.

The issue of ownership and control of alternative water systems is central. The questions of who owns the equipment and who will be responsible for managing and maintaining it are crucial. Alternative systems can only be considered when an adequate service capacity exists for operation and maintenance services and the supply of necessary replacement parts and materials. Note that it may be more difficult to successfully maintain numerous distributed water treatment units than to maintain one large central treatment facility. USEPA allows Point-of-Use (POU) treatment to be used by a water system for compliance with regulatory standards, so long as the water system retains responsibility for the operation and maintenance of the POU devices.

In addition, water sector regulators need to be prepared to monitor water quality from a variety of different sources (e.g. fresh water abstraction, harvested rainwater, grey water and reclaimed wastewater) in a multiple of settings (in central plants, commercial and industrial buildings, and private houses). This requires capacity, financial and human resources. Distributed, real time water quality monitoring systems are needed.

Adjust the regulatory framework

Nelson (1998) notes that, in the US, tight, uniform regulations, designed and implemented to protect public health and the environment, have resulted in several adverse effects, including a resistance to technological and practical innovation, an inevitable tendency of standard one-size-fits-all systems that either over-protect or under-protect the environment, depending on local circumstances, and a growing public opposition to top-down government mandates and enforcement. This diagnosis certainly resonates in a number of OECD countries.

It readily applies to water supply. While a variety of technical options exist to provide water, options in use are limited by planning regulation, norms for the quality of the product or service, standards for grey water reuse and for the techniques to be used.

In the US and in most OECD countries, most state and county health departments and legislatures have resisted widespread permitting of newer technologies and a shift to performance codes for several reasons (see Nelson, 1998, for US experience). This is because alternative systems pose greater risks of mechanical failure than passive, conventional systems. There are few trained professionals for the more demanding designs, installations, and maintenance needs of these new systems. Government bureaucracies are not equipped for increased oversight roles. These issues are all the more sensitive that, as any water-related infrastructure and service, alternative water systems must deliver dependable public health protection.

This suggests that a number of issues have to be addressed before alternative water systems can be deployed where they are relevant. Recent developments of regulation, at supra national, national and sub-sovereign levels indicate that such changes are taking place.

Sub-sovereign initiatives at regulatory reform

In California, the Water Code Section 13550-13556 states that using potable domestic water for non potable uses, including cemeteries, golf courses, parks, industrial and residential irrigation, and toilet flushing, is an unreasonable use of potable water if recycled water is available. In California, the "Show Me the Water" laws require developers to prove that enough water is available to serve proposed new housing. Reclaimed water can be counted as a source of water in that context. The City of Malibu inserted grey water installation requirements in its general plan: Policy 3.123 reads "New development shall include a separate grey water treatment system where feasible".

In Japan, some cities (e.g. Fukuoka) request building owners to install decentralised systems for newly constructed buildings of certain size or water demand (Funamizu et al., 2008). Similar regulations are in place in Beijing, as already mentioned.

In Calcutta, India, the objective of the Kolkata Municipal Corporation (KMC) is to minimize municipal sewerage and drainage load and to provide drainage facility at maximum areas of the city and its added and fringe areas. KMC has issued a directive according to which all large housing, commercial and other development projects in and around Calcutta have to treat wastewater in an in-house wastewater treatment plant. The treated wastewater can either be reused by the inhabitants or discharged into the municipal sewer, or the nearby pound or canal. Rainwater harvesting and wastewater reclamation have become part of the architectural and construction management business (Bose, 2008).

National regulation on alternative water systems

A number of countries lack regulation defining reclaimed wastewater as water resources (see Jimenez and Asano, 2008). Things are changing as new regulation is being introduced for urban reuse (in Spain, in Italy).

In France, the Ministry of Health has issued a recommendation not to use rainwater or reused water inside a building, based on hygiene and public health considerations. Exceptions may be granted by the local branch of the Ministry (DDASS), the sole habilitated agency to issue permits for water reuse. In August 2008, this Ministry, together with the Ministry of Environment and other ministries, issued a decree that regulates the conditions under which non potable water can be used inside a building (see Box 7).

Box 7. French decree authorizing rainwater harvesting for indoor non-potable uses

The decree "*Arrêté du 21 août 2008, relatif à la récupération des eaux de pluies et à leur usage à l'intérieur et à l'extérieur des bâtiments*" is a major breakthrough in French policies regarding indoor uses of alternative sources of water. The decree states that rainwater can only be used inside a building to clean floors, flushing excreta and, on an experimental basis, to wash clothes.

For the first time, a permit was issued authorizing a developer in Paris to harvest rainwater from the roof area of a new building for sanitary uses inside the building (Tour Olivier de Serre). Because the permit allows harvesting water from the roof only (and not from the *parvis*), the payback period has expanded from 10 to 19 years.

USEPA is promoting best practices for alternative water systems in a series of documents, including[4]:

- Guidelines for Water Reuse (September 2004). This document presents and summarizes water reuse guidelines for utilities and regulatory agencies. The guidelines cover water reclamation for non-potable urban, industrial, and agricultural reuse, as well as augmentation of potable water supplies through indirect reuse. Technical, regulatory, legal, funding, and public involvement issues related to water reuse are discussed (available at http://www.epa.gov/ORD/NRMRL/pubs/625r04108/625r04108.htm);

- STEP Guides (Simple Tools for Effective Performance) to help small scale, non-community drinking water systems comply with the current legislation;

- More technical literature to develop and monitor point-of-use, distributed systems.

Prospects for supra national regulation in favour of alternative water systems

At a supra-national level, the Commission of the European Communities (2007) presents a set of policy options to address the challenge posed by water scarcity and droughts. It stresses that national priorities can be counterproductive, when they promote additional water-related infrastructures, instead of supporting water saving and efficiency in the first place. It notes that alternative water systems, including desalination and wastewater reuse, are increasingly considered as potential solutions across Europe. The risks associated with alternative options are being assessed by the Commission.

The Communication by the Commission mentions that consideration should be given to developing a new Directive, similar to the Energy Performance of Building Directive, for water performance of buildings. It could cover taps, showers and toilets, rainwater harvesting and reuse of grey water. Water efficiency criteria would be included in performance standards for buildings.

Create markets for alternative water systems

Setting the prices right for water and sanitation is the first step towards stimulating markets for alternative water systems when they are needed. Fuller cost recovery for water supply and taxing

[4] additional references are available at USEPA's website

wastewater discharge at its real economic value (or setting caps on volumes and pollution loads to be discharged) can only shorten the payback period for alternative water sources.

As captured by the modelling exercise by Yang and Abbaspour in the case of Beijing, "wastewater reuse potential is sensitive to the prices for reclaimed wastewater as well as freshwater for different uses. The high cost of wastewater treatment lowers the optimal scale of wastewater reuse. On the other hand, the low freshwater prices in relation to the reclaimed wastewater prices discourage the reuse of the latter" (Yang, Abbaspour, 2007, p.249).

Similarly, recognition of the benefits of decentralized solutions for the overall community is legitimate, as the market failures discussed above confirm. Public finance should be wisely used in this domain, for instance to stimulate more R&D in the sector. Major areas for further research include new technologies and processes (e.g. based on membranes, or ultraviolet light); the treatment of emerging pollutants; sensor and ICT for distributed, real time water quality monitoring systems; and the societal and institutional adaptations required to design and implement alternative water management strategies (see in particular Livingtson et al., 2004).

Public procurement, in an appropriate institutional and regulatory framework, and in the context of multi stakeholder governance, can stimulate innovative combinations of prevailing and alternative ways of providing water. In so doing, they would accelerate the learning curve, on technological, economic, and institutional dimensions. This requires clear political commitment, as the appropriate options will be tailored to stated policy objectives.

In the Hong Kong environment, rainwater harvesting and grey water reuse would be very costly to set up and the potential quantity of water saved would be small. They will not generally be a priority measure in the Total Water Management programme (see Box 2 above). However, the government will conduct trials in projects of appropriate scale and nature, to gather experience and encourage private developers to consider them. Both grey water and rainwater recycling systems are being planned for some new public projects such as schools (see ACQWS, 2008).

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