Cities xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Cities

journal homepage: www.elsevier.com/locate/cities

Saving water in cities: Assessing policies for residential water demand management in four cities in Europe

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ARTICLE INFO

Keywords:
Urban water demand management
Water policy
Household water consumption
Residential water conservation
Water quality
Urban planning

ABSTRACT

Policies for water demand management (WDM) have evolved in recent decades as an important strategy to reduce water consumption in cities. The objective of this study is to identify what WDM policies have been most effective, based on the perspectives of water utilities and experts. To this end, four cities with a low per capita residential water usage were identified: Berlin, Copenhagen, Tallinn and Zaragoza. A mixed-methods approach, including a questionnaire for water utility officials, semi-structured interviews, and review of secondary data and information, was used to identify successful policies. Results show that residential consumption from 1995 to 2015 has reduced in all four cities, irrespective of which policies were perceived to be more or less effective, though savings have been larger for cities with a larger number of perceived effective policies. WDM policies rated as highest-impact were renovation and maintenance of networks, and campaigns for water-saving technologies, followed by universal installation of water meters, rapid leak detection, public awareness campaigns, and municipal regulations. Tariff reforms were mentioned as impactful only in one case. However, lowering the level of urban water use by too much may lead to technological and financial challenges for water utilities.

1. Introduction

Managing scarce water resources in an efficient, effective and sustainable manner is an essential public service challenge for cities (Brown, Keath, & Wong, 2009; Grafton et al., 2015; OECD, 1999, 2008, 2016). Cities are particularly vulnerable for water scarcity as a spatial mismatch of available freshwater resources and population concentrations – rather than an overall lack of water resources – can lead to supply challenges. Population growth, increasing urbanization, climate change induced droughts and rising temperatures exacerbate the situation, leading to the risk of depleting reservoirs and reduced groundwater recharge.

In Europe, at least 11% of the population and 17% of its territory have been affected by water scarcity since 2007, and this is expected to increase due to climate change (EC, 2016). At the municipal level, the cities need to address water management and governance challenges for too much, too little, and too polluted water. Among 48 – predominantly European – cities surveyed in a recent OECD (2016) study, the key challenges to effective water governance were: ageing or a lack of infrastructure; national laws and regulations; extreme events; climate change; water pollution; and a lack of attention of water on the political agenda. Most cities also mentioned urban growth and growing populations as problems, while a minority identified shrinking populations as a challenge.

In this context, water demand management (WDM) has emerged as an important policy response to water scarcity and environmental sustainability concerns in Europe and elsewhere. Many cities have implemented WDM policies to reduce consumption to more sustainable levels (Arbués, García-Valiñas, & Martínez-Espiñeira, 2003; Grafton et al., 2015; Hughes, Pincetl, & Boone, 2013; Inman & Jeffrey, 2006; Renwick & Green, 2000; Willis, Stewart, Panuwatwanich, Williams, & Hollingsworth, 2011). The objective of this study is to assess the effectiveness of these policies, based on the perceptions of water utilities and experts, in reducing household use in four cities with low per capita residential water consumption: Berlin, Germany; Copenhagen, Denmark; Tallinn, Estonia; and Zaragoza, Spain. The next sections provide a conceptual overview of WDM, related policies in Europe and their impact on reducing residential water use, and present research results on the perceived effectiveness of individual policies in each city, including subsequent analysis with additional information from interviews and secondary research. Lessons learned are of particular interest to municipal policy makers, city planners and utility managers in the water sector.

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https://doi.org/10.1016/j.cities.2018.03.008
Received 21 July 2017; Received in revised form 20 December 2017; Accepted 9 March 2018
0264-2751/

2. Water demand management: concepts, policies, impacts

2.1. The conceptual basis for water demand management

For most of the 20th century, water demand management (WDM) received little attention. Water planners simply calculated future water use by multiplying expected use per capita with population to be served. Water infrastructure, such as reservoirs and pipelines, was then constructed to store and transport the quantity needed (Gleick, 2000).

In the 1970s and 1980s, however, a combination of factors led planners to rethink their narrow focus on supply-side management: (1) fewer untapped water resources near cities while those remaining became more difficult to access; (2) contaminated and/or depleting groundwater resources further limiting available supply; (3) increasing droughts and more intense competition between urban, industrial and agricultural water users; (4) a rising awareness about the environmental costs of large-scale water infrastructure developments; (5) increased public understanding about the interdependence of water, a functioning ecosystem, and human health; and (6) high costs of constructing and maintaining water infrastructure decreasing the enthusiasm for investments from water agencies (Baumann & Boland, 1998; Gleick, 2000, 2002). The result was a shift from focusing on tapping unused water resources to new ways to meet water needs with less resources, at a lower cost, and with less ecological deterioration.

The conceptual basis of WDM is water conservation, i.e. any beneficial reduction in water use or in water losses (Baumann & Boland, 1998). Thus, managing water demand also implies changing individual and organizational behavior towards more sustainable usage patterns. Brooks (2006) provides an operational definition: WDM is any measure – administrative, economic, financial, technical, or social – that achieves one or more of the following five objectives: (1) reducing the quantity or quality of water required to accomplish a specific task; (2) adjusting the nature of the task so it can be accomplished with less or lower quality water; (3) reducing losses in movement from source through use to disposal; (4) shifting time of use to off-peak periods; and (5) increasing the ability of the system to operate during drought.

Water quality is an important element of the WDM concept, as it directly affects the quantity of potable water. For example, using non-potable water for specific tasks can leave more freshwater resources available for other uses. Similarly, reducing water pollution also helps to increase the amount of water available for potable uses at any given time.

From a governance perspective, WDM has been described as a policy framework aiming at limiting water use to the amount that meets the socioeconomic needs without squandering resources, at reasonable cost and without stripping other areas and future generations of critical natural resources (Bithas, 2008). The sustainability aspect of WDM is stressed, i.e. not using (or polluting) more water than can be treated for future use. Also, a combination of different policies is considered necessary to ensure efficient, non-wasteful water use, limit environmental deterioration, and charge adequate fees, thus balancing the need for cost recovery with equality and ecological concerns.

2.2. Water demand management policies in Europe: Water Framework Directive (WFD)

The Water Framework Directive (WFD) shapes demand management policies in cities in the European Union (WISE, 2008). Ratified in 2000, it promotes a set of policies to achieve more efficient use among water users. Its main objective is to ensure water quality, i.e. to achieve good ecological status in all waters (Alcon, Martin-Ortega, Berbel, & de Miguel, 2012; Meyer & Thiel, 2012). Key goals are to manage the interrelated challenges of water scarcity, quality deterioration, and managing costs for water supply services, including full cost recovery. Governance solutions focus on sustainable water use, facilitated by demand management policies and innovative cost recovery pricing for water services (Bithas, 2008).

Specific policy and analytical tools to address water scarcity include pricing policies for cost recovery, taking into account the "user pays principle"; new investment projects; new regulations; and negotiated agreements with polluters. Cost-effectiveness and cost-benefit analysis help identify most effective policy alternatives, and ensure public funds are well spent. Since the largest users of public utility water are households (Eurostat, 2012), demand management policies and tools have been implemented by a number of municipalities in Europe to reduce residential water demand.

By encouraging a rational use of water, including criteria of efficiency and savings, the WFD illustrates the strong linkage between managing water quality and quantity. It calls for reducing water consumption, recycling and reusing water wherever possible, minimizing pollution, and treating wastewater properly.

2.3. Water demand management policies in cities: impact on residential water use

A review of the literature on WDM reveals that policies fall into two main categories: tariff measures include water price increases or tariff reforms, while non-tariff measures take the form of operational improvements, regulations and restrictions, information campaigns, and technological innovations (Inman & Jeffrey, 2006; Jorgensen, Graymore, & O'Toole, 2009; Olmstead, Hanemann, Stavins, & Kennedy, 2003; Olmstead & Stavins, 2008). The effectiveness of policies and tools varies significantly depending on the context they are used in. For an overview of the impact of different policies found in the literature, see Table 1.

2.3.1. Tariff policies

One key insight is that indoor water demand appears to be largely inelastic to price (Arbués & Villanúa, 2006; Domene & Saurí, 2006; Inman & Jeffrey, 2006; March & Sauri, 2010; Olmstead et al., 2003; Olmstead & Stavins, 2008). Hence, policymakers' ability to reduce household consumption through tariffs seems limited. Yet, three considerations deserve attention. First, the studies show that in the United States, price responsiveness – while varying significantly depending on place and time – averages 3–4% of urban residential water use reduction for every 10% price increase, hence, there is some response. Second, the same studies show that long-term price elasticity for households is somewhat larger, at 6% reduction for 10% increase. Third, as a consequence, the effectiveness of water tariff reforms is largely variable depending on context and location. For example, price elasticity has been shown to be higher in Europe than in the United States, allowing for different policy responses (OECD, 1999, 2008).

2.3.2. Non-tariff policies

2.3.2.1. Operation and regulation. Leakage detection and repair of the utility's water infrastructure is considered one of the most effective policies, and thus a policy applied in various cities intent on reducing their water consumption and non-revenue water (Inman & Jeffrey, 2006; Kayaga & Smout, 2014; OECD, 2016; Tortajada & Joshi, 2013). Note that these measures do not strictly affect per capita water consumption, but they are commonly included in WDM policies. Plumbing codes and water efficiency labeling – voluntary or compulsory – lead to water savings, e.g., 5–10% in Australia and the U.S. (Inman & Jeffrey, 2006). Water restrictions are usually only applied in areas facing serious droughts. In this case, specific purposes of water (i.e. outdoor use) are curtailed or prohibited, or water availability may be restricted to certain times. While restricting water use can lead to significant water savings, its effectiveness depends upon residents following the policy, which can be difficult to enforce (Olmstead et al., 2003; Olmstead & Stavins, 2008).

2.3.2.2. Raising awareness. Several studies show that attitudinal factors