SUSTAINABILITY OF THE PUBLIC WATER SUPPLY AND SEWERAGE SERVICES OPERATING SYSTEM: A CASE STUDY ON THE EXAMPLE OF THE CZECH REPUBLIC*

M. Hájek[1], L. Petružela[2]

[1]Czech University of Life Sciences Prague, Prague, Czech Republic
[2]T.G. Masaryk Water Research Institute, Prague, Czech Republic

Water services, as a necessity for natural ecosystem functions and a key output from public governance, play a crucial role in forming sustainable relationships between natural, economic, and social factors in the development of society. Primarily, these relationships relate to the natural impacts of weather and climate on the variability of the hydrological cycle. Secondary relationships exist between providers and consumers of the services. Services provided by operators of public water supply and sewerage systems are a specific segment of water services. Their sustainability is controlled on the one hand by public regulation and and on the other by a combination of economic, social, and environmental objectives and the means by which they are achieved. The aim of this paper is, based on the parameters of supply and demand, to quantify the most important aspects of sustainable management of water supply and sanitation enterprises in connection with the current model for state regulation. The methodology is based on an examination of consumer behaviour indicators which can be interpreted from 'water bills'. The comparison of household expenditure on water services in the Czech Republic shows that some are already approaching, and even exceeding, the limit of what is considered social acceptability.

water services; sustainable management; economic regulation; social acceptability; water price

DE GRUYTER OPEN

doi: 10.1515/sab-2016-0006
Received for publication on January 10, 2015
Accepted for publication on December 4, 2015

INTRODUCTION

Water services play a key role in ensuring sustainable development of society. In recent decades, impacts which increase the uncertainty of the sustainability of these services have been strengthening (Zhou et al., 2010; Katko et al., 2012). Primarily, these are the impacts of climate change on the variability of the hydrological cycle (Frederick, Major, 1997; Slavíková et al., 2013), which emphasizes the importance of water accumulation, energy use of water treatment/distribution, water quality, flood and drought prevention, and sustaining ecosystem services. This is reflected in the growth of public expectation that drinking water supply, wastewater removal, and sewerage treatment will all be provided at a reasonable (affordable) price. These services, a subset of water services, are provided by organizations which specialize in public water supply and sanitation. In the Czech Republic, this set of specialists is made up of owners of technical infrastructure (municipalities) and operators who provide water for drinking and the removal of waste water. The operators are public interest enterprises (often privately owned and profit based) and undertake their operations within a framework of environmental, economic, and social objectives set out in law. Sustainable management of these enterprises is related to a complex set of specific economic (natural constraints and technical monopoly), social (focused on public health and safety), and environmental (pollu-

* Supported by the Technology Agency of the Czech Republic, Project No. TD020112.

tion prevention and internalization) constraints which determine costs and revenues, and which influence each other (Del Borghi et al., 2013). The scope of relevant sustainable development issues in this area is evident, *inter alia*, from the Global Reporting Initiative methodology indicators (GRI, 2013).

A major influence on the sustainable management of water supply and sanitation enterprises is – under European rules – the regulation of economic activity and entrepreneurship in the field of public services (in the EU – services in general interest). Public water supply and sanitation services are characterized by economic specificities such as: local monopoly (natural monopoly based on the source of water, technical monopoly based on the use of unique infrastructure), public subsidies/grants (with a link to the public nature of services), and strong links in the social, environmental, and safety areas (Lenton et al., 2008). These enterprises operate in an environment where two principles collide and create tension: the functioning of water supply and sanitation systems in real market environment (resources purchased including labour, consumable materials, energy and infrastructure investment) and the regulation of economic and ecological behaviours and the distribution of social and other public benefits (François et al., 2010). Regulation affects all areas. Public services are largely operated by private companies with exclusive rights for a limited time period and a well-defined geographical space (Boag, McDonald, 2010). This is the result of the process of partial privatization of the water management sector in the Czech Republic in the 1990s. The analyses can therefore be based on data, procedures, and methods common for enterprises on the one hand, and on the other on reference economic regulation, ecological and social functions which combine to directly enforce its extension to a sustainable development framework.

The aim of this paper is, based on the parameters of supply (quantity, price) and demand (consumption, acceptability), to quantify the most important aspects of sustainable management of water supply and sanitation enterprises in connection with the current way of the state regulation. The paper describes the trend of prices of water (followed by sewage) tariffs, the impact on drinking water consumption, and the impact on different population groups. The opportunity for a change in regulation, in the case of the Czech Republic, is also outlined.

MATERIAL AND METHODS

A steady decrease in the consumption of domestic water supplies draws the attention of enterprises because it directly impacts on the economy of operation, costs and revenues, the affordability of innovation activities (including infrastructure upgrades and new process technologies), and the financing of facilities. There appear to be difficulties in public cost recovery and private profitability (Del Borghi et al., 2013). Raising prices for consumers has become a major and effective tool in addressing these problems (OECD, 2010; Wang, Segarra, 2011). Other options for improving enterprise finances (leakage reduction, general cost management) are already partially depleted (progressive residual loss reduction measures tend to be more costly as the 'quick fixes' are attended to first) and other options are constrained by the conditions set by the regulatory environment (the method of cost-based pricing according water law, tenders, grants/subsidies). The urgency of addressing this issue in economic terms can be illustrated by examination of the relationship between the price of water supplied and the income of consumers' demand and their sensitivity to price changes. The first relationship is sometimes referred to as 'social acceptability' of water price (Wang et al., 2010) and is defined by the proportion of households where expenditure on water services exceeds 2–3% of net household income (Hung, Chie, 2013). The latter – income elasticity of demand – characterizes active consumer behaviour and in a specific case it can be interpreted in the context of the theory of demand (McEachern, 2010). Assuming that the quality of supplied drinking water is similar throughout the Czech Republic, then the main indicator of social and other effects is the quantity consumed. Another prerequisite for an investigation of consumer behaviour is transparency of payments (billing according to actual consumption), which is not always a matter of course (Wallsten, Kosec, 2005). The relationship between the amount of water consumed and the social effect is not simple. From a certain level, however, it may pose a more serious problem than 'cost management' and with further general decrease in consumption the social effect may escalate (OECD, 2011).

Regarding environmental aspects, water services enterprises are governed by the laws regulating water abstraction, quality of water from the tap and wastewater discharges in terms of quantity and quality. It can only be stated that the trend of water and sewage tariffs has a positive effect on the abstraction of water as a natural resource, i.e. that the amount of water abstracted for consumption shows a long-term decrease per head of population. This fact, however, has significant implications in the above-mentioned social area (Hung, Chie, 2013), and these are dealt with in this paper.

The general methodology is based on indicators of consumer behaviour (households) as reflected in the water bills (OECD, 2011). Payments for drinking water, including sanitation, are one of the items studied by social statistics in a sample set of respondents. These indicators are compared with the average values of the total amount of billed potable water and

payments for water and sewage tariffs in the Czech Republic as a whole.

The paper builds on an analysis based on Czech Statistical Office (CZSO) data sets: Water Supply and Sewerage Systems (time series 2005–2012), Household Budget Survey and Household Income and Living Conditions (time series 2005–2012) (data broken down by CZSO household definition and the EU or OECD standard), and average prices of the water services at the Ministry of Agriculture of the Czech Republic (MoA) and T.G. Masaryk Water Research Institute (MWRI) data. Basic statistical data and their economic interpretation allow the specification of social stratification in consumption of drinking water, which has a technical dimension (the effect of demographic development on technical capacity and efficient operations), an economic dimension (the impact on cost recovery and economic stability of both owners – municipalities and operators), a social dimension (the direct effect of affordable water services on the quality of life), and a political dimension (the equality in access to water services is limited by price). This is not a transient detail, but an essential characteristic of a broader issue.

As for the previous situation, this one can be indicated by several ways. The basic indicators include the quantification of the specific consumption of drinking water (per person per day). Using the economic analytical apparatus it is possible to determine the response of consumption to price and its sensitivity (Klaiber et al., 2014). If we intend to use 'price' as an instrument in 'demand management', it is necessary to identify as best as possible the relationship between domestic consumption and benefits derived from water and the point at which this is optimized so that the development in the water services sector does not show a tendency to create a social problem.

From the 1990s, water and sewage tariffs in the Czech Republic have been steadily rising and are accompanied by a declining per capita consumption of public water supply and sanitation services. This is not exceptional. In developed countries with more than 100-year-long tradition of public water supply systems, this trend has been evident for decades. In comparison with other European countries and the OECD average, however, water consumption per household member in the Czech Republic is lower (OECD, 2011). The main driving forces for rising prices of water and sewage services are generational replacements of technologies (Kallis, 2010) and basic infrastructure along with increased mandatory technical standards in the development of extensive networks. Implementation of new generations of technologies and materials used to reduce losses and waste is also a driver in price increases. Another influence comes from the attempts to liberalize and privatize the sector (Bel, Warner, 2008), where accompanying negatives have so far been only partially remedied by regulation and re-communalization. Specifically, in the post-communist countries, this price signal has a significant influence on consumer behaviour (Schleich, Hillenbrand, 2009).

The theory of demand derives a change (decrease) of quantity in dependence on the growth of price from marginal utility (Klaiber et al., 2014). Thus, consumption decreases with the growth of prices due to setting prices to the level of full costs and due to the growth of input prices. Water is given as an example of the necessity, the demand for which little depends on the price. Demand is inelastic (Wang, Segarra, 2011). In applying these principles to the case of domestic water supplies we encounter several problems. It is a service which is strongly linked to the subsequent disposal of wastewater, within which the consumer pays for the pollution. Supply of domestic water and sanitation is associated with housing (OECD, 2011). The costs of water and sewage tariffs are therefore strongly linked with housing costs. Domestic water supplied by a local operator – where there is natural and technical monopoly – has no possibility of substitution (Sibly, Tooth, 2008). Due to the strict regulation of water quality standards the quality standard is practically the same for all suppliers (in the Czech Republic). Supply cannot significantly increase or decrease the level of technical equipment required, offer assortment or lower quality for a lower price and *vice versa*. Finally, water for drinking is a necessity, but qualitatively a seemingly homogeneous supply is comprised of some entirely essential parts (drinking consumption, basic hygiene) and parts related to household equipment (dishwasher, swimming pool, gardening etc.). The essential part is seemingly very little elastic (Wang, Segarra, 2011) (consumers decide 'about the life and health'). However, the increase in costs and prices of water resources, technologies, and wastewater treatment have raised the price of domestic water so that it has encouraged households to invest in saving equipment (Ward, White, 2014), not only for environmental or moral reasons, but purely for economic reasons – for example, the marginal cost of a dual-flush toilet will be returned in a few years. The problem for suppliers of domestic water is that consumption reduced in this way also means reduced sales for water treatment companies. Savings in operating costs as a consequence of reduced consumption will not result in savings of fixed costs, linked to long-term costly investments in infrastructure and supply networks (Cabrera et al., 2013). Efforts to cover the costs of reduced consumption will result in a further growth of the supply price. The response of consumers is becoming progressively smaller as price elasticity decreases. If the price of drinking water – for some consumer groups – affects their ability to afford enough water for direct consumption and sanitation (after the introduction of saving techniques in the household), the water and sewage tariff

within the household bills becomes independent and acts competitively against the affordability of other necessities of life. These processes can be described by the relationship between demand and household income (Parker, Wilby, 2013) and examination of the cross effects of necessities (Bakker et al., 2008). The issue of cost recovery for suppliers is associated with the problem of price affordability for consumers and the way in which it can act as a barrier to achieving the desired social and safety outcomes of domestic water supply (Hung, Chie, 2013). Paradoxically, the problem in question is not primarily a lack of water or neglected infrastructure, but the problem of economic management of supply and demand, which cannot be avoided even by developed countries. The ecological effects are impacted by this situation through knock-on pressures on the costs of collecting wastewater sewerage and treatment. For the operator of new publicly funded investment this represents a substantial increase in operating costs and, therefore, makes necessary an increase in sewage tariffs (François, 2010).

The points of demand dependence are derived from the equilibrium situation in each year, which is corresponded to by the price and the identified quantity of drinking water consumed. Both income and price elasticities of demand are defined as the proportion of annual increases in quantity and price (Haque, 2006), i.e.:

$$E_{DP} = \frac{Q_2 - Q_1}{(Q_1 + Q_2):2} : \frac{P_2 - P_1}{(P_1 + P_2):2}$$

$$E_{DI} = \frac{Q_2 - Q_1}{(Q_1 + Q_2):2} : \frac{I_2 - I_1}{(I_1 + I_2):2}$$

where:
E_{DP} = price elasticity of demand
E_{DI} = income elasticity of demand
Q_1, Q_2 = quantity (previous and current period)
P_1, P_2 = previous and current period prices
I_1, I_2 = previous and current period household incomes

The values are always expressed in positive numbers. Price elasticity estimates are generally found in the range of 0 to 0.5 in the short run and 0.5 to 1 in the long run. Income elasticity estimates are of a much smaller magnitude (usually) and positive. When calculating income elasticities of demand, statistical data describing aggregate domestic drinking water demand are used (in the Czech Republic). These data include approximately 94% of inhabitants which are supplied from public water systems and represent aggregate consumer behaviour. The remaining 6% include individual systems (water wells).

Further, water price elasticities are found to be higher in summer than in winter and price elasticities are generally the highest in situations where outside water usage is the highest (Griffin, Chang, 1991) including e.g. lawn and garden watering, car washing, and filling swimming pools. However, the research in the Czech Republic confirms no impacts of the season variables (temperature or rainfall) on drinking water consumption (Slavíková et al., 2013).

The dependence of the number of employees on the number of residents and the area of the town was calculated using the Pearson's correlation coefficient (r) (Hendl, 2012):

$$r = \frac{\sum_{i=1}^{n}(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{n}(x_i - \bar{x})^2 \sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

The correlation was selected as the preferred method because it expresses interdependence. The result was assessed using a test of statistical significance through setting a zero hypothesis.

RESULTS AND DISCUSSION

Three areas are worth discussing at this stage. Firstly, expected results correspond to the theory of consumer behaviour with increasing prices and/or with lower income effective consumer demand decreases. Secondly, parameters of income elasticity of demand for drinking water in different household groups (income deciles) to be expressed as short-term (average annual), medium-term (blocks of 4 years), and long-term (entire period, i.e. 8 years) response of demand with changing income. Thirdly, affordability of water and sewage tariff prices. The Czech Republic is included in OECD countries, where expenditure on domestic water, including sanitation services, exceeds the level of affordability proposed by Hung, Chie (2013) and meets the conditions for 'water poverty'technically defined as equal to or more than 2–3% of net household income.

The presented results are based on the use of household bills obtained from household budget survey. Calculations made concurrently using statistics concerning living conditions show somewhat different results. The differences between the calculations of weighted average price for water and sewage tariffs according to CZSO and Ministry of Agriculture data are small, and do not affect the overall results. The effect of changes in the VAT rate also did not show up markedly. A significant discrepancy can be found in the comparison of recalculated specific consumption of domestic water per person with the average statistically recorded and reported volume of billed water per supplied (connected) consumer. Additional and more detailed comparison carried out on the basis of household incomes and living conditions confirmed the overall picture and the tendency to social stratification in domestic water consumption in the Czech Republic.

Table 1. Development of drinking water price and quantity of domestic consumption in the Czech Republic

Year	1994	1995	1996	1997	1998	1999	2000	2001
Current price (CZK)	9.39	10.70	12.08	13.64	15.25	16.73	18.00	19.06
Domestic consumption (mil. m^3)	696	656	631	604	580	564	554	536

2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
20.47	21.56	22.76	23.58	24.56	25.83	28.56	30.63	32.01	33.88	37.28
545	547	543	531	528	532	517	505	493	486	481

basic data: CZSO, MoA, MWRI

Behaviour of consumers

The behaviour of consumers of domestic water in the Czech Republic corresponds to theoretical assumptions (O E C D , 2011). It confirms the so far prevailing influence of economic drivers, prices, and financial constraints for households, on this situation (compared to social, health, etc.). The results are not sufficient as evidence for the definition of demand as part of the water market, but they confirm the effectiveness of the application of general economic methods to identify the characteristics of demand. The demand curve can be constructed using empirical data of price development, using current prices, or using prices net of inflation and value added tax. Connection by the best relation to reliability gives smooth curves (Fig. 1, original source of data is mentioned in Table 1) corresponding to the theoretical course of demand. To assess the level of dependence, Pearson's correlation coefficient was used. Its value $r = 0.91965$ expresses the high level of dependence, which reflects a decline in domestic consumption with the rising price of drinking water. In testing statistical significance there was assessed the zero hypothesis with the assumption that a decline in domestic consumption is not dependent on the price of drinking water. The test rejected this hypothesis and confirmed the dependence.

Income elasticity of demand

The demand for drinking water in most of the monitored situations in households (70 points, characterized by the parameter of income elasticity) shows two different types of behaviour depending on the period: rather inelastic demand (< 1) and rather elastic demand (> 1) (Fig. 1). Short-term (annual) elasticity (AverYears) is on average higher than medium-term (Med 2Term) and long-term elasticity (LongTerm). Medium-term elasticity in the second 4-year period is higher (see Fig. 2). While the long-term elasticity confirms the character of domestic water as the necessity (less dependent on conditions), the evident difference in income deciles should be interpreted with caution as a more significant link between demand and income is to be expected in lower income groups. The increasing sensitivity of consumption relative to income in the second (later) 4-year period can be considered as an indicator of the growing importance of water services within the framework of housing. It is also interesting to

Fig. 1. Drinking water demand in the Czech Republic
basic data: CZSO, MoA, MWRI

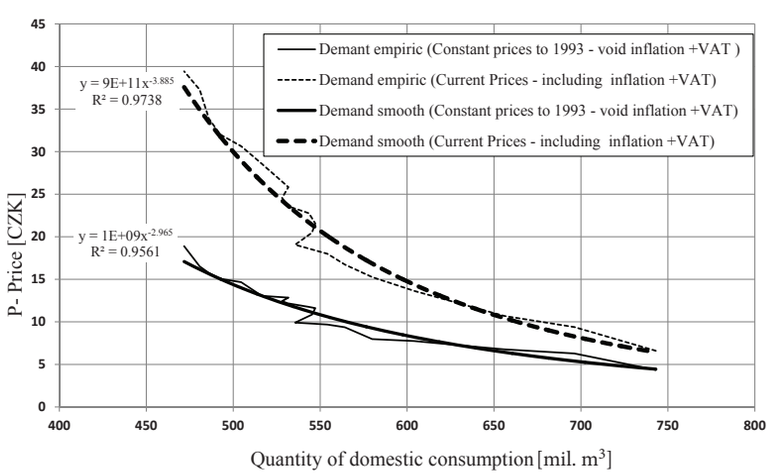

Table 2. Domestic water and sewage bills as a percentage of the net budget of households

Year	Income deciles (%)									
	1	2	3	4	5	6	7	8	9	10
2005	**2.72**	1.83	1.74	1.58	1.51	1.42	1.21	1.16	1.07	0.80
2006	**2.70**	1.87	1.66	1.61	1.44	1.46	1.29	1.22	1.12	0.74
2007	**2.71**	1.83	1.62	1.53	1.50	1.46	1.25	1.16	1.03	0.73
2008	**2.52**	1.73	1.57	1.57	1.49	1.39	1.30	1.18	1.06	0.80
2009	**2.52**	1.67	1.59	1.52	1.50	1.43	1.32	1.19	1.12	0.76
2010	**2.57**	1.78	1.70	1.57	1.57	1.44	1.35	1.22	1.10	0.80
2011	**2.72**	1.88	1.79	1.67	1.66	1.43	1.44	1.25	1.19	0.86
2012	**2.74**	**2.06**	1.76	1.88	1.72	1.63	1.49	1.44	1.20	0.91

water tariff: prohibitive vulnerable affordable

basic data: CZSO, MoA, MWRI

compare two medium-term periods, of which the later falls in with the conditions of economic crisis.

Affordability

Affordability of drinking water in the Czech Republic (P e t r u ž e l a et al., 2009) is indicated by stratification by income and the development over time (Table 2). The results derived from water bills suggest that the problem of water poverty – in the definition mentioned above (R e y n a u d , 2007) – covertly occurs in about a third of households throughout the monitored period. It is evident that the number of households falling into this group increases to reach as much as 25% in the years affected by the decline of economic growth. If we use water services expenditure > 2% in the net household income as the critical indicator for water poverty, then the data shows an affordability gap growing between the two parts of the population: households in income decile 4 and below, compared with households in income decile 5 and above. For income decile 4 the latter years of the time series (2009 onwards) represent a shift to water poverty which is concurrent with recession and economic measures introduced to improve economic performance.

CONCLUSION

Based on the results of the investigation it is clear that a current, and very important, issue in sustainable water supply management and sanitation enterprises is decreasing consumption, which has a negative economic and social impact. This is also associated with the

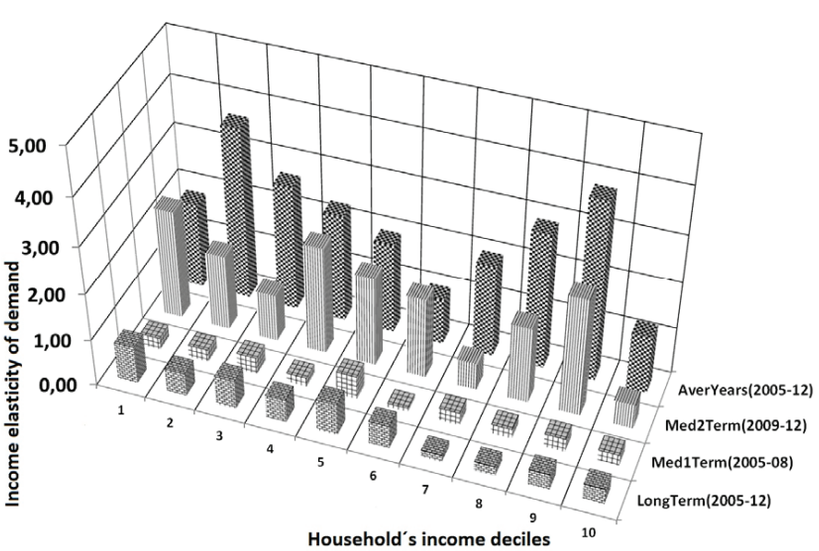

Fig. 2. Agregate demand income elasticity in the Czech Republic
AverYears = short-term (annual) elasticity, MedTerm = medium-term elasticity, LongTerm = long-term elasticity
LongTerm data express the difference between the values reached in the first and the last year of the reference period; AverYears data express the average for individual years of the reference period
basic data: CZSO, MoA, MWRI

method of price regulation by the government, since it affects domestic water consumption and therefore supports these negative tendencies.

The investigation was based on the structured statistical series from the Household Budget Survey (including water services payments) and parallel statistics on household consumption of domestic water, plus water and sewage tariffs in the Czech Republic in 2005–2012. This confirmed the applicability and effectiveness of economic methods, derived from the theory of consumer behaviour, by investigating the behaviour of drinking water demand. It allowed the identification of the social impact on domestic water consumption, which indicates, as expected, a negative correlation between price and volume of consumption and a positive correlation between consumption and increasing household income. The long-term income elasticity ranges are mainly in the zone of inelastic demand, less than 1, and so consumption responds to changes in income rather slowly. The response is higher in the first, compared to the second, monitored 4-year period. Further research may confirm, *inter alia*, the effectiveness of social modification of the price tool – water tariff in the form of block rates (O E C D , 2011) or warn against optimism in recovery of drinking water demand by using pricing manipulations.

REFERENCES

Bakker K, Kooy M, Shofiany NE, Martijn EJ (2008): Governance failure: rethinking the institutional dimensions of urban water supply to poor households. World Development, 36, 1891–1915. doi: 10.1016/j.worlddev.2007.09.015.

Bel G, Warner M (2008): Does privatization of solid waste and water services reduce costs? Resources, Conservation and Recycling, 52, 1337–1348. doi: 10.1016/j.resconrec.2008.07.014.

Boag G, McDonald DA (2010): A critical review of public–public partnerships in water services. Water Alternatives, 3, 1–25.

Cabrera E, Pardo MA, Caberra Jr. E, Arregui FJ (2013): Tap water costs and service sustainability, a close relationship. Water Resources Management, 27, 239–253. doi: 10.1007/s11269-012-0181-3.

Del Borghi A, Strazza C, Gallo M, Messineo S, Naso M (2013): Water supply and sustainability: life cycle assessment of water collection, treatment and distribution service. The International Journal of Life Cycle Assessment, 18, 1158–1168. doi: 10.1007/s11367-013-0549-5.

François D, Correljé AF, Groenewegen JPM (2010): Cost recovery in the water supply and sanitation sector: A case of competing policy objectives? Utilities Policy, 18, 135–141. doi:10.1016/j.jup.2010.03.001.

Frederick KD, Major DC (1997): Climate change and water resources. Climatic Change, 37, 1–23. doi: 10.1007/978-94-017-1051-0_2.

GRI (2013): Sustainability Topics for Sectors: What do stakeholders want to know. GRI Research and Development Series: 155. Global Reporting Initiative, Amsterdam.

Griffin RC, Chang C (1991): Seasonality in community water demand. Western Journal of Agricultural Economics, 16, 207–217.

Haque MO (2006): Income elasticity and economic development: methods and applications. Springer, Dordrecht.

Hendl J (2012): Overview of statistical methods: analysis and meta-analysis of data. Portál, Prague. (in Czech)

Kallis G (2010): Coevolution in water resource development: the vicious cycle of water supply and demand in Athens, Greece. Ecological Economics, 69, 796–809. doi: 10.1016/j.ecolecon.2008.07.025.

Katko TS, Juuti PS, Schwartz K (2012): Water services management and governance: lessons for a sustainable future. IWA Publishing, London.

Klaiber HA, Smith VK, Kaminsky M, Strong A (2014): Measuring price elasticities for residential water demand with limited information. Land Economics, 90, 100–113.

Lenton R, Lewis K, Wright AM (2008): Water, sanitation and the millenium development goals. Journal of International Affairs, 6, 247–258.

McEachern WA (2010): Microeconomics: a contemporary introduction. Cengage Learning, Mason.

OECD (2010): Pricing water resources and water and sanitation services. OECD, Paris.

OECD (2011): Greening household behaviour: the role of public policy. OECD, Paris.

Parker JM, Wilby RL (2013): Quantifying household water demand: a review of theory and practice in the UK. Water Resources Management, 27, 981–1011. doi: 10.1007/s11269-012-0190-2.

Petružela L, Jílková J, Slavíková L, Jansa D (2009): The problem of social acceptability of water and sewage tarrifs in the Czech Republic. In: Žák M (ed.): Sustainability accounting and reporting at macroeconomic and microeconomic level. Linde, Praque, 37–40.

Reynaud A (2007): Social policies and private sector participation in water supply – the case of France. United Nations Research Institute for Social Development, Geneva.

Schleich J, Hillenbrand T (2009): Determinants of residential water demand in Germany. Ecological Economics, 68, 1756–1769. doi: 10.1016/j.ecolecon.2008.11.012.

Sibly H, Tooth R (2008): Bringing competition to urban water supply. Australian Journal of Agricultural and Resource Economics, 52, 217–233. doi: 10.1111/j.1467-8489.2007.00433.x.

Slavíková L, Malý V, Rost M, Petružela L, Vojáček O (2013): Impacts of climate variables on residential water consumption in the Czech Republic. Water Resources Management, 27, 365–379. doi: 10.1007/s11269-012-0191-1.

Wallsten S, Kosec K (2005): Public or private drinking water? The effects of ownership and benchmark competition on U.S.

water system regulatory compliance and household water expenditures. Working Paper No. 05-05, AEI-Brookings Joint Center for Regulatory Studies, Washington, D.C. doi: 10.2139/ssrn.707131.

Wang C, Segarra E (2011): The economics of commonly owned groundwater when user demand is perfectly inelastic. Journal of Agricultural and Resource Economics, 36, 95–120.

Wang H, Xie J, Li H (2010): Water pricing with household surveys: A study of acceptability and willingness to pay in Chongqing, China. China Economic Review, 21, 136–149. doi:10.1016/j.chieco.2009.12.001.

Ward M, White C (2014): Managing residential water demand in the OECD. In: Grafton RQ, Wyrwoll P, White C, Allendes D (eds): Global water: issues and insights. ANU Press, Canberra, 11–15.

Zhou J, Erdal ZK, McCreanol PT, Montalto F (2010): Sustainability. Water Environment Research, 82, 1376–1395. doi: 10.2175/106143009X12445568399938.

Corresponding Author:

doc. Ing. Miroslav H á j e k , Ph.D., Czech University of Life Sciences Prague, Faculty of Forestry and Wood Sciences, Kamýcká 1176, 165 21 Prague 6-Suchdol, Czech Republic, phone: +420 731 384 103, e-mail: hajek@fld.czu.cz