Assessing Drinking Water Affordability in the EU: A Quantitative Approach

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Maria Gutorova
Joachim I. Schellekens
Prof. Dr. Henri L.F. de Groot

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Disclaimer:
This project is an independent research effort by Ecorys' water policy experts. The aim of this research is to support the national, European and/ or international policy debate by providing new (quantitative) insights on the status of drinking water affordability in the EU. Specifically, findings should increase understanding of the impact of the "Right2Water" initiative (Article 13) in the proposal for a revision of the EU Drinking Water Directive; and provide local utilities a tested economically justified approach to measure affordability of various income groups.

For question please contact Joachim Schellekens: joachim.schellekens@ecorys.com / +31620649476

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Introduction

It has been universally recognized that access to clean and safe drinking water is a basic human right. In the EU the European Citizens' Initiative “Right2Water” challenges whether the provision of drinking water and sanitation services (WSS) is affordable for all. Future investments, either due to replacement of ageing pipe infrastructure or additional provisions in the proposal for a revised Drinking Water Directive, put an upward pressure on water tariffs. The proposed new article 13 aims to address this and “*obligates member states to take all to take all measures necessary to ensure access to drinking water for vulnerable and marginalised groups*” (COM(2017)753 final). To adhere to this new article, invest in infrastructure and at the same time achieve full cost recovery it is of utmost importance to know to what extent the rates can be raised without jeopardizing the affordability of water. However, existing affordability standards offer little leverage on that challenge as they lack quantitative justification and are often arbitrary in their nature. This study investigates what indicators can be applied to measure drinking water affordability in a more reliable and economically justified manner.

Methodology

This study employs two affordability measures, originally developed in the U.S., and adapts them to the European setting. These measurements are (1) the affordability ratio (AR), which presents water bills as a share of *free* disposable income; and (2) the hours of work at the prevailing minimum wage (HM) required to pay for a monthly water bill. It becomes evident that a broad consensus needs to be reached on the minimum amount of water to cover the (basic) consumption needs of an individual as it is one of the main parameters both in AR and HM formulas. It is also clear that applying a uniform standard for all would be misleading due to cultural, social and geographical differences. This study analyses the affordability of drinking water for the poorest segments of the population (i.e. those whose income is in the 1st quintile of the distribution) as well as the average affordability of all 28 member states, both at the basic (WHO) and actual consumption level. For the AR measurement *free* disposable income is calculated. Selection of minimum consumption (cost of living) is a volatile indicator in the AR measurement and a sensitivity analysis is performed to show how a minor change in cost of living will affect affordability of drinking water. Resulting AR and HM measurements are compared to prevailing drinking water ‘rule of thumb’ affordability thresholds. Used thresholds are based on recent political and theoretical ideas on what a reasonable share of income spent on drinking water is.

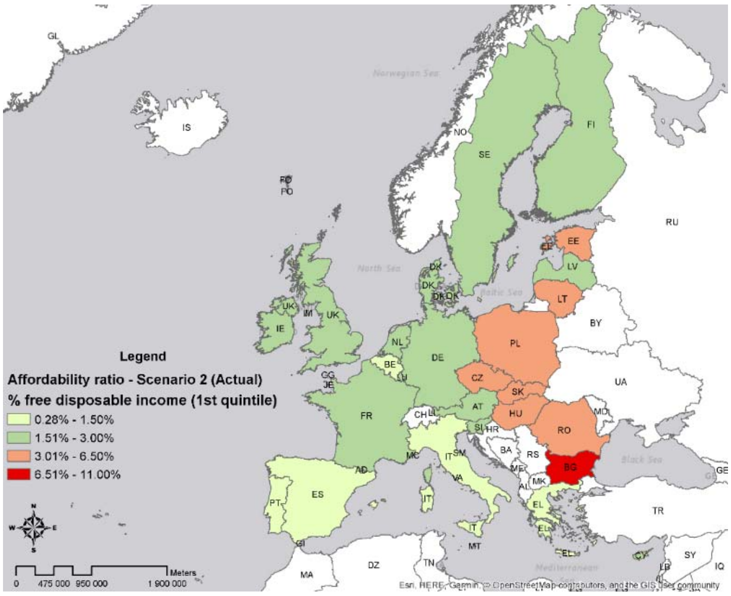
Key findings

The results of the affordability assessment at the level of the EU Member States show that currently affordability issues are most apparent in the countries of Eastern Europe (6). This is best illustrated by Figure 1 which reflects the AR for the poorest segments of the population in the EU MS. Even though there are a few discrepancies between the AR and HM calculation results, Bulgaria and Hungary are always classified as struggling to provide affordable WSS. The most striking difference between the two measures is that HM identifies Croatia, a country outside of Eastern Europe, as having affordability issues (no data are available to test this with AR). The analysis carried out here reveals that low free disposable income levels are responsible for limited affordability of WSS.

The sensitivity analysis for the AR values at basic water consumption for low income groups show that Latvia and Poland are at risk of crossing the affordability threshold. In the countries that are already have an affordability problem the issue escalates further, with the Bulgarian AR reaching an absolute maximum of 10.18 percent.

Note that it is important to be aware that the assessments in this paper are performed based on the national average values for water cost and consumption, and a more disaggregated level of analysis is required to identify the true problem regions. Since the statistics on water prices and use on the micro scale deviate from the national average, water utilities could benefit from implementing AR and HM assessments locally to determine if water is affordable for their customers.

Figure 1. Affordability ratio, 1st income quintile (actual average water consumption)



Discussion

The concept of drinking water affordability was quantified in this study using *free* disposable income and hours of labour rather than traditional standards, and different affordability levels among the EU MS were shown. To make sure that water is financially accessible for all, we need to define which affordability levels are socially acceptable. This paper offers one possible way for doing that, but what matters most here is the economic justification behind such rules of thumb rather than absolute numbers. The same logic should be applied to the selection of essential expenditures for the AR measurement as with the help of this parameter the results of the affordability assessment can easily be manipulated (see impact sensitivity analysis). In contrast, HM measures are more straightforward in terms of calculations, which makes it more reliable and easier to justify.

This paper makes a number of suggestions for further research. The most interesting one is the inclusion of bottled water consumption into the affordability analysis. Bottled water can be considered an essential need when the quality of tap water or its sensation is not satisfactory to the consumer. A starting point for such an analysis is provided in this paper. To carry out a full analysis, however, it is vital to collect disaggregated data on sales of still and sparkling water since the latter is considered to be a luxury good and should not be taken into account when assessing affordability. Secondly, we suggest that drinking water utilities perform both for the average and first income quantile an AR and HM measurement and compare this with set thresholds. This insight will can support the discussion between local stakeholders, the national government and utilities when facing investment cost related with implementing requirements in the revised Drinking Water Directive and/ or when ageing infrastructure needs to be replaced.

1 Introduction

The importance of water for human life and well-being can hardly be overemphasized. In the Resolution 64/292 issued in 2010, the United Nations General Assembly recognized "*the right to safe and clean drinking water and sanitation as a human right that is essential for the full enjoyment of life and all human rights*" (UN, 2010). This issue has received a lot of policy attention throughout the International Decade for Action "Water for Life" 2005-2015 and has become one of the UN Sustainable Development Goals (UN, 2018). The EU has also recognized that "*all States bear human rights obligations regarding access to safe drinking water, which must be available, physically accessible, affordable and acceptabl*e" (Council of the European Union, 2010).

Yet such high-level commitment also signifies the complexity of the goal to ensure access to safe drinking water for all. It is much more easily said than done, and in many countries across the globe, both developed and developing, poor regulation and deteriorating infrastructure remain the biggest obstacles to implementation of the ambitious water-for-all objective. The most challenging task here is twofold: to provide affordable and high-quality drinking water service for all while also raising sufficient funds to maintain and expand the network in a sustainable way. This can only be done with a very good understanding of the nature of water as an economic good, its demand and supply as well as a carefully crafted pricing policy (Rouse, 2013; Hanemann, 2005; Dalhuisen et al., 2002; Dalhuisen et al., 2000). Existing drinking water affordability standards offer little leverage on that challenge. For example, the US Environmental Protection Agency's indicator of 2.5 percent of median household income is said to have many flaws: it does not show the financial pressure on poor residents, it ignores the local cost of living, and its nature is only arbitrary (Circle of Blue, 2017). The same arguments can also be used against the European Parliament's standard of 3 percent of household income. Most importantly, these standards lack quantitative justification, and clear indicators of affordability of water bills need to be developed to allow for assessment of affordability of WSS that better takes into account the financial situation of various income groups.

On the EU-level drinking water regulation is guided by the Drinking Water Directive 98/83/EC. Even though it foresees a mechanism for revision of its Annexes (Council of the European Union, 1998), a number of internal and external factors have propelled the European Commission to the major revision of the directive itself. These factors include results of the REFIT[1] evaluation, the implementation of the Commission's response to the European Citizens' Initiative (ECI) 'Right2Water', which urged that "*EU institutions and Member States be obliged to ensure that all inhabitants enjoy the right to water and sanitation*" (Right2Water, 2018); and the EU's commitment to contribute to meeting the targets of the Sustainable Development Goals (European Commission, 2018a). As a result, a proposal for a revised drinking water directive was adopted by the European Commission in February 2018. As the original document, the revised directive allows Member States (MS) "*a margin of discretion in deciding how to implement the obligation to improve access to safe drinking water*" (European Commission, 2018b). This approach shows respect to the sovereignty of the MS but can also be dangerous in a sense that it leads to a great variety of interpretations of the term "*improvement of the access to safe drinking water*" and of associated indicators to measure such an improvement.

1 REFIT stands for the Commission's Regulatory Fitness and Performance Programme.

The concept of the access to water has at least two dimensions: a physical one and an economic one. This study investigates the latter since a recent report on Affordability in European Water Systems prepared by European Water Regulators (WAREG, 2017) claims that physical accessibility of water services is no longer a major concern in the EU countries: "*existing infrastructures seem to be adequate and reach almost all domestic customers*". What remains an issue in the EU Member States, and also in other countries around the world, is the ability of all households, and vulnerable population groups in particular, to pay for water services (Right2Water, 2018). It is expected that prices for residential water supply may rise in the future due to increased scarcity, water infrastructure maintenance or reconstruction needs and more stringent environmental regulations (Schleich & Hillenbrand, 2009). Moreover, Article 9 of the EU Water Framework Directive requires that water prices in the Member States shall cover environmental and resource costs "*in accordance in particular with the polluter pays principle*" (Official Journal of the European Communities, 2000). This principle together with full cost recovery is reinstated in the 2018 proposal for a revised drinking water directive (Article 13, European Commission, 2018b). It gives the national water regulators the green light to increase the price of water in the name of environmental protection (Kaika, 2003). This study investigates how affordability of drinking water can be quantified and what indicators can be applied to measure it in a reliable and economically justified way.

Reading guide

To answer this question, the following topics are considered in this report. Section 2 sets the theoretical background of the study and looks into the characteristics of water as an economic good, the established principles for drinking water pricing including design of the water tariffs and the definition of the concept of affordability, as well as water supply and demand. Section 3 presents the model used to quantify affordability of drinking water bills and discusses different benchmarks for the minimum amount of drinking water an individual needs and has a right to consume. In this section special attention is given to data limitations and suggestions are made on how the study can be extended. Section 4 provides the results of the modelling exercise and shows the variety of affordability levels across the EU MS. Sensitivity analysis is performed to identify the EU MS at risk of becoming unaffordable in case of an increase in price of the essential goods and services, and decomposition analysis is conducted to disentangle the price and income effects of the affordability problem. The last section discusses the main findings and provides some final remarks.

2 Theoretical Framework

2.1 Drinking Water as an Economic Good

While there is a universal agreement that water is an economic good, it is not trivial to categorise due to its unique characteristics and various functions it performs. In this regard, the OECD experts believe that if viewed from different angles, water can fall in each of the four categories of economic goods (see Table 1).

Table 1. Categorization of water as an economic good.

	Excludable	Non-excludable
Rival	Private good (e.g. drinking water supply)	Free access or "common pool good" (e.g. groundwater aquifer when individual pumping for irrigation is not monitored).
Non-rival	Club good (non-rival until a "saturation threshold" is reached) (e.g. networked services, with the threshold linked with the capacity of the system; recreational use of a water body, if monitoring of access is feasible).	Public good (flood management, resource and ecosystem protection, hydrological monitoring, storm-water drainage).

Source: OECD, 2009.

A number of stakeholders, including the European Federation of Public Service Unions and other organisations and individuals united under the European Citizens' Initiative (ECI) "Right2Water", are of the opinion that drinking water is a public good (Right2Water, 2018). However, this statement is at odds with economic definition of the concept. Public goods are non-excludable, meaning that people do not need to pay to have access to them, and non-rival, implying that a good has no scarcity value and marginal costs of supplying an additional consumer are not positive (OECD, 2009). While water does bear some degree of non-excludability in a sense that its property rights are not clearly defined, there are definitely costs associated with serving additional users, which leads to rivalry in consumption. Dalhuisen et al. (2000) argue that drinking water is a common pool resource "*meaning that there is a finite amount that must be shared in common over a variety of uses and over geographic areas*". In the European Parliament resolution of 8 September 2015 on the follow-up to the ECI Right2Water (2014/2239(INI)), water is recognised as a common good, which should be provided at affordable prices that respect people's right to a minimum quality of water.

The same resolution also states that everyone is entitled to "water for personal and domestic uses which is of good quality, safe, physically accessible, affordable, sufficient and acceptable" (European Parliament, 2015). Out of these requirements, affordability is notoriously tricky to determine. For example, in one of its reports on water management, the OECD stresses the need to carry out an assessment of actual local affordability constraints (OECD, 2009). On the other hand, water regulators also have to aim at full cost recovery - another major principle for water pricing embedded in the European legislation (Kallis & Nijkamp, 1999), meaning that water tariffs should reflect the capital costs of water delivery infrastructure as well as its operation costs and environmental costs. While this principle is not only very difficult to operationalise as one would

need to “identify the amount of subsidies being paid in support of water management and to assess and value the (environmental) externalities associated with the production and the use of drinking water” (Dalhuisen et al., 2002), it also comes at the expense of affordability of WSS. This dichotomy lies at heart of the drinking water pricing debate.

2.2 Drinking Water Policy Objectives and Design

There are many dimensions to the drinking water policy: apart from affordability, sustainable cost recovery and environmental protection, a number of important secondary objectives can be named. These include minimizing water losses, maintaining water quality, motivating customers to pay their bills on time, and generating political support for the water delivery operation (Wichelns, 2013). Drinking water pricing is a crucial instrument with the help of which these objectives can be achieved. The literature on urban water management points out several requirements that a successful drinking water policy ideally should fulfil. Dalhuisen et al. (2002) mention the following four principles of a tariff system for water use:

1. Pricing should be determined in such a way that it enables the supplier of water to cover his costs;
2. Prices should be set such that they are considered from a social perspective as 'fair';
3. The pricing should provide incentives to consumers of water to use water efficiently;
4. The pricing system that will be used should be administratively feasible and efficient.

While there is a general agreement on these principles among different scholars, some of them go a step further and split the second principle to make a distinction between equity and affordability (Molinos-Senante & Donoso, 2016). However, no clear conclusions have emerged from the scientific discourse as to what extent the pricing principles can be mutually exclusive or if it is possible to find a reasonable trade-off between them. The general belief is that financial sustainability and affordability of water services are not necessarily incompatible (OECD, 2009). It is true that achieving all objectives with a single policy instrument such as pricing is a rather ambitious task. Therefore, a successful water policy will require that complementary policies and interventions are employed alongside tariffs (Wichelns, 2013). This is in line with the ‘Tinbergen Rule’ which states that each policy goal should be addressed by a separate policy instrument (Tinbergen, 1952).

The OECD argues that *“effective financial planning for the water sector requires finding the right mix of revenues from the so-called “3Ts”: tariffs, taxes and transfers”* (OECD, 2009). It is imperative that water infrastructure operators are able to raise sufficient revenues from the customers, as it is an important pre-condition for access to the external sources of funding (such as loans). Tariff structure therefore plays a major role in urban water management. The rates can be set on the basis of either average cost or long-run marginal social cost. The former is the simplest but rather insensitive way to achieve full cost recovery, while the latter works much better in terms of providing incentives for efficient water use. Long-run marginal social cost pricing reflects the scarcity value of water, the value of negative and positive externalities which arise in the course of supplying an additional unit of water as well as capital and operating costs of water delivery facilities (Dalhuisen et al., 2000). That being said, it comes as no surprise that complex calculations are involved in designing a tariff based on long-run marginal social cost pricing. A detailed overview of various types of financial tools for water policy is presented in Table 2.

Table 2. Typical components of water and wastewater tariffs.

Tariff component	Description
Basic service charge	
Fixed charge	This is a fixed amount, paid per month or year, and does not allow any minimum amount of consumption. The charge usually depends on the meter size and accounts for the cost of infrastructure and account maintenance. There can be combined or separate basic charges for water and wastewater.
Minimum charge	This is a fixed amount, paid per month, and allows a minimum amount of free consumption of water.
Volumetric water charge	
Increasing block tariff (IBT)	This is a charge per unit volume which increases stepwise according to the level of consumption.
Decreasing block tariff (DBT)	This is a charge per unit volume which decreases stepwise according to the level of consumption.
Constant unit charges (CUC)	This is a charge per unit volume which is the same for all levels of consumption.
Seasonal charge	This is a charge per unit volume which changes with the time of the year to account for peak (summer) and off-peak (winter) demands. The tariff can be of any of the three types listed above (IBT, DBT, or CUC).
Wastewater or sewerage charge	
Volumetric charge	Volumetric charges can take the form of any of the three tariffs listed above (IBT, DBT or CUC). Generally, the volume of wastewater generated is considered to be the same as the volume of water delivered.
Flat	A flat charge is a fixed percentage (usually less than 100%) of the water bill. Mathematically, this can also be interpreted as a volumetric charge, but in this case a rate per unit volume is not specified.
Additional components	
Conservation or pollution tax	These are additional components that account for the scarcity value of water or the environmental externalities caused by discharge of wastewater. These are usually a fixed portion of the total water bill.
Stormwater or property drainage charge	This fixed charge per month or year, which varies with property size, accounts for the fact that rainwater falling on a paved surface ultimately discharges into public sewers, thus increasing the volume of wastewater requiring treatment.
Water resource development fee or capital contribution	Some utilities impose a temporary fixed charge on consumers to earn revenue for development of additional infrastructure to meet expanding demands.

Source: Hoque & Wichelns, 2013.

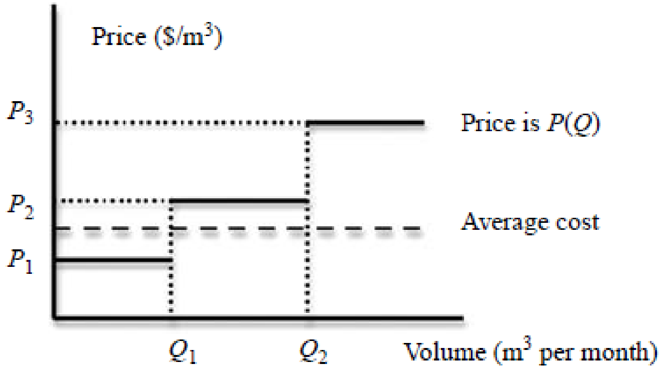
Increasing block tariffs (IBT, see Figure 2) particularly stand out in terms of its potential to achieve the double objective of financial sustainability and affordability of WSS as advocated by several researchers (Wichelns, 2013; Hoque & Wichelns, 2013; Molinos-Senante & Donoso, 2016). The arguments in its favour include that:

- it is a conservation-oriented rate design;
- it promotes equity by allowing for cross-subsidization between poor residential customers and wealthy households;
- it can raise sufficient revenues to recover costs (Molinos-Senante & Donoso, 2016).

However, there is a number of important requirements to the design of an IBT: it will only be successful if (1) consumption in the initial pricing block is subsidized; (2) the volumetric rate in the second pricing block is sufficient to cover the operational costs and subsidies provided to consumers in the first pricing block; and (3) the volumetric rate in the third block is sufficient to cover both operational and investment costs (Wichelns, 2013). For an IBT to be successful in

bringing in enough revenues, a non-marginal number of users will have to pay more than the long-term average cost of the service (OECD, 2009).

Figure 2. A typical IBT, with three prices and consumption blocks. *P(Q)* denotes that the unit price of water increases with the volume delivered each month.



Source: Wichelns, 2013.

One of the obvious drawbacks of IBT is that it can only be applied in a setting where metering of water use is introduced. Whittington (2011) is also concerned that many IBT do not recover the costs because the upper consumption blocks are not priced at sufficiently high levels and/or because the first consumption block is so large that almost all users only consume in that level. IBT also does not work as intended in the countries where the poorest households are not connected to water supply systems and thus cannot benefit from the low-priced initial consumption block. Another problem arises when the fixed part of an IBT is set too high, so consumers can enjoy little flexibility in price rates and therefore there is no incentive for them to change their consumption behaviour. Nevertheless, it has been observed that a shift is taking place worldwide from decreasing block tariffs and flat rate systems towards the use of two-part tariffs which include a fixed fee and a uniform or increasing block volumetric component (OECD, 2009).

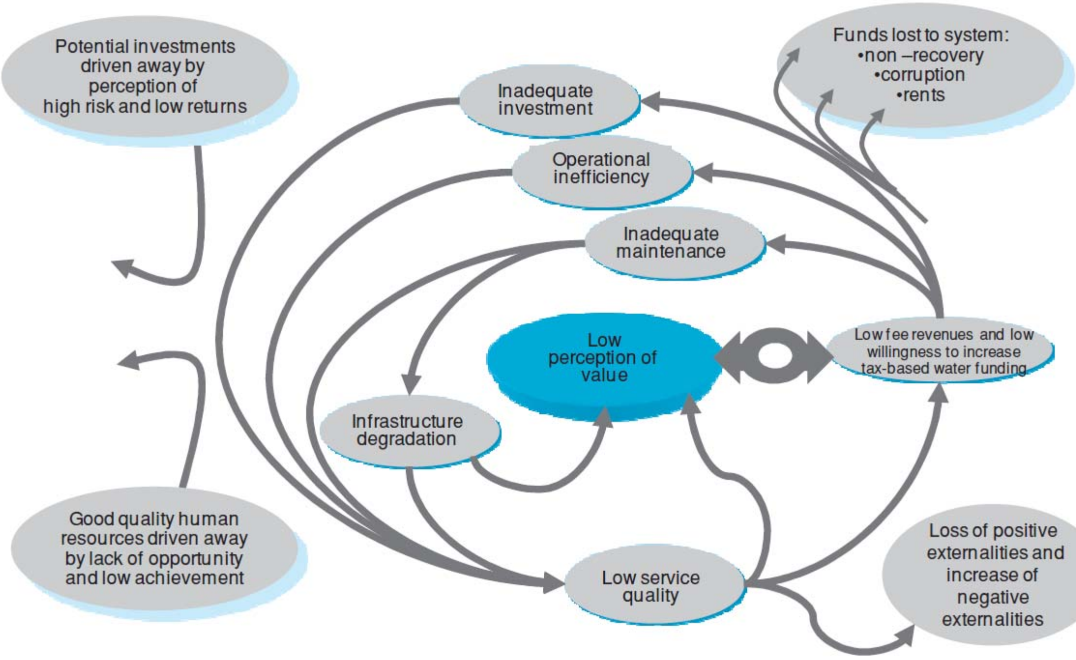
2.3 Supply Side

One of the most pressing issues on the supply-side of urban water management is the need for major investments in water delivery infrastructure. Biswas-Tortajada (2013) and Kallis & De Groot (2002) emphasize that existing water facilities are deteriorating all over the world and the need for infrastructure upgrade becomes more and more acute. The biggest challenge in providing sustainable urban water services is financing it. Rapid population growth requires large-scale investment in new infrastructure; but equally large-scale investment is needed for proper maintenance of existing infrastructure. Years of neglect make the task of renovating the existing facilities even more complicated. The results of decades of little or no maintenance are low pressure and high leakage. This means that “*costs per capita (for the same level of operational efficiency) will increase and result in a required increase in per capita cost recovery, which can only come from water charges*” (Rouse, 2013).

This situation shows the conflict between two major objectives of the drinking water policy: financial sustainability and affordability. On the one hand, water tariffs should be the main source of financing of water infrastructure, and on the other hand, the tariff rates cannot be set too high, so they remain affordable for all. Low tariffs designed to protect the vulnerable population groups may in fact hurt them most if the same rate is applied for all users regardless of their affluence, since there simply may not be enough revenue collected for maintenance of existing facilities and extension of water networks to deprived communities. Revenue shortfalls are usually dealt with by

reducing spending on new infrastructure, maintenance or even operations (Zetland & Gasson, 2013), which creates the vicious circle of underinvestment (see Figure 3). Water regulators should therefore design different tariff rates for different income groups, thus allowing for cross-subsidization among users.

Figure 3. The vicious circle of underinvestment and unrealised benefits.



Source: OECD, 2009.

To avoid the threats posed by underinvestment, the regulators should also aim for sustainable cost recovery. A definition of sustainable cost recovery, issued by the International Water Association, is as follows: "*costs that are recovered so that a water services undertaking can achieve and maintain a specified standard of service, both for the present and future generations*" (Rouse, 2013). However, it is important to note that a price that contributes to sustainable water management will need to reflect not only the costs of supply (i.e. service delivery), but also costs related to the scarcity of the resource itself (e.g. externalities and opportunity costs) (SIWI, 2016; Hughes et al., 2009; Molinos-Senante & Donoso, 2016).

Several scientists (Dalhuisen et al., 2003b; Dunn et al., 2017; Kallis & De Groot, 2003; Rouse, 2013) argue that an integrated approach to water governance is needed to ensure its sustainability. The advocates of this approach argue that the whole water chain needs to be integrated both physically and organizationally, water management and land-use planning should be governed jointly, and local users need to be consulted in order to design tariff structures that are efficient and most desirable for them. Synergies that an integrated approach to water management can achieve remain a very interesting area for research. However, this topic lies outside of the scope of this study.

2.4 Demand Side

It is imperative to know the price elasticity of water demand before employing the pricing instruments to regulate water use. The price elasticity of demand measures the responsiveness of demand to price changes and is defined as the percentage change in demand that will result from one percent increase in price (OECD, 2009). Since access to water is a basic need, theory

suggests that the demand for the minimum necessary amount of water should not be very elastic. However, empirical estimates of price elasticities presented in the literature yield a wide range of results: from 0.02 to 1.6 (Hoffman & Worthington, 2008). It has been found that short-run as well as indoor elasticities tend to be smaller than long-run and outdoor elasticities, which is in line with the theory. A few examples help to shed light on the diversity of estimates. Having conducted a comprehensive meta-analysis of 64 US econometric studies, Dalhuisen et al. (2003a) report a mean price elasticity of –0.41. Hoffman et al. (2006) carried out a panel data study of urban water demand in Brisbane and estimated a price elasticity of between –0.67 and –0.55. A panel data study by Xayavong et al. (2008) in Perth yields an estimate of an indoor elasticity of between –0.70 and –0.94, and an outdoor elasticity of between –1.30 and –1.45, which shows that outdoor water use can hardly be considered as a pure necessity. A study by Grafton and Kompas (2007) estimated aggregate demand for urban water in Sydney, with a price elasticity of –0.35. A number of empirical studies have revealed that under the increasing block rate pricing, relatively high price elasticities occur together with relatively low income elasticities (Dalhuisen et al., 2003a). It is also important to bear in mind that the price elasticity of water demand varies considerably with the household size as has been found in a paper that analysed residential water demand in Zaragoza, Spain (Arbues et al., 2010). The results of the empirical analysis in this study show that while all households respond to changes in water prices, small households (one and two members) are more sensitive to prices than medium ones (three members), and compared to other household sizes, pricing has the smallest impact on large households (four and more members). This finding provides valuable insights for water regulators.

It has been empirically proven that water consumption does not increase proportionally to income, meaning that expenditure share for water decreases as income rises (Schleich & Hillenbrand, 2009). In a meta-analysis of variations in income elasticities of residential water demand, which includes 161 observations, Dalhuisen et al. (2003a) show that the distribution of income elasticities has a median of 0.24. Another survey of residential water demand modelling, which analysed 37 empirical papers, reports most income elasticities within the range of 0.03–0.7 with the median value of 0.18 (Hoffman & Worthington, 2008). These estimates mean that drinking water demand is income inelastic. However, the researchers expect that income elasticities could be higher if the studies utilized the samples with more variation in household income, and if long-run elasticities were taken into consideration along with the short-run ones. Another factor that may bias the estimation is that increasing and decreasing block rates also influence income effects.

Although some scholars assume that consumers may not react to price signals (due to complex tariff schedules that are difficult to understand or lack of information on available possibilities for economizing on the water use (Dalhuisen et al., 2003b)), there is a general agreement in the academic literature that price instruments do have an influence on the demand for water. An interesting finding is that consumers respond more strongly to the changes in tariff structures (e.g. a switch from flat to volumetric rates) than to marginal price changes; however, the effect of the former reaction might only be temporary (OECD, 2009).

While sustainability is the major concern on the supply side, on the demand side it is affordability. It can be interpreted in two ways:

1. As the right for all households to have physical access to safe drinking water infrastructures (*accessibility concept*);
2. As the ability of all households or of specific groups to pay (*economic concept*). This in turn can be interpreted as:
   a. the possibility for the entire population to pay a fair price for water and wastewater services, without hampering their access to other essential services (macro-level definition);

b. as the possibility for the poorest segments (lower income) of the population to pay a reasonable price for water and wastewater services (micro-level definition) (WAREG, 2017).

As mentioned in the introduction of this study, for European countries the economic concept of affordability appears to be much more relevant than the accessibility concept. Then the question how to measure affordability arises. Teodoro (2017) has developed a model which allows for its direct measurement. He looks at an affordability ratio (AR), which compares a water bill to free disposable income for households at the twentieth percentile of the income distribution, meaning the bottom fifth, which is where affordability problems begin to be most apparent (in the US setting). A key difference, when compared to traditional methods to assess affordability, is that the model calculates affordability as share of *free disposable* income instead of median income. Another way that Teodoro proposes is to equate hours' labour at minimum wage (HM) with water bills. This is done by calculating the number of hours at the local minimum wage that a person would need to work in order to pay for a monthly household water bill at 50 gallons (or approximately 190 liters) per person per day. This is an estimate of a typical minimal residential water flow which is meant to "*reflect indoor, non-discretionary water use to maintain health in a contemporary American home*" (Teodoro, 2017). The researcher also suggests the rules of thumb, or affordability thresholds, of 10 percent of the free disposable income for the AR measurement, and 8 hours of minimum wage labour for the HM assessment. Teodoro stresses that these rules of thumb are not, however, based on welfare economics, law or philosophy, and were designed to express his subjective opinion as an answer to repeated questions of professionals and policymakers. That being said, it is interesting to reflect on the difference between the two rules of thumb: 8 hours of work at minimum wage are approximately equal to 5 percent of the monthly income of a person working 40 hours a week. This is at odds with the AR affordability threshold of 10 percent. However, the difference between the two numbers does not appear so striking any more if one is to recall that the AR rule of thumb relies on the *free* disposable income, that is, income corrected both for taxes and other essential expenditures such as food, clothing etc. (see section 3.1.1 for more details). The HM rule of thumb is based on the after-tax income only. It is larger than free disposable income since non-water related essential expenditures are not deducted in this case. Thus, the discrepancy between the two numbers is justified.

Despite having a certain degree of subjectivity, the rules of thumb introduced by Teodoro are a good starting point for an initial analysis of affordability. A broader consensus will however be required to adopt them for common use. It becomes especially clear that when talking about the rules of thumb for affordability, "*the problem of water is not one of economics but politics*" (Hanemann, 2005).

3 Methodology

3.1 Model

Within the framework of this study two measurements of affordability developed by Teodoro (2017) are adapted to the European setting which will be discussed in turn.

3.1.1 Affordability Ratio

The affordability ratio (AR) is defined as the percentage or ratio of basic water and sewer costs to individual free disposable income:

$$AR = \frac{WQ}{E},$$

where W are the costs of essential water and sewer services per cubic meter; Q is essential water use per person in cubic meters; E is a proxy for free disposable household income per capita, which is calculated as total household consumption expenditures per capita less essential expenditures per capita.

In this study AR is essentially a measurement of water bills' affordability at an individual level. Since drinking water services should be affordable even for single-person households, individual level is considered appropriate for the analysis. That is the difference of our approach compared to the method used by Teodoro who looks at affordability at the household level. AR is calculated for (1) a country average household income per capita and (2) for the income of vulnerable population groups (also per capita). The latter is operationalised as the income in the first quintile building on the work of Teodoro (2017). He argues that, according to mainstream welfare economics, the income level in the first quintile of the income distribution usually corresponds to the lower boundary of the middle class. The expenditures approach to identification of free disposable income is another difference from the Teodoro method. It has been chosen due to data availability, especially for low-income groups.

Essential household expenses are one of the most sensitive parameters in AR. Teodoro (2017) considers costs of taxes, housing, food, medicine, health care, and home energy as falling into the category of essentials, but he also advises to modify this selection according to local preferences. This study relies on the Eurostat's definition of material deprivation, which refers to a state of economic strain and durables, defined as the enforced inability (rather than the choice not to do so) to pay unexpected expenses, afford a one-week annual holiday away from home, a meal involving meat, chicken or fish every second day, the adequate heating of a dwelling, durable goods like a washing machine, colour television, telephone or car, being confronted with payment arrears (mortgage or rent, utility bills, hire purchase instalments or other loan payments) (Eurostat, 2016). Therefore, the expenses on the above-mentioned categories were considered essential for calculations of AR. A detailed overview of essential expenditures by COICOP2 level included in the assessment is presented in Annex A.

[2] Classification of individual consumption by purpose abbreviated as COICOP, is a classification developed by the United Nations Statistics Division to classify and analyse individual consumption expenditures incurred by households, non-profit institutions serving households and general government according to their purpose (Eurostat, 2018).

Lastly, the rule of thumb (although being arbitrary and a result of politics rather than economics) for affordability is also adjusted to reflect the context of the study. The individual level of the analysis performed here would require transforming the threshold of 10 percent of free disposable income as applied by Teodoro (2017). It would then be around 4 percent[3]. However, as the average amount of water consumed and net income in the U.S. is on average significantly higher than in Europe[4] this rule of thumb is not fit (too high) for the European context. The European Parliament resolution of 8 September 2015 on the follow-up to the European Citizens' Initiative Right2Water (2014/2239(INI)) states that "*3 percent of household income should be seen as a maximum for water payments where payments apply*" (European Parliament, 2015). Within the framework of this study, adopting both Teodoro and the European Parliament resolution, an affordability threshold of 3 percent of *free disposable* income is used.

3.1.2 *Hours' Labour at Minimum Wage*

Another way to assess affordability is to consider water costs as hours of work at minimum wage (HM). It is calculated as follows:

$$HM = \frac{WQ}{A},$$

where W are the costs of essential water and sewer services per cubic meter; Q is essential water use per person in cubic meters; A is net minimum wage per hour worked in the respective Member State's labour market.

Similar to AR, this assessment is also performed at a per capita level. Out of 28 EU Member States Denmark, Italy, Cyprus, Austria, Finland and Sweden do not apply a generally binding statutory minimum wage. For these countries mean nominal monthly earnings in the least well paid economic activity are used as a minimum wage proxy. It is recognized that the level of the mean nominal monthly earnings is slightly higher than the level of minimum wage because the earnings represent remuneration in cash and in kind paid to employees for time worked as well as for time not worked, such as annual vacation and other type of paid leave[5] (ILO, 2018). However, the sensitivity analysis has shown that this does not influence the results of the affordability assessment.

Since no official references to the relationship between the hours worked at minimum wage and water bills exist in the European legislation, affordability threshold is set at 3.15 hours[6] in this case following Teodoro (2017).

3.2 Widely Accepted Benchmarks

In operationalizing affordability, it is crucial to draw a clear distinction between essential and non-essential water use, since only the former will be priced below the long-run average cost of the service and will be considered when introducing income support policies. Essential water is defined as the amount needed for basic sanitation, drinking, bathing and food preparation needs (Hughes

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3 10 percent divided by the size of an average American household - 2.54 persons (U.S. Census Bureau, 2017) ~ 4 percent.

4 Average per capita consumption in the U.S. is 190 LPD, in Europe average consumption is 120 LPD. 4 * 120 / 190 = ~2.5. Net income in the U.S. is however higher due to lower income taxation, as such a slightly higher rule of thumb of affordability using free disposable income is deemed fitting for the EU context.

5 This includes long-service awarded leave, payment for public holidays and other recognized holidays, other time-off granted with pay such as study leave, leave for family reasons, trade union or civic duties (ILO, 2018).

6 Teodoro uses 8 hours as affordability threshold for HM at the household level. Transforming it to per capita level requires: 8 h / 2.54 persons (average American household size) = 3.15 h.

et al., 2009). Opinions on what exactly this amount is differ. Table 3 provides an overview of the benchmarks found in the literature. The origins of each of the numbers is discussed below.

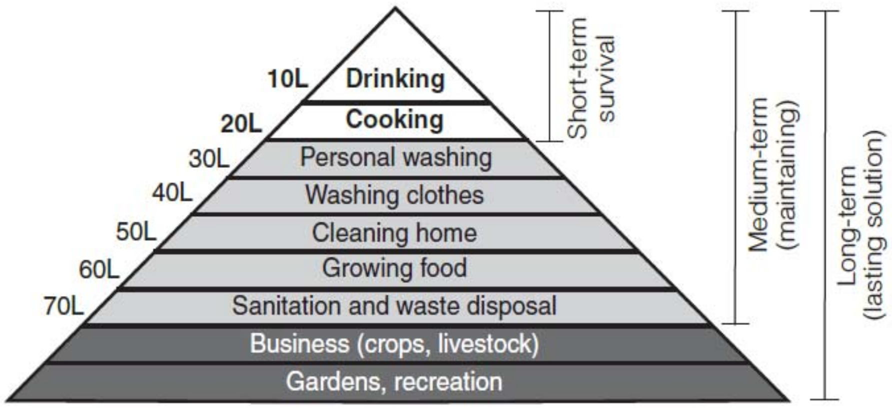
Table 3. Water use benchmarks.

	Source	Essential water use per person	
		per month, m^3	per day, litres
BASIC	Wichelns (2013)	1.5	50
BASIC	European Parliament	1.5-3	50-100
BASIC	WHO	2.13	70
OPTIMAL	European Parliament	3-6	100-200
OPTIMAL	OECD	5	164

Wichelns (2013). The benchmark of 50 litres per person per day (LPD) is used as a size of an IBT's initial consumption block within which only vulnerable population groups are allowed to purchase water.

WHO. WHO has developed a hierarchy of water requirements with 20 LPD being the minimum quantity of safe water required to realise minimum essential levels for health and hygiene (WHO, 2013). However, the definition of essential water also includes such needs as basic sanitation and bathing. Therefore, an upper boundary of 70 LPD was included in the overview above.

Figure 4. Hierarchy of water requirements.



Source: WHO, 2013.

European Parliament. The European Parliament resolution of 8 September 2015 on the follow-up to the European Citizens' Initiative Right2Water (2014/2239(INI)) recognizes that an optimal amount of water an individual needs is between 100 and 200 litres per day, "while noting that 50 to 100 litres is required to ensure that basic needs are met and few health concerns arise" (European Parliament, 2015).

OECD. The OECD suggests the benchmark of 15 m^3 per month per three-person household as a reference water consumption (OECD, 2009). This works out to roughly 164 LPD, which is considerably higher than the WHO standard. However, that is what some studies find to be used as the size of the initial consumption block in an IBT tariff (Wichelns, 2013; Hoque & Wichelns, 2013), and thus the amount of water that even the poorest population groups should be able to afford.

The benchmark of 70 LPD appears to be especially useful for the analysis since this is the amount of water for which demand is expected to be inelastic, which proves that this is a basic necessity.

Using the uniform benchmark for all EU MS however does not seem to be a good idea: due to differences in climatic conditions as well as cultural habits it is expected that the minimum amount of water an individual needs will vary per country. To take this variation into account, the standard of 70 LPD is scaled based on the national deviations from the actual average water use in EU-28 in 2015. For a given Member State (MS), the scaled minimum amount of drinking water is:

$$Q_{MS}^{min} = 70 * Q_{MS}^{Act} \big/ \overline{Q^{Act}},$$

where Q_{MS}^{Act} is actual average per capita water use per MS; $\overline{Q^{Act}}$ is actual average per capita water use in EU-28.

For the cases where, as a result of the above calculations, the minimum water consumption falls below 70 LPD[7], actual average water consumption is taken as a reference value since it is believed that in these countries average water use is already at its minimum. In addition, the affordability levels are also calculated for current actual average water uses in the EU MS, for the sake of comparison.

3.3 Data and Limitations

This study looks into affordability of drinking water in the EU Member States. Due to data availability, 2015 is chosen as a reference year. Table 4 provides an overview of main datasets used and their sources.

Table 4. Major data sources

Nr.	Dataset	Source
1.	Costs of essential water and sewer services per cubic meter	Ecorys
2.	Water use statistics	Ecorys
3.	Final per capita consumption expenditure of households by COICOP level	Eurostat
4.	Gross statutory minimum wages	Eurostat
5.	Mean nominal monthly earnings in the least well paid economic activity	Eurostat/ILO
6.	Personal income tax rates	OECD and other[8]

No data for per capita consumption expenditures of households by COICOP level in Croatia is available so the results of the affordability ratio assessment for this country are not reported here.

The analysis here is conducted on the country level. While it is recognized that a more micro level analysis (ideally, the level of water utilities) is preferred to capture the variation in major factors that influence water consumption, i.e. exact water tariff rates, household size and composition, spatial distribution of households; due to data and time constraints it was not possible to perform such analysis within the framework of this study.

Finally, due to data limitations, it has only been possible to carry out a decomposition analysis for the HM measurement. To decompose price and income effects in the AR, it is necessary to know the shares of essential expenditures in different income quintiles inside each of the 28 EU MS.

7 These cases include Malta, Lithuania, Estonia, Romania, Latvia, Slovakia, Czech Republic and Hungary.

8 PwC, KPMG, Ministry of Finance of Bulgaria.

These data are not readily available and it was not feasible to gather under the time constraints of this study. However, collecting this information and performing the decomposition analysis for AR will be a valuable extension of this work.

4 Results

Before presenting the results of the assessment it is useful to see if any trends can be observed in the data9. Figure 5 to **Error! Reference source not found.** show the scatterplots with relationships (or the absence thereof) among national average water prices, actual water consumption levels and free disposable income per capita.

As can be noticed from Figure 5, both water prices and water consumption levels vary considerably across the EU MS. Higher water charges are observed in the countries of Western and Northern Europe, while the biggest amounts of water are consumed in the South of Europe. However, this graph does not confirm the existence of a relationship between the two variables as the observations are scattered too far apart from the line of fitted values. This is also the case for **Error! Reference source not found.** and **Error! Reference source not found.**. Therefore, no clear conclusions emerge with regard to the relationship between water use and free disposable income.

Figure 5. Scatterplot of average water prices against monthly actual average water use per person.

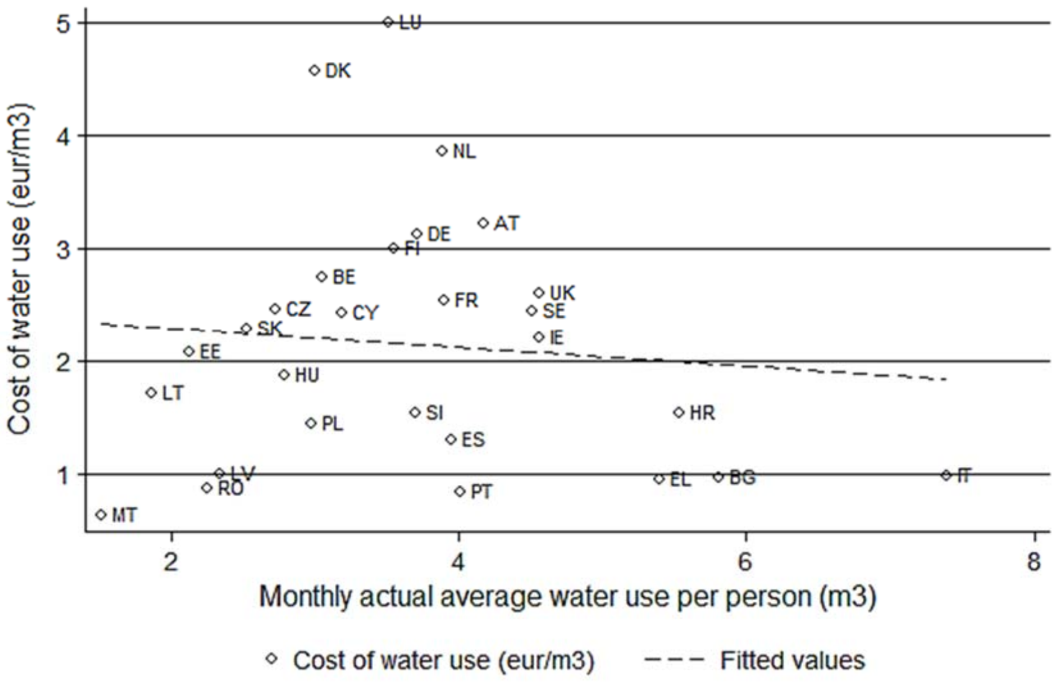


Figure 6 and **Error! Reference source not found.**, on the contrary, reveal a positive correlation between water price and free disposable income in the EU MS. The variables seem to move in the same direction: when the income rises, so does the water price. It is interesting to note that in all Eastern European states free disposable income falls below EUR 5 000, which is the lowest compared to the rest of the EU. This notion will be of a high importance in the following sections.

As described in section 3.2, two scenarios have been developed for calculating AR and HM: the first one aims to reflect affordability of basic water use and relies on the WHO benchmark of 70 LPD, while the second one looks into affordability of the current actual average water use.

9 All figures used for water prices and water use can be found in
Annex B – Average Cost of Water Use and Average Water Consumption in the EU-28.

Figure 6. Scatterplot of average water prices against average free disposable income.

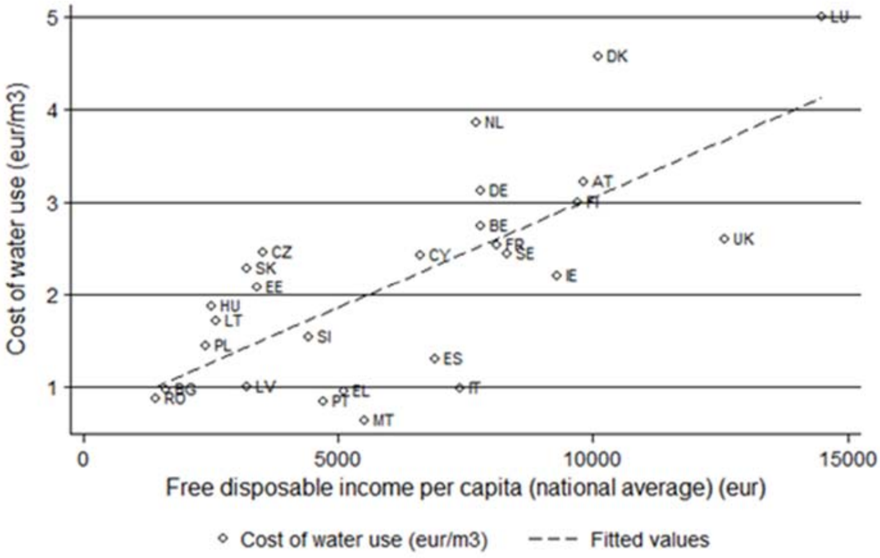


Figure 7. Scatterplot of average water prices against free disposable income in the 1st income quintile.

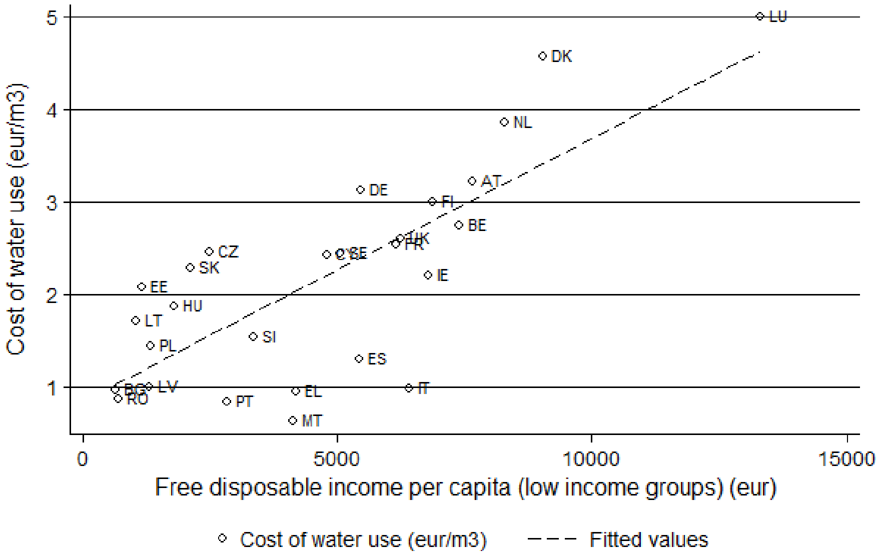


Figure 8. Scatterplot of monthly actual average water use per person against average free disposable income

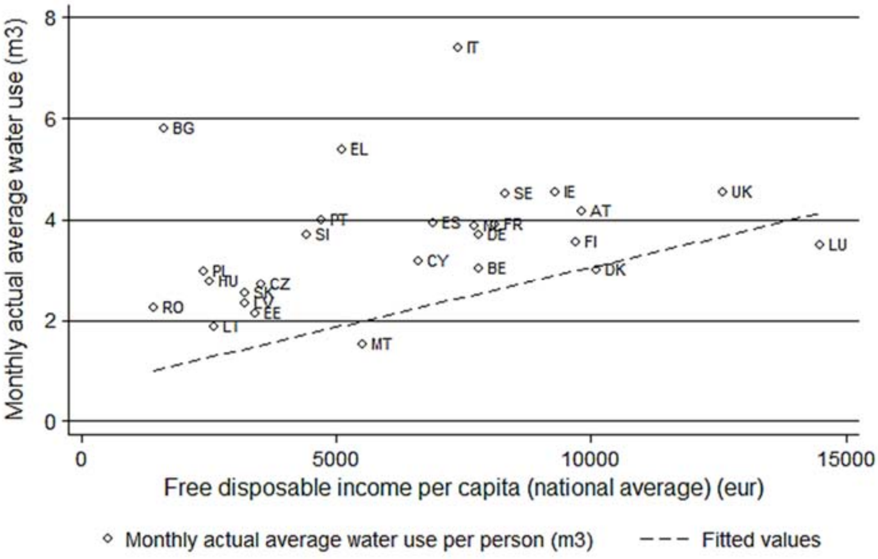
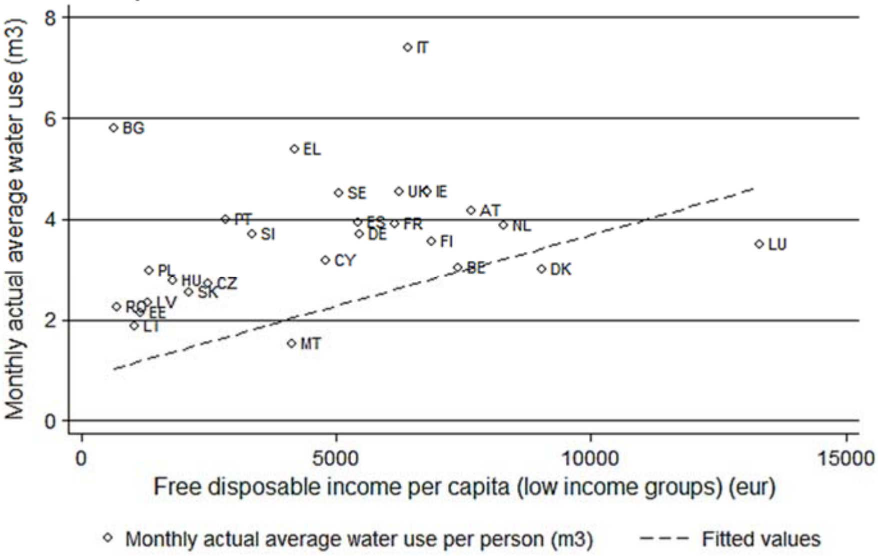


Figure 9. Scatterplot of monthly actual average water use per person against free disposable income in the 1st income quintile.



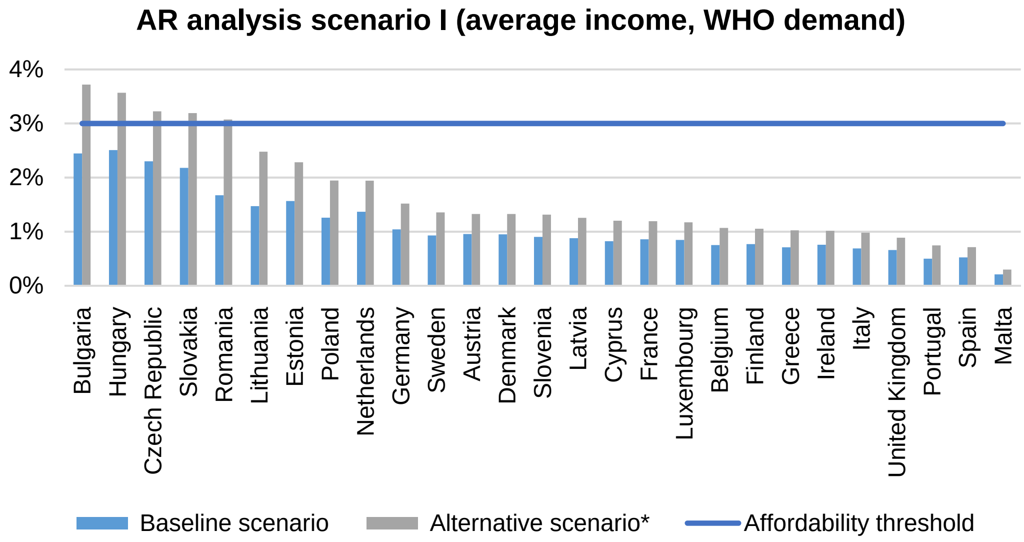
4.1 Affordability Ratio

4.1.1 At National Average Income

AR assessment of basic water needs (scenario 1) has shown that no EU MS exceeds the ‘rule of thumb-threshold’ of 3 percent of the national average free disposable income per capita (see Figure 12). It reveals a clear pattern that countries in the East of Europe are less affordable than their western, northern and southern neighbours. Hungary has an AR score approaching the affordability threshold – 2.51 percent. It is closely followed by Bulgaria with an AR of 2.44 percent and Czech Republic with 2.3 percent. Slovakia and Romania are also among the bottom performers with 2.18 percent and 1.67 percent respectively. This means that water in these countries can easily become unaffordable should either the price of water or other essentials rise. At the opposite end of the spectrum are Italy, the UK, Spain, Portugal and Malta – each of these countries has an AR below 0.7 percent.

A sensitivity analysis is performed to identify which countries will be the most vulnerable in case of an increase in price of the essential goods and services (including water prices). It appears to be a very relevant exercise in light of the recent debate on the increase of the low VAT rate in the Netherlands (NLTimes, 2017). Since low VAT is applied exactly for the goods and services that are considered essential, it is expected that such a price change will affect the affordability of water services. Figure 10 shows which countries will exceed the affordability threshold, should prices of essential goods and services (including water prices) rise by 15 percent as a result of an increase in the low VAT tax rate.

Figure 10. Analysis of affordability for AR values at minimum necessary water consumption for national average free disposable income per capita.



* Increase in prices of essential goods and services (including water) by 15 percent.

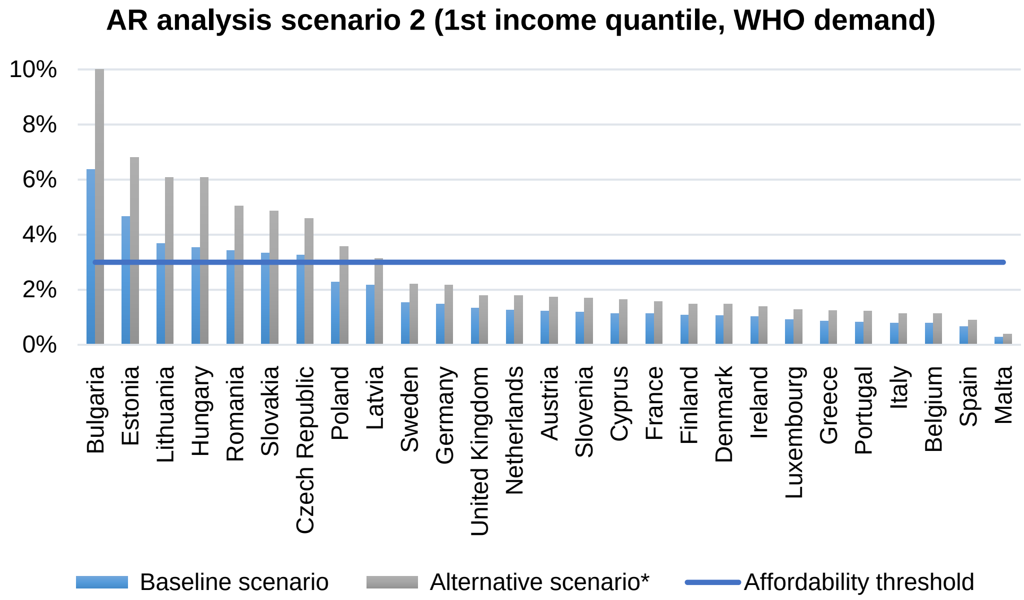
If actual water consumption levels are taken into consideration (scenario 2), all EU MS countries except one – Bulgaria – remain within the affordability threshold (see Figure 13). AR for this country jumps to 4.2 percent. Even though the cost of water use in Bulgaria is among the lowest in the EU (see Figure 5), the combination of very high actual water consumption and low income levels explain why this state exceeds the affordability standard. Compared to the scenario 1, the list of top five countries with the highest AR remains largely unchanged. The only difference is that the Netherlands with an AR of 2.35% has replaced Romania (AR of 1.67%) in this list. This is due to the fact that Romanian actual levels of water use are very close to its minimum ones whereas the Dutch are not. Due to the same reason, Latvia with an AR of 0.88% and water use close to the minimum, has now entered the top five countries with the lowest AR score while Italy (AR of 1.19%, water use far exceeding the minimum) has lost this status. Water in Spain, Malta, Portugal and the UK remain the most affordable under both scenarios.

4.1.2 In the 1st Income Quintile

Below maps (Figure 14 (scenario 1 – basic water needs) and Figure 15 (scenario 2 – actual water consumption)) display the results of an AR assessment for the low income population groups. They show an already familiar pattern with a few key differences from the situation at the national average. Firstly, even in the scenario 1 there are countries that exceed the affordability threshold: these again can be found in the region of Eastern Europe. Bulgaria tops the list of the countries where issues with drinking water affordability are most pronounced under both scenario 1 and 2 with an AR of 6.37 percent and 10.96 percent respectively. Secondly, the assessment has revealed that even though at the national average income level water can be considered affordable in

Estonia and Latvia, it is not the case for the low-income groups in these countries. On the side of top-performers, another notable difference is that Belgium seems to support its low-income groups very well, which allows it to enter the top 5 most affordable MS under both scenarios. The rest of this category is again composed from the countries of the Southern Europe: Italy, Malta, Spain and Portugal.

Figure 11. Sensitivity analysis for AR values at minimum necessary water consumption for per capita free disposable income in the 1st quintile.



* Increase in prices of essential goods and services (including water).

The sensitivity analysis for the AR values at basic water consumption for low income groups has been carried out in the same way as the one discussed in the previous section. According to the results of the analysis, under alternative scenario Latvia and Poland will cross the affordability threshold in addition to other 7 countries where water is unaffordable already. In these countries the affordability problem will escalate further with the Bulgarian AR reaching an absolute maximum of 10.18 percent.

A full overview of the results of the AR assessment is provided in Annex C..

Figure 12. Affordability ratio, national average income level (minimum average water consumption based on the WHO standard of 70 LPD).

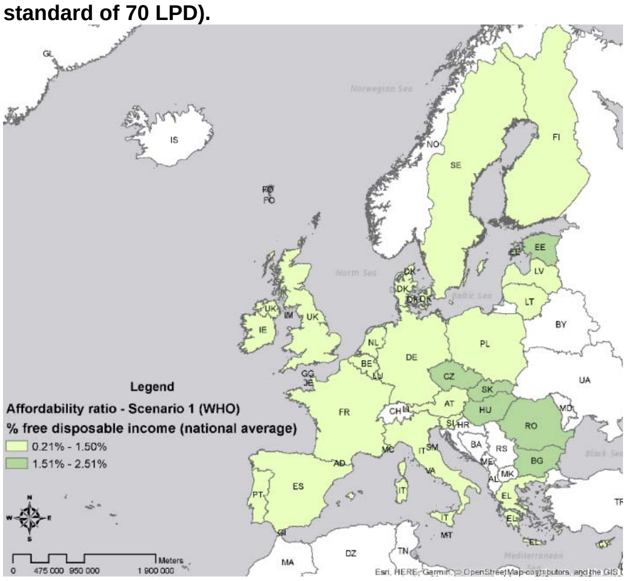


Figure 13. Affordability ratio, national average income level (actual average water consumption).

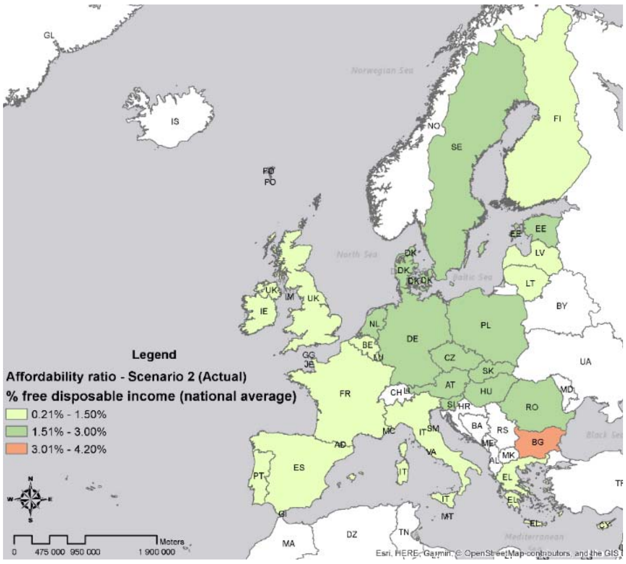


Figure 14. Affordability ratio, 1st income quintile (minimum average water consumption based on the WHO standard of 70 LPD)

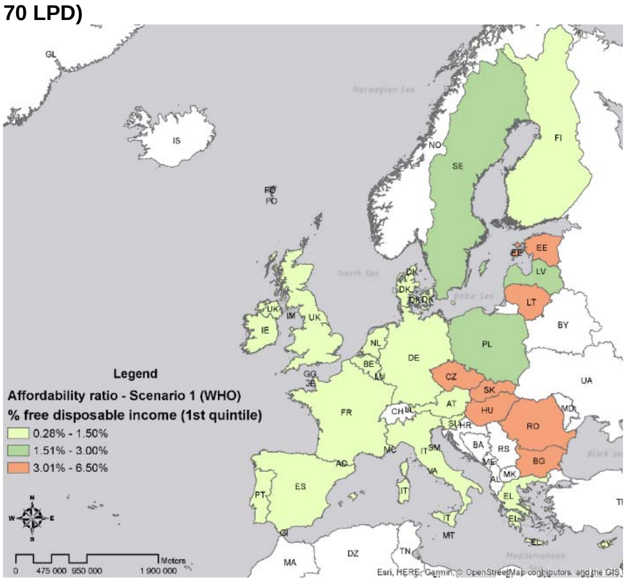
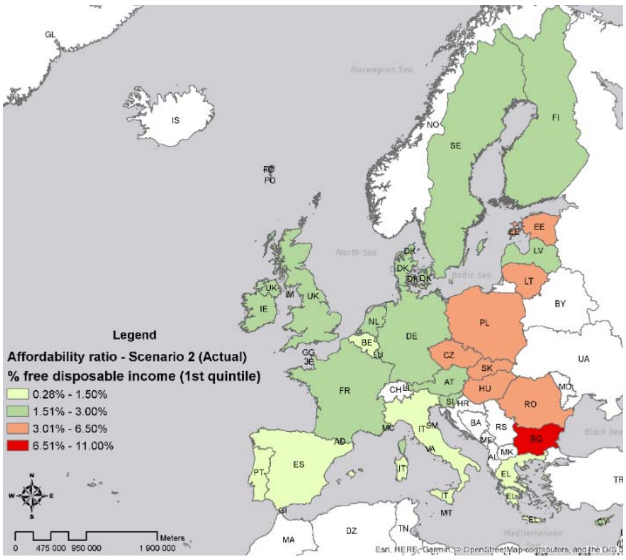


Figure 15. Affordability ratio, 1st income quintile (actual average water consumption)



4.2 Hours' Labour at Minimum Wage

The results of the HM estimation reinforce those of AR, which confirms the robustness of the findings. Similar to AR, HM is also performed for an estimation of affordability of minimum monthly water use (scenario 1) as well as actual average water consumption levels (scenario 2). Recalling that the affordability threshold for this type of measurement is set at 3.15 hours (see Footnote 6 for explanation), it is clear from Figure 17 presenting the results of the scenario 1 that three EU MS are already above this threshold. A citizen of Czech Republic needs to work almost 4 hours at the minimum wage to be able pay for her minimum monthly water consumption, which is the highest number of hours compared to the rest of the EU. Bulgarian nationals are in the situation similar to their Czech counterparts though: here 3.3 hours of labor at minimum wage are required to pay the water bills. Slovakia is just above the threshold with 3.17 hours, which is very close to the Hungarian HM of 3.14 hours. It is interesting to see that Croatia is also among the top five countries where people need to work the most to afford drinking water. This suggests that its AR would also be in the upper range of values. The Northern European countries together with Malta and Italy fare the best in terms of HM: in these MS approximately half an hour of work at minimum wage or less is enough to cover a monthly water bill.

Analysis of affordability of actual average water use levels (see Figure 18) has again shown that the countries where a large gap between the minimum and actual average consumption coincides with low minimum wage rates, become unaffordable. Vivid examples of such countries are Bulgaria and Croatia where almost 6 and 5 hours of minimum wage labor respectively will be equivalent to a monthly water bill payment. HM estimates for Czech Republic, Slovakia and Hungary remain unchanged since actual average water use in these countries is already at the minimum. The group of the best performers stays the same as under scenario 1, although HM values slightly increase in absolute terms.

A full overview of the results of the HM assessment is provided in Annex D.

4.3 Decomposition Analysis

For additional insights into price and income effects in the affordability problem it is useful to carry out a decomposition analysis. It is performed for the minimum average water consumption since it is the policymakers' prime target to make this amount of water affordable for all. In order to do this, the HM formula is modified: in the first case, EU-28 average price of water is used for calculations while the rest of the parameters are allowed to vary per MS, and in the second – EU-28 average minimum wage is the only constant parameter in the model. The analysis shows how the national deviations of water prices and minimum wages from the EU averages influence the HM.

The results of this exercise are presented in Figure 16. It is important to note that in most countries where the affordability problem is acute, i.e. Eastern European MS, water prices are below the EU average (see

Annex B – Average Cost of Water Use and Average Water Consumption in the EU-28). Thus, when the price is held constant at the EU average, it inflates the HM values for these countries even further. Czech Republic is the only exception here as water price in this country is slightly above the average. It becomes evident from the figure below that HM with the EU average minimum wage yields a better result in terms of affordability: in this case all EU MS remain well below the affordability threshold. As mentioned in the introduction of this section, income levels in the Eastern European countries are below the EU average, so applying the EU average minimum wage helps to drive the HM for these MS down.

This exercise shows that if the minimum wage is increased in the countries with high HM or other income-support programmes are introduced there, this might be an efficient way to relieve the affordability problem. An alternative would be to consider reductions in the water price. On the one hand, it may endanger the full-cost recovery objective of the water pricing policy. On the other hand, if water tariffs are designed such that only low-income customers can purchase water under reduced price, and cross-subsidisation between high-income and low-income customers is in place, this can also be a solution to the affordability issue. A more disaggregated level of analysis, ideally at the level of water utilities, is needed to determine which strategy will be helpful: the one aimed at income support or at water price reduction.

Figure 16. Decomposition analysis.

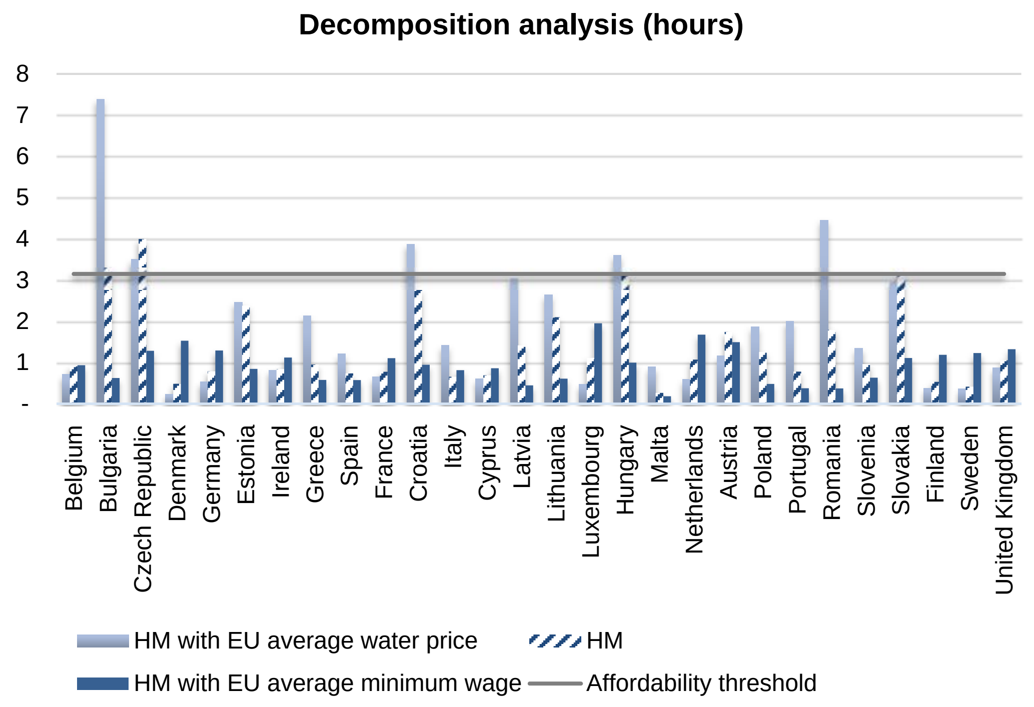


Figure 17. Hours of labour at minimum wage needed to pay for monthly water bills (minimum average water consumption based on the WHO standard of 70 LPD).

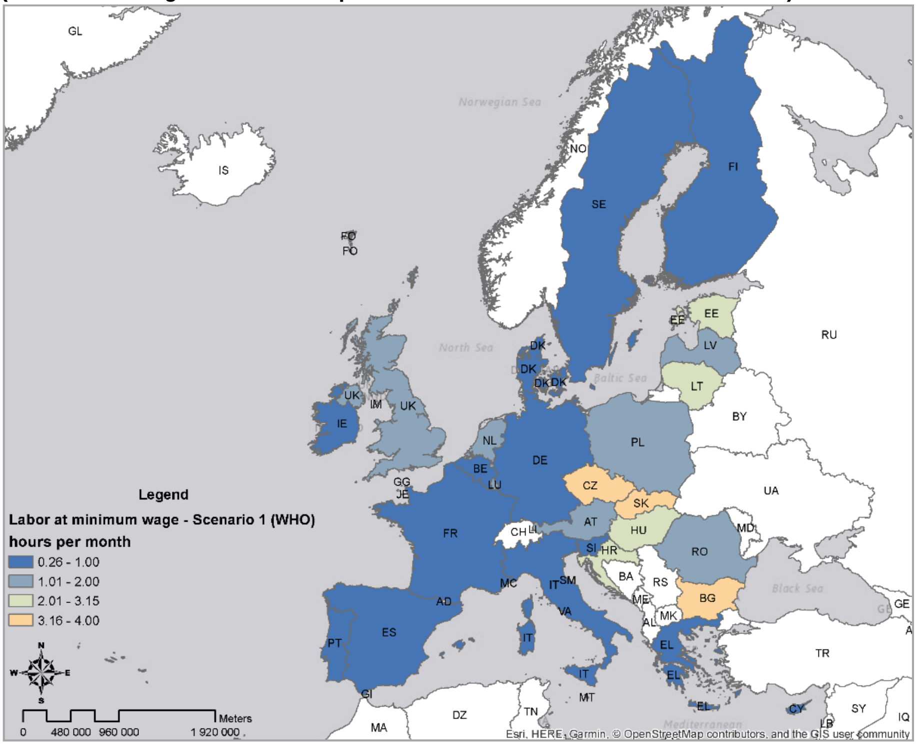
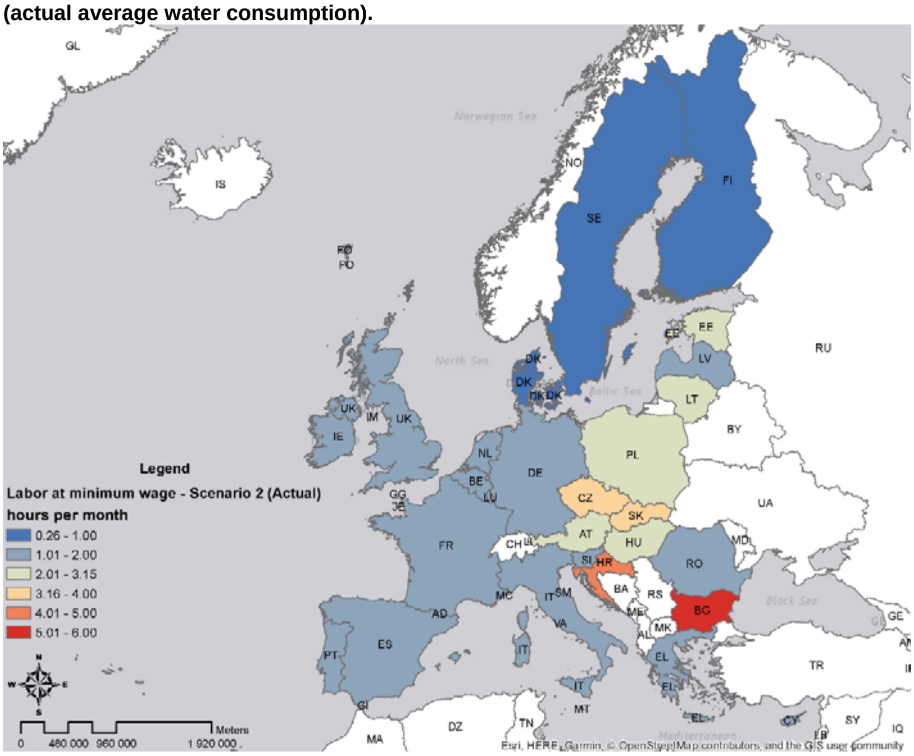


Figure 18. Hours of labour at minimum wage needed to pay for monthly water bills (actual average water consumption).



5 Conclusion and Discussion

This study has adapted the measures for affordability of drinking water services initially developed for the U.S. by Teodoro (2017). The topic is particularly relevant in light of the discussions around the revision of the EU Drinking Water Directive (DWD) that are currently taking place (EurEau, 2018). The proposal for a revised DWD contains provisions on both affordability and full cost recovery as water pricing principles in the EU. A major contribution of this study is the quantification of the concept of affordability within the European context. AR and HM measurements have direct policy implications: they can be used for development of tariff rates as well as water-related income support policies. However, it is important to remain mindful of the challenges that come with implementation of the AR and HM assessments. One of the key issues where a broad consensus needs to be reached on is the amount of water for non-discretionary use that a person should be able to afford. It is clear that applying a uniform standard for all would be misleading, thus there is a need to adopt widely accepted criteria that will allow to adjust the uniform standard for minimum water consumption according to local realities. This study attempts to provide a starting point in this regard. Another important parameter that has a big impact on the results of the affordability assessment are the expenditures that are considered essential. Since it is very easy to manipulate AR by inclusion or exclusion of some categories of expenditures, strict and unified principles for doing so should be developed. In contrast, HM measurement is more straightforward in terms of calculations, which also makes it more reliable and easier to justify.

The AR and HM assessment results produced an interesting finding which deserves to be discussed further. As mentioned in Section 3, the region where water affordability issues appear to be the most apparent is Eastern Europe. Similar results have been found in a study analysing determinants of the residential water demand in Germany where water prices and consumption levels in old and new (former DDR) federal states are compared (Schleich & Hillenbrand, 2009). It has been observed that new federal states have higher water prices, a considerably lower water demand but also much lower income levels than old federal states. This resembles the pattern that has been discovered in this study in relation to the Eastern European MS. Schleich & Hillenbrand (2009) mention that after the reunification of Germany the residential buildings in the new states were modernised and equipped with water-saving appliances which provided incentives to reduce water consumption. This offers a possible explanation for the differences in water consumption levels across Europe but not for the affordability issue itself. However, income levels in Eastern Europe are among the lowest in the EU which seems to be the root cause of the affordability problem as shown by the decomposition analysis. At this point it is important to note that one should not immediately point the finger at Eastern European MS: the assessments here were performed based on the national average values for water cost and consumption, and a more disaggregated level of analysis is required to identify the true problem regions. Since the statistics on water prices and use on the micro scale deviate from the national average, water utilities need to implement AR and HM assessments locally to determine if water is affordable for their customers.

An important extension of this study will be inclusion of the analysis on the economies of scale in the residential water consumption. It has been widely recognized that opportunities for economies of scale in water use exist (Arbues et al., 2010; Deaton & Muellbauer, 2009; Hanemann, 2005). Four people do not need proportionally more water than three people, meaning that water consumption is more connected to common household uses of water (such as cooking, cleaning or washing clothes) rather than the number of household members. Such an assessment will require data on total and per capita water consumption and tariff rates at the municipal level as well as number of households and their size. Additional insights can be brought in if information on the age

of household members is available since considerable differences exist between water use habits of children, young adults and old people. For example, the results of a study that analysed residential water demand in Germany indicated that as people become older, they use more water (Schleich & Hillenbrand, 2009). This can be explained by the fact that children need less water for washing and also that elder people tend to spend more time at home and therefore use more water for flushing and washing. Similarly, different trends for water consumption can be observed among households located in the urban and rural environments, which, for example, may be explained by the need to grow food. Seasonal dimension can also be incorporated in the analysis. Many studies examining residential water demand try to incorporate these effects by adding variables such as average number of days with rainfall or average temperature per month (Schleich & Hillenbrand, 2009; Arbues et al., 2010; Dalhuisen et al., 2003a).

Another aspect to consider when looking at affordability of drinking water is how it can be influenced by the consumption of bottled water. The results of the EU Public Survey on the Quality of Drinking Water carried out in 2014 (Ecorys, 2015) have shown that roughly 26 percent of respondents disagree that in the EU the quality of drinking water is good and that its sensation is good (see Annex E). This means that to satisfy their drinking needs, people are more likely to buy bottled water, which is always many times more expensive than water from the tap. A starting point for such an analysis can be found in Annex F. To carry out a full analysis, however, it is vital to have disaggregated data on sales of still and sparkling water since the latter is considered to be a luxury good and should not be taken into account when assessing affordability.

Finally, valuable insights can be gained if the supply side of the drinking water problem is also included in the research. Since the full cost recovery principle is one of the cornerstones of the European legislation on drinking water, it is of high importance to understand whether the water services provided at an affordable price, generate enough revenue to cover the costs associated with maintenance of the existing water supply networks and construction of new ones. A challenge here is that the data on the costs of water supply infrastructure are not readily available and considerable effort should be put in collection of this information. However, such an analysis is necessary to compliment this study and to provide a full picture of the economics of drinking water in Europe.

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Annex A - Detailed Overview of Essential Expenditures by COICOP[10] Level Included in the Affordability Ratio Assessment

COICOP Code	Category name	Considered as essential
CP01	**Food and non-alcoholic beverages**	✓
CP011	Food	
CP012	Non-alcoholic beverages	
CP02	**Alcoholic beverages, tobacco and narcotics**	
CP021	Alcoholic beverages	
CP022	Tobacco	
CP023	Narcotics	
CP03	**Clothing and footwear**	✓
CP031	Clothing	
CP032	Footwear	
CP04	**Housing, water, electricity, gas and other fuels**	
CP041	Actual rentals for housing	✓
CP042	Imputed rentals for housing	
CP043	Maintenance and repair of the dwelling	✓
CP044	Water supply and miscellaneous services relating to the dwelling	
CP045	Electricity, gas and other fuels	✓
CP05	**Furnishings, household equipment and routine household maintenance**	✓
CP051	Furniture and furnishings, carpets and other floor coverings	
CP052	Household textiles	
CP053	Household appliances	
CP054	Glassware, tableware and household utensils	
CP055	Tools and equipment for house and garden	
CP056	Goods and services for routine household maintenance	
CP06	**Health**	✓
CP061	Medical products, appliances and equipment	
CP062	Out-patient services	
CP063	Hospital services	
CP07	**Transport**	✓
CP071	Purchase of vehicles	
CP072	Operation of personal transport equipment	
CP073	Transport services	
CP08	**Communications**	✓
CP081	Postal services	
CP082	Telephone and telefax equipment	
CP083	Telephone and telefax services	

[10] Classification of individual consumption by purpose abbreviated as COICOP, is a classification developed by the United Nations Statistics Division to classify and analyse individual consumption expenditures incurred by households, non-profit institutions serving households and general government according to their purpose (Eurostat, 2018).

COICOP Code	Category name	Considered as essential
CP09	**Recreation and culture**	
CP091	Audio-visual, photographic and information processing equipment	
CP092	Other major durables for recreation and culture	
CP093	Other recreational items and equipment, gardens and pets	
CP094	Recreational and cultural services	
CP095	Newspapers, books and stationery	
CP096	Package holidays	✓
CP10	**Education**	
CP101	Pre-primary and primary education	✓
CP102	Secondary education	✓
CP103	Post-secondary non-tertiary education	✓
CP104	Tertiary education	✓
CP105	Education not definable by level	
CP11	**Restaurants and hotels**	
CP111	Catering services	
CP112	Accommodation services	✓
CP12	**Miscellaneous goods and services**	
CP121	Personal care	
CP122	Prostitution	
CP123	Personal effects n.e.c.	
CP124	Social protection	
CP125	Insurance	
CP126	Financial services n.e.c.	
CP127	Other services n.e.c.	

Annex B – Average Cost of Water Use and Average Water Consumption in the EU-28

	Average cost of water use	Monthly actual average water use per person	
EU MS	€/m³	m³	LPD*
Belgium	2.75	3.05	100
Bulgaria	0.97	5.81	191
Czech Republic	2.46	2.73	90
Denmark	4.58	3.00	99
Germany	3.13	3.71	122
Estonia	2.08	2.13	70
Ireland	2.21	4.56	150
Greece	0.96	5.40	177
Spain	1.31	3.95	130
France	2.55	3.90	128
Croatia	1.54	5.53	182
Italy	0.99	7.39	243
Cyprus	2.43	3.19	105
Latvia	1.00	2.34	77
Lithuania	1.71	1.86	61
Luxembourg	5.00	3.51	115
Hungary	1.87	2.79	92
Malta	0.63	1.52	50
Netherlands	3.87	3.89	128
Austria	3.22	4.17	137
Poland	1.45	2.98	98
Portugal	0.84	4.01	132
Romania	0.87	2.25	74
Slovenia	1.54	3.70	122
Slovakia	2.29	2.53	83
Finland	3.01	3.55	117
Sweden	2.45	4.51	148
United Kingdom	2.61	4.56	150
EU-28 average	**2.15**	**3.66**	**120**

*LPD = litres per person per day.

Annex C – Results Affordability Ratio

EU MS	Water bills as a percentage of the national average free disposable income per capita (2015)		Water bills as a percentage of the income in the 1st quintile (2015)	
	Based on minimum necessary water consumption (WHO)	Based on actual average water consumption	Based on minimum necessary water consumption (WHO)	Based on actual average water consumption
Belgium	0.75%	1.29%	0.79%	1.36%
Bulgaria	2.44%	4.20%	6.37%	10.96%
Czech Republic	2.30%	2.30%	3.26%	3.26%
Denmark	0.95%	1.63%	1.06%	1.83%
Germany	1.04%	1.79%	1.49%	2.56%
Estonia	1.56%	1.56%	4.67%	4.67%
Ireland	0.76%	1.30%	1.04%	1.79%
Greece	0.71%	1.22%	0.86%	1.49%
Spain	0.52%	0.90%	0.67%	1.14%
France	0.86%	1.47%	1.13%	1.94%
Croatia	n/a	n/a	n/a	n/a
Italy	0.69%	1.19%	0.80%	1.37%
Cyprus	0.82%	1.41%	1.13%	1.95%
Latvia	0.88%	0.88%	2.18%	2.18%
Lithuania	1.47%	1.47%	3.68%	3.68%
Luxembourg	0.84%	1.45%	0.92%	1.58%
Hungary	2.51%	2.51%	3.55%	3.55%
Malta	0.21%	0.21%	0.28%	0.28%
Netherlands	1.37%	2.35%	1.27%	2.18%
Austria	0.96%	1.64%	1.23%	2.11%
Poland	1.26%	2.16%	2.28%	3.92%
Portugal	0.50%	0.86%	0.84%	1.44%
Romania	1.67%	1.67%	3.43%	3.43%
Slovenia	0.90%	1.55%	1.19%	2.04%
Slovakia	2.18%	2.18%	3.34%	3.34%
Finland	0.77%	1.32%	1.09%	1.87%
Sweden	0.93%	1.60%	1.53%	2.63%
United Kingdom	0.66%	1.13%	1.34%	2.30%

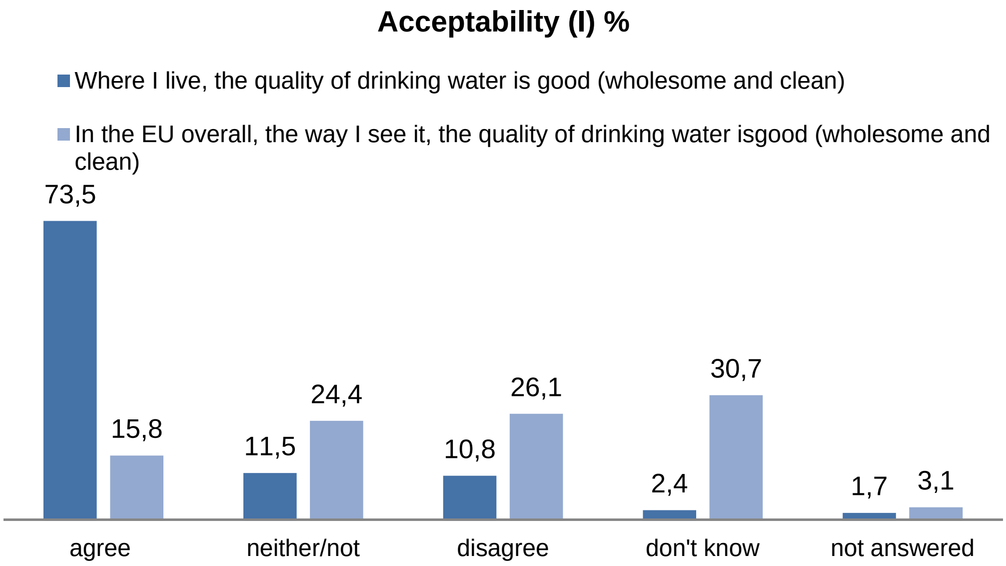
*The highest 5 values are highlighted with red and the lowest 5 – with green.

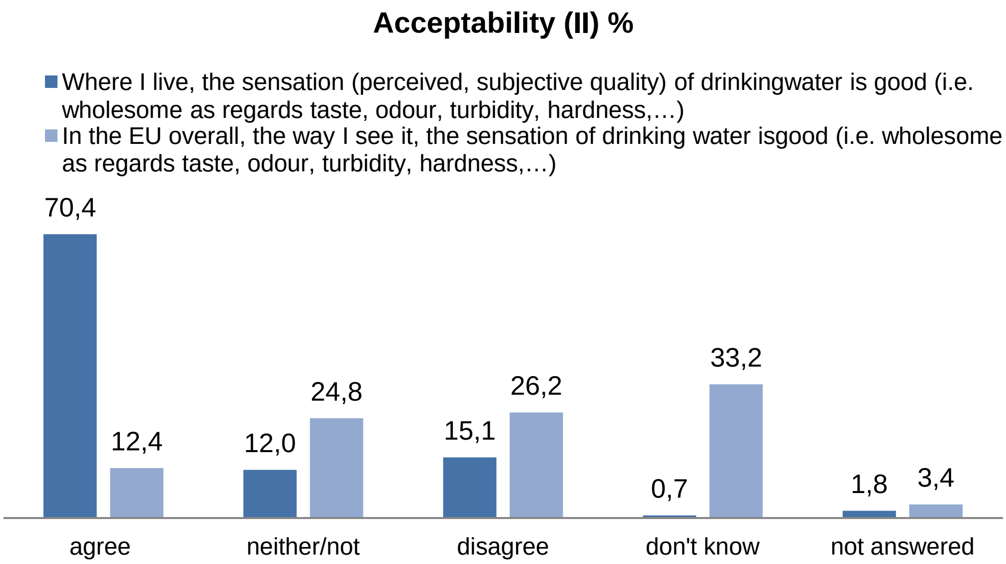
Annex D – Results Hours of Labour at Minimum Wage

EU MS	Hours of labour at national minimum wage to be able to pay for a monthly water bill	
	Based on 70 LPD minimum necessary water consumption (WHO)	Based on actual average water consumption
Belgium	0.91	1.56
Bulgaria	3.31	5.68
Czech Republic	3.99	3.99
Denmark	0.49	0.84
Germany	0.79	1.36
Estonia	2.39	2.39
Ireland	0.84	1.45
Greece	0.95	1.63
Spain	0.74	1.27
France	0.77	1.33
Croatia	2.77	4.76
Italy	0.65	1.13
Cyprus	0.69	1.19
Latvia	1.42	1.42
Lithuania	2.10	2.10
Luxembourg	1.11	1.92
Hungary	3.14	3.14
Malta	0.26	0.26
Netherlands	1.07	1.84
Austria	1.74	3.00
Poland	1.26	2.16
Portugal	0.78	1.34
Romania	1.79	1.79
Slovenia	0.96	1.65
Slovakia	3.17	3.17
Finland	0.53	0.91
Sweden	0.41	0.71
United Kingdom	1.05	1.81

*The highest 5 values are highlighted with red and the lowest 5 – with green.

Annex E – Selected Results of the EU Public Survey on the Quality of Drinking Water





Annex F – Bottled Water Extension

While this study is primarily focused on the tap water affordability, some might argue that for several countries consumption of bottled water can be considered a component in the average cost of living in the EU. Namely, as shown in Annex E, a substantial number of people do not agree that the quality of drinking water or its sensation is good. Hence, for some people it will not be far from the truth to assume that part of water demand (especially personal essential drinking needs, e.g. 10L according to the WHO) stems from bottled water. It is therefore important to adjust affordability calculations so that they reflect the higher costs incurred when bottled water is purchased.

The model is modified in the following way:

$$AR = \frac{WQ_t + PQ_b}{E},$$

where W are the costs of essential tap water and sewer services per cubic meter; Q_t is essential tap water use per person in cubic meters; P is the price of bottled water per liter, Q_b is the quantity of bottled water consumed in liters; E is a proxy for free disposable household income per capita, which is calculated as total household consumption expenditures per capita less essential expenditures per capita.

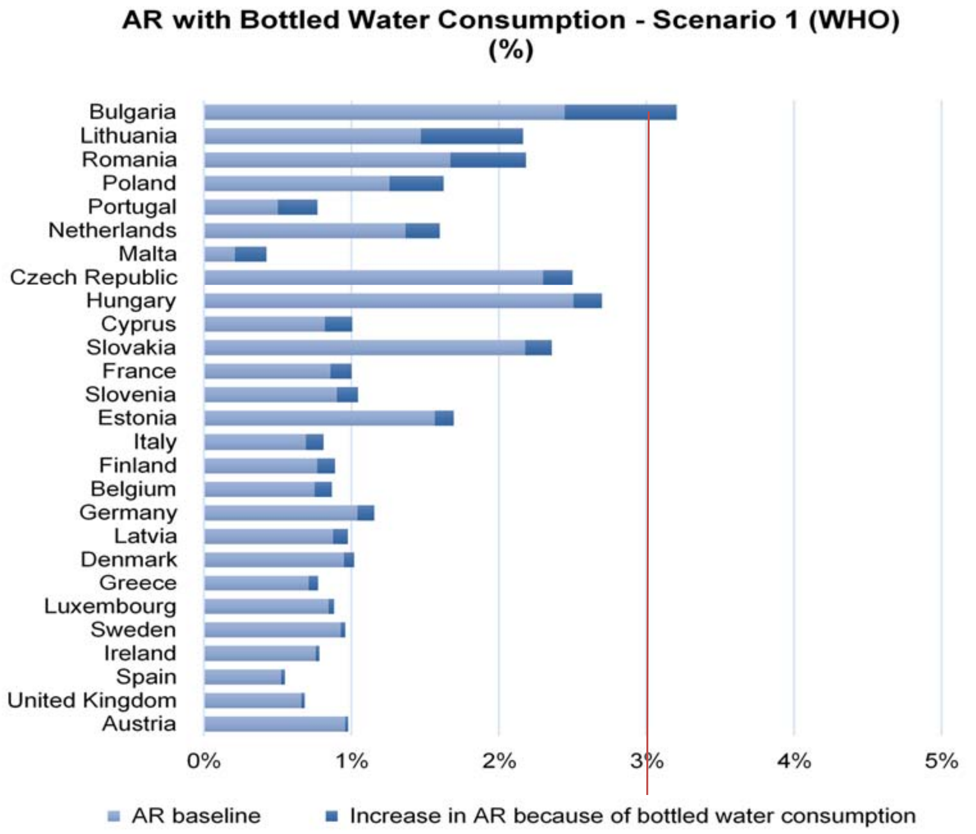
$$HM = \frac{WQ_t + PQ_b}{A},$$

where W are the costs of essential tap water and sewer services per cubic meter; Q_t is essential tap water use per person in cubic meters; P is the price of bottled water per liter in Euros, Q_b is the quantity of bottled water consumed in liters; A is net minimum wage per hour worked in the respective Member State's labour market.

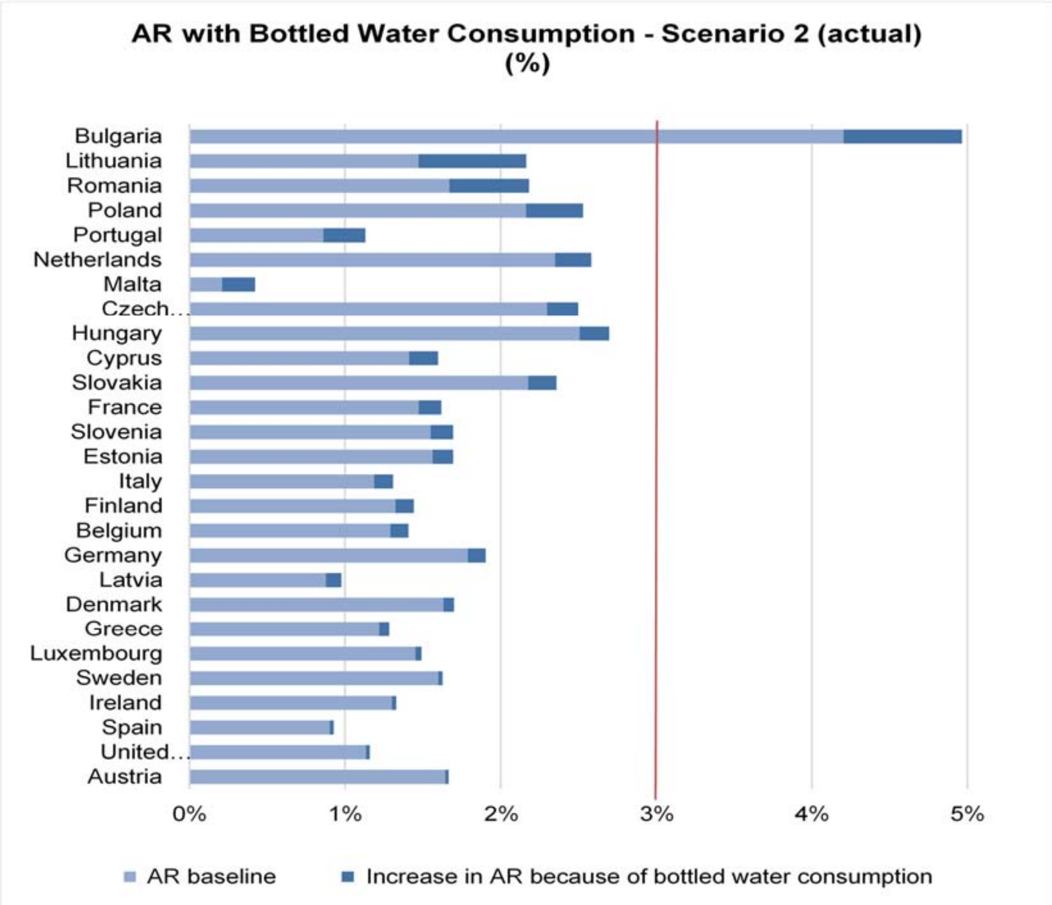
The AR assessment is performed at national average income level only since the figures on the sales of bottled water are also taken as average (shown in Table 5). Bottled water consumption in low-income population groups thus remains an area for further research. The price per litre of bottled water is assumed to be EUR 0.1 (Ecorys, 2016); a conservative estimate.

The results of this exercise are presented below. The goal here is to see by how much the consumption of bottled water drives up the baseline AR and HM values.

When AR with bottled water consumption is considered, the most striking difference with the baseline is that Bulgaria now exceeds the affordability threshold even at the minimum necessary water use. The rest of the EU MS stay within the affordability limits. Another important thing to note is that the biggest increase in AR values is observed not only in the countries of the Eastern Europe, but also in Malta, Portugal and Cyprus.

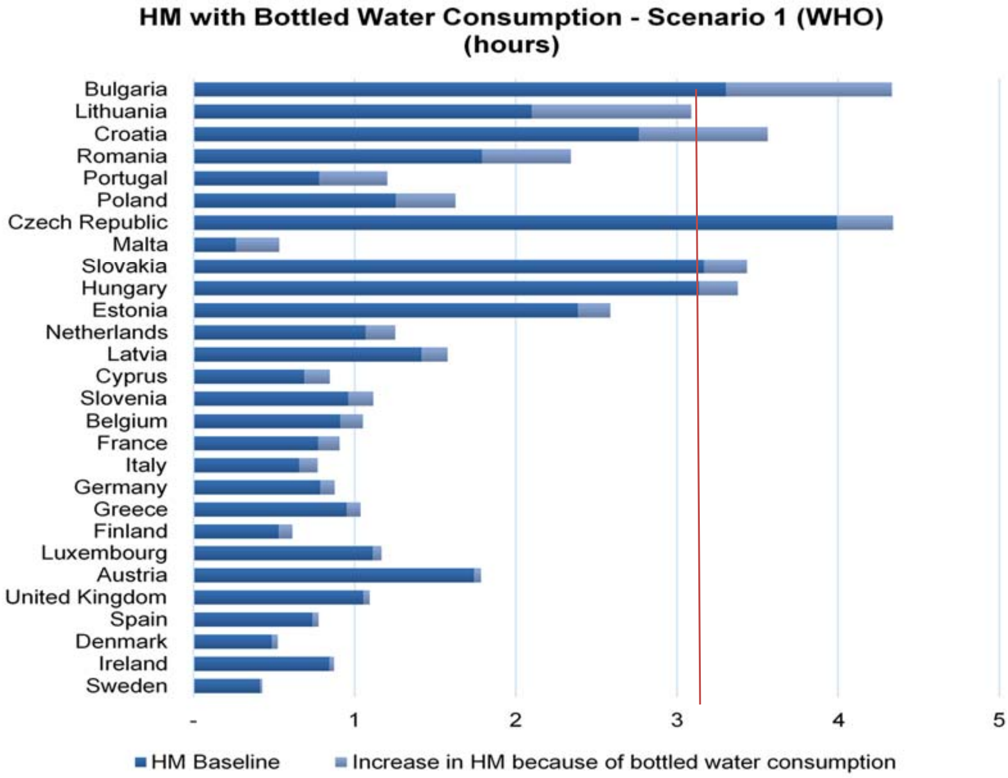


Source: own contribution

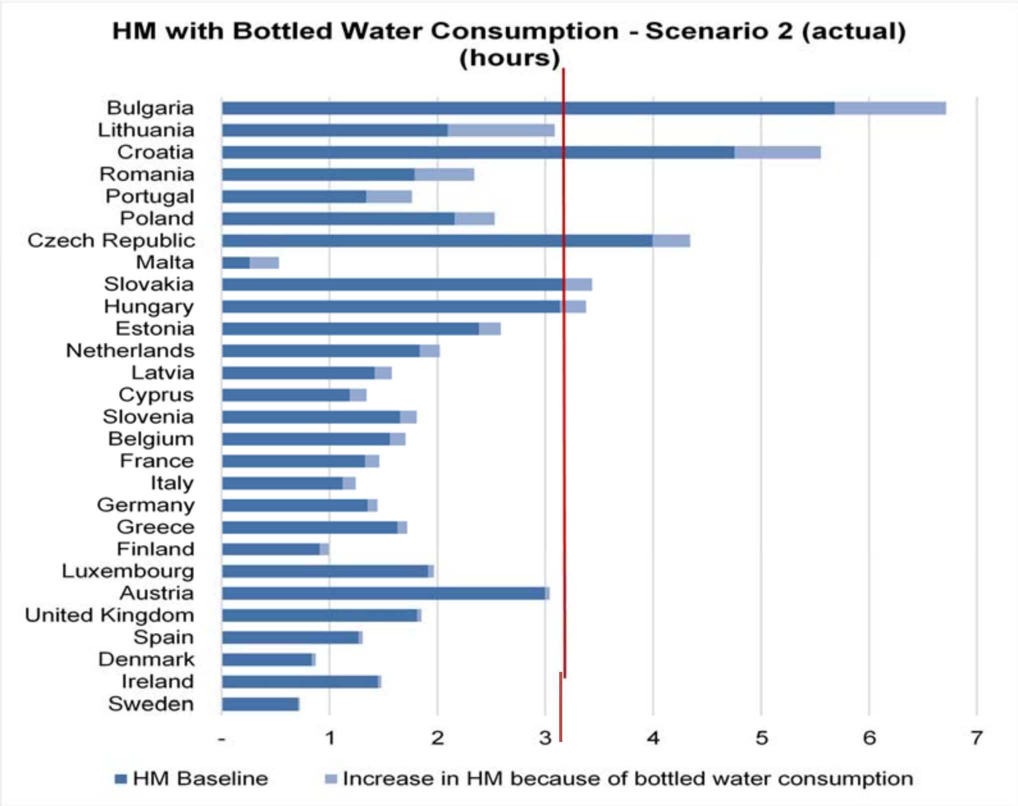


Source: own contribution

Under HM measurement, as a result of bottled water inclusion, Croatia and Hungary join Bulgaria, Czech Republic and Slovakia, which already exceeded the affordability threshold in the baseline. Unlike any other EU MS, the Maltese AR as well as HM value doubles after the inclusion of the bottled water consumption in the assessment. A similar pattern can be found in Portugal and Lithuania: their AR and HM values jumps 1.5 times due to bottled water. However, the increase in AR and HM in other European countries is more moderate.



Source: own contribution



Source: own contribution

Overall, the results of the assessment prove that bottled water consumption should not be neglected in the affordability measurements since it can have a considerable influence on the outcome. It should be noted that precision of the results can be improved if better data on average bottled water prices is collected and if a distinction is made between the sales of still and sparkling water, since only the former can be considered as a necessity.

Table 5. Sales of bottled water.

EU MS	Sales of bottled water Litres per capita per day	EU MS	Sales of bottled water Litres per capita per day
Belgium	0.25	Lithuania	0.49
Bulgaria	0.33	Luxembourg	0.16
Czech Republic	0.19	Hungary	0.13
Denmark	0.19	Malta	0.32
Germany	0.25	Netherlands	0.49
Estonia	0.12	Austria	0.06
Ireland	0.07	Poland	0.24
Greece	0.09	Portugal	0.35
Spain	0.05	Romania	0.20
France	0.32	Slovenia	0.17
Croatia	0.47	Slovakia	0.16
Italy	0.25	Finland	0.32
Cyprus	0.34	Sweden	0.07
Latvia	0.09	United Kingdom	0.08

Source: Ecorys (2015), Impact Assessment revision EU Drinking Water Directive

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