Pricing and non-pricing measures for managing water demand in Europe

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Glossary

Anthropogenic: Caused by humans or their activities.

Benchmarking: A measurement of the quality of an organization's policies, strategies, etc., and their comparison with standard measurements, or similar measurements of its peers. The objectives of benchmarking are (1) to determine what and where improvements are called for, (2) to analyze how other organizations achieve their high performance levels and (3) to use this information to improve performance.

Double-log regression model: Using natural logs for variables on both sides of a regression model is called a *log-log model*. This model is handy when the relationship is nonlinear in parameters, because the log transformation generates the desired linearity in parameters (linearity in parameters is in fact one of the OLS assumptions – see below).

Elasticity: In economics, elasticity is the measurement of how responsive an economic variable is to a change in another. In other words, elasticity refers the degree to which individuals, consumers or producers change their demand or the amount supplied in response to price or income changes. It is predominantly used to assess the change in consumer demand as a result of a change in a good or service's price. It is the measure of the percentage change in one variable brought about by a 1 percent change in some other variable.

Elasticity of demand: The degree to which the number of products sold changes when the product's price changes. It is the percentage change in the quantity demanded of a good in response to a 1 percent change in its price.

Environmental and resource costs: Environmental costs represent the costs of damage that water uses impose on the environment and ecosystems and those who use the environment (for example, a reduction in the ecological quality of aquatic ecosystems or the salinisation and degradation of productive soils).

Resource costs represent the costs of foregone opportunities that other uses suffer due to the depletion of the resource beyond its natural rate of recharge or recovery (e.g. costs related to groundwater over-abstraction).

Instrumental variable estimation method (linear regression): Instrumental variable methods allow consistent estimation when the explanatory variables (covariates) are correlated with the error terms of a regression relationship. Such correlation may occur when the dependent variable causes at least one of the covariates ("reverse" causation), when there are relevant explanatory variables which are omitted from the model, or when the covariates are subject to measurement error. In this situation, ordinary linear regression generally produces biased and inconsistent estimates. However, if an *instrument* is available, consistent estimates may still be obtained. An instrument is a variable that does not itself belong in the explanatory equation and is correlated with the endogenous explanatory variables, conditional on the other covariates.

Linear regression: Linear regression attempts to model the relationship between two variables by fitting a linear equation to observed data. One variable is considered to be an explanatory variable, and the other is considered to be a dependent variable. For example, a modeler might want to relate the weights of individuals to their heights using a linear regression model.

Multiple regression: Multiple regression is an extension of simple linear regression. It is used when we want to predict the value of a variable based on the value of two or more other variables. The variable we want to predict is called the dependent variable (or sometimes, the outcome, target or criterion variable). The variables we are using to predict the value of the dependent variable are called the independent variables (or sometimes, the predictor, explanatory or regressor variables).

Ordinary Least Squares (OLS) regression method: In statistics, OLS is a method for estimating the unknown parameters in a linear regression model, with the goal of minimizing the differences between the observed responses in some arbitrary dataset and the responses predicted by the linear approximation of the data (visually this is seen as the sum of the vertical distances between each data point in the set and the corresponding point on the regression line - the smaller the differences, the better the model fits the data). The resulting estimator can be expressed by a simple formula, especially in the case of a single regressor on the right-hand side.

Polluter pays principle: The Polluter Pays Principle (PPP) is an environmental policy principle which requires that the party responsible for producing pollution is responsible for paying for the damage done to the natural environment.

Public water supply (PWS): Water supplied by economic units engaged in collection, purification and distribution of water (including desalting of sea water to produce water as the principal product of interest, and excluding system operation for agricultural purposes and treatment of waste water solely in order to prevent pollution).

Regression analysis: In statistical modeling, regression analysis is a statistical process for estimating the relationships among variables. It includes many techniques for modeling and analyzing several variables, when the focus is on the relationship between a dependent variable and one or more independent variables (or 'predictors'). More specifically, regression analysis helps one understand how the typical value of the dependent variable (or 'criterion variable') changes when any one of the independent variables is varied, while the other independent variables are held fixed.

Residential or Domestic sector: The combination of households and tertiary sectors.

Water efficiency: Water efficiency is the smart use of our water resources through water-saving technologies and simple steps we can all take around the house. Using water efficiently will help ensure reliable water supplies today and for future generations. Water efficiency is measured by the amount of water used versus the minimum amount required to perform a specific task. In irrigation, the amount of water beneficially applied divided by the total water applied.

Water reuse: Reused water is water used more than once and has been treated to a level that allows for its reuse for a beneficial purpose.

Water operator / Water services / Water suppliers / Water utilities: A service in charge of water production and distribution, whose management can delegated to a public or a private company.

List of abbreviations

AATO: Autorità d'Ambito Territoriale Ottimale (Italy – Authority of optimal territorial unit)

AEAS: Asociación Española de Abastecimientos de Agua y Saneamiento (Spanish Association of Water Supply and Sanitation)

AEEGSI: Autorità per l'Energia Elettrica, il Gas e il Servizio Idrico (Italy - Authority for electricity, gas and water and sanitation services)

ANRSC: Autorităţii Naţionale de Reglementare pentru Serviciile Comunitare de Utilităţi Publice (Romania - National Authority for Regulating the Public Services of Communal Household)

BDEW: Bundesverband der Energie- und Wasserwirtschaft (Germany - Association of Energy and Water Industries)

CEEP: European Centre of Employers and Enterprises providing Public Services

CIS: Common Implementation Strategy of the Water Framework Directive

CREEF: Centro Ricerche Economiche Educazione e Formazione della Federconsumatori (Italy – Research Center for the education and training of the national consumer federation)

DEFRA: Department for Environment, Food and Rural Affairs (UK)

EC: European Commission

EEA: European Environment Agency

EP: European Parliament

EU: European Union

EU WFD: Water Framework Directive (Directive 2000/60/EC) of the European Union

Hh: Household

HQE: Haute Qualité Environnementale (High Environmental Quality) – Quality label

ILI: Infrastructure Leakage Index

INE: Instituto Nacional de Estadística (Spain – National Statistical Institute)

INRA: Institut National de la Recherche Agronomique (France - National Institute for Agronomic Research)

IV: Instrumental Variables

IWA: International Water Association

JRC: Joint Research Center of the European Commission

LEMA: Loi sur l'Eau et les Milieux Aquatiques (France - Law on water and aquatic environment)

Ml: Million liters

MS:	Member States of the European Union (see below)
MTI:	Metodo Tariffario Integrato (Italy - Integrated Tariff Method)
OECD:	Organization for Economic Cooperation and Development
OLS:	Ordinary Least Squares (regression)
ONEMA:	Office national de l'eau et des milieux aquatiques (France – National office for water and the aquatic environment)
PTA:	Piano di Tutela della Acque (Italy – (Regional) Plan for water resource protection)
RBD	River Basin Disctrict
SF:	Structural Funds (European Union)
UBA:	Umweltbundesamt (Germany - Federal Environment Agency)
VAT:	Value Added Tax
WSS:	Water and Sanitation Services

Member States of the European Union			
AT	Austria	IT	Italy
BE	Belgium	LV	Latvia
BG	Bulgaria	LT	Lithuania
HR	Croatia	LU	Luxembourg
CY	Cyprus	MT	Malta
CZ	Czech Republic	NL	Netherlands
DK	Denmark	PL	Poland
EE	Estonia	PT	Portugal
FI	Finland	RO	Romania
FR	France	SK	Slovakia
DE	Germany	SI	Slovenia
EL	Greece	ES	Spain
HU	Hungary	SE	Sweden
EI	Ireland	UK	United Kingdom
Non-EU EEA member countries			
IS	Iceland	CH	Switzerland
LI	Liechtenstein	TR	Turkey
NO	Norway		

Executive summary

Findings and some key takeaways:

1. Pricing mechanisms and their effects on water demand is often unclear

All surveyed countries (Germany - DE, Denmark - DK, Spain - ES, France - FR, Italy - IT, Romania - RO, Sweden – SE and Cyprus - CY) have mechanisms in place to provide an incentive for a more efficient water use in the domestic sector, ranging from simple metering and volumetric tariffs to rising block tariffs. But the evidence on the real incentiveness of existing pricing (tariffs) for a more efficient water use is scarce, if available at all.

The results of the case studies show that in some locations, price does not appear to be a significant determinant of water demand. For example, in the cases of DE, DK, DE, ES and FR, the results suggest that changes in price have relatively small effect on the quantity of water demanded. This does not mean that the demand for water in these countries are unresponsive to price as the same quantity of water will not be demanded at any price.

Some examples indicate that none of the variables considered (e.g. household income, household size) are deemed as significant determinants of water demand. Other cases illustrate that water demand is responsive to *income* and *household size*, meaning that water consumption increases more than the increase in income and household size.

Overall, it can be observed that case study results are very diverse and they do not allow for a homogeneous interpretation of the overall effects of water pricing in determining demand. However, facing a price increase, EU households will react by reducing their water consumption. This demonstrates that water prices may play a role in signaling water scarcity or water costs to households. Despite the limited number of case studies, the results demonstrate that they are in line with the scientific literature, in particular with the most recent study on price elasticity in the 28 Member States (Reynaud, 2015).

Important considerations:

- To achieve more significant reductions of household water consumption, it is recommended that public authorities complement their price policies with non-price policies, such as education or awareness campaigns.
- Although it appears that pricing mechanisms are not fully effective in managing water demand and reducing water consumption, water pricing remains the key instrument to ensure cost recovery of water services. Thus, increasing water prices remains a key objective in those countries with unoptimal cost recovery levels – independently from water consumption reduction targets.

2. Non-pricing mechanisms reduce water consumption

The uptake of a range of non-pricing water demand measures, including reduction of leakage in water supply networks, water saving devices and more efficient household appliances, has the potential to save up to 50 % of water abstracted and to reduce water consumption from 150 litres per person per day to 80 litres per person per day. For domestic water saving appliances, it is estimated that up to 40 % of water could be saved per year in each household. Public awareness campaigns are also considered to be effective in reducing household water consumption.

In contrast, restrictions of water supply in times of acute water scarcity are generally considered to be effective in reducing the water demand in the short term, while they have no or marginal effect on water demand in the long term if they are not accompanied by other measures.

Important considerations:

- One of the key challenges of non-pricing mechanisms, in particular in times of restricted public finances, is that they often require considerable financial resources for their implementation. This is the case for subsidies for the installation of water saving devices and for consumer awareness campaigns – even though the implementation costs of awareness campaigns are relatively low as compared to many other (infrastructure-like) measures.

3. Reduced water consumption can foster unintentional impacts on the performance and management of water supply networks and infrastructures

Decreasing water demand means reduced revenues for water companies, which can pose issues for cost recovery or eventually lead to an increase in water prices so that cost recovery is guaranteed. However, scarce and mixed evidence is available on the effects of such decreases on cost recovery levels and the sustainability of water supply and sewage infrastructure.

Important considerations:

- Based on available, scarce evidence, the study identifies two non-mutually exclusive approaches to face the negative effects of consumption reduction on cost recovery: 1) The development of a financial plan to ensure the self-sustainability of the water supply system in the face of an expected decrease of water consumption; and 2) The use of mixed tariffs, including a fixed charge – as it is the case in the surveyed countries. Low levels (or absence) of the fixed part would in fact lead to a higher sensitivity of services income to water demand, thus posing a risk on cost recovery levels in case of decreased water demand.

4. Water demand management strategies should focus on designing the most effective mix of pricing and non-pricing instruments

The results from the case studies show that water pricing policies are implemented in combination with other non-pricing measures, such as leakage reduction, water saving devices and awareness campaigns. In most of the cases, these combinations of instruments have been effective in reducing domestic water consumption. This suggests that the different packages of measures put in place for addressing water quantity issues have been overall effective in reducing water demand. It is more challenging, however, to assess whether non-price measures have been more or less effective than price measures – or than the combination of some non-price and price measures.

Important considerations:

- When designing an effective mix of pricing and non-pricing instruments, consideration should be given to the combination of measures on the specific features of each country in terms of water availability and water demand challenges.
- If decision makers want to use pricing policies as water demand management instruments, the first step to be taken is to ensure that the water supply system functions (at least partly) as a market. This means that water pricing must allow for recovering supply costs, and that

consumers have complete information on the service provided (for example on price levels). In many countries, this is far from being common practice as consumers are not yet aware of how much they are paying for water (and for one additional unit of water in particular).

- Any changes in pricing policies to manage water demand more effectively must account for the multi-level nature of water governance systems. Generally speaking, lower levels of governance (e.g. municipalities, private water companies, water boards, etc.) have full discretion for using pricing approaches (e.g. setting tariffs). Most European countries follow a framework in which policy made at the national level sets the rules for water service provision in place, which are then followed by local or municipal governments which themselves are at the core of providing water services or regulate private utilities.

1. Introduction

Source: © John Simm

1.1 Context – the challenges ahead

Water is increasingly considered as a scarce resource. Water is an important natural resource, demanding careful management. Europe's water resources are under increasing stress with a worrying mismatch between demand for and availability of water resources across both temporal and geographical (spatial) scales (EEA, 2012b). It is essential for life and integral to virtually all economic activities, including producing food, energy and industrial outputs. The availability of water in sufficient quantities is not only a prerequisite for human health and well-being but also essential for ecosystems and the many services that they provide (EEA, 2012a).

Water stress affects over 100 million people, one third of the EU territory all year around (EC, 2012b and c). During summer months, water scarcity is more pronounced in Southern European countries but is also becoming increasingly important in the Northern countries, including the United Kingdom and Germany. In some regions, for example, water scarcity events are becoming more frequent as an effect of climate change. Changing climate conditions are also affecting the frequency of and intensity of droughts and their environmental and economic damages appear to have increased over the past 30 years (EC, 2012b).

Pressures on water resources, including those arising from agriculture, industry, urban areas, households, tourism, etc. question the sustainable use of water. Additional driving forces also arise from natural variability in water availability (rainfall) and changes in Europe's climate. These driving forces on the need for water are intimately linked with policy responses. In essence, there are two different modes of policy responses to water demand management.

One is *supply-oriented* and focuses on the expansion of the network infrastructure and the exploitation of new resources.

The other approach is *demand-oriented* and has its origin in the development of protection and demand management programs to influence the demand for water and water use sustainability. It is more and more considered as an essential supplement for supply-oriented policy measures. Water protection and demand management include fostering the adoption of water-saving appliances, awareness campaigns, eco-labeling and price and taxation measures.

Europe is continuously exploring pathways to better deal with the driving forces putting pressures on water. This is progressively being crystallised in policy responses for better *water demand management*.

For example, at the European level the *Blueprint to Safeguard European Waters* seek to identify policy options to deal with these issues, integrate water-efficiency priorities into policy and face up to the challenges presented by climate change. The Blueprint identifies two main courses of action to promote water efficiency, namely: (i) the development of water-efficient technologies; and (ii) the implementation of water pricing policies that provide an incentive to use water efficiently, coupled with the wide-spread installation of metering devices (which is in fact a pre-condition for effective pricing).

The *Water Framework Directive* (WFD) provides a solid legislative basis for long-term integrated water management in the EU (EP, 2015). The implementation of the WFD Article 9 (see Box 1) is important for strengthening water efficiency. Water pricing instruments are considered to have a high potential to provide an incentive for a more efficient water use as it provides a signal to users of the relative scarcity of water. More specifically, it calls for application of water pricing into water management and water policy decision-making. Indeed, it has been acknowledged that water pricing and non-pricing measures have a high potential to provide an incentive for a more efficient water use and thus helps to achieve the environmental objectives under the Directive. However, actual evidence on existing pricing and non-pricing measures to manage water demand in Europe, as well as on their efficiency, are limited or outdated.

Box 1 - Article 9 of the Water Framework Directive "Recovery of costs for water services"

In terms of regulatory principles, Article 9 of the WFD introduces the principle of cost recovery for water services in accordance with the polluter-pays principle (PPP). In addition, the Article promotes the internalisation of environmental and resource costs that result from existing uses of water resources and of aquatic ecosystems.

In more detail, Article 9 establishes that:

1. *Water prices must allow for the (adequate) cost recovery of water services, including environmental and resource costs;*
2. *The main water uses (disaggregated for households, industry and agriculture) must adequately contribute to the recovery of costs of water services, proportionally to their contributions to the pressures imposed on aquatic ecosystems in line with the PPP;*
3. *Water pricing policies must provide adequate incentives for users to use water resources efficiently and thereby contribute to the environmental objectives' of the WFD.*

The *Roadmap to a resource-efficient Europe* under the Flagship Initiatives of the European 2020 Strategy identifies resource pricing as a key issue to be tackled, recognizing that, in some cases, market and prices, taxes and subsidies do not reflect the real costs of resource use, locking the economy into an unsustainable path (see Box 2). Water, in particular, is identified as one of the resources for which pricing policies do not often convey the right signals. The policy orientation and course of action indicated by the Roadmap focuses on water efficiency, efficiency targets and better demand management through economic instruments.

Equally, other relevant EU legislation related directly or indirectly to water demand management establishes frameworks to promote resource efficiency, including Directives like the *Energy Efficiency Directive*, *Energy Labelling Directive*, *Ecodesign Directive* and the *Ecolabel Regulation.* All have a common denominator of ensuring the promotion of efficiency and environmentally-friendly products (e.g. non-pricing measures).

Box 2 – Water resources in the Roadmap to a Resource Efficient Europe

"*Water is a vital resource for human health and an essential input for agriculture, tourism, industry, transport and energy. […]*

20 % to 40 % of Europe's water is wasted and ***water efficiency*** *could be improved by 40 % through technological improvements alone. An improved approach for sustainable management of water resources requires close coordination with agriculture, transport, regional development and energy policies as well as* ***effective and fair water pricing*** *as required by the WFD. Changes in ecosystems, land use, in production and water consumption and re-use patterns could cost-effectively reduce scarcity and ensure water quality.*

Milestone: By 2020, all WFD River Basin Management Plans (RBMPs) have long been implemented. Good status – quality, quantity and use - of waters was attained in all EU river basins in 2015. The impacts of droughts and floods are minimized, with adapted crops, increased water retention in soils and efficient irrigation. Alternative water supply options are only relied upon when all cheaper savings opportunities are taken. Water abstraction should stay below 20 % of available renewable water resources".

However, the ability to adopt cross-cutting perspectives is key in the recent development of European environmental policy. Strategies like the *Blueprint to Safeguard Europe's Water Resources* and the *EU Biodiversity Strategy to 2020* points to a redefined logic that sets coordination and compatibility as drivers of efficiency in the pursuit of the region's objectives. In this regard, the European water sector is not an exception. As mentioned above, the Blueprint was developed by the European Commission to tackle the obstacles which hamper action to safeguard Europe's water resources, based on an extensive evaluation of the existing policy.

In a report by the European Parliament on *Water Legislation – Cost on Non-Europe Report*[1] (EP, 2015) the assessment identified a number of policy challenges, where the absence of European action leads to significant costs, in particular current policies on water pricing lacks complementary rules on the mandatory use of water meters by end-users. Water pricing on a volumetric basis is a proven incentive for reducing the use of fresh water and also leads to lower water bills (EEA, 2013). The absence of water meters in households leads to a cost for non-Europe of 200 million euro per year (EP, 2015). In addition the absence of European criteria for maximum water consumption by showerheads and water taps, and the current exclusion of showerheads and water taps in the Eco-design Directive, leads to a cost of non-Europe of 1.2 billion euro per year (EP, 2015).

Europe's ability to adapt to the increasing risks of water scarcity, drought and over-abstraction can hence be enhanced by using water more efficiently. It should thus be recognized that water saving issues cannot be effectively tackled by looking solely at the drinking water component (domestic sector). Industry, energy and in particular agriculture must also increase their efforts (APE, 2014). Analysis indicate that domestic water consumers are still disproportionately charged for water cost recovery compared with agriculture and industry (EEA, 2013).

As described in the EEA study *Towards a more efficient use of water resources* (EEA, 2012), water pricing instruments have a high potential to provide an incentive for a more efficient water use. The EEA study on *Assessment of cost recovery through water pricing* (EEA, 2013) revealed that there is a varying degree of cost recovery between EU Member States and between water-use sectors, in line with the more recent assessments of the WFD's first RBMPs carried out by the European Commission. There also seem to be limited implementation of incentive pricing requirements of the WFD. When analysing individual EU Member States, it is evident that such obstacles are commonly

1 Costs of Non-Europe (CoNE) reports are designed to study the possibilities for economic benefits and the achievement of a 'public good' through common action at EU level. They attempt to identify policy areas which can benefit from deeper EU integration, where the added value of action at EU level is potentially significant.

related to the specific context of the country in question, and a complex array of factors ranging from cultural traits to socio-economic aspects.

One common obstacle to the implementation of cost recovery through water pricing is the lack of metering infrastructure in the domestic sector, which leads to households being short of incentives to use water wisely. However, increasing water prices to recover costs appears to be a useful instrument to manage domestic water demand. Higher water prices are also necessary to fulfill the cost recovery principle in a context of declining water consumption (APE, 2014).

It is clear that in many cases resistance exists from stakeholders and users to the rise in water prices (EEA, 2013). This resistance may in some cases originate from the lack of information, while in others it is due to multiple social issues. Generally, customers, particularly households, have at best limited knowledge about the economic instruments set up by water agencies.

Moreover, actual evidence on the price elasticity of water demand is outdated and the incentive structures of water charge schemes are currently being disputed in many countries. Besides, the implications for cost recovery of a more efficient water use need to be better explored.

Against this background an important question that comes in mind is how to manage water better by moving towards a more water-efficient and water-saving economy?

1.2 Objective and methodology

With this critical question in mind, the *objective* of the following report is to provide an analysis and evaluation of the economic aspects of water management practices and water demand management in Europe, in particular focusing on eight Member States, namely Germany - DE, Denmark - DK, Spain - ES, France - FR, Italy - IT, Romania - RO, Sweden – SE and Cyprus – CY.

The study mainly concentrates on the *domestic sector*, although some insights on the agricultural sector are also provided. It addresses and analyses the price or non-price approaches and their relative performance towards managing water demand/use more efficiently, including the barriers and enabling factors for implementing price and non-price approaches.

In addition the report analyses whether the incentive structures for water demand management are in place to encourage more efficient water use/water conservation – i.e. how they are implemented, how cost recovery is taking place and where the revenue goes. Managing water demand via price approaches refers to incentivizing efficient water use through a wide range of instruments such as tariffs, charges or fees, taxes or subsidies. This study presents an overview of these instruments and then focuses mainly on *water tariffs*. The reason for this is that water tariffs were identified as the most used instrument and is recognised in this context as the one that addresses domestic water demand in the most direct way.

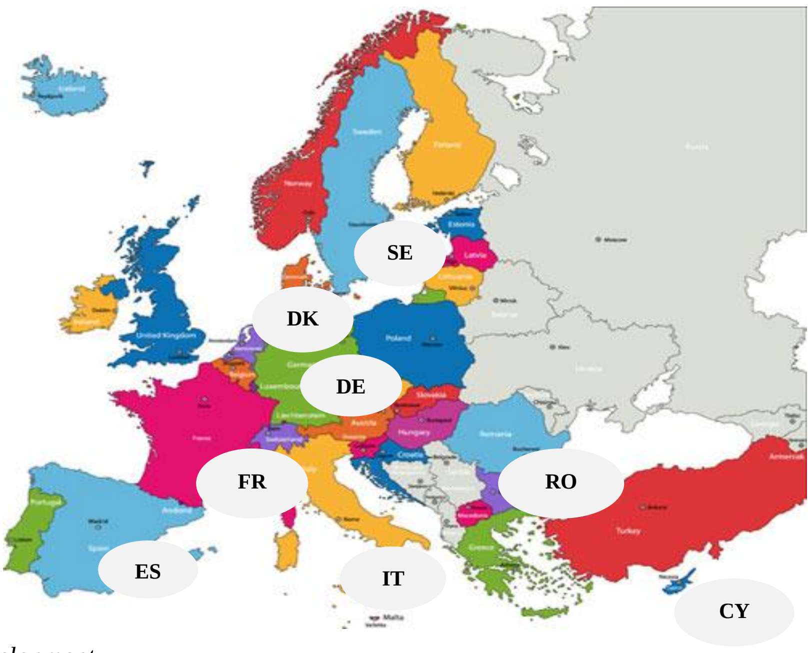
The report contributes to an update of the knowledge base on price elasticity of water demand to gain insights on how price evolution influences water consumption and evaluates the effectiveness of pricing instruments in managing water demand against technological developments or other non-price measures. At present, most of the existing evidence on price elasticity is outdated – with the exception of the recent JRC study (Reynaud, 2015) and thus the need for an updated overview of price elasticity for domestic water demand.

The *methodology* implemented to achieve these objectives implies two types of assessments:

(i) a country-level assessment for 8 selected countries (Figure 1), built on available data and literature;
(ii) a case-study based assessment, aimed at assessing price elasticity of water demand from primary data at the water operator level (10 case studies are carried out for the domestic sector).

The full MS templates related to the MS-level assessment, the full case study fiches for the domestic sector and the full review of existing case studies on agricultural water demand are published in a separate document to this report on the NRC EIONET Freshwater Interest Group (https://forum.eionet.europa.eu/nrc-eionet-freshwater/library/other-reports-and-assessments/water-management-europe-price-and-non-price-approaches-water-conservation/supporting-documents).

Figure 1 Countries selected



Source: own development.

The eight countries have been selected on the basis of two main criteria:

- a wide *geographical coverage* of EU countries, thus reflecting the diversity of water demand management issues and approaches, as well as water stress levels;
- *good data availability* on water management and pricing instruments.

The geographical coverage of the selected countries help ensuring that:

(i) both water abundant and water-scarce countries are included in the assessment and thus different water management challenges are tackled;
(ii) different levels of water efficiency are taken into account, as in some countries considerable efforts to reduce water consumption have already been made (e.g. SE, DE).

1.3 Guidance for the reader

Chapter 2 presents the current water management practices and incentive structures. The chapter illustrates the trends of domestic water demand in selected countries. It further provides an overview of governance and institutional settings of the urban water sector, including insights on the role of price and non-price instruments for water demand management. An overview of their effectiveness as well as opportunities and challenges for implementation is provided, including some conclusions on the relevance of particular approaches for different contexts. It then focuses on pricing measures and on existing incentive structures for a more efficient water management. In particular, the following is analysed:

- performance of the main water demand management measures being applied in the selected MS;
- barriers and opportunities to the implementation of such measures;
- impact of pricing policies, as well as other instruments, on water demand;
- implications of incentive pricing –and thus a more efficient water use- on cost recovery levels.
- Consumers' responsiveness to water price changes (price elasticity of water demand). It assesses and establishes fresh evidence on price elasticity of water demand (most quantitative) building on primary data and summarizes the main findings of the 10 case studies undertaken for the domestic sector.

Chapter 3 summarises the main results that can be drawn from the findings in the analysis. It reflects on the different pricing and non-pricing measures that have been implemented in the selected countries and whether the different packages of measures put in place for addressing water quantity issues have been effective in reducing water demand.

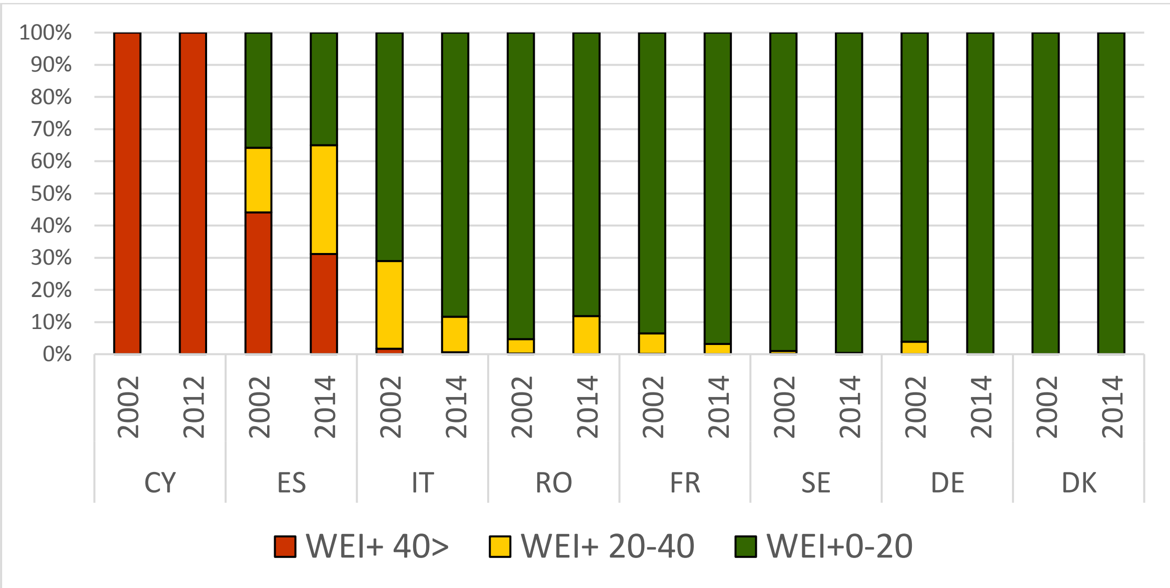
2. Current water management practices and incentive structures – towards more efficient water use

Source: © Bruno Rebelo

2.1 Setting the scene: an overview of main challenges and trends

Due to their geographical distribution, the selected countries differ in climatic conditions and intensity of exploitation of water resources. Figure 2 provides the Water Exploitation Index (WEI)[2] for the 8 countries from 2002 to the latest available observation in 2014, thus showing: (i) the level of water stress of each country; and (ii) the variations across the last 12 years.

Figure 2 WEI from 2002-2014 in selected countries



Source: Nihat Zal, EEA.

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[2] The **water exploitation index** (WEI) is the mean annual total abstraction of freshwater divided by the mean annual total renewable freshwater resource at the country level, expressed in percentage terms. www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources.

The Y axis shows percentage of area covered by a certain level of Water Exploitation Index value. The information can be classified as follows:

- 0-20 % no water scarcity;
- 20-40 % water scarcity;
- 40 %> severe water scarcity.

It should be noted that this classification is disputable among experts, as there are no commonly agreed tresholds for assessing water scarcity[3].

As it can be seen in Figure 2, selected countries include:

(i) one country in sever water stress (CY);
(ii) two countries in water stress (ES, IT);
(iii) two countries with low water stress (RO, FR);
(iv) three countries with no water stress (DK, DE, SE).

Different levels of water stress correspond to different main water management challenges, as shown in Table 1. Water demand challenges were also reported in countries with no water stress, although it can be expected that in such countries such challenges are not as pressing as in water-stressed countries.

Table 1 Main water management issues in the selected countries

Water management challenge	Countries				
Droughts and water scarcity (also with increasing intensity and frequency in recent years), sometimes leading to abstraction restrictions	CY	ES	FR	IT	RO
Overexploitation of groundwater resources	CY	DK	ES	IT	
Mismatches between water demand and water availability: seasonal peaks in periods with low precipitations, geographical concentration of water demand versus distribution of water resources (e.g. along coasts)	CY	DE	ES	IT	
Scarcer groundwater resources due to pollutants	DE	DK	ES		
Low efficiency of the water network	IT	RO			

Sources:
CY - WDD, 2012); EC, 2012
DE – UBA, 2015a; UBA, 2015b; UBA, 2015c; UBA, 2015d; UBA, 2014; UN-ESC, 1997; Statista, 2015 ; Branchenbild, 2015; BDEW, 2015
DK – Danish Economic Council, 2015
ES – OECD, 2015; World Bank, 2008; OECD, 2014; Fuentes, 2011
FR – Onema, 2011
IT – OECD, 2013; DPS, 2014
RO – Romanian Waters, website.

Drought and water scarcity events are posing challenges to water demand management strategies in all Mediterranean countries, as well as in Romania, although different countries are affected in different ways. In France, for example, around 20 departments were subject to seasonal abstraction restrictions during average years, whereas more than 60 departments were affected by restrictions during drought years (INRA, 2006). In addition, the analysis of natural flows shows that water-scarce

[3] See the following link: https://www.sei-international.org/mediamanager/documents/Publications/SEI-Report-WaterFutures-AssessmentOfLongRangePatternsAndProblems-1997.pdf.

periods have been getting more frequent and intense in the last 40 years, especially in the South (ONEMA, 2011). However, droughts and desertification can also threaten countries with relatively abundant water resources, such as Romania: where these phenomena are largely caused by anthropogenic factors, such as deforestation and destruction of the irrigation systems.

In all case study countries, with the exception of Romania, water scarcity and drought events are leading to the *overexploitation of groundwater resources*. In Cyprus, for example, scarce water resources must meet a growing residential (including tourism), industrial and agricultural water demand. This is to the point that only 40 % of total water abstraction is sustainable and one aquifer has been mined down to 15 % of its original reserve[4]. Over abstraction issues can also be found in countries with high water availability: in Denmark, for example, overexploitation of water resources still occurs, especially in the densely populated eastern part of the country, even though existing policy tools have reduced water demand by approximately one third in the last 20 years (GEUS, 2007).

Water scarcity issues can be exacerbated, if not brought to light, in cases of *seasonal or geographical mismatches between water availability and water demand.* This is the case, for example, of Mediterranean countries, where water demand peaks occur in summer along the coasts: typically, summer is the driest season in that area. The concentration of inhabitants in only some areas, namely the coasts, poses a further challenge to the management of water demand and the allocation of available resources.

Pollution of groundwater resources can lead to reduced water availability, also in those countries generally characterized by abundant water resources, such as Denmark: where pesticide pollution accounts for 20 % of well closures, whereas nitrate pollution is responsible for 10 % of closures (Danish Economic Council, 2015).

Source: © Ian Murray/Loop Images/Corbis. Eutrophication caused by agricultural runoff from nitrate fertilizers shows algae blooms in a drainage ditch.

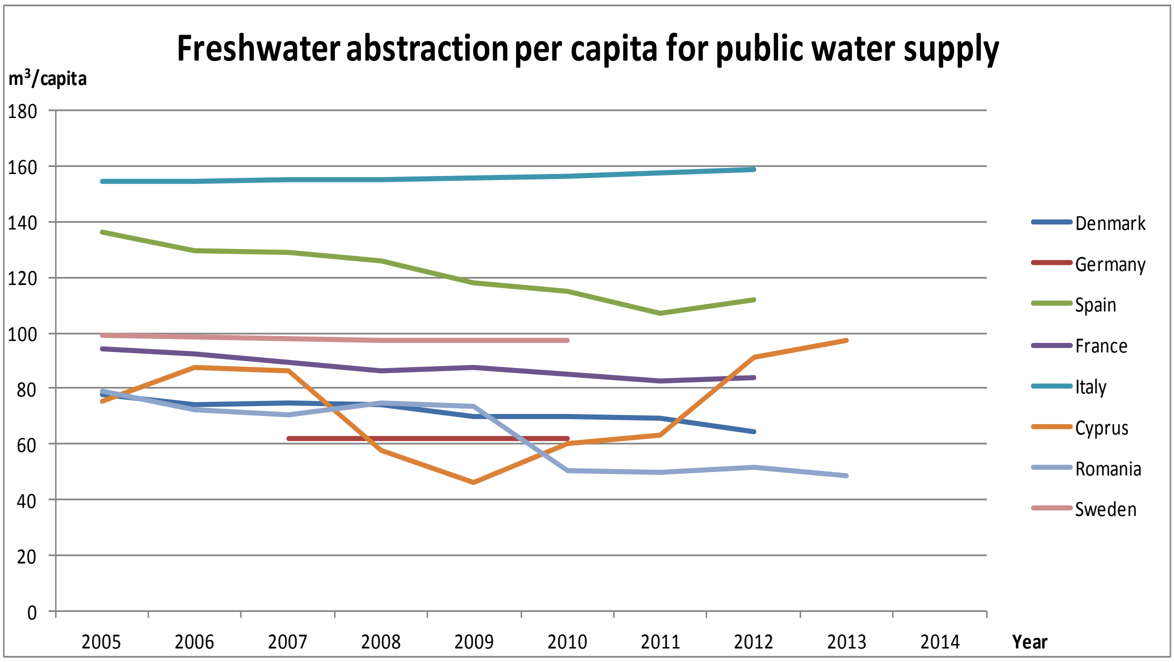
Low efficiency of water distribution networks is also an important water demand management issue in Italy and Romania. There can be several reasons for such inefficiency. In Italy, for example, the water and sanitation sector is still characterized by weak regulatory oversight, dysfunctional governance, institutional mis-match and uncertainty, as well as lack of funding (also due to low

[4] Source: River Basin Management Plan – Status Assessment.

tariffs). Conflicts of interests at the local level also often occur, as the local regulators are often also utility shareholders. These issues act as a break to private investment in the sector. This, coupled with inadequate pricing levels, results in insufficient levels of funding for water supply and wastewater infrastructures and obsolete infrastructures (OECD, 2013). This clearly leads to low efficiency levels of Italian water infrastructures, which concern all sectors (domestic, industrial, agriculture).

Overall *water abstraction per capita for public water supply in the selected countries shows decreasing trends* in the period 2005-2013, as shown in Figure 3. Italy is an exception, as water abstraction per capita has slightly increased over the observed period. In contrast, in CY water abstraction per capita drastically decreased between 2007 and 2009, to start rising again since 2009 onwards; in 2013, levels of water abstraction per capita were higher than 2007.

Figure 3 Water abstraction for public water supply in the selected countries, period 2005-2013



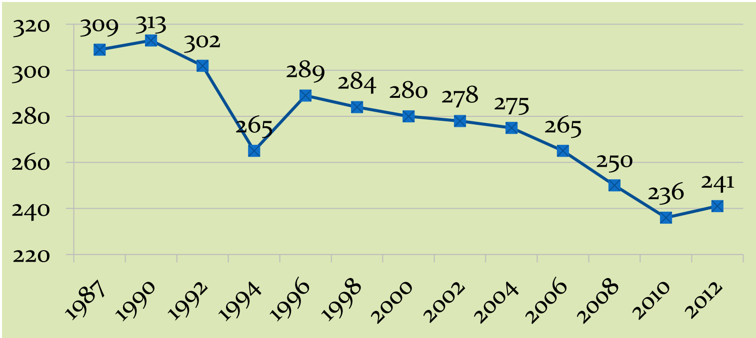
Source: Own elaboration from Eurostat data – datasets: env_wat_abs, demo_pjan. Missing years were interpolated.

Decreasing trends were observed, for example, in Romania: where water abstracted for domestic purposes decreased from 2.22 Billion m^3 in 1990 to 1.01 Billion m^3 in 2013 (Romanian Waters, 2014). In Denmark, domestic water consumption per capita decreased by 39 % in the last 25 years[5]. A significant decrease in domestic water demand was also observed in Sweden.

In Spain, since 1987, and biennially, the Spanish Association of Water Supply and Sanitation (AEAS), conducts a survey on drinking water supply and sanitation. As shown in Figure 4, there has been a reduction of 22 % in the amount of water supplied in the period 1987-2012.

[5] Bo Sörensen and Susanne Vangsgård, DANVA, personal communication.

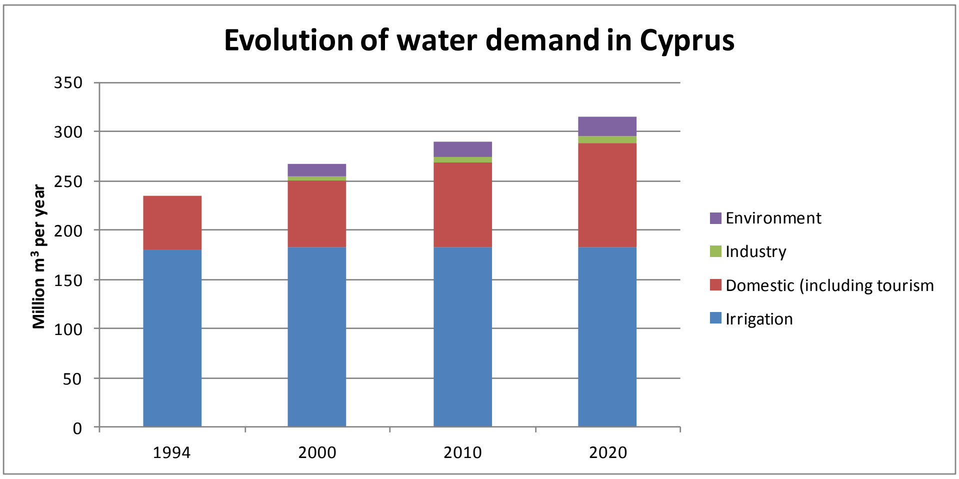
Figure 4 Evolution of water supplied in Spain in the period 1987-2012, in liters/person/day



Source: AEAS, provided by Eureau.

Cyprus is one country where an opposite trend was observed. Figure 5 shows observed (1994-2010) and projected (to 2020) total water demand by sector – the figure includes ecological flows[6] required to meet WFD requirements: here, the domestic demand (including the tourism sector) increased in the period 1994-2010 and it is expected to further increase in 2020; in contrast, agricultural water demand has remained stable over the observed period, whereas industrial demand only slightly increased (Cyprus Government, 2010).

Figure 5 Observed and projected evolution of water demand in Cyprus, by sector, in the period 1994-2020



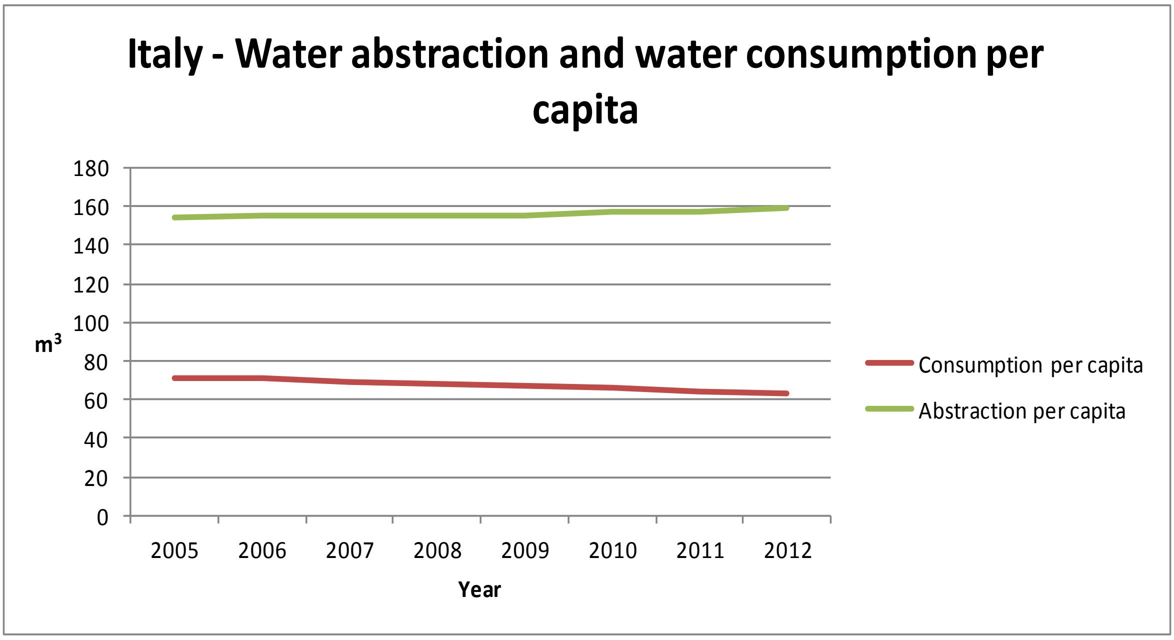
Source: Cyprus Government, 2010.

Some further insight is provided by a comparison between volumes abstracted for public water supply and volumes effectively used by households; this could be done for Italy, where complete figures on water consumption per capita were available. As shown in Figure 6, water abstraction per capita is more than double the water consumption per capita; in addition, water consumption shows a decreasing trend, whereas water abstraction has increased over the observed period. This might be an indication of the current low efficiency levels of the Italian water distribution system which is an

[6] Ecological flows are considered within the context of the WFD as "an hydrological regime consistent with the achievement of the environmental objectives of the WFD in natural surface water bodies as mentioned in Article 4(1)".

important indicator of the evolution of water distribution efficiency, in individual years and as a trend over a period of years. High and increasing annual volumes of leakage indicate ineffective planning and construction and low operational maintenance activities. Failure to quickly repair visible leaks is highly damaging to a Utility's reputation. To the general public, media and politicians, high leakage levels in water distribution networks are generally perceived as waste and inefficiency on the part of the water service providers and damaging to the environment (EC, 2015b).

Figure 6 Water abstraction and water consumption per capita trends in Italy, in the period 2005-2012



Sources: (i) water abstraction: Eurostat; (ii) water consumption: AEEGSI, 2014.

2.2 Urban water sector: governance and institutional settings

Governance and institutional settings of the urban water sector are very diverse across the eight surveyed countries, as summarized in Table 2. From the table, it can be seen that in most of the surveyed countries water services are mostly managed at the municipal level – or even at a lower level, as is the case of Denmark. There are only two exceptions: in Italy, the territorial unit of management and operation is on different scales (regional, province or local scale); in Romania, water is mostly distributed by regional operators. Overall, it can be inferred that the regulation and management of water services is still quite fragmented in the eight MS.

The type of management differs from country to country and often, also within the same country. In CY and SE only direct private management exists; in IT, the management of water services is mostly delegated to public entities and in some cases, to mixed public and private entities; in RO, management is mostly delegated to public entities, with the exception of two large mostly private companies in Bucharest and Ploiesti. In the other countries, different types of management coexist: in DE, for example, management can be delegated to both public and private entities, but it can also be directly undertaken by private entities. Similarly, in ES, management can be delegated to both private and public entities, but it can also be directly undertaken by public bodies (municipalities).

Table 2 Governance and institutional water settings of the urban water sector in the eight countries (from various national sources)

Country	Type of management	Responsible authority	Type of water operators
CY	Direct public management	Drinking water: the Water Development Department is in charge of the central distribution network. Distribution is supervised by Town Water Councils in cities, or by a committee made up of members of Municipalities of Councils in other areas. Wastewater treatment: Sewerage Boards are in charge of primary and secondary treatment, as well as tertiary treatment in rural areas[7]; the Water Development Board is in charge of tertiary treatment and water reuse in urban areas.	Water is directly provided by the Water Development Department, the Town Water Boards, and groups of Municipalities or Communities. All operators are public.
DE	Delegated public management	In 9 out of 16 Länders, responsibility for the water supply remains with the municipalities, even if the operational business is transferred to a third party. In the remaining 7 Länders, water supply is an optional task of municipalities, which allows for the transfer of the operational business and legal responsibility to a third party. The legal framework allows private companies to operate and own water supply systems, provided that the pricing and revision authority is still in the hands of the municipalities. However, in the case of delegation in the form of a concession, the charges are determined by the non-public bodies of the private operator.	A large number of water suppliers (6,605) are active. Suppliers are very divers in organizing institutions, forms of organization, size and activities. 62% of water suppliers operated under public law, representing about 40% of water abstraction. The remaining 60% is abstracted by private companies, which tend to be larger in size.
DK	Delegated public management – Direct public management	Since 2009 the Vandsektorloven (Water Sector Law) regulates the distribution of water for all utilities supplying in excess of 200 000 m^3 per year. The most innovative feature of the law is a price ceiling, set individually for each utility on the basis of e.g. supplied volume, costs, investments and efficiency demands. After an evaluation of the law in 2013 the parliament reached a decision that the law needs to be altered and work to do so is underway (2015). The main issues concern cost efficiency and user transparency.	There are roughly 2100 water utility companies in Denmark. Out of these around 322 are governed by the water sector law and the rest are privately owned, primarily in smaller user-owned entities. In addition to these there are around 50 000 small water utilities, serving less than 10 households. There are around 1000 waste water treatment plants, out of which 98% are owned by municipalities.

[7] 'Primary treatment' means treatment of urban waste water by a physical and/or chemical process involving settlement of suspended solids, or other processes in which the BOD5 of the incoming waste water is reduced by at least 20 % before discharge and the total suspended solids of the incoming waste water are reduced by at least 50 %. 'Secondary treatment' means treatment of urban waste water by a process generally involving biological treatment with a secondary settlement or other process“(Council Directive 91/271/EEC).

ES	Delegated private and public management	In Spain, urban water supply, sanitation and wastewater treatment services are under municipal jurisdiction. The decentralized character of the water sector in Spain leads to its complex structure and processes regarding its regulation and operation. Various viable models for the administration and management of the water cycle yield a framework where responsibilities are shared between a number of public and private actors involved at different spatial levels. Each one of the 8,116 municipalities of the country has the competence to provide the water services in its area of jurisdiction. Tariff regulation is a factor also varies according to the municipality and the service. In this matter, the Committee on Prices (an entity dependent on the Autonomous Communities) and the administration of the municipality are commonly in charge of authorizing prices for the main water services in a locality.	Municipalities may opt to provide water services on their own or to integrate public communities called local water entities (entidad local del agua) in order to provide water services in a broader area. They may also choose between public, private or joint models of management for the provision of water and sanitation services. 42% of the country's population was provided with water services by public companies, 40% by private companies, 11% by joint ventures, 6% directly by local authorities, and 1% by other means.
FR	Delegated public or private management	In France, water supply and waste water treatment are under the responsibility of municipalities or group of municipalities, constituting water services. Water Agencies (6 for metropolitan France) are in charge of the coordination of rivers and water environment protection, including abstractions for domestic use. LEMA (Law on water and aquatic environment) from 2006 supervised water management, and includes an objective of improving public water and sanitations services (i.e. transparency of management and water supply for all). LEMA transposed WFD into French law.	35 000 water services (including water supply services, collective waste water services and non-collective waste water services). They can be managed by public authorities (70% of services, supplying 40% of the population) or their management can be delegated to private companies.
IT	Delegated public management	The Authority for Energy, Gas and Water Services (AEEGSI) is in charge of the regulatory oversight of the water supply and sanitation sector, including the development of the national methodology for tariff setting, which must be applied in the whole national territory. Until recently, the responsible authorities for water supply and sanitation services were the ATOs (Autorità d'Ambito Territoriale Ottimale), which operated on the local scale (region, province or group of municipalities). After 2014, AATOs must be substituted by new bodies identified by regional laws –with an obligation for local institutions to participate in this new authority. In each territorial unit, integrated water services must be managed by a unique operator.	Public providers or mixed public-private providers.

RO	Delegated public management	The National Administration "Romanian Waters" is in charge of enforcing the national law on water provision; together with the 11 subordinated river basin Administrations, it is in charge of issuing water management permits to water operators. Most water utility companies act as regional operators and their shareholders are public organisations (County and Local Councils). There are two notable exceptions to this rule (in Bucharest and Ploiesti), where the water utility companies are mostly privately owned. In these cases, the public share of the company is 16.31% in Bucharest and 27% in Ploiesti. Water Utility Companies are responsible for local water supply and sewage.	Most water utility companies act as regional operators and their shareholders are public organizations (County and Local Councils). Only in Bucharest and Ploiesti water utilities are mostly privately owned, the public share of the companies being 16% and 27% respectively.
SE	Delegated public management	The law of public water services (2006:412) stipulates that the municipalities are responsible for providing their citizens with drinking water and waste water treatment. Municipalities are allowed to finance the water services by means of taxes or fees, 99% of the cost are covered by means of the latter according to sector statistics.	Municipal water companies in Sweden's 290 municipalities operate around 1750 water plants. The majority of these are very small and only around 250 cater to more than 2000 customers. The combined turnover for the sector was 17,2 billion SEK in 2014.

Sources:
CY –WDD, 2010; WDD, 2011
DE - Rudolph and Bloc, 2001; Hansen et al., 2004 ; BDEW, 2013 ; Kraemer, 2009; Wackerbauer, 2009
DK – Withana et al, 2014; DANVA, 2015; Deloitte, 2013
ES – AES-AGA, 2014; Garcia-Rubio et al., 2015; ACA; Canete & Mendez, 2009; Ministerio de Medio Ambiente, 2007; Confederacion Hidrografice del Ebro, 2011; AEAS, 2012
France - ONEMA, 2015
Italy - Argento & van Helden, 2010; OECD, 2013; Decreto Sblocca Italia, 2014
Romania – Romanian Water, website
Sweden - Svenskt vatten, 2014.

2.3 Non-price approach to water demand management

2.3.1 Overview and challenges of the main non-price measures applied in selected countries

As presented in the previous chapter, the sustainable use of water resources cannot be accomplished without careful management of urban water demand. Prominent non-price measures that are generally used are presented in Table 3.

Table 3 Prominent non-price water demand management measures

Non-price measure	Purpose
Water Licensing	Control of water resource use by enthrusting the right of granting access to the natural resource to the state
Water restrictions	Control on abstraction and consumption applied during periods of acute water shortage
Network leakage reduction	Reducing water losses from water infrastructure (e.g. pipes)

Benchmarking	Reducing water losses and increase water use efficiency by comparing performance and by sharing best practices between e.g. water utilities
Water efficient devices	Uptake of water technologies (e.g. taps) that use less water for the same level of performance
Consumer awareness campaigns	The provision of information that promotes behavioural change leading to a reduction in water consumption
Alternative water sources	A range of measures based on reducing demand for clean water from conventional sources (e.g. rivers, groundwater, desalination[8]) by supplying alternative sources of water, such as rainwater harvesting and reused water.

Source: Olmstead & Stavins, 2009; Grafton et al., 2011; Bello-Dambatta, et al., 2013.

According to Dziegielewski (2011), demand-side approaches in the urban water sector offer multiple benefits compared to supply-side approaches, such as: reduced costs from reduced water treatment and energy use (e.g. treatment, heating); savings in capital expenditures through downsized new supply projects; and increased environmental benefits of reduced withdrawals. At the same time, water demand management requires a high level of expertise, knowledge and know-how, together with sometimes large capital (upfront) investments, for example, the systematic installation of water meters or the replacement of distribution networks. The efficiency and effectiveness of particular non-price and price measures will thus depend on several dimensions, such as the level of water scarcity, level of awareness, institutional context or the quality of the infrastructure (Dziegielewski, 2011).

While the use of non-price measures for reducing water demand is in theory a good objective, several challenges to their implementation exist, which call for adequate attention to their advantages and disadvantages in different contexts (Table 4).

Table 4 Opportunities and challenges of non-price measures

Non-price measure	Opportunities	Challenges
Water Licensing	• Better monitoring of water uses; • Contributes to strengthen policies aiming to balance water use between sectors; • Supports implementation of WFD.	• Complexity of administrative and enforcement arrangements; • Conflict with historical water rights; • Difficulty to enforce properly.
Water restrictions	• Reduce peak consumption during drought periods; • If planned, transparent prioritisation of water uses during droughts.	• Reduction of metered revenue; • Increase in operational costs.
Network leakage reduction	• Increase performance of water utilities and maximises utility of water produced.	• Requires large investments in monitoring systems and capital costs.
Benchmarking	• Builds on competition between water utilities (e.g. public image); • Helps utilities to improve performance through comparison.	• Performance is only assessed in relative terms between utilities: little incentive to go beyond the performance of the majority.

[8] Another alternative water supply is desalination which e.g. in Cyprus plays a big role. It is a very energy intense process and is critical as long as it is not solar driven and made carbon neurtral. Desalination is not included in this analysis.

Water efficient devices	• Can lead to reduction in bills if volumetric pricing (and no change in pricing structure); • Can lead to energy saving.	• Potentially large upfront costs; • Retrofiting of existing buildings more complex.
Consumer awareness campaigns	• Can reach out to large population; • Promotes change in behaviour.	• Difficult to monitor effectiveness.
Alternative water sources	• Diversifies sources of water and reduces pressure on conventional sources of water.	• Quality standards on health risks required; • May reduce return flows to rivers thereby increasing impact of low flows.

Source: own elaboration from study findings.

As described in Table 3 and 4, water managers have several available non-price measures at their disposal. They are briefly presented in turn below.

2.3.2 Water Licensing

The implementation of the EU Water Framework Directive (2000/60EC) (WFD) has fostered European-wide impetus to better regulate water uses. Reforms of water rights or the establishment of *licensing schemes* have been observed across Europe (e.g. Scotland, Cyprus). Although it can be argued that systematic monitoring of water uses through licensing is an appropriate policy to enhance integrated management of water resources, permanent or even temporary controls on drinking water use (e.g. through licensing of abstraction or the use of water rationing) may be more controversial to water users. In particular, water rationing on water utilities pose technical and economic challenges, including a reduction of metered revenue and an increase in operational costs.

Basically, the *licensing of water abstractions* entails the control of water resource use by entrusting the right of granting access to the natural resource to the state. Licensing of water abstractions for public supply as well as self-supply is a common practice in European countries. This takes on many different forms, according to the prevailing conditions and legal framework in the respective countries. In Sweden for example, two types of licensing exist – municipal and private. This implies that a majority of the population will be connected to the municipal water service network and only those living in remote or rural locations will be allowed to extract drinking water from private wells.

Regarding self-supply in France, since 2009, every domestic well must be declared to the municipal authority and added to the national data base concerned. Volumes abstracted from these wells can be inspected by water services. For example, the Guadalquivir river basin authority (RBA) in ES has personnel in charge (guardería fluvial) of visiting, metering and controlling water abstraction and full compliance with requirements set out in the water-use license.

Monitoring of abstractions, in particular of groundwater, is weak and registration of groundwater abstraction rights is still incomplete. Though there are likely tens of thousands of illegal water abstractions across the RBD, the administrative process for fines and/or closure is very complex; it has been successfully applied for only some hundreds of illegal abstractions over the last few years, possibly at a lower ratio than the increase of new illegal abstractions and is often bottlenecked due to political sensitivity and irrigator lobbying. In addition, access to farms to identify illegal abstractions is often impeded when rangers attempt this without court authorisation. Illegal abstraction is considered a minor infringement and fines have a low impact (EEA, 2013).

The main challenges with implementation of licensing of water abstraction and the use of water rationing are linked to the complexity of the administrative and enforcement arrangements. Licensing, for example, does not necessarily prevent over-abstraction as historical water rights are difficult to reform. Over-allocation of water persists in areas of Spain such as Segura district, the Júcar district and the Guadiana basin (OECD, 2015). Dealing with illegal extractions also poses a major challenge. In Spain again, undeclared and illegal groundwater abstractions are still frequent, despite experience gathered from water allocation systems in place since the 19th century and their improvements over time (Molinero et al., 2008). The scale of the challenge is further illustrated by a pilot project in one region of Cyprus, which was carried out in 2008 to identify unlicensed boreholes (domestic and agriculture). It utilised satellite images and found 9000 boreholes, of which 6000 were licensed and 3000 were unlicensed (majority domestic use).

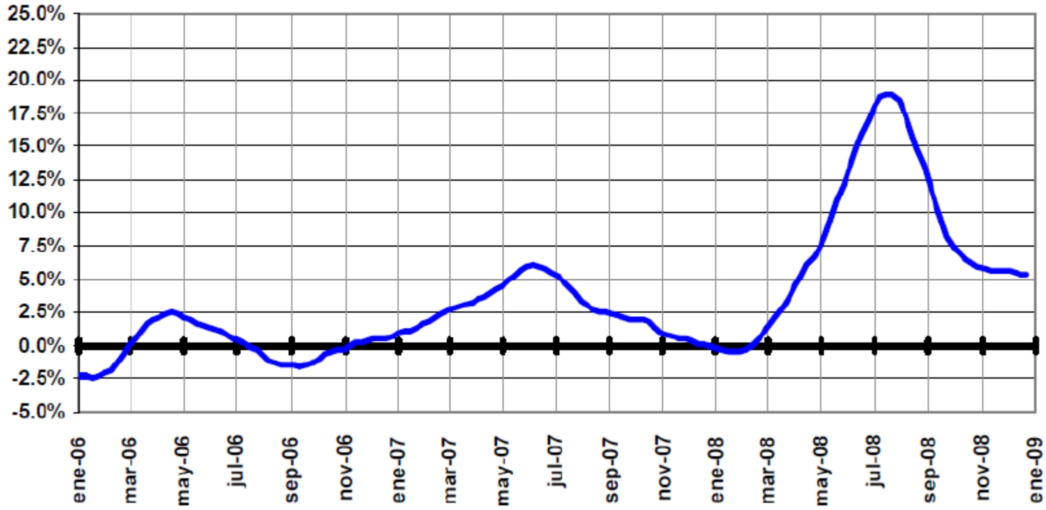
Licensing acts best as effective water demand management when licensed volumes are near or lower to water demand: in these cases, water users have an interest in maximising the use of abstracted water to avoid shortages. Furthermore, licensing can be an effective tool to maximise environmental benefits when licensed volumes are based on the quantitative status and ecological flows of the respective water bodies, including the variability and seasonality (i.e. low flow periods) of the hydrological regime. In Germany, a licence for the abstraction of water by a utility can be obtained in most cases only if it does not impair the ecological status of the respective water body, as required by the EU Water Framework Directive. Another strategy for maximising welfare benefits of water use is to enable the trading of abstraction allocations between water users. While this is more established outside Europe (e.g. Australia), some Member States have started exploring (e.g. England, DEFRA, 2014) or establishing (e.g. Spain) water markets to optimise water rights allocation while controlling overall water demand.

2.3.3 Water restrictions

In the countries on which this study focuses, *restrictions or rationing of the water supply* to households are only applied during periods of acute water shortage. Restrictions of water supply in times of acute water scarcity are generally considered to be effective in reducing the water demand in the short term, while they tend not to have an effect on water demand in the long term if not accompanied by other measures (Cominola et al., 2015). Cyprus for example, had to deal with severe water shortages between 2008 and 2009 (Polycarpou & Zachariadis, 2011). Periodic interruptions of residential water supply were applied as an urgent water saving measure. While this measure was effective in mitigating the problem of water shortage during this period, a study showed that it did not encourage citizens to change their consumption patterns and thus had no impact on long term water demand (Polycarpou & Zachariadis, 2011). However, examples of a change in consumption following a drought have been observed in some cases. The severe 2007-2008 drought episode in Barcelona for example, may have led to a reduction in water consumption of about 5 % on average (Martin-Ortega and Markandya, 2009; Bernando et al. , 2015). A combination of non-price measures was applied. Water use by local authorities (e.g. fountains, gardens, street cleaning and swimming pools) was restricted and intense public information campaigns took place, encouraging water saving behaviour and delivering warnings. Water saving devices were also distributed to households. In total, in the period from March 2007 to January 2009, approximately 506 Hm^3 of water was saved - about 14 % of the water demand for this period (see Figure 7) in the Barcelona metropolitan area, served by the Ter-Llobregat system (supply network).

Guaranteeing the water supply to private households is generally seen as a priority and countries often establish a “water hierarchy” which sets out a list of priority uses. For example, in France public drinking water supply is a priority use (with health, hygiene and civil security) and in cases of drought, abstractions will not be submitted to restrictions (but it can be submitted to a water withdrawal permit setting a maximum amount of water to withdraw).

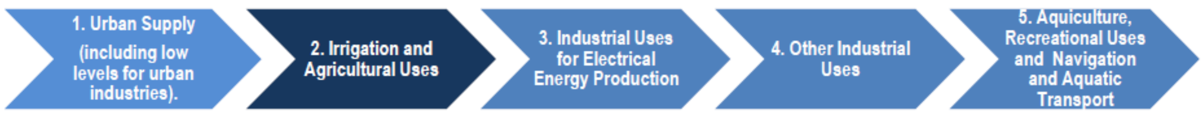
Figure 7 Evolution of water savings in the Ter-Llobregat system – Barcelona metropolitan area (% of water savings to baseline)



Source: Catalonian Water Agency in Martin-Ortega and Markandya, 2009.

In Spain, the order of priority given to the different type of uses must be defined in the River Basin Management Plan. If this is not fulfilled, the Water Act (the main piece of legislation governing water allocation in Spain) provides a default priority sequence (see Figure 8). In any case, drinking water supply is always the priority use.

Figure 8 Priority classes for water allocation pre-defined in the Water Act.



Source: OECD (2015).

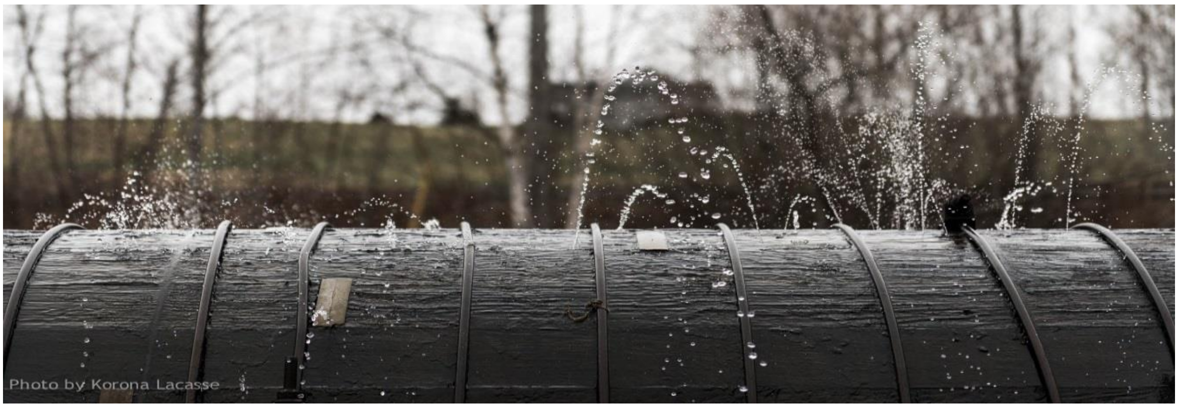
Water infrastructure is a long term asset of which performance is highly dependent on a large range of factors, such as physical conditions of geochemistry and topography as well as discipline in planning, quality of execution and maintenance records.

2.3.4 Network leakage reduction

Network leakage reduction or reducing water losses in water infrastructures is a complex task which must account for these legacies and different contextual conditions. Problems with leakage in the distribution networks is not compatible with the increasing trend towards sustainability, economic efficiency and environmental protection. Leakage losses are still significant in many water networks, which is commonly due to the poor condition of water mains (EC, 2015b). Losses of water in the networks are not only related to efficiency of the networks but also to water quality, as contamination of drinking water might increase if the pressure in the distribution network is very low.

Water losses are an inevitable part of the practice of public water supply, which from a resource efficiency perspective should be minimised. The term includes production losses and distribution losses, which again includes real losses in the network, unbilled consumption (e.g. firefighting) and apparent losses (EEA, 2014). Nevertheless, the assessment and tracking of leakage levels has become a central strategy in many European water utilities (EC, 2015). Several procedures have now been developed: mechanical and acoustics approaches to leakage detection, assessment models (e.g. water balance and Night Flow analysis) and digital approaches (e.g. Pressure Managed Areas, District Metered Areas). Typical water leakage reduction measures include:

i) appropriate asset management (with regular pipe replacement and speedy repair);
ii) pressure management (in particular avoiding rapidly fluctuating pressures);
iii) active leakage control.



Source: © Korona Lacasse. Example of a network leakage.

Currently, losses in the drinking water network can represent a high percentage of the volume initially produced; however, the situations vary widely between European countries. It was estimated that water leakage in EU countries varied between less than 10 % in Denmark (DANVA, 2015) to more than 60 % in countries such as Bulgaria, with the majority of countries in the range of 30-50 % (Dworak et a., 2007).

Germany, for example, has relatively low leakage levels due to a combination of favourable soil conditions, treatment to reduce the aggressiveness of the water supplied, easy access to repair mains and a high level of mains replacement (Liemberger, 2005). Data on distribution losses from a benchmarking exercise in Germany show mean values between 0.9 and 3.1 m3/km/day, whereas mean values from 32 large water utilities in geographical Europe show levels around 8.5 m3/km/day. Additional data provided from water associations in France, Sweden and Denmark show weighted mean values ranging from 1 to 10 m3/km/day with the lowest in Germany, Denmark and France and the highest in Sweden (EEA, 2014).

However, the significant water losses due to network leakages in many countries are often a result of low maintenance of existing infrastructure. To reduce water losses, water service providers should measure the volume of lost water. Once the volume is known, revenue losses can be determined and cost effectiveness of implementing corrective action can then be determined. The economic benefits of leak detection and repair can be easily estimated. For an individual leak, the amount lost in a given period of time, multiplied by the retail value of that water will provide a monetary amount. Here, of course, water service providers should also factor in the costs of developing new water supplies and other “hidden” costs.

In defence of not fixing network leakages, water services providers often offer the position that they are operating as efficiently as they can, given their specific circumstances, and that further increases in efficiency to reduce levels of leakage would require increased tariffs that are always politically unpopular. So investments needed for improved leakage efficiency must compete with other priorities for Operating and Capital funds from revenues, and must be based on a sound financial case of costs and benefits (EC, 2015b).

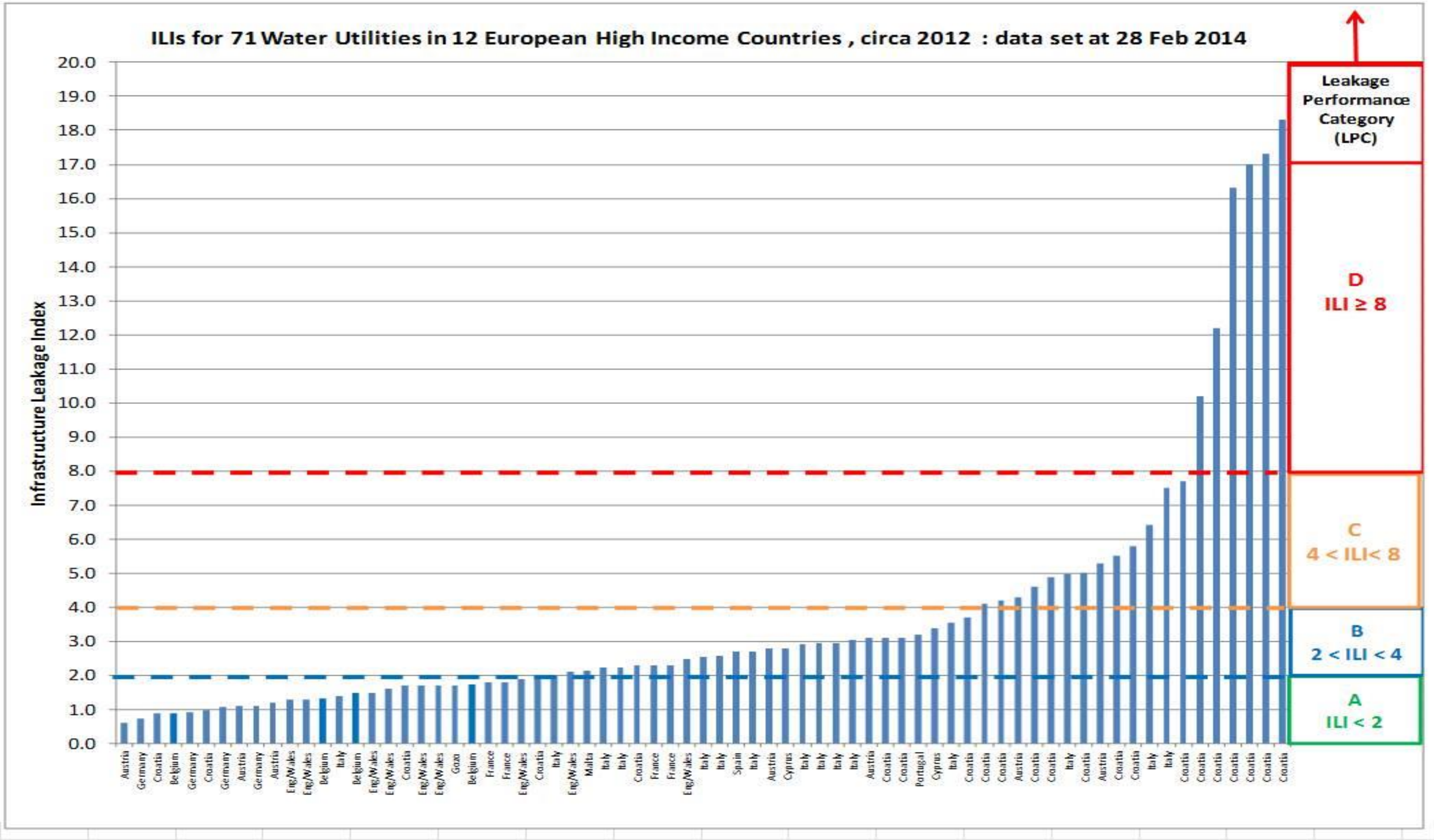
The Infrastructure Leakage Index (ILI) method, developed by the International Water Association, allows for the ranking of water utility performances while differentiating between current water losses and "unavoidable" water loss[9]. Unavoidable water loss is a measurement of the water used by the infrastructure (e.g. flush after repairs or contamination), water used illegally, authorised unbilled uses and metering inacurracies. ILI allows also to identify leakage reduction that is technically and economically feasible. ILI results are typically classified into ranges – called Leakage Performance Category (LPC) - which are associated with a set of recommendations for leakage management associated for that LPC. Categories also help set milestones for utilities in their attempt to improve their performances.

A European comparison of ILI index (Figure 9) shows that large variations exist between countries and also between utilities within a country. For example, in Figure 9, some Croatian utilities perform highly (ILI below 2) while others very poorly (ILI above 8). Many utilities in Europe have now achieved low ILIs (i.e. < 1 which is associated with high performance in international standards) which led to further splitting the A category into two sub-categories (i.e. A1 and A2).

Leakage reduction in public water networks is also technically and economically challenging. Leakage reduction often involves investments in monitoring systems (e.g. district metered areas) and capital costs (e.g. reparation, replacement). According to the CIS reference document on leakage management (EC, 2015), the appropriate budget for active leakage control is dependent upon the value placed on leakage: utilities producing or purchasing expensive bulk water or using desalination can justify increased leakage control activity compared to those with cheaper sources. However, leakage control should also be coherent with the resource availability: further leakage control may not be required in cases of high performing systems where resource is plentiful, while leakage control could be a priority for poor performing system where water scarcity is a threat. In that context, tools such as the ILI or benchmarking activities between water utilities can help identify appropriate performance targets.

[9] It is closely related to the more common concept of "non-revenue water" which is a measurement of the discrepancy between volumes of water produced and those billed to customers.

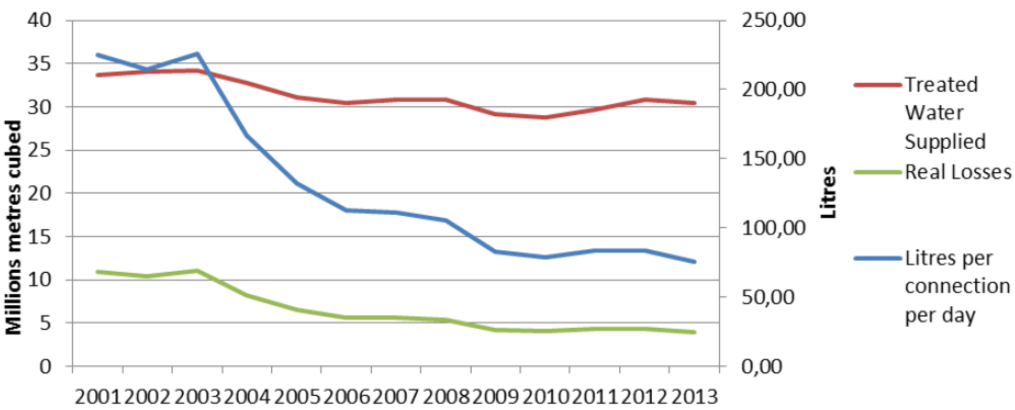
Figure 9 Water loss performance of sampled European water utilities using the Infrastructure Leakage Index (ILI).



Source: *http://www.leakssuite.com/global-ilis/european-ilis-2/* .

There is yet no firm European-wide evidence of the effectiveness of leakage reduction, however, numerous successful cases exist at local and regional levels. The CIS guidance on leakage management (EC, 2015) presents, 16 examples of successful programmes in drinking water networks across Europe. Most cases have used the International Water Association methods for assessing and managing leakages, and most applied pressure management together with District Metered Areas as the main leakage control tool. In Scotland, despite plentiful resources, the water utility has achieved a 48 % reduction (from 1.104 to 575 Ml/day) between 2006 and 2013, therefore going beyond targets set by the regulator. More drastically, in Malta, where there is high pressure on available resources, the application of pressure management and active leakage control in district metered areas has led, since 2001, to a leakage reduction from 200 to 70 litres per day per user connected (Figure 10), being equivalent to a reduction of ILI from 20 to 2,1. To further illustrate, such savings have helped avoiding the need to build 2 desalination plants out of 5 initially planned to cover demand.

Figure 10 Leakage reduction in Malta



Source: EC, 2015.

Effective reduction in leakage can be made more complex with increasing water shortages and reduction in consumption. In Cyprus for example, an ambitious leakage reduction programme was initiated in 2002, achieving leakage reduction from 138 to 92 litres/connection/day (ILI from 2,66 to 1,96). However, intermittent supply due to shortages between 2008 and 2009 lead to an increase of 300 % in reported mains breaks. Despite continuous supply and full reinstatement of pressure management, leakages remain at 127 litres/connection/day in 2013, in part due to damages to joints and fittings during the shortages. Breaks in the distribution system are linked to rapid changes in pressures, e.g. daily. When a distribution system enters a phase of scarcity, the last resort is to stop distributing water for parts of the day to allow some replenishment of the reserves. In contrast, a leakage reduction programme is not linked to sudden, large changes in pressure, but rather to careful (slow) pressure management and targeted infrastructure repair. Thus it does not put strain on the infrastructure.

As for water savings through leakage reduction programmes, there is yet little evidence at national or European level of the effectiveness of water saving measures.

2.3.5 Benchmarking

Benchmarking approaches are used to increase the performance of water utilities by comparing performance and practices at different levels and by sharing best practices. It is not a single action, but a tool to encourage continuous developments and improvements. This significantly contributes to improving the transparency and accountability of water service providers by giving citizens access to comparable data on the key economic, technical and quality performance indicators of water operators (EEA, 2014). Benchmarking networks collect data from their members related to a number of technical and economic parameters used for performance comparison and discuss improvement opportunities. It is used around the world, for example the USA, Australia and Brazil. In Europe, benchmarking is an established activity in several Member States, in particular in the Netherlands and Denmark where such schemes were started in the 1990's. The European Benchmarking Co-operation is an industry based initiative and runs an annual programme since 2007, mainly for Western European water and wastewater utilities. In 2014, 48 utilities participated.

2.3.6 Water efficient devices

Improving *water use efficiency* in buildings and houses is an important approach for the management of water demand. It is recognised at EU level through the 7th Environmental Action Programme, which aims to increase resource efficiency use and more specifically the Ecodesign Directive (2009/125/EC), which is a main piece of EU legislation for reducing the freshwater use by water-using products. Key household appliances include toilets (31 % of average household water use), showers (33 %), taps (10 %), washing machines (11 %) and dishwashers (3 %) (BIO, 2009).

Outdoor water equipment (e.g. garden irrigation, cleaning equipment) represents only 3 % of average household use, although real consumption varies widely between areas and income levels. Water saving appliances aim to reduce water use while maintaining the same level of service. Common water saving appliances include low-flow shower heads and dual-flush toilets, and more efficient washing machines and dishwashers. It should be noted that the possibilities provided by the Ecodesign Directive are limited as it focuses on energy-related products. This means that not all water-using products, such as toilets and irrigation systems, fall within the Directive's scope. This focus on energy use diminishes the water-saving potential of the Directive. Research shows that if all domestic water-using products were covered by the Directive, a 19.6 % reduction in EU total public supply could be achieved (around 10 % if only energy-related products were included, excluding dishwashers and washing machines). This would correspond to a 3.2 % reduction in the EU's total annual abstraction volume (BIO, 2009).

Water metering is a complementary measure to eco-design. Effective metering makes end-users aware of the amount of water they use and the savings made by installing more efficient water-using products. Especially when effective water metering is linked to effective water pricing, water metering can lead to lower consumption. Research shows, for example, that introducing volumetric charging in agriculture can reduce the volume of water used by 10 -20 % (EEA, 2013).

With regards to the installation of water efficient, water recycling or rainwater harvesting technologies, the main challenge is related to the retrofiting of existing buildings. While it can be more cost-effective to directly install water efficient devices in new buildings, especially when associated with savings on energy bills (e.g. tanks to reduced use of heated water), retroffitting could require careful planning to modify the existing built environment and infrastructure. Households and businesses may perhaps be reluctant to pay for upfront costs, and governments might not have sufficient resources at their disposal to support capital investments in times of restricted public finances (Polycarpou and Zachariadis, 2011; Pesic et al., 2012; Bello-Dambatta et al., 2013).

Authorities can promote the uptake of water saving devices in buildings and households via various means:

(i) direct distribution of devices among the population or;
(ii) more indirectly, through regulations, labels, quality starndards and subsidies;
(iii) awareness campaigns (see section 2.3.7).

Direct distribution is usually frequently triggered during periods of high water stress. In the Gironde Department in France for example, 80 000 packages of water saving devices - including 2 flow reducers for taps, 1 low-flow shower head and 1 toilet flush reducing bag- were directly distributed to households in 2013. The water-saving packages were distributed to the consumers by the SMEGREG with the support of the water agency, the water authority and some municipalities.

Regulation, labelling, quality standards and subsidisation for promoting the uptake of water efficient devices might be more appropriate during non-water-scarce periods. In Spain, a nation-wide Code for the incorporation of technical elements that promote the saving and control of water in newly constructed buildings was approved in 2006 (González-Gómez et al., 2012). Further, the Decree 202/1998 of the administration of Catalonia stipulates that newly constructed or renovated buildings, either of public or private ownership, should incorporate water saving taps and flush interruption mechanisms for toilets. Similarly, the Ordinance of Efficient Management and Use of Water of the city council of Madrid sets mandatory regulations for water using products in residential and commercial buildings and encourages the installation of water efficient products in the city (Benito et al., 2009).

Labels and certification schemes are more commonly used than regulatory standards in Europe to promote water savings. For example, the label High Environmental Quality ("Haute Qualité Environnementale" or HQE) in France aims to improve the environmental, including water use-performance, of buildings and towns (HQE, 2016). The French government now requires 20 % of its new buildings certified HQE. More generally, such green procurement policy can help improve the water efficiency of buildings since the public sector is responsible for 40 % of EU construction activity (BIO, 2012).

In some cases, water saving technologies have been adopted without having to change lifestyles, thereby largely facilitating their widespread use. For example, average water used by washing machines has steadily decreased from 170 litres per cycle in 1970 to 50 litres per cycle in 1998 with no performance loss (Benito et al., 2009). In other cases, implementation of water saving devices may be a challenge. In Sweden, sewage pipes in older buildings are not dimensioned for the lower water volume associated with the use of dual flush or other types of low volume flushing toilets. This can consequently cause blockages that have to be mechanically removed by technicians, which has led the Swedish Consumer Agency to recommend against installing these types of toilets in older buildings or always using the larger flush for dual mode models, thus negating positive effects (SR, 2014).

The setting of quality standards has focused attention on the development of rainwater harvesting, recycled water and wastewater re-use. Too strict standards may constrain use and adoption, too lax standard may increase risks to human health. Also, these techniques may reduce return flows from wastewater systems to the rivers, thereby increasing the risk of environmental damage, especially during the dry and low flow seasons.

Water savings through reducing leakages in networks and the uptake of water efficient technologies usually offer promising results. Dworak et al. (2007) for example, found that the uptake of a range of non-price water demand measures, including reduction of leakage in water supply networks, water saving devices and more efficient household appliances, had the potential to save up to 50 % of water abstracted and reduce water consumption from 150 litres per person per day to 80 litres per person per day. The same study estimated potential savings in the tourism sector (including camping sites, bed and breakfasts and hotels) could lead to 30-50 % water savings and the application of technical measures in industries (excluding energy), such as changes in processes, higher water recycling rates or use of rainwater could lead to savings of between 15 and 90 % between countries and a European average of 43 % (Dworak et al., 2007).

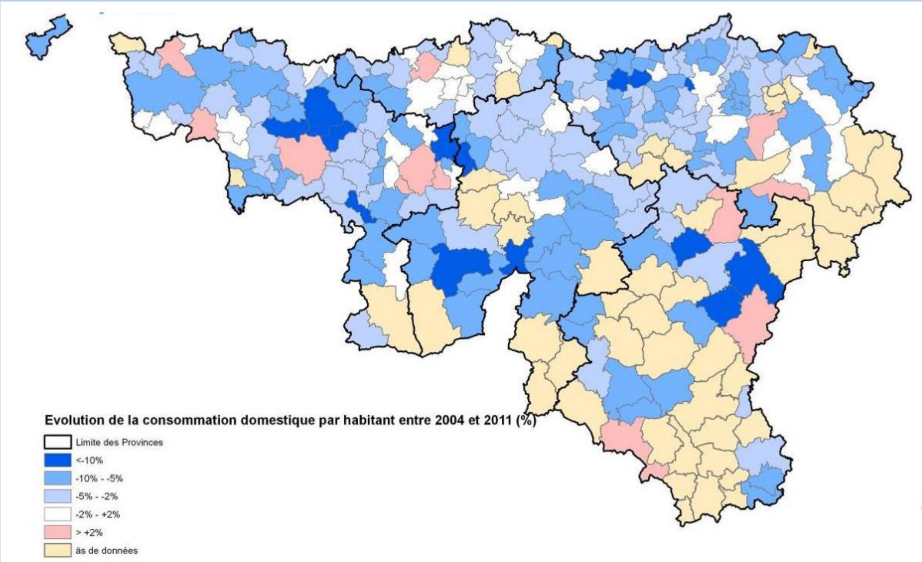
However, it is generally thought that the cumulative effect of the uptake of water efficient devices offer great potential in water savings. In the Netherlands, average water use has reduced by 65 % between 1995 and 2010 for dishwashers and by 56 % for washing machines. In theory, currently, dishwashers represent the greatest potential to become more efficient (55 % water saving potential) followed by toilets (53 %) and washing machines (32 %), and replacing all standard residential appliances could result in an overall decrease in yearly water consumption of 32 % (BIO, 2009). It has been suggested that water savings through the cumulative uptake of water efficient devices in households may explain the reduction in water demand in Belgium (see Box 3).

More measurable and rapid gains can be realised by targeting large businesses such as supermarkets, shopping centers and other enterprises and industries connected to the mains. However, several factors, other than technological change, may explain changes in total household water use, including population, socio-economic and behavioural changes. In addition, some authors (Olmstead & Stavins, 2009; Grafton et al., 2011) argue that water savings through the installation of water efficient devices is diminished due to the “rebound effect”, known in behavioural economics as the Jeveson paradox, whereby efficiency improvements in one technical process in the use of a resource is ultimately defeated through a higher overall use. For example, Olmstead & Stavins (2009) observed that households that implemented low-flow showerheads started taking longer showers. However, while evidence may be growing on the rebound effect in water savings in agriculture (Dumont et al., 2012), little evidence exist on the household sector.

Box 3 Linking water demand reduction to non-price measures in Wallonia

Total water consumption in Wallonia has decreased by 2 % between 2005 and 2012, despite growths in population and GDP. Water consumption per capita decreased from 110 litres/inhabitant/day in 2000 to less than 100 litres/inhabitant/day in 2012. The study from AquaWal indicates that the reduction is associated with small water users (households) (see Figure 11). Analysing reasons through spatial correlations, the study suggests that two factors may have an influence: adoption of rainwater tanks and socio-economic level of the population. However authors rule out the role of rainwater use as estimated potential savings appear too limited. The authors also found no correlation between price and water consumption or income levels. Despite lack of data on market uptake, the study concludes that the decrease in water demand in Wallonia is likely to be mostly explained by uptake of water saving devices and technological evolution, on the basis that similar results were observed in other European cities. The study rules out water pricing as a determining factor of the observed decrease.

Figure 11 Water demand reduction in Wallonia by small end-users (consumption of <250m^3/day).



Source: Aquawal, 2013.

2.3.7 Consumer awareness campaigns

Awareness and informational campaigns aim to change the behaviour of households, e.g. taking short showers instead of baths. They can also be used to inform households about the benefits of water saving appliances (Bello-Dambatta, et al., 2013). Awareness campaigns targeted at households have been applied in Cyprus, Denmark, France, Italy, Spain and Sweden – examples for Cyprus and Spain are provided in Box 4. The campaigns often encompass the distribution of information on websites, organisation of events, educational activities for children and the use of multimedia (radio, newspapers, television). An example is the Max100 (Water Hero) campaign run by the Greater Copenhagen Utility in Denmark, which set the explicit goal of decreasing the water consumption of its customers to 100 liters per person per day. The core of the campaign is the "Water hero" website[10] with a range of suggestions on how consumers can decrease their water consumption and hence their water bill, given the high water prices locally. The information takes the form of both short films and texts. The actions are divided into four categories: kitchen, washing, garden and bathroom. There are also information categories for small utilities, schools and local communities.

[10] See http://www.hofor.dk/skole/

The EU Ecolabel, which is a voluntary scheme that producers, importers and retailers can choose to apply for to label their own products, helps consumers with information on which products or services are both environmentally friendly and of good quality. The logo can be found on the packaging of every EU Ecolabel product and is an important indicator as to whether specific technologies and e.g. water saving appliances are effective and efficient to manage water resources better.

Box 4 Awareness-raising for water saving in Zaragoza and Cyprus

Innovation uptake in Zaragoza relied heavily on an effective communication campaign over several years organised through the Water Saving City Programme. The Programme started in 1997 with an awareness-raising campaign targeted to households, scaled up in 2000 to other sectors, such as public buildings, parks and gardens, industries and the service sector. Good practices were identified and disseminated, and more than 10.000 pocket guides were distributed among the city's major water consuming sectors. Between 2006 and 2008, the Zaragoza water saving city considered it important to have achievable and measurable targets for the broad public, such as 100,000 commitments from institutions or citizens in adopting at least 4 certified actions on water use. Zaragoza hosted the International Exhibition Water and Sustainable Development in 2008 with 200 lectures and educational events. The municipality has also developed a self-explaining water bill in order to make the invoicing more transparent.

In Cyprus, public authorities organise awareness-raising events in cooperation with other relevant organisations, such as primary schools, water boards, municipalities, radio stations or environmental organisations. One specific example is the Award event competition conducted together with the Water Boards and the Primary Education of the Ministry of Education and culture. This is a writing story award on cultivating water consciousness, e.g. for the theme "Creative with water". Further offers are lectures to organized groups and the maintenance of Water Museums, which are often visited by schools and the public.

While the effectiveness of softer approaches such as awareness campaigns are more difficult to monitor, they may cost less than more technical measures. This can be seen for example in Cyprus, where water awareness is one of the only measures which were not cancelled following the cuts to governmental budget with the recent economic crisis. Furthermore, awareness campaigns enable policy-makers and water managers to target children and young adults, which are hard to reach with other policy tools such as pricing, given that they rarely pay their own utility bills.

Because awareness-raising campaigns focus on affecting household behavioural change, their effectiveness is commonly difficult to measure. However, in some cases, campaigns can play a key role in determining consumer behaviour and that can result in large scale shifts in consumption. Another opportunity with campaigns is that they can be combined with other water demand measures (price and non-price), increasing the effectiveness of the latter. For example, the effectiveness of water saving technologies can be increased when their promotion is accompanied by educational campaigns on their appropriate use (Cominola et al., 2015).

A concrete number of water savings related to campaigns is given by Kondouri et al. (2011), who estimate that the potential water saving from awareness-raising in Cyprus will be 2 million m^3 by 2020. BIO (2012) estimated that that labelling of products could enable between 1,5 and 6,1 % of water savings in water consumption in Europe by 2050, depending on the existence of accompanying information campaigns and/or financial incentives. However, using stronger forms of governmental interventions through mandatory water performance ratings and minimum water performance requirements for new buildings could result in around 8 % of water saving across Europe by 2050. Other studies have attempted to estimate effectiveness of past awareness-raising campaigns. For example, the information campaign conducted in Zaragoza during 1997 and 1998 has been directly associated with water savings of 1,176 million litres in 1998 alone, the equivalent to 5.6 % of the city's annual water consumption (Saurí and Cantó, n.d.). The local sales of domestic appliances with built-in water savers increased by 15 % and four times as many individual meters and 6 times as many water-saving taps were sold as before the campaign (EC, 2002).

Conveying the importance of decreasing water demand may be hard in other, water-rich contexts such as Sweden, given that the supply of clean drinking water, with very few exceptions, is ample. Experience in other water rich countries, but water stressed due to high population density such as England, nevertheless suggests that awareness-raising campaigns can be effective in fostering the adoption of water efficient devices (Box 5). Several parts of the country have seen retrofit programmes promoted by water utilities combining the installation of water efficient devices with individual assessment and advice at household and business levels. Recent successful examples include: Thames Water "Five-Step Plan" targeted at businesses that led to 17.3 Million litters per day saved between 2009 and 2014; and the United Utilities household campaign, that led to a cut in household water usage by 11.6 % within 6 months (EA, 2015).

Box 5 The award-winning H2eco retrofit programme of Essex and Suffolk Water

Since 2007, Essex and Suffolk Water has carried out the H2eco project to promote, educate and deliver water efficiency to customers. The project involves free water efficiency appointments within customer's home in a selected town or area. The visit involves a trained plumber assessing the property and installing a range of free water saving devices wherever possible. This retrofit programme is based on financial incentives to encourage participation. It is accompanied by a wider awareness-campaign (with the "Every drop counts" slogan) with the following activities: bus shelter adverts, vehicles (advan), local radio, TV, project vans, customary introductory mailing, pre-mailer card, invitation mailing, and reminder card. Various ways are offered to customers to respond: mail, telephone, web-site, text message, and e-mail.

Recent campaigns in Wooler and Billericay achieved uptake rates of respectively 27 % and 20 % per targeted households resulting in average measured savings of respectively 24.500 litres per day and 18.300 litres per day, or an equivalent of 50,8 litres per property per day and 6,07 litres per property per day. The higher savings in Wooler is explained by the installation of service valves on internal pipework which has reduced the flow of water from many taps from 25 to five litres per minute.

Essex and Suffolk Water developed a number of additional activities to further water savings. A Water Energy Calculator was developed in partnership with the Energy Saving Trust to help customers foresee the costs of their water and energy usage. Media campaigns target local radio stations and newspapers and aims to raise awareness of water saving potential through particular activities such as gardening. Education is an important part which involves e.g. getting secondary school students into online surveys, talks and problem solving challenges, and primary school students into theatre plays and games.

Source: ESW (2014) and Mouchel (2016) - https://www.eswater.co.uk/media-centre/3190_3662.aspx.

2.3.8 Alternative water sources

The promotion of *alternative water sources* such as rainwater harvesting from, for example, roofs and impermeable surfaces[11] and recycled water from domestic activities such as laundry, dishwashing and showering has gained prominence in a number of countries. This harvested and recycled water can substitute potable water for specific uses in buildings when the lower quality does not affect consumer's health, such as for gardening or toilet flushing. As BIO (2009) highlights, the benefits of grey water recycling will depend on how much can be stored, while the benefits of rainwater harvesting will also be dependent on how much it rains. Rainwater harvesting is a proven

[11] In line with the EU Green Infrastructure Strategy.

alternative water supply that is now used in different contexts in Europe and labels such as the above-mentioned HQE usually promote these technologies.

Wastewater re-use is another alternative water source, traditionally reserved for agricultural purposes but increasingly for urban (e.g. gardening, municipal), tourism (e.g. golf courses) and industrial application (Kellis et al., 2013). Europe's ability to adapt to the increasing risks of water scarcity, drought and over-abstraction could be enhanced by wider reuse of treated waste water. The re-use of water is covered (directly or indirectly) by the WFD and the Urban Waste Water Treatment Directive (UWWTD) and also forms part of the Water Scarcity and Drought (WS&D) policy. Reclaimed water is also covered by other EU water-related legislation but coverage depends on the final use. For example, irrigation and 'green agriculture' generally fall under the scope of the Common Agricultural Policy (CAP), while quality standards for drinking water are set by the Drinking Water Directive (DWD). Further to the obligations laid down by water legislation, initiatives have been carried out, under which re-used grey and wastewater replaces the use of freshwater, for example, in irrigation in agriculture, industrial processes, non-potable urban applications, groundwater recharge and in recreational activities. The data on the two largest consumers of conventional water resources, agriculture and electricity generation, show that two-thirds of agriculture's water needs are already sourced from re-used water, while electricity generation hardly uses re-used water at all (EP, 2015).

At present, however, the uptake of water reuse solutions remain limited in comparison with their potential. This appears to be due to a number of factors, including low economic attractiveness of reuse solutions, low public acceptance of reuse solutions and limited awareness of its benefits, inadequate water pricing, insufficient control over freshwater abstraction, a lack of common EU environmental/health standards for reused water, and poor coordination of the professionals and organisations who design, implement and manage such schemes (EC, 2015a). The issue of reuse of treated waste water for different purposes is not specifically addressed by EU water policy through EU wide standards. For example, the UWWTD only encourages water reuse without setting standards (Art. 12, paragraph 1 of Directive 91/271/EEC *"Treated waste water shall be reused whenever appropriate. Disposal routes shall minimize the adverse effects on the environment."*

Water reuse may have a lower environmental impact than other alternative water supplies such as water transfers or desalination, under certain conditions, and may offer a range of environmental, economic and social benefits. For example, reusing water generally consumes less energy than alternative supply options (desalination/inter-basin transfers) and may allow for less energy consumption in waste water treatment, which can eventually contribute to making EU countries less dependent on energy imports, in the framework of an Energy Union (EC, 2015a).

However, three progressive stages exist in conventional wastewater treatment: primary treatment removes solids; secondary treatment involves the removal of postulate, dissolved organic matter and some pathogens, and the oxidation of ammoniac nitrogen; tertiary treatment involves further filtration and cleaning for nitrogen, phosphorus, some toxins and microorganisms.

Primary and secondary treatments are most common; however most wastewater reuse require tertiary treatment. A steady growth in wastewater reuse has been observed in Europe, with particular interest by Mediterranean countries (e.g. Spain, Italy) but also northern countries (e.g. England, The Netherlands). In France, Paris has a double network of drinking and grey water used for municipal purposes such as cleaning roads and watering public gardens.

In Cyprus, alternative water supply options have been strongly promoted in recent years. In 2010, roughly 14.6 M m^3 of recycled water was produced annually, which covered the need for irrigation of crops and green areas. From this quantity, about 10 Mm^3 covered the need of the water balance, about 2.5 Mm^3 was used for enrichment of groundwater aquifers and the remaining 2 Mm^3 (winter production) flowed to the sea. In this context it should also be mentioned that desalination contributes significantly to the water balance in Cyprus. For example the water demand for the provinces of Nicosia, Larnaca, Famagusta and Limassol together is 72.300.000 m^3/year. Desalination contributes with 46.862.000 m^3/year (minimum yearly production)[12]. In 2010 the desalination plants contributed to the water balance with 65 % of the total demand in drinking water.

2.4 Pricing approaches to water demand management in selected countries

The implementation of European policies on drinking and urban wastewater treatment, notably via the Drinking Water Directive 98/83/EC and the Urban Wastewater Treatment Directive 91/271/ECC, has resulted in significant investments in the water sector over the last 25 years. These investments have usually been financed through a combination of European and state contributions, as well as end-user contributions through charges included in the water bill. Stricter standards regarding the discharge of wastewater into the aquatic environment in particular have required important investments in treatment facilities across Europe. It was, for example, estimated that compliance costs with the UWWTD 91/271/ECC from 2005/06 onwards was in the order of 45 billion € for new investments only (not reinvestments) (EC, 2010). An adequate mix of water pricing approaches is required to contribute in sustaining such expenditure levels and to send the right signals regarding the use of water resources.

In its Article 9, the Water Framework Directive (WFD) 2000/60/EC establishes a number of principles and provisions towards the appropriate pricing of water in the EU (EC, 2003) for example:

- The principle of recovery of the costs of water use, whereby the capital, operational and maintenance costs of water services provision, as well as the associated environmental and resource costs, must be internalized;
- The Polluter Pays Principle (PPP), which states that the cost of pollution reduction measures should be borne by the polluter. In the case of domestic consumers, these costs may entail those related to the sanitation of their wastewater and other activities that affect the quality of aquatic ecosystems, like discharges, abstractions, impoundments and engineering;
- The economic analysis of water services based on long-term forecasts of water supply and demand at the river basin district level to aid in cost recovery efforts;
- The use of economic or fiscal instruments to adequately incentivize efficient water resource use.

The implementation of the WFD has led to greater attention to pricing measures in water resource management, including the investigation of levels of cost recovery, relative contribution of the different sectors to the financing of water services, revisions to water pricing policies and, in some cases, introduction or reforms of other economic instruments such as abstraction charges.

Several policy aims may be sought when implementing water pricing approaches, like guaranteeing the continuous and sustainable provision of good quality drinking water or reducing consumption levels in areas where water is a scarce resource. As mentioned earlier, the WFD puts forward some specific provisions in this respect. It is important to point out, however, that given the essential

[12] See link: http://www.cyprus.gov.cy/moa/wdd/Wdd.nsf/0/24B06DE543FBD990C22576EB002E2633/$file/Desalination.pdf

character of water, aligning the objectives of water pricing approaches is frequently a highly political and complex task. While the points below are simplified abstractions of these dynamics, they serve to exemplify how the outcomes of water pricing policy may, in some instances, enable the fulfilment of the WFD principles listed above, while in others they may have contradictory results. For instance:

- Internalising environmental and resource costs through a specialized tax or levy on water use could serve to offset the environmental pressures and forgone opportunities of alternative water uses that result from supplying drinking water to a certain community. On the other hand, the overall increase in the price of water resulting from such an implementation could lead to issues of affordability in certain sectors of society;
- Establishing an increasing block tariff structure for public water services to provide incentives for efficient resource use could result in reduced water consumption levels. However, under specific circumstances where fixed costs (e.g. investments on infrastructure and technology) make up a substantial proportion of the total costs of providing the water service, financial sustainability could become an issue;
- Subsidising tariffs for irrigation to support farm income and agricultural production while taxing higher income generating water uses could provide benefits for society by efficiently allocating costs between the different water users. Nonetheless, this could result in lower financial contributions coming from sectors who are actually emitting higher amounts of pollution into the environment, countering the polluter pays principle.

Ultimately, wider awareness of the public on these issues is necessary to ensure a properly functioning market for water services in Europe. Further exploration is also necessary to adequately counterbalance any undesired effects of policy implementations. In addition, it is essential to identify where efficiency gains could be achieved along the value chain.

2.4.1 Overview of pricing strategies in the selected countries

The literature on pricing approaches for water services covers a wide range of instruments whose main purpose is to stimulate efficiency in the allocation and use of water resources. However, often the definitions of these economic instruments are disputed, overlapping, or simply not clearly discussed. To harmonize the terminology used in this section, the typology of water pricing instruments developed by Lago et al., 2015 is adopted[13]. Following this typology, it could be said that managing water demand via price approaches refers to incentivizing efficient water use through tariffs, charges or fees, and taxes or subsidies. Table 5 provides definitions of these different economic instruments. Table 6 goes on to show examples and describe some of their main purposes.

Table 3 Typology of water pricing instruments.

Type of pricing instrument	Definition
Tariffs	Price to be paid for a given quantity of water or sanitation service, either by households, irrigators, retailers, industries, or other users.
Taxes	Compulsory payment to the fiscal authority for a behaviour that leads to the degradation of the water environment.

[13] Which is also based on the 3Ts concept that has been developed by the OECD Horizontal water programme in order to describe and categorise the three ultimate financial sources of investment for the water sector: Taxes, Tariffs and Transfers (primarily official development assistance).

Charges (or fees)	Compulsory payment to the competent body (environmental or water services regulator) for a service directly or indirectly associated with the degradation of the water environment.
Subsidies on products	Payments from government bodies to producers with the objective of influencing their levels of production, their prices or other factors.
Subsidies on practices	Payments from government bodies to producers to encourage the adoption of specific production processes.

Source: Excerpt from Lago et al., 2015.

Table 4 Examples of water pricing mechanisms and their main purpose.

Pricing Mechanism	Main purpose
Volumetric water pricing	Incentive for using less water.
Charge/fee on abstraction licenses	Disincentives on abstraction.
Subsidies for water saving technologies	Incentive for uptake of water efficient devices.
Tax breaks for utilities with low water leakage	Incentive for increasing efficiency of network.
Subsidies for water re-use equipment / lower tariffs for consuming reused water	Incentives on alternative water sources or for using grey water.

Source: Excerpt from Lago et al., 2015.

The most frequent pricing mechanisms used in the surveyed case studies are volumetric water pricing based on water use metering. In some countries, volumetric water pricing for public drinking water services dates back several decades, for example Cyprus, where it was introduced in the 1970s.

The use of charges on abstraction (and wastewater discharge) to account for the environmental and resource costs was also frequently observed in the surveyed countries. In fact, France and Germany first adopted such mechanisms in 1964 and 1986 respectively (Strosser & Speck, 2004; Möller-Gulland et al., 2015) and since then further expansion has followed. Abstraction charges are usually associated with the registration and licensing of water uses (see non-price approaches). However it is rare that abstraction charges are used as water demand management measures, instead they usually serve to recover the costs of administrating the registration and licensing scheme.

Incentives for uptake of water efficient devices can take the form of tax breaks on specific products, lower VAT or subsidies. Subsidy schemes have been common in the industrial and agricultural sectors, but seldom used in the domestic sector. Zaragoza provided subsidies for the uptake of water saving equipment by households as part of its water saving campaigns of the 2000s.

In Denmark, the water supply tax has been found to provide an important incentive for leakage control by making utilities liable for the tax if their metered water supply is less than 90 % of the abstracted volume in any given year. Withana (2014) reports that this has contributed to reducing leakage to around 10 %. Furthermore the general water abstraction tax, of around 1 euro per m^3, which all water utilities are liable for, also includes non-revenue water, further increasing incentives to address water leakage. Apart from the Danish example, none of the case studies have reported the use of incentives for increasing the efficiency of the water network and reducing leakage. Such instruments could nevertheless be envisaged by national regulators for water utilities.

Other incentives may target alternative water sources or the use of grey water, for example, subsidies for water re use equipment or lower tariffs for consuming reused water. In the past, the Cyprus government has provided subsidies for incentivising the use of inferior quality groundwater (via investments in abstraction wells at household level) and promoting the installation of grey water equipment for the flushing of toilets and watering house gardens.

The following sections provide a more detailed coverage of *water tariffs* in the surveyed countries, as this was found to be the most prominently used instrument and is seen here as the one that addresses domestic water demand in the most direct way. Nevertheless, the reader must keep in mind that the other types of pricing instruments briefly introduced in this section (Table 5) are also commonly used across the EU and could have g an influence on domestic water consumption levels.

2.4.2 Pricing frameworks (tariffs) and levels in the selected countries

The review of case studies has revealed significant variations in price structures and levels for water tariffs (Table 7). Water tariffs are influenced by a number of different factors, including capital, operational and maintenance costs for abstracting, treating and distributing drinking water and for collecting and treating wastewater, social and political factors, and increasingly so (as a requirement of the WFD) environmental and resource costs.

Several types of tariffs exist (EEA, 2012):

- Fixed water tariff, where the price is unrelated to the quantity of water consumed;
- Uniform volumetric tariff, where a fixed amount is paid for each cubic meter of water consumed;
- Two-part binomial tariff, combining a fixed part (unrelated to quantity consumed) and a volumetric part;
- Increasing or decreasing block tariffs, where the volumetric rate increases or decreases with the amount of consumption.

Fixed drinking water tariffs are commonly found in countries where water has historically been abundant. These tariffs can be based on the type of end-user (e.g. households, commercial entities), serviced areas (e.g. suburbs, municipalities, property prices) or the diameter of the pipe used by the customer to connect to the distribution network. In Scotland, fixed water tariffs are often associated with the municipal tax and thus to the serviced areas (and their average property price). There are several advantages related with fixed tariffs, mainly regarding their ease of administration and their provision of a stable cash flow. However, because water is not metered under this approach, no message can be conveyed to the user via the tariff to promote efficient use. Volumetric and mixed tariffs are in use in all surveyed countries and are described in detail in the following paragraphs.

None of the case studies surveyed were found to have a price structure based solely on fixed tariff approaches for drinking water. Table 7 provides an overview of pricing structures and levels in the selected countries. Based on these figures, Figure 12 illustrates differences in average pricing levels of water services. Pricing levels in the graph indicate the average unitary price that customer’s pay, which commonly includes[14]:

- Fixed tariff: in most countries, water tariffs include a volumetric component and a fixed component, i.e. a fixed amount charged on customers on a monthly or yearly basis. The

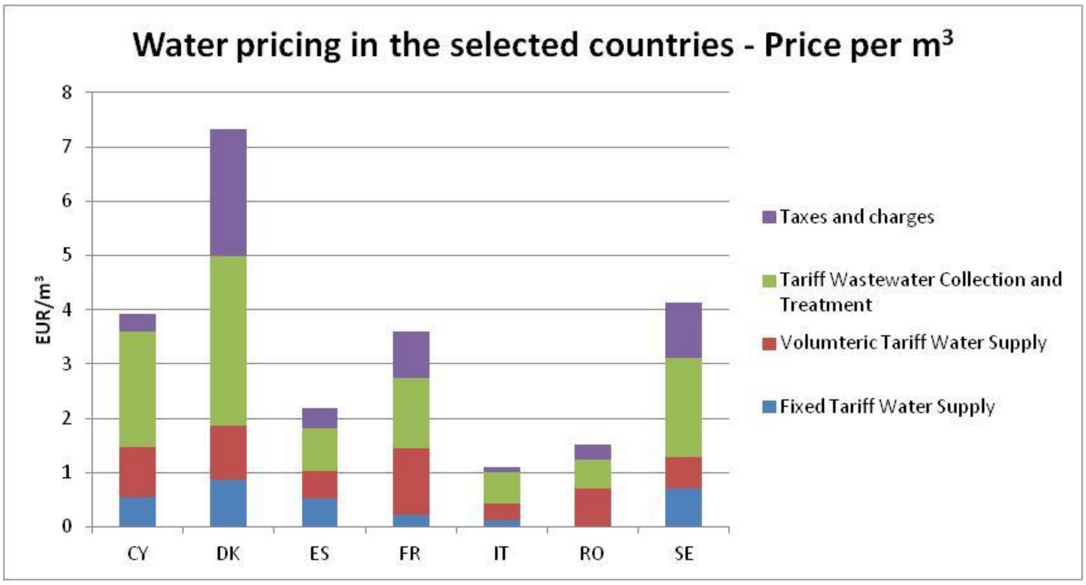
[14] As stated in this chapter, there are no widely accepted definitions of the economic instruments listed, therefore differences in the use and interpretation of the terminology is common (e.g. what are described here as charges are also often quoted as taxes).

tariff is attached to the supply of drinking water, wastewater or sewerage collection and treatment;

- VAT and other taxes;
- Abstraction charges for drinking water: these are usually paid by the water provider to the competent body and then included in the overall price charged on to the customer;
- Other charges associated to supply or sanitation, such as pollution charges for wastewater discharge: similarly to abstraction charges, these charges are paid by the wastewater operator to the competent body and then included in the overall price charged on to the customer.

The aim of the table and graph is to provide a synthetic picture of average water pricing in the 8 countries for a recent year, whereas further details on pricing structures and levels will be provided in the case studies presented in Annex I.

Figure 12 Average pricing levels in the selected countries for year 2013



Source: Adapted from IWA, 2014.

Grafton et al. (2011) found uniform volumetric tariffs to be the most effective mechanism to influence residential water consumption in their study of 10 OECD countries, including France, Italy and Sweden. The Water Development Department of the Cyprus Government applies uniform water tariffs onto water providers for the provision of bulk water from the central distribution network (Cyprus Government, 2010). It is also currently introducing a volumetric tariff of 0,13 €/m^3 on self-suppliers to cover for environmental and resource costs (Cyprus Government, 2010). Because people pay according to the quantity they actually use, uniform volumetric tariffs are easy to understand and can promote water conservation (Grafton et al., 2011). As opposed to the case of fixed charge tariffs, volumetric pricing requires water metering, which can raise both financial and political costs. In addition, under certain circumstances (e.g. when the variable component represents a high proportion of the water bill) volumetric pricing can result in lower levels of cost recovery, as customers may drastically reduce their consumption and with it the revenues perceived by the utility.

The most common tariff in the surveyed countries, perhaps for the reasons described above, is a two-part fixed and volumetric tariff, also called a binomial tariff. The fixed part usually corresponds to the costs of production and administration. In France, the water bill for 95 % of municipalities is composed by:

(i) a fixed annual or bi-annual part;
(ii) a volumetric part;
(iii) charges dedicated to environment protection;
(iv) VAT (Montginoul et al., 2014).

Sanitation is billed at the same time when a collective system exists (i.e. 75 % of municipalities). In Denmark, France and Italy, wastewater services do not necessarily include a fixed component (the fixed component shown in Table 7 is in many cases associated to the supply service). In Sweden, wastewater costs are systematically included in the fixed and volumetric parts.

Block tariffs are a special type of volumetric tariffs, where categories of consumption, or consumption brackets, are defined and allocated a certain price per unit of water. Block tariffs have a step wise structure whereby the price per unit remains constant for a certain quantity of consumption. Beyond a consumption threshold, the end user will pay higher volumetric price for each additional m^3 consumed and so on until the highest block. From the countries surveyed, Spain is the one using block tariffs most widely as the volumetric component of the water tariff: 5 % of the population supplied is billed using a two block system, 35 % is billed using a four block tariff system, and 55 % is billed using a three block tariff system. The remaining 5 % is billed using a flat rate (AEAS, 2014b). Cyprus also applies volumetric rising block tariffs for retailed water supplied by water providers to end-users.

In Italy, the volumetric component for water provision is set as progressive tariffs. In contrast, the volumetric component for wastewater collection and treatment is, most often, a fixed unitary rate which does not depend on consumption levels (Federconsumatori and CREEF, 2014). In France, a large variation exists in the structure of the volumetric rate. It is a fixed unitary rate in most cases (for 61 % of services in 2013 for 72 % of the population), but increasing block rates are becoming more common (for 29 % of districts in 2013 for 11 % of the population).

The structure and levels of block tariffs should ideally depend on the local consumption pattern (e.g. per capita consumption). In order to effectively moderate water consumption, price increases in increasing block tariffs should focus on blocks where the average consumption on small households is situated (Arbués et al., 2010). While increasing block tariffs can be effective in promoting water conservation while considering the issue of affordability for the poor, it has a complex structure and end users do not necessarily pay according to the cost their water use imposes.

Table 5 Comparison of average annual water cycle charges in 2013 related to a consumption of 100 m³ in EUR.

Countries	Price structure	Fixed Tariff Water Supply	Volumetric Tariff Water Supply	Tariff Sewerage	Tariff Wastewater*	Taxes and Charges**	Total Annual Payment
CY	Volumetric (government infrastructure) and fixed + volumetric (water providers)	55,37	90,93	49,88	163,53	33,07	392,80
DK	Fixed + volumetric	87,04	100,06	0,00	312,46	232,04	731,61
ES	Fixed + volumetric, with majority using block tariffs for water provision	51,66	51,26	21,61	56,19	37,10	217,82
FR	Fixed + volumetric	23,09	121,98	35,46	93,78	85,82	360,13
IT	Fixed + volumetric, often with block tariffs for water provision	11,80	30,37	15,47	42,27	10,27	110,18
RO	Fixed + volumetric	0,00	70,35	0,00	52,49	29,48	152,32
SE	Fixed + volumetric	69,77	59,60	104,65	78,36	100,89	413,27

Source: Adapted from IWA, 2014. * The tariff for wastewater treatment may include in some cases the cost of wastewater collection (e.g. DK and RO). ** Other taxes and charges include a range of economic instruments (such as environmental charges, pollution taxes, VAT, etc.) which will vary between countries.

Declining block tariffs are usually used when water supply is abundant and when the connection of large industrial end users can enable economies of scale. However, declining block rates do not encourage water conservation as they favour big consumers. Declining rates and more complex rates exist in France in 4 % of the districts (respectively 8 % and 9 % of the population).

A number of other tariffs exist that aim to be more dynamic in nature:

- Seasonal tariffs temporary increase tariffs during scarcity periods, for example, when seasonal population increases while water availability reduces in Mediterranean regions. Seasonal tariffs have the potential to persuade consumers towards more rational water use and thus promote resource conservation, while enabling water suppliers to cover peak-season costs (Pesic et al., 2012; Rinaudo et al., 2012).
- Peak-hour tariffs, linked with smart metering which can record time of use and associate specific tariffs. These can help control peak daily demand when resources are limited (Harou, et al., 2014).

The levels of water tariffs remain very different *between the surveyed countries* (Table 7). Danish water tariffs are, for example, considered one of the highest amongst OECD countries, with a total average price of EUR 693,6 per household per year (consuming 84m^3) (Forsyningssekretariatet, 2014)[15]. Overall, the price difference may be related to a range of factors including the level of investment and the consideration of environmental costs (Withana et al., 2014).

There are also large variations in the amount charged *across households within the same country*. For example, in Sweden, the water bill can vary from around SEK 2900 (approx. EUR 310) per household and year to around SEK 11 000 (approx. EUR 1176) per household and year (Svensk vatten, 2015). These differences are mainly determined by geographical location and population density. All of the 25 municipalities with the highest tariffs are either very small in population (less than 16 000 people) or have a coastal location. In Romania, prices charged for water supply varied between 3 lei/m^3 (approx. 0,65 €/m^3) in Gorj county and 5,69 lei/m^3 (~ 1,30 €/m^3) in Bucharest (Euragio, 2014). Figure 13 presents the differences between Spanish provinces.

Figure 13 Average prices for water supply and sanitation services in all Spanish provinces in 2012. Figures without brackets refer to the water supply services and figures in brackets refer to the sanitation and wastewater treatment services. The color code shows the sum of both prices.

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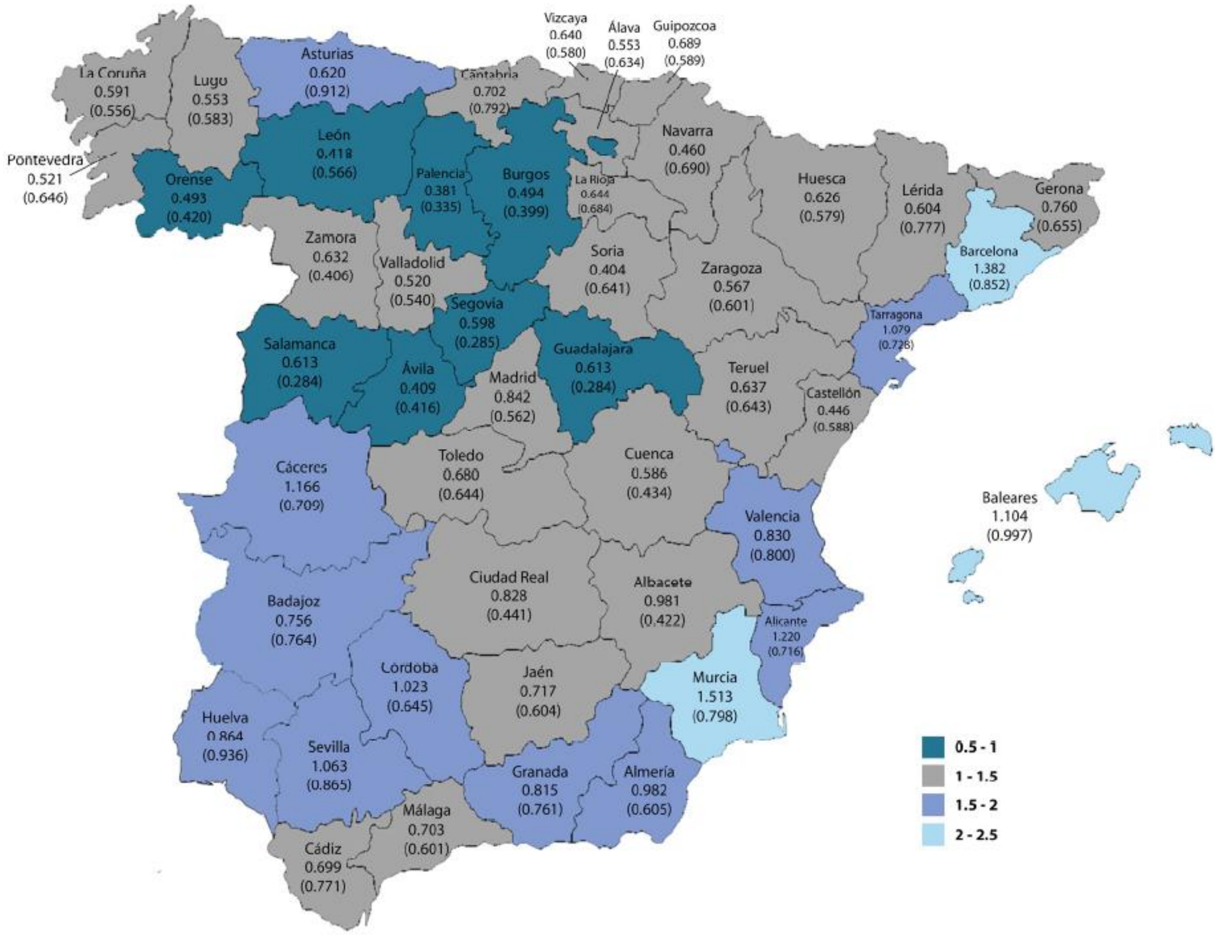
[15] Yearly expenditures for water presented in Table 7 refer to a yearly reference consumption of 100 m3/year. The yearly expenditure provided by Forsyningssekretariatet, 2014 i.e. 693.4 EUR/year refers to the actual average yearly consumption in DK, 84 m3/year. The data of Table 7 and the figure of 693.4 EUR/year come from different sources. Thus, if we apply the figures provided in Table 7 to the average consumption of 84 m3/year, we obtain a slightly different figure (614 EUR/year). This can be explained by the fact that two different sources are used.

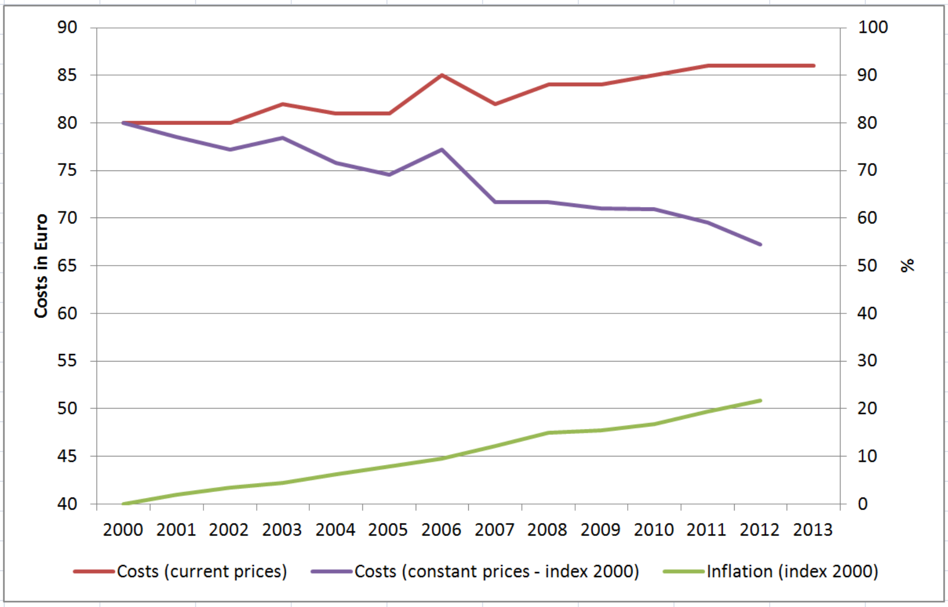


Source: García-Rubio et al. (2015).

According to a study by the OECD, average real prices for household water supply and sewage disposal in selected OECD countries generally increased in the 1990s. For example, the price increase rate in France was approximately 7 % per year between 1991-1996; in the Netherlands the rate was approximately 4 % per year between 1990-1998, similar to Germany's 3.8 % increase between 1992-1997.[16] Sweden was on the lower end of the range with an increase of roughly 2 % between 1991-1998 (OECD, 2001). Prices have also been increasing more recently in Southern Europe, for example in Cyprus (see Box 6) and in Spain, where between 2000 and 2009 drinking water prices have increased ranging from approximately 30 % to approximately 57 % (based on domestic water price figures from the AEAS and figures for the whole urban water cycle from the National Statistics Institute (INE) respectively). A more recent report by the German Association of Energy and Water Industries shows the average yearly drinking water costs in real prices in Germany have decreased steadily in the last 13 years (Figure 14).

Figure 14 Average yearly drinking water costs in Germany, per inhabitant, per year.

[16] Data for Germany relates only to public water supply.



Source: Adapted from BDEW, 2013.

Box 6 - Price evolution in Cyprus

The price of drinking water supplied in Limassol, Nicosia and Larnaca-Famagusta (0.57 €/m³ in 1994) was increased to 0.77 €/m³ in 2004. At the same time, the price of drinking water supplied by the Government Water Projects in Pados increased from 0.27 €/m³ to 0.56 €/m³. A special case is the Paphos scheme, which applies a different tariff as most of the water comes from groundwater which is comparatively cheaper. Industrial and animal husbandry users were set at 0.17 €/m³ while watering of sport fields, road islands, hotel gardens and other green areas is charged at 0.34 €/m³. No additional water was to be allocated for new golf courses which should use recycled water.

Recycled water has become an important source of water in Cyprus in the 2000s and will continue to increase as more wastewater is being treated. Recycled water requires a third treatment, which is mostly carried out and distributed by the Water Development Department. The prices of tertiary treated water are considerably lower than the fresh water ones in order to encourage the use of the recycled water and to substitute the use of fresh water. In 2010, recycled water was charged between 0.05 €/m³ for agricultural organizations and 0,07 €/m³ for private individuals and up to 0,21 €/m³ for golf courses.

Prices for drinking water provision have been reformed in 2014 to apply greater levels of cost recovery following the implementation of the WFD. The planned average price for the supply of bulk water by Government Water Projects was to reach 1,32 €/m³. Tariffs by water providers to water users will follow the same price structure across providers (binomial) based on a national methodology, but price levels will vary. It is expected that the average price would vary between 1,36 €/m³ and 1,68 €/m³ between water boards and municipalities.

2.4.3 Pricing reforms: implementation challenges and opportunities

As mentioned earlier, several European countries have experienced water price increases in the last 25 years due to the combination of a range of factors, such as increased investment levels, compliance costs with environmental directives or the application of the cost recovery principle. Implementing price changes is, however, known to be challenging. In Cyprus for example, a first price increase was assessed in 1993 but only agreed in 2002 after 9 years of postponements at the House of Representatives. The second price increase, justified with the need to comply to the WFD cost recovery principle (Article 9), occurred in 2014 following propositions from the Government in 2010. Barriers have included the perception from politicians that water price increases will not be effective in reducing water demand, while at the same time price increases were unpopular.

It is certain that water pricing and their reform can be challenging to implement. For example, Italy has experienced several attempts since 1994 to re-organise the water sector to improve service delivery performance, and increase cost recovery levels and investments. More recent reforms for further privatisation and cost recovery of capital costs have failed for a variety of reasons, including a weak regulatory framework, fear of price increases and failing service standards. Another telling example is Ireland, where the decision in 2009 to reintroduce water charges (abolished in 1996) and reorganise the water sector (i.e. by establishing a single national water utility from services then held by local authorities) was accompanied with questions on affordability, the public and private ownership of water and the adequate form of regulatory control. The reform was adopted, albeit important controls such as a cap on maximum yearly charges (i.e. at 260 € per year for households of 2 adults or more for supply and wastewater services) and a child allowance of 21m^3 per child per year.

Metering is a precondition for effective water pricing mechanisms (Cominola et al., 2015). Moving towards volumetric pricing must thus take into account the materials and labour costs of installing and using meters (Zetland, 2016). In England for example, the average cost of installing meters in England is GBP 220, with recurring costs of GBP 30 per meter per year, mainly for monitoring purposes (Walker, 2009). Although economies of scale are possible with high penetration rate, metering may not be efficient everywhere and may depend on household attributes, in particular, whether water price is elastic or not (Barraqué, 2011; Zetland, 2016). Furthermore, the additional costs of metering on individual household and the aggregated cost for water utilities can increase social injustice and impact disproportionally poorer households; these distributional impacts call for government intervention through appropriate programmes of transfers and taxes to protect most vulnerable households (Zetland, 2016).

In reality, any successful water pricing reforms will need to take a global approach and consider the various dimensions of the financial management of water utilities, regulation and overall governance of the water sector. While legitimate justifications for water pricing reforms are essential, adequate asset management and long term financial forecasting are needed to ensure that tariffs are set at affordable levels while meeting the various objectives on cost recovery, or indeed applying the user and polluter-pays principles and acting as an effective measure for water demand management.

Pricing reform must account for the multi-level nature of urban water governance systems. Examples of approaches to governance of price setting mechanisms from the case studies surveyed, complemented with information from the EEA (2012) are provided in Table 8. Generally speaking, lower levels of governance (e.g. municipalities, private water companies, water boards, etc.) have full discretion for setting tariffs. In Germany, price setting is mainly a matter of local decision making but with state (Länder) oversight. In the case of a public supplier, the tariff is set by the local government in cooperation with the utility and oversight by the local parliament and local authorities. Administrative courts (at Länder level) are usually involved when consumers have their bill checked if they believe them to be incorrect. In the case of a provider under private law, the price is set by the utility in accordance with state legislation and oversight by the local civil court and the respective state or federal antitrust authorities.

Table 6 Approaches to governance of price setting mechanisms: examples

Countries	Governance of price setting for urban water services
Cyprus	Set by water providers following unified national methodology and oversight by the Cyprus Government.
Denmark	For utilities handling less than 200.000 m^3/year: Price is set by the utility with a final approval given by the municipality.

	For utilities handling 200.000 m^3/year or more: Price is set by the utility with pre-determined ceilings set by the Water Division of the Danish Consumer and Competition Agency.
England & Wales	Set by private water utilities with regulatory oversight by the Water Services Regulation Authority which also sets a price cap.
France	Set by municipalities and water utilities within a strict national legal framework.
Germany	In the case of the supplier being a public entity: The fee is set by the local government in cooperation with the utility and oversight by the local parliament and controlled by local authorities (Kommunalaufsicht) as well as by the administrative courts. In the case of the supplier being a private entity: The price is set by the utility in accordance with state legislation and oversight by the local civil court and the respective state or federal antitrust authorities (Kartellaufsicht)[17].
Italy	Set by municipalities and water utilities following a unified national methodology.
Romania	Set by water utility with oversight by municipalities and National Authority for Regulating the Public Services of Communal Household.
Scotland	Set by Scottish Water following principles and within limits set by the Water Industry Commission for Scotland.
Spain	In most cases tariffs are approved by municipalities and subsequently authorized by the Committee on Prices (an entity dependent on the Autonomous Communities who authorizes price revisions). Less frequently prices are set by public entities like regional governments, clusters of municipalities, inter alia.
The Netherlands	Set by public regional water companies with national performance benchmarking.
Sweden	Set by municipalities with pre-determined ceilings set by the national government.

Sources: national sources and comments from the Advisory Group of the study.

Most European countries follow a framework in which policy made at the national level sets the rules for water service provision in place, which are then followed by local or municipal governments which themselves are at the core of providing water services or regulate private utilities. For example in France, water tariffs are strictly regulated at national level. A first law was voted in November 1992 which aimed to dissociate the use of water tariffs for the municipal water budget. Most significantly, it required that urban water services balance their budget. Further specification is included in the "Loi sur l'Eau" of 2006 transposing the WFD. In particular, Article 57 forbids, in most circumstances, flat rates and declining water rate structures. Article 57 also limits the fixed part: it cannot represent more than 30 % (for urban districts) or 40 % (for rural services) of the water bill (calculated for 120 m^3 annual consumption), except for utilities facing a high seasonal population.

In some European countries, European funds may add additional influencing rules. In Romania for example, prices are in theory proposed by water utilities based on a methodology issued by the National Authority for Regulating the Public Services of Communal Household (ANRSC). Local public authorities have the right to verify, approve or reject proposed prices and tariffs, if they do not compromise the profitability, the quality and the efficiency of the service. However, in practice, tariffs are highly influenced by Cohesion Fund rules because tariff assumptions may be part of the calculations on the financing gap[18], which means that Cohesion Fund criteria can have a significant influence on water governance.

[17] Bianca Drogosch, CEEP, personal communication.

[18] Stephen Hart, EIB, personal communication.

2.5 Pricing measures: incentive structures for a more efficient water use

2.5.1 Water pricing and incentiveness for a more efficient water use

Incentiveness for a more efficient water use is one of the declared objectives of water policies in most of the countries selected for the assessment and this is reflected in water pricing structures. Table 9 summarises, for each country, the tariff mechanisms introduced to provide an incentive for a more efficient water use. However, in most countries, no evidence is available about the real incentiveness of existing tariffs for a more efficient water use and *the relation between pricing mechanisms and their effects on water demand is often unclear.*

Table 9 Water pricing and incentiveness for a more efficient water use: a summary of evidence from the 8 countries (from various national sources)

Country	Mechanisms to ensure incentiveness	Evidence of incentiveness of price structures/levels for a more efficient water use
CY	One of the main objectives of the pricing reform of 2014 is to provide an incentive for a more efficient water use through the following mechanisms: metering, volumetric pricing, overconsumption charge and rising block tariffs.	However, different authors noted that so far water pricing has been an ineffective policy instrument in reducing water demand, in fact, water demand has increased over the last years. At present, it is too early to understand whether the pricing reform is being effective in reducing demand.
DE	Mixed tariffs: fixed component + volumetric component	In Eastern Germany, water consumption has declined. This is the result of several factors: better environmental awareness, water saving devices in households, renewal of drinking water networks and also increased prices. In addition, a study revealed that German domestic users have only limited knowledge of actual price levels.
DK	All households are metered.	Water demand has been reduced substantially over the last 25 years. In all likelihood, this is a combined effect of obligatory metering, green tax reform and information campaigns.
ES	Progressive tariffs and price increases	The Spanish Association of Water Supply and Sanitation points out that the constant reduction in water consumption registered in Spain in the last decade is a result of a mix of measures, including increased efficiency in service provision, awareness raising campaigns, better household appliances and progressive tariff schemes.
FR	Mixed tariffs: fixed component + volumetric component	Domestic water consumption decreased by around 15 % since the 1990's. However, at present there is no clear evidence that the observed decrease of domestic water consumption in the country is actually linked to increased prices.
IT	Mixed tariffs: fixed component + Rising block tariffs Water prices have constantly increased in recent years.	Although domestic water consumption decreased by almost 18 % in recent years, there is no clear evidence that this decrease is due to increased prices. In fact, reduced consumption might also be linked to the increased efficiency of domestic devices and to a larger public awareness of the economic value of water.
RO	Volumetric pricing is applied, but no other mechanism is in place targeting household consumption. In addition, bonuses are applied to water utilities which demonstrate	The actual impact of existing pricing structure and measures for water companies cannot be ascertained due to lack of data.

	their concern with rational use of water, whereas penalties are imposed for those water companies which do not respect contractual agreements.	
SE	Metering and volumetric prices. In Sweden, though, water pricing is not used as a water demand management, but rather as a cost recovery instrument.	Metering proved to have an effect on water consumption and such effect seems most prominent for large consumers. However, it is difficult to conclude whether the current pricing in Sweden has any incentive effect: not all households are metered and current pricing levels reflect the cost of providing the service., Basically consumers have no direct influence over prices.

Sources:
CY - Metaxas and Charalambous, 2005; Kondouri et al., 2011; Polycarpou and Zachariadis, 2013
DE – UBA, 2014; I.S.E.K., 2013
DK – LOV nr 469 af 12/06/2009; Deloitte, 2013
France – Montginoul, 2013; Montginoul, 2015
Italy - CONVIRI, 2011; Federconsumatori and CREEF, 2014; Sardegna Ambiente, website
Romania – Romanian Waters, website
Sweden - Hjerpe and Krantz, 2006.

A review made by the OECD in 1999 based on a number of studies in the 1980s and 1990s concludes that the introduction of metering and charges usually results in a decrease in water use (OECD, 1999). It was also observed that metered households consume less water than households that were not metered (Bello-Dambatta, et al., 2013). A study in England showed that after a meter was fitted, households on average reduced their water consumption by about 10 % (DEFRA, 2008). In Denmark, the installation of water metering from whole buildings to individual flats, associated with a real water price increase between 1993 and 2004, was associated to a decrease in urban daily water demand per capita of 155 litres to 125 litres (OECD, 2008). A 10 country household survey has found that households subject to volumetric pricing based on metering use 25 % less water (Grafton et al., 2011). New applications for smartphones are now being developed to increase the effectiveness of pricing and "smart" metering, which involves the instant monitoring of water use and reporting on individualised water balance sheets for households, by comparing private water use to better performing householders and highlighting potential bill reduction.

Metering certainly can make it easier for water utilities to manage demand and track water flows, and this is the basic information needed to plan and implement action to reduce consumption, reduce leakage and environmental abstraction (Zetland, 2016). At household level, metering can certainly increase awareness of water use and leaks. However, it is difficult to disentangle the impact of metering as opposed to pricing on household water demand reduction. A recent study by the University of Southamption (Ornaghi and Tonin, 2015) further investigated the effect of water installation and metered water pricing on household behaviour amongst Southern Water customers in England, UK. The study distinguishes three impacts: the *"information effect"*, which arises because, in conjunction with meter installation, the water company conducted an information campaign on the benefits of water conservation; the "*anticipation effect*", which is associated with the adjustment in consumption behaviour between the installation of the meter and the switch of contract towards volumetric pricing; and the *"switch effect"*, which reflects changes in water consumption due to actual change in pricing scheme. Over the three years of observations (2011-2014), the study found evidence that the metering and volumetric programme had an overall reduction in consumption of 16,5 %. The authors also found that households started changing their behaviour before the switch to a meter, and one and a half years after the change in price structure, newly metered households behave as older metered customers.

Regarding the effectiveness of water pricing for reducing water demand, the additional following points are important:

- The proportion of the bill between the charge for water supply and the other components (e.g. wastewater collection and treatment, fees and taxes). In France for example, the weights of charges for water and for sanitation are approximately equal (39 % for each of the total), while various fees and taxes for water agencies, State and the public waterways management represent 22 %. It may be difficult for the end user to estimate their potential savings with complicated water bills.
- The proportion between the fixed and volumetric may be critical. A large fixed part in the water bill is unlikely to encourage water saving, while a large volumetric part may be more effective. In Germany, on average, the fixed part represents 10 % of the bill.

2.5.2 Potential impact of reduced water demand[19] on the performance and management of water supply and wastewater networks and infrastructure

As previously observed, water consumption has decreased in most surveyed countries in the last 10-20 years. However, scarce and mixed evidence is available on the effects of such decrease on cost recovery levels and the sustainability of water supply and sewage infrastructure.

In Germany for example, such evidence could not be found, although reduced water consumption led to another type of issue. Especially in Eastern Germany the water consumption was reduced from 142 liter per inhabitant per day in 1990 to 93 liter per inhabitant per day in 2000. This was due to two factors: firstly, the structural change in the early 1990s, part of the population migrated from Eastern to Western Germany; secondly, the whole distribution system became more efficient. Increased efficiency of the water system also occurred in Western Germany, leading to reduced water consumption. In both *cases the water infrastructure, partly built in the 70s, is now over dimensioned* for the current exploitation levels and this increases maintenance costs; water pipelines now have low water levels, so they need to be flushed regularly to avoid corrosion, sediments or hygienic problems (BDEW 2015, Branchenbild 2015, UBA 2014).

In other cases, for example the Sardinia region in Italy, decreased water consumption is a key water management objective, so that the existing water management plan (PTA, Piano di Tutela della Acque) includes *a financial plan to ensure the self-sustainability of the water supply system* in face of an expected decrease of water consumption. The financial plan for WSS was developed to meet the following objectives:

(i) absorb existing deficit;
(ii) limit, as much as possible, tariff increases, within the limits set out by the national methodology (Metodo Tariffario Idrico);
(iii) in the first six years (programming period linked to EU Structural Funds) tariff revenues must be able to cover 30 % of investments in infrastructures (as demanded by SF);
(iv) develop a financially sustainable plan;

[19] Resulting from higher prices or other measures.

(v) use in the most efficient way available public resources (Structural Funds and national funds).

The resulting financial plan takes into account both social aspects (affordability) and financial sustainability aspects from the point of view of the operator. It includes: (i) a tariff increase within national limits, as set by the MTI (+24 % in the first 6 years and +53 % maximum in the 22nd year); (ii) investments of EUR 774.69 million in the first 6 years, of which EUR 542.28 million from public funds and EUR 232.41 million provided by the water operator (30 % of private funds in infrastructural investments). This corresponds to an investment of EUR/inhabitant 1080, or EUR/inhabitant/year 39.51 (Sardegna Ambiente, 2016).

An accurate financial planning is not the only way to ensure the sustainability of water and sanitation services and a *mixed tariff including a fixed charge can play a major role*. An analysis conducted in France revealed that a pricing structure with a fixed part is the most common one for water services; in fact, low levels (or absence) of the fixed part would lead to a higher sensitivity of services income to water demand, thus posing a risk on cost recovery levels in case of decreased water demand. Moreover, a low fixed charge disadvantages the large consumers and may result in a higher water bill for them (considering that the level of the volumetric price is set in order to maintain a stable bill for a reference 120m3 consumer); these customers may then adopt saving devices and behavior to reduce their water bill, but they may also mobilize alternative resources (individual wells, raw water), further reducing their water consumption from the public network, and their contribution to the costs of the service, but without necessarily reducing their total water consumption.

2.6 Price elasticity of water demand

Source: © Strategic Pricing Solutions

2.6.1 Price elasticity of demand

In the previous sections we have studied both water demand management through non-price techniques and pricing instruments. We know that price, in principle, can be used by water managers as an effective and efficient instrument to manage water demand (Stavins, 2011). However, an important factor in being able to manage water effectively is knowledge of its price elasticity of demand. Strictly speaking price elasticity of water demand is the measure of the relationship between a change in the quantity demanded and a change in its price. It provides a measure of how demand for a specific good, here water, reacts to price changes. Price elasticity of demand is an economic term, often used when discussing price sensitivity. The formula for calculating price elasticity of demand is in mathematical terms:

Price elasticity of demand (E) = % change in quantity (Q) demanded / % change in price (P)

The elasticity records how Q changes in percentage terms in response to a percentage change in P. Because P and Q move in opposite directions (except in the rare case of Giffen's paradox[20]), the price elasticity of demand will be *negative*[21]. For example, a value of E of -1 (E = -1) means that a one percent rise in price leads to a one percent decline in quantity, whereas a value of E of -2 (E < -1) means that a one percent rise in price causes quantity to decline by two percent. A distinction is often made among values of elasticity that are less than, equal to, or greater than minus one. Table 10 lists the terms used for each value.

Source: © Investopedia

If the price elasticity of demand is equal to 0, demand is perfectly inelastic (i.e. demand does not change when price changes). Values greater than minus one[22] indicate that demand is inelastic. A product is inelastic if a large change in price is accompanied by a small amount of change in quantity demanded (or alternatively this occurs when the percent change in demand is less than the percent change in price or when price increases proportional more than quantity decreases). When price elasticity of demand equals minus one, demand is unit elastic (the percent change in demand is equal to the percent change in price). Finally, if the value is less than minus one, demand is elastic. If a small change in price is accompanied by a large change in quantity demanded, the product is said to be elastic (or responsive to price changes i.e. demand is affected to a greater degree by changes in price or a price increase causes a more than proportional quantity decrease).

Goods with close substitutes (small cars, calculators, and so on) are subject to large substitution effects from a price change. For these kinds of goods, we can presume that demand will be elastic i.e. E < -1. Goods with few close substitutes (water, salt, etc.) have small substitution effects when their prices change. Demand for such goods will be inelastic with respect to price changes i.e. E > -1.

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[20] According to the Law of Demand, when the price of a commodity falls the demand for it rises. Giffen's Paradox is an exception to this law. In case of Giffen goods quantity demanded will vary directly with price. Again an increase in income will generally cause the consumption of most goods to increase. But there are a few goods for which the pattern is reversed. It means an increase in income causes a decrease in consumption. Here for a good to be Giffen, the income effect must dominate the substitution effect.

[21] It should be noted that sometimes the price elasticity of demand is defined as the absolute value of the definition mentioned in the fomula above. Using such a definition, elasticity is never negative; curves are classified as elastic, unit elastic, or inelasctic depending on whether E is greater than, equal to, or less than 1. One need to recognise this distincion as there is no consistent use in economic literature.

[22] It is important to remember that numbers like -3 are less than -1 whereas -0.5 is greater than -1. Because we are accustomed to thinking only of positive numbers, comparisons among price elasticities can sometimes be confusing.

Table 10 Elasticity coefficients: what do values mean? A summary

Elasticity coefficient	What does it mean?
E = 0	Demand is perfectly inelastic → demand does not change when price changes
E > -1	Demand is inelastic → the percentage change in demand is less than the percent change in price
E = -1	Demand is unit elastic → the percent change in demand is equal to the percent change in price
E < -1	Demand is elastic → the percentage change in demand is larger than the percent change in price

Source: EEA

Box 7 - Price elasticity of domestic water demand

Price elasticity of domestic water demand is generally between 0 and -1, mainly ranging from -0.2 and -0.4. This means that water demand has a weak reaction to price changes: for a unit price increase, water demand shrinks by a much lower extent.

According to the literature, *domestic water use is generally inelastic to price*, particularly for indoor water use. It has been shown that the elasticity depends on household income (higher price elasticity has been observed in low-income households), family size, age and other demographic characteristics. The outdoor consumption is usually more (less) price-elastic in wet (dry) seasons (Mansur and Olmstead 2007). The results of studies vary considerably, to a large extent as a result of differences in methodologies applied, data quality and aggregation (Dalhuisen, Florax et al. 2001; Productivity Commission 2008). Dalhuisen et al. (2003) analysed 64 studies with 314 (mainly short-run) price elasticity estimates; *most of these estimates fall within the range between 0 and – 1,* thus providing evidence which supports the hypothesis of price inelasticity. Another review (Montginoul, 2013) also found out that price-elasticity typically varies between -0.1 and -1.0, and it is *mainly ranging from -0.2 and -0.4* (a short summary is provided in Box 7).

In 2015, the JRC conducted a cross-country econometric analysis of domestic water demand in the 28 MS (Reynaud, 2015), largely based on existing public data sources at the national and sometimes regional level consolidated into a coherent way. The results are in line with the literature: price elasticity assessed in this study typically varies between -1.0 and -0.10. As this is the most recent (as well as the most comprehensive) study on price elasticity, the results obtained in the case studies were compared to the values obtained here.

While a number of studies focus on price elasticity, less is known about *income elasticity* (see Box 8), or namely, how the demand reacts to the increases in household income. Calculating the income elasticity of demand is essentially the same as calculating the price elasticity of demand, except we are now determining how much the quantity purchase changes in response to a change in income. As Dalhuisen et al. (2001) observes, a successful mix of water demand management options decreases households' expenses which, as an unintended outcome, in case of elastic demand may translate into higher water consumption i.e. an increase in income will lead to a rise in demand.

Box 8 – Income elasticity of demand

Income elasticity measures the responsiveness of demand due to an increase or decrease in consumer income. The formula for calculating income elasticity of demand is:

Income elasticity of demand (E) = % change in quantity (Q) demanded / % change in income (Y)

By looking at the income elasticity, we can measure the responsiveness of the quantity demanded for a good due to a change in income. We can then classify the good as normal, inferior, luxury, or necessity. More specifically:

- *Inferior good (E<0).* These are goods whose consumption decreases with an increase in income.
- *Normal good (E>0).* These are goods whose consumption increases with an increase in income.
- *Necessity good (E<1).* These are goods whose consumption increases an amount smaller than an increase in income.
- *Luxury good (E>1).* These are goods whose consumption increases an amount larger than an increase in income.

Income elasticity of demand can be a positive or negative number, and it makes a real difference which it is. If the income elasticity of demand is negative, then the commodity is an *inferior good*. An inferior good is one whose demand decreases as incomes increase or demand increases as incomes decrease (as an example, rice and potatoes are often discussed as inferior goods but it clearly depends on case specific conditions whether a good is inferior or not). In other words, an inverse relationship exists between demand and income, and the income elasticity of demand is negative. This relationship is unusual.

The opposite situation is a *normal good* - normal because you get the expected or normal relationship. For a normal good, as income increases, the good's demand increases. That's what you expect, and most goods are normal. As your income increases, your demand for restaurant meals, cars, etc. increases. And the opposite will happen if your income decreases. Therefore, normal goods have a direct relationship between income and demand, and the income elasticity of demand is positive.

An example of a *necessity good* is drinking water. Here it is unlikely that consumption of water will increase an amount more than the income increases. For instance, if ones income were to increase by 25 percent, it is unlikely that one would consume 25 percent more drinking water.

A *luxury good* is e.g. a round of golf. With low income, ones consumption of rounds of golf will likely be zero. However, once income rises enough to afford to play, ones increase in rounds of golf might be higher than the increase in income. In other words, when one make enough money to play the first round of golf, ones increase in round of golf consumption will be 100 percent while the increase in income may have only been 15 percent.

Finally, the larger the number (either positive or negative) for the income elasticity of demand, the more responsive demand is to a change in income. A large number for the income elasticity of demand means a large change in demand occurs when income changes.

2.6.2 Selected approach for case studies

Selected case studies and available data

The price elasticity of water demand was assessed for the domestic sector[23] and in particular:

- *10 case studies* were developed for the *domestic sector*[24];

[23] The price elasticity was also assessed for the agricultural sector. A review of 11 case studies were conducted looking into the price elasticity of irrigation water demand. The results of this complementary analysis can be found in Annex II.

[24] Initially, it was planned to conduct 15 case studies, 12 for the domestic sector and 3 for the agricultural sector. However, it was not possible to conduct 12 cases for the domestic sector: in one case, three water utilities in Italy agreed to provide data, but data were not provided in the end; in one case (France) data were provided by the water company, but they were not sufficiently accurate to allow for the development of a case study. For the agricultural sector, it was deemed more relevant to conduct a review of existing case studies (see dedicated section for more details).

- Only case studies with good reliability and consistency of data for an elasticity assessment (i.e. with a sufficient number of observations, either in terms of number of years, number of municipalities or both) were selected. In addition, only those case studies for which sufficient information was available were selected, i.e. those case studies including sufficient differences in water tariff structure and consumption between years and/or municipalities so that the assessment of elasticity is significant (a linear tariff structure and marginal changes in water prices during a series of years would have led to a challenging assessment).

The selected model

In the literature, residential water consumption is mostly modeled with Ordinary Least Square (OLS) regression method[25] (Worthington and Hoffmann, 2006). However, when using an average price with a block rate pricing system, volume of water consumed and price are directly correlated generating a simultaneity bias. To avoid this, many researchers apply the more complex Instrumental Variables (IV) estimation method. Differences in the robustness of the different methods are however marginal (Arbués et al., 2003), as OLS is as relevant as others methods when it comes to build reliable models.

Different functional forms of regression equation can be found in the literature. While the linear form is easier to estimate, it implies that the change in quantity demanded in response to a price change is the same at every price level. The double-log form yields a direct estimation of elasticities and is the more commonly used model. However, it leads to a water demand with a constant elasticity in relation to price (Grafton et al., 2011).

Alongside price, *households' income* is a variable widely studied for its role in determining water consumption (Arbués et al., 2003). No consensus emerged on the elasticity of income and water consumption, although it is commonly recognized that income works as a positive factor.

Others variables commonly integrated in models include: *describers of household composition*, mainly household size (Worthington and Hoffmann, 2006) and *weather or seasonal factors* (commonly implemented in model to take into account variability over time or across regions).

In recent years, authors have also integrated additional variables in their residential water consumption models. In some cases, variables include a finer description of housings (e.g. housing types and impacts of different water saving devices). Other authors tried to better capture the weight of outdoor water uses (e.g. watering gardens or owning a swimming pool) in total water consumption, along with the impact of private well ownership.

In line with the literature, Reynaud (2015) focused on the impact of water price, household income, climate condition and some household characteristics including average household size or age structure.

In this study, data on *water price trends and water consumption levels* across the selected time period were collected. Water price is the most studied determinant of residential water consumption. But economists have not reached a consensus on the adequate variable that best captures price (Worthington and Hoffmann, 2006). Indeed water price may be expressed in many (non-excluding) ways: by its different components (fixed part and/or variable part), by the mean price for a reference

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[25] In statistics, *ordinary least squares (OLS)* or *linear least squares* is a method for estimating the unknown parameters in a linear regression model, with the goal of minimizing the differences between the observed responses in some arbitrary dataset and the responses predicted by the linear approximation of the data (visually this is seen as the sum of the vertical distances between each data point in the set and the corresponding point on the regression line - the smaller the differences, the better the model fits the data). The resulting estimator can be expressed by a simple formula, especially in the case of a simple regression (only one variable is tested).

consumption or for the mean consumption, or by the marginal price (relevant to block tariff structure). The following considerations were taken into account to choose the price variable used in this study to assess price elasticity of water demand:

(1) detailed information on the price structure (fixed part and per-unit volume charge generally) could not be collected for all case studies so the marginal price option was not considered;
(2) in situation with fixed part plus per-unit volume charge or block rate tariff, using the average price for a consumer or in a given area generates a simultaneity bias that would lead to test complex statistic models;
(3) as consumers seem to be not much aware of tariff structure details, using an average price can be more relevant to predict elasticity (versus the marginal price) and was more common in papers (House-Peters and Chang, 2011). Hence, the average price for a reference consumption was used in the present study.

The reference consumptions was chosen equal to 120 cubic meter per year. This is the reference water consumption per household defined in the French law[26], and is close to the mean consumption of a French household per year. Even though mean consumption per household may vary widely between and within European countries, the choice of this value does not have a determinant impact on elasticity assessment (what is important is to have a common way to express price in all case studies)[27].

In addition to these, the following information was also gathered:

- Climate data (number of rainy days and number of days with a temperature above 28°C in a year, for example) used as contextual data or as explanatory variable;
- Contextual data: average household income, average household size, share of individual houses/permanent houses, population density, other water demand management instruments in place (taken from MS review and complemented with more local information if relevant) – specifying if relevant the year of application, etc.

Data on housing size and/or the proportion of individual houses in the study area could often be easily gathered. However, this was not the case for the other variables mentioned above, that in consequence could not be included in the models tested.

With these data, two different models were tested in each case study, as described in Box 9. Using both models for each case study provided a better understanding of the determinants of water consumption for each case study.

Box 9 - Models for assessing elasticity of water demand in the case studies
Model 1: Simple regression
This model consists in a simple price elasticity assessment, i.e. building on a water demand function (expressed in cubic meters per capita or household and per year) depending on water price, as illustrated below.
$\mathbf{\ln(C) = \alpha_0 + \alpha_1 \ln(P) + \varepsilon}$ *with P the average price for a 120 m³ demand*

[26] Arrêté du 6 août 2007 relatif à la définition des modalités de calcul du plafond de la part de la facture d'eau non proportionnelle au volume d'eau consommé.

[27] However, in one case study different consumption levels were used, as available data were referring to that yearly consumption level. Nevertheless, this does not have an impact on the comparability of results.

	with C the average annual consumption of water per capita or household.
Model 2: Multiple regression[28]	
Price elasticity of water demand is still assessed by correlating water price and water consumption, with the difference that complementary information are now included in the regression function as explanatory variables, as illustrated below. $\mathbf{ln(C) = \alpha_0 + \alpha_1 ln(P) + \alpha_2 D_I + \alpha_3 D_{II} + \varepsilon}$ *with D_X the households descriptors (income, size, individual houses).*	

Source: models proposed on the basis of existing literature on price elasticity of water demand, summarized in the previous paragraphs.

With a few exceptions, case studies were conducted at the level of *one water operator* (utility). If the area covered by the water operator was considered as too large, or if there were no sufficient data for some municipalities, a subset of the total area served by the operator (i.e. in a smaller number of municipalities) was considered as a case study.

A key issue relates to the number of observations that can be considered as sufficient to conduct an elasticity assessment. Twenty observations were considered as a minimum (consisting of 20 years for one service with a given water price and volume of consumption for each year, or 5 years of data for 4 different municipalities, or any other possible combinations). In most cases, work was done with panel data (i.e. several municipalities over a time serie) or time series for price and water consumption, even if complementary information's were often available for only one (most recent) year.

Whenever possible, information and data were collected at the water service's territory scale (i.e. for a given municipality served by one water service provider or for a group of municipalities that are served by the same water service provider). The sources of information include:

- Data available at water services, and that can be accessed via a direct demand to water service managers;
- National observatory of water and sanitation services;
- Water services websites;
- Reports on price and quality of water services (so called "RPQS" in France) or equivalent;
- National statistics data base.

2.6.3 Over all consideration and main results from case studies

The main results of the case studies are presented in the case study fiches (see Annex I). The complete case studies, including a thorough overview of all data collected for each case, are provided in a separate report (https://forum.eionet.europa.eu/nrc-eionet-freshwater/library/other-reports-and-

[28] With multiple regression, the effects of different expected determinants of water demand were analysed, together with price. The price determinants looked at in the study (depending on available data for each case study) are the following: median income per capita or medina household income, mean household's size, share of individual houses, share of summer houses, number of hot days, number of rainy spring and summer days.

assessments/water-management-europe-price-and-non-price-approaches-water-conservation/supporting-documents/) The elasticity coefficients estimated in the 10 case studies are summarized in Table 11.

The results of the case studies must be used with caution: as only 1-2 case studies per country were developed, it is not really possible to generalize the results, and the conclusions made in this section are only valid for the case studies performed here. Nevertheless, it is possible to extract some messages from these results.

Table 11 Synthesis of the elasticity coefficients estimated in the 10 case studies

MS	Case study	Elasticity coefficient – Model 1	Elasticity coefficient – Model 2
DE	**Berlin Wasserbetriebe**	-0.202	Not significant
DE	**Stuttgart – EnBW Energie Baden-Württenberg AG**	-0.311	Not significant
DK	**Denmark – Country level**	-1.089	-0.84
			Other variables not significant
ES	**Aguas de Barcelona**	-0.142	-0.149
			Income: 0.435
FR	**Eau de Grenoble**	-0.614	-0.613
			Household size: 0.787 Household income: 0.697
IT	**Viveracqua – Verona province**	Not significant	Not significant
			Household size: 1.649 Household income: 1.458
RO	**Regional Water Company Bacau (CRAB)**	Not significant	n/a
RO	**Somes Water Company**	Not significant	n/a
SE	**Sweden – Country level**	Not significant	Not significant
UK	**England – Essex and Suffolk Water**	Not significant	Not significant

Legend	
	Demand is elastic to price
	Demand is inelastic to price
	Not significant/ Irrelevant

Source: own elaboration from case study results.

In some of the case studies, price did not appear to be a significant determinant of water demand – and sometimes none of the considered variables (e.g. household income, household size) is a good determinant. In several cases, however, *water demand was inelastic to price* (in DE, DK, DE, ES, FR and IT) with coefficients ranging from -0.14 to -0.84 (considering both models). In other words, it means that when the price goes up, consumers' water demand stays about the same and when the price goes down, consumers demand for water also remain unchanged.

In this regard it is important to stress that there is a critical distinction between the technical term "inelastic demand" and the phrase "unresponsive to price". As mentioned previously, inelastic demand will decrease by less than one percent for every one percent increase in price. In contrast, if demand is truly unresponsive to price, the same quantity of water will be demanded at any price. This may be true in theory for a subsistence quantity of drinking water, but it has not been observed for water demand in general in 50 years of published empirical analysis (Stavins, 2011).

Furthermore, in ES, FR and IT water demand is also positively correlated with *income,* although to a different extent: in FR and ES, water demand increases when income increases, but to a lesser extent ($E < 1$). In IT, in contrast, water demand increases by a factor of 1.5 with increasing income. In IT and FR, water demand is also positively correlated to household size (by a factor of 1.6 and 0.8 respectively).

In all cases, the two models (single and multiple regression) do not fully explain water demand trends, meaning that other factors and characteristics are likely to have an influence on water consumption.

As can be seen from the results of the case studies, they are quite diverse, which is not surprising as the underlying data from the case studies differ widely. The results suggest that on the one hand water demand seems little responsive to price changes, but on the other hand, in some cases like France (coefficient of -0.6 in Grenoble) or Denmark (coefficient of -1), demand is showing responsiveness to price. This can be taken as a testament to the fact that *price elasticity of water demand largely depends on the type of market existing for water in each country*. In economic terms, water is a distinct good and in many countries there is no actual functioning market for water. The results of the elasticity assessment can provide useful indications on whether water supply functions as a market in a given country, as shown, for example, by results in Denmark and Sweden.

In Denmark, water is supplied by many operators (2100 utilities): 322 of them are subject to the water sector law, and thus they have to respect a price ceiling, whereas the rest of the utilities are small utilities which are not subject to the law. When using a simple regression for the case studies in Denmark, water demand resulted in being elastic, with an elasticity coefficient < -1 (i.e. the percentage change in demand is larger than the percent change in price). However, the explanatory power of this model is quite low. In contrast, when one controls for socioeconomic and geographical factors (additional variables included), the available data lead to a reasonable price elasticity estimate of -0.84 - hence inelastic to price (i.e. the percentage change in demand is less than the percent change in price). This can be taken as an indication that the Danish water supply system indeed functions, at least partly, as a market[29]. There are some indications that this is a relatively recent development given that the elasticity estimate reported in the meta-analysis of Dalhuisen et al. (2003) during the 1980's is around 0.0 to -0.10. This is also well in line with the major reforms, e.g. environmental taxes etc. that were instated in the early 1990's in Denmark.

In Sweden all utilities are owned by municipalities, which finance their operations by means of taxes or fees. In contrast, demand for water does not appear to be directly influenced by its price in the case study. Likely, this is both the effect of legislation that stipulates cost coverage as the only

[29] Danish water consumers are facing by large the highest water price as shown in Figure 12 and Table 7. Hence, there is a need for further analysis of how elasticities in the countries changed over time in the context of an increase of the water price. In this study it has not been possible to look into the causality between the size/height of the water price and the elasticity.

permissible basis for pricing, and also an effect of Swedish consumers viewing water as an abundant resource rather than a traded scarce good. This is possibly exasperated by the fact that relatively few households are directly metered for their water service charge.

The results suggest that in Denmark water supply functions partly as a market, whereas this is not the case in Sweden. When looking at the governance structure of the water sector in the two countries, this also seems to make sense.

This suggests that, if decision makers want to use *pricing policies as water demand management instruments*, the first step to be taken is to ensure that *the water supply system functions (at least partly) as a market.* This does not only mean that water pricing must allow for recovering supply costs, but also that consumers have complete information on the service provided, for example on price levels. In fact, in many countries consumers are not aware of how much they are paying for water: in France, for example, only 35 % of consumers are able to estimate the unitary price (per m^3) they are actually paying for water; in addition, French consumers often check (and are aware of) only the yearly amount paid for water[30].

Moreover, one should also consider the limitations of the models used in this study. *Regression is a statistical tool which only measures the "strength" of the relation between two variables (if they move together).* However, it does not say anything about the casual direction (which variable determines the other). The casual direction in regression estimation is a logical inference made by the observer. Precisely in the case of water pricity, *there are good arguments to state that it might as well be that consumption determines the price,* and not vice-versa[31]. In this study, the assumption was made that price determines consumption, and not the other way around. The influence of price on consumption should therefore be proved with other statistical tools and, in any case, the "time-variable" is crucial to determine the real influence (and in particular, there must be observations of water consumption close enough to the variation of the price).

In addition to this, there are some additional potential determinants of water demand which could not be tested for lack of data, such as share of households with water saving devices, awareness on water scarcity or environmental concerns. The characteristics of the services could also explain partly the more or less good correlation of demand with price, but these data were not always available and could not be tested (cost recovery, public or private management, etc.).

Overall, it can be observed that case study results are very diverse and they *do not allow for a homogeneous interpretation of the overall effects of water pricing in determining demand.* However, the findings from Reynaud (2015) demonstrate that, for most of the countries, the estimated price elasticity of the household water demand is found to be negative. *Facing a price increase, EU households will react by reducing their water consumption*. It is then demonstrated that water price may play a role in signaling water scarcity or water cost to households. In addition, the study illustrated that household water demand functions are typically inelastic for most of the EU-28 countries. This means that the household water consumption decreases by less than 1 % for every 1 % increase in price. The price elasticities typically vary between -0.5 and -0.1 across countries.

[30] Centre d'information sur l'eau, Baromètre C.I.EAU/TNS-SOFRES "Les Français et l'eau" (16ème édition) - Communiqué de presse, 13 Octobre 2011

[31]It is somehow clear that the consumption determines the price, in particular in the context of sewerage plants. The plant is built for a specific capacity and the fixed costs have to be covered by the sewage tariff, i.e. by the water price. Therefore the water tariffs are very high in east Germany as too big sewage plants were constructed under the assumption that water demand is increasing or at least stable. Now they face a reduction in water demand due to abandonment of people.

Facing a price increase by 10 %, it is then expected that the household water consumption will be reduced by 1 to 5 % (Reynaud, 2015).

To achieve more significant reductions of household water consumption, public authorities should complement their price policies/measures with non-price policies/measures such as education, awareness campaigns and water-saving appliances.

3. Conclusions: what emerges from the study?

In the last 10-20 years, water consumption has steadily decreased in most of the countries investigated in this study with the exception of Cyprus. At the same time, different pricing and non-pricing measures have been implemented in these countries. This suggests that the different packages of measures put in place for addressing water quantity issues have been overall effective in reducing water demand. It is more challenging, however, to assess whether non-price measures have been more or less effective than price measures, or than the combination of some non-price and price measures.

The objective of the study was to evaluate the effectiveness of pricing instruments in managing water demand as compared to non-price measures. The study combined two approaches:

- An **extensive literature review** was conducted in 8 countries to investigate: (i) the performance of price and non-price measures in managing water demand; and (ii) the effectiveness of incentive structures in place to encourage more efficient water use.

- **Fresh evidence on price elasticity of water demand** was produced for selected case studies that assessed the relationship between water price and consumption (as well as other variables) at the water operator level.

In the case of **non-pricing measures**, the literature provided some indications of their effectiveness. Overall, the uptake of a range of non-pricing water demand measures including reduction of leakage in water supply networks, water saving devices and more efficient household appliances, has the potential to save up to 50 % of water abstracted, and to reduce water consumption from 150 litres per person per day to 80 litres per person per day (Dworak et al., 2007). For domestic water saving appliances, it was estimated that up to 40 % of water could be saved per year in each household. Education and public awareness campaigns are also considered to be effective in reducing household water consumption.

In contrast, restrictions of water supply in times of acute water scarcity are generally considered to be effective in reducing the water demand in the short term, while they have no or marginal effect on water demand in the long term if they are not accompanied by other measures.

One of the key challenges of non-pricing measures, in particular in times of restricted public finances, is that they often require considerable financial resources for their implementation. This is the case for subsidies for the installation of water saving devices and for consumer awareness campaigns, even though the implementation costs of awareness campaigns are relatively low as compared to many other (infrastructure-like) measures.

In the case of **pricing measures**, all surveyed countries have mechanisms in place to provide an incentive for a more efficient water use, ranging from simple metering and volumetric tariffs to rising block tariffs. But the evidence on the real incentiveness of existing tariffs for a more efficient water use is scarce, if available at all. And the relation between pricing mechanisms and their effects on water demand is often unclear.

The results of the case studies carried out in the context of this study, help in gaining a better understanding of the role of pricing measures in managing water demand. In some of the case studies, price does not appear to be a significant determinant of water demand. There are cases where none of the variables considered (e.g. household income, household size) are considered as significant determinants of water demands. In other cases (in DK, DE, ES and FR), the results of the case studies for the domestic sector suggest that **water demand is inelastic to price**, with elasticity coefficients ranging from approximately -0.1 to -0.8 (i.e. a given percentage of price increase results in a proportionally smaller decrease in quantity demanded). Despite their limited number, the results of the case studies are in line with the literature, in particular with the most recent study on price elasticity in the 28 member states (Reynaud, 2015). In some of these cases, water demand is also positively correlated with income and household size.

A pricing reform must account for the multi-level nature of urban water governance systems. Generally speaking, lower levels of governance (e.g. municipalities, private water companies, water boards, etc.) have full discretion for setting tariffs or water prices. Most European countries follow a framework in which policy made at the national level sets the rules for water service provision in place. These are then followed by local or municipal governments which themselves are at the core of providing water services or regulate private utilities. When talking about water demand management, aimed at increasing efficiency and thus reducing consumption, it must be kept in mind that, in water abundant countries, the overall economic cost of reducing consumption might out weight the benefits of reducing water use, especially in those countries where efforts to do so have already been made.

From a water demand management perspective, some important messages can be drawn from the assessment. Water pricing policies alone might not be fully effective in reaching water consumption reduction targets. The study demonstrated that in the surveyed countries water pricing policies are normally undertaken in combination with other non-pricing measures. These combinations have proved to be effective in reducing domestic water consumption for most of the surveyed countries. Although it appears that pricing measures are not fully effective in managing water demand and reducing water consumption, water pricing remains the key instruments to ensure cost recovery of water services. Hence, if decision makers want to use pricing policies as water demand management instruments, the first step to be taken is to ensure that the water supply system functions (at least partly) as a market.

References

AEAS (2012) Guía de las tarifas de los servicios de abastecimiento y saneamiento de agua.

AEAS-AGA (2014) XIII Encuesta de Suministro de Agua Potable y Saneamiento en España.

Aqua Publica Europea (2014). Aqua Publica Europea's position on the role of water pricing as a key element of sustainable water management. Brussels, 4 December 2014.

Aquawal (2013). Etude relative à la baisse de la consommation d'eau en Wallonie. Available at: http://www.aquawal.be/fr/etude-relative-a-la-baisse-des-consommations-d-eau-en-wallonie.html?IDC=678

Arbués, F., Villanúa, I., Barberán, R., 2010. Household size and residential water demand: an empirical approach. Australian Journal of Agricultural and Resource Economics, Volume 54, Issue 1, pages 61–80, January 2010.

Arbués, F., Garcia-Valinas, M. A., and Martinez-Espiñeira, R., 2003. Estimation of residential water demand: a state-of-the-art review, The Journal of Socio-Economics, 32, 81–102, 2003.

Asociación Española de Abastecimientos de Agua y Saneamiento (AEAS), 2014a. Suministro de Agua Potable y Saneamiento en España XIII Encuesta Nacional; AEAS: Madrid, Spain, 2014.

Asociación Española de Abastecimientos de Agua y Saneamiento (AEAS), 2014b. Tarifas 2012. Precio de los Servicios de Abastecimiento y Saneamiento en España; AEAS: Madrid, Spain, 2014.

Autorità per l'energia elettrica, il gas e il sistema idrico (AEEGSI), 2014. Relazione annuale sullo stato dei servizi e sull'attività svolta. March 31, 2041. http://www.autorita.energia.it/allegati/relaz_ann/14/RAVolumeI_2014.pdf

Barraqué, B. 2011. Is individual metering socially sustainable? The case of multifamily housing in France. *Water Alternatives* 4(2): 223-244.

BDEW, 2015. Wasserfakten im Überblick. Mai 2015. https://www.bdew.de/internet.nsf/id/C125783000558C9FC125766C0003CBAF/$file/Wasserfakten%20-%20%C3%96ffentlicher%20Bereich%20Mai%202015.pdf

BDEW (2013): Die öffentliche Wasserversorgung in Deutschland. https://bdew.de/internet.nsf/id/7277607F9D0C6A63C1257BB7002797D6/$file/Wasserversorgung%20-%20Mitgliederbereich%20August%202013.pdf, accessed: 19 November 2015.

Bello-Dambatta, A., Kapelan, Z., Butler, D., Oertlé, E., Wintgens, T., Rozos, E., Makropoulos, C., Mamassis, N., 2014. Guidance on evaluation and selection of sustainable water demand management technologies.

Benito, P., Mudgal, S., Dias, D., Jean-Baptiste, V., Kong, M.A., Inman, D., Muro, M., 2009. Water Efficiency Standards. Bio Intelligence Service and Cranfield University, Report for European Commission (DG Environment).

Bernardo, V., Fageda, X., Termes, M., 2015. Do droughts have long-term effects on water consumption? Evidence from the urban area of Barcelona, Applied Economics, 47:48, 5131-5146, DOI: 10.1080/00036846.2015.1042147. http://dx.doi.org/10.1080/00036846.2015.1042147

Bio Intelligence Service and Cranfield University, 2009. Water Efficiency Standards. Report for European Commission (DG Environment)

Branchenbild (2011): ATT, BDEW, DBVW, DVGW, DWA und VKU (2011): Branchenbild der deutschen Wasserwirtschaft. Wirtschafts- und Verlagsgesellschaft. Bonn.

Cañete, R., Menéndez, D., (2009) The Water Sector in Spain. Working paper CIRIEC No. 2009/04

Cominola, A., Giuliani, M., Piga, D., Castelletti, A., Rizzoli A.E., 2015. Benefits and challenges of using smart meters for advancing residential water demand modeling and management: A review. Environmental Modelling and Software (Impact Factor: 4.42). 10/2015; 72:198 - 214. DOI: 10.1016/j.envsoft.2015.07.012

CONVIRI, 2011. "Rapporto sullo stato dei servizi idrici – Situazione organizzativa, investimenti, tariffe, criticità". Commissione nazionale per la vigilanza sulle risorse idriche, Roma, December 2011.

Confederación Hidrográfica del Ebro (2011) Propuesta de Proyecto de Plan Hidrológico de la Cuenca del Ebro. Memoria. Versión 3.7, Zaragoza, junio de 2011

Council Directive of 21 May (1991) concerning urban waste water treatment (91/271 /EEC).

http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:31991L0271

Council of the European Union, 2012. Council conclusions (17872/12) on a blueprint to safeguard Europe's water resources. 3211th Environment Council meeting, Brussels, 17 December 2012.

http://www.consilium.europa.eu/uedocs/cms_data/docs/pressdata/en/envir/134398.pdf

Cyprus Government (2010). Cost assessment and pricing of water. Water Development Department, Cyprus.

Dalhuisen, J. M., Florax, R. J. G. M., de Groot, H. L. F., Nijkamp, P., 2003. Price and Income Elasticity of Residential Water Demand : a Meta-Analysis. Land Economics, 2003? Vol. 79, 2:292-308. http://ron-griffin.tamu.edu/x677/readings/dalhuisen.pdf

Dalhuisen, J. M., Florax, R. J. G. M., de Groot, H. L. F., Nijkamp, P., 2001. Price and Income Elasticities of Residential Water Demand: Why Empirical Estimates Differ. Tinbergen Institute Discussion Paper, No. 01-057/3. Tinbergen Institute, AmsterdamRotterdam

Danish Economic Councils (2015) *Economy and Environment 2015*. ISBN: 978-87-89027-80-7

DANVA (2015) Water in figures – DANVA benchmarking 2015. Process Benchmarking and statistics.

DEFRA, 2014. Making the most of every drop consultation on reforming the water abstraction management system - Summary of consultation responses. Department of Environment and Rural Affairs, July 2014. https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/328442/abstraction-reform-sum-resp.pdf

DEFRA, 2008. Action taken by government to encourage the conservation of water. Department for Environment, Food and Rural Affairs, London

Deloitte (2013) Evaluering af vandsektorloven. Deloitte Statsautoriseret Revisionspartnerselskab, November 2013

Dipartimento per lo Sviluppo e la Coesione Economica (DPS), 2014. “Accordo di partenariato 2014-2020 – Italia – Sezione 1°”. Conforme all’articolo 14 del Regolamento UE N.1303/2013 – Settembre 2014.

Dumont, A., Mayor, B., and López-Gunn, E. (2011). Is the rebound effect or Jevons paradox a useful concept for better management of water resources? Insight from the irrigation modernisation process in Spain. Aquadic Procedia, 1, 64-76.

Dworak, T., Berlund, M., Laaswer, C., Strosser, P., Roussard, J., Grandmougin, B., Kossida, M., Kyriazopoulou, I., Berbel, J., Kolberg, S., Rodriguez-Diaz, J. A. and Montesinos, P., 2007, EU water saving potential (Part 1 - Report), European Commission report, Brussels, Belgium.

Dziegielewski, B. (2011). Management of water demand: Unresolved issues. *Journal of contemporary water research and education*, *114*(1), 1.

EA (Environment Agency) (2015). Water demand management bulleting. April 2015.

ESW (East and Suffolk Water) (2014). Water efficiency newsletter. December 2015, Issue 9.

European Commission (2015a). Optimising water reuse in the EU. Final report – Part I

http://ec.europa.eu/environment/water/blueprint/pdf/BIO_IA%20on%20water%20reuse_Final%20Part%20I.pdf

European Commission (2015b). EU reference document good practices on leakage management, WFD CIS WG PoM. European Union.

https://circabc.europa.eu/sd/a/ec13ae01-7800-4114-8d72-98827b509e18/Good%20Practices%20on%20Leakage%20Management%20-%20Case%20Study%20document._Final.pdf

European Commission (2012a). Report from the Commission to the European Parliament and the Council on the Implementation of the WFD RBMP. Member State: Cyprus. SWD(2012) 379 final, Brussels.

European Commission (2012b). Report on the Review of the European water scarcity and droughts policy. COM(2012) 672 final, Brussels, 14.11.2012. http://ec.europa.eu/environment/water/quantity/pdf/COM-2012-672final-EN.pdf

European Commission (2012c). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - A Blueprint to Safeguard Europe's Water Resources. COM(2012) 673 final, Brussels 14.11.2012.

http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52012DC0673

European Commission, 2011a. “Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - A resource-efficient Europe: Flagship initiative under the Europe 2020 Strategy”. COM(2011) 21, Brussels, 26.1.2011. http://ec.europa.eu/resource-efficient-europe/pdf/resource_efficient_europe_en.pdf

European Commission, 2011b. “Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions - Roadmap to a Resource Efficient Europe”. COM(2011) 571 final - Brussels, 20.9.2011. http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

European Commission, 2010. Compliance costs of the Urban Wastewater Treatment Directive. A report from COWI to DG Environment. European Commission, Brussels.

European Commission, 2007. “Communication from the Commission to the European Parliament and the Council on addressing the challenge of water scarcity and droughts in the European Union”. COM(2007) 414 final, Brussels, 18.7.2007.

European Commission, 2003. Economics and the environment, The implementation challenge of the Water Framework Directive. Guidance document no. 1 prepared by Working Group 2.6 – WATECO Common Implementation Strategy. 2003

European Commission (2002). Water, an essential resource. LIFE and the new European water policy.
Luxembourg: Office for Official Publications of the European Communities. URL: http://edz.bib.uni-mannheim.de/daten/edz-bn/gdu/02/water_en.pdf

European Environment Agency, 2012a. Towards efficient use of water resources in Europe. Report No. 1/2012. http://www.eea.europa.eu/publications/towards-efficient-use-of-water

European Environment Agency, 2012b. European waters — current status and future challenges. EEA Report No. 9/2012. http://www.eea.europa.eu/publications/european-waters-synthesis-2012

European Environment Agency, 2013. Assessment of cost recovery through water pricing. EEA Report No. 16/2013. http://www.eea.europa.eu/publications/assessment-of-full-cost-recovery

European Environment Agency, 2014. Performance of water utilities beyond compliance. Sharing knowledge bases to support environmental and resource-efficiency policies and technical improvements. EEA Report No. 5/2014. http://www.eea.europa.eu/publications/performance-of-water-utilities-beyond-compliance

European Parliament, 2015. Water legislation - cost of non-Europe report. European Parliamentary Research Service (EPRS). http://www.europarl.europa.eu/RegData/etudes/STUD/2015/536369/EPRS_STU(2015)536369_EN.pdf

Federconsumatori e Centro Ricerche Nazionale Economiche, Educazione e Formazione (CREEF), 2014. XIII indagine nazionale e campione sulle tariffe 2013 del servizio idrico integrato. May 13, 2014. http://www.helpconsumatori.it/wp-content/uploads/2014/05/Indagine-nazionale-tariffe.pdf

Fuentes, A. (2011) Policies Towards a Sustainable Use of Water in Spain”, OECD Economics Department Working Papers, No. 840, OECD Publishing. http://dx.doi.org/10.1787/5kgj3l0ggczt-en

García-Rubio et al., 2015. Urban Water Tariffs in Spain: What Needs to Be Done? Water 2015, 7, 1456-1479; doi:10.3390/w7041456.

GEUS, 2007. "The Danish action plan for promotion of eco-efficient technologies – Danish Lessons". Available at: http://eng.ecoinnovation.dk/media/mst/8051461/Vandforsyning_artikel.pdf

González-Gómez, F., García-Rubio, M. A., Guardiola, J., 2012. Introduction: Water Policy and Management in Spain, International Journal of Water Resources Development, 28:1, 3-11.

Grafton, Ward, To, & Kompas, 2011. Determinants of Residential Water Consumption: Evidence and Analysis from a 10-country Household Survey. *Water Resources Research*, Vol. 47, No. W08537, doi:10.1029/2010WR009685.

Hansen et al. (2004): Gutachten - „Nachhaltige Wasserwirtschaft in Deutschland vor dem Hintergrund europäischer Liberalisierungstendenzen“. Ecologic. Berlin.

Harou, J.J., Garrone, P., Rizzoli, A. E., Maziotis, A., Castelletti, A., Fraternali, P., Novak, J., Wissmann-Alves, R., Ceschi, P.A., 2014. Smart Metering, Water Pricing and Social Media to Stimulate Residential Water Efficiency: Opportunities for the Smart H2O Project.16th Conference on Water Distribution System Analysis, WDSA 2014. Procedia Engineering 89 (2014) 1037 – 1043.

Hjerpe, M., & Krantz, H. (2006). Individuell mätning av vatten-om hushållens respons och praktikerns överväganden. Vatten: tidskrift för vattenvård, 62, 83-90.

House-Peters, L. a. and Chang, H.: Urban water demand modeling: Review of concepts, methods, and organizing principles, 360 Water Resources Research, 47, 2011.

Kellis, M, Kalavrouziotis, IK, Gikas, P. (2013). Review of wastewater reuse in the Mditerranean countries focusing on regulations and policies for municipal and industrial applications. Global NES journal 15(3), 333-350.

Kondouri, P. (Ed) (2011). Water Resources Allocation. Policy and socio-economic issues in Cyprus. Springer, London, 164pp.

Konkurrence- og forbrugerstyrelsen (2013) *De danske husstandes udgifter til drikkevand og afledning af spildevand i 2012.* Forsyningssekretariatet – Center for Vand, May 20

Kraemer, R. A., Grünig, M.; Marcelinno, D. (2009): Water Pricing and Costs of Services in Germany. Detailed Financial Analysis – Germany. Berlin.

INRA, 2006. Amigues J.P., P. Debaeke, B. Itier, G. Lemaire, B. Seguin, F. Tardieu, A. Thomas (éditeurs), 2006. Sécheresse et agriculture. Réduire la vulnérabilité de l'agriculture à un risque accru de manque d'eau. Expertise scientifique collective, synthèse du rapport, INRA (France), 72 p.

International Water Association (2014) International Statistics for Water Services. Information every water manager should know. Specialist Group Statistics and Economics - Working Group Statistics. 2014.

I.S.E.K. (2013): Studie: Qualität und Image von Trinkwasser in Deutschland. Gefördert durch VKU. Präsentation, Dr. Uwe Pöhls, 22.7.2013. http://www.wvw-wnd.de/fileadmin/user_upload/02_Aktuelles/Studie_QualitA_t_und_Image_von_Trinkwasser.pdf, accessed 19 November 2015.

Lago, M., Mysiak, J., Gómez, C.M., Delacámara, G., Maziotis, A., Eds. (2015) Use of Economic Instruments in Water Management – Insights from International Experience. Springer International Publishing AG, Cham (2015).

Liemberger, R. (2005): The new German water loss regulations in context with other international applications of the IWA water balance and real loss performance indicators. Conference Proceedings IWA Conference Efficient 2005, Santiago de Chile, Chile.

Mansur, Erin T. & Olmstead, Sheila M., 2012. "The value of scarce water: Measuring the inefficiency of municipal regulations," Journal of Urban Economics, Elsevier, vol. 71(3), pages 332-346. http://faculty.tuck.dartmouth.edu/images/uploads/faculty/erin-mansur/mansur_scarce_water.pdf

Martin-Ortega, J., Markandya, A., 2009. The costs of drought: the exceptional 2007-2008 case of Barcelona. BC3 Working Paper Series 2009-09. Basque Centre for Climate Change (BC3). Bilbao, Spain

Ministerio de Medio Ambiente, 2007. "Precios Y Costes De Los Servicios Del Agua En España; Informe Integrado De Recuperación De Costes De Los Servicios De Agua En España," (Madrid: Ministerio de Medio Ambiente, 2007), p.16.

Molinero, J. et al. (2008) Groundwater in Spain: Overview and Management Practices. Revista de la Real Academia de Ciencias Exactas, Fisicas y Naturales, Vol. 102, No. 1, Universidad Complutense, Madrid.

Möller-Gulland, J., Lago, M., Anzaldua, G. (2015) Water Abstraction Charges and Compensation Payments in Baden-Württemberg (Germany). Book Chapter in: Use of Economic Instruments in Water Management – Insights from International Experience. Springer International Publishing AG, Cham (2015).

Montginoul, M.et al., 2015. Water Pricing in France: Toward More Incentives to Conserve Water in the book Water Pricing Experiences and Innovations, Dinar et al. p.139-160, Springer.

Montginoul, M., 2013. La consommation d'eau en France : historique, tendances contemporaines, déterminants, Revue SET, pp. 68–73, 2013.

Mouchel (2016). H2eco Phase 11. Report for Essex and Suffolk Water on the water efficiency retrofit project H2eco.

Observatoire National des Services d'eau et d'assainissement, 2013. Analyse de l'impact du plafonnement de la part fixe sur la tarification des services d'eau - Synthese de l'etude. Eau France, February 2013. http://www.services.eaufrance.fr/docs/synthese/rapports/Synthese_part_fixe.pdf

OECD, 2015. Water Resources Allocation. Country profile: Spain. OECD Studies on Water, OECD Publishing.

OECD (2014) Economic Surveys of Spain 2014. OECD Publishing: Paris, France, 2014. http://www.keepeek.com/Digital-Asset-Management/oecd/economics/oecd-economic-surveys-spain-2014_eco_surveys-esp-2014-en#page79

OECD, 2013. "OECD Environmental Performance Reveiws – Italy 2013". OECD Publishing. http://www.keepeek.com/Digital-Asset-Management/oecd/environment/oecd-environmental-performance-reviews-italy-2013_9789264186378-en#page4

OECD, 2008. Environmental Performance of Agriculture in OECD countries since 1990. Paris, France

OECD, 2001. The price of water: trends in OECD countries. OECD, Paris, France.

Olmstead, S. M., and R. N. Stavins (2009), Comparing price and nonprice approaches to residential water conservation, Water Resources Research, Vol. 45, No. W04301, doi:10.1029/2008WR007227

Onema, 2015. Observatoire des services publics d'eau et d'assainissement - Panorama des services et de leur performance en 2012,Les Rapports, Juillet 2015

ONEMA, 2011. Les impacts du manque d'eau sur les milieux aquatiques. ONEMA, 29 juin 2011 - http://www.onema.fr/dossier-secheresse-2011

Ornaghi, C. and Tonin M. (2015). The effect of metering on water consumption. Policy Note. University of Southampton.

Pesic, R., Jovanovic, M., Jovanovic, J., 2012. Seasonal water pricing using meteorological data: case study of Belgrade, *Journal of Cleaner Production*, 2012, **37**, 299

Polycarpou, A., Zachariadis, T., 2013. An Econometric Analysis of Residential Water Demand in Cyprus. Water Resources Management, Springer, vol. 27(1), pages 309-317, January.

Reynaud, A., 2015. Modelling Household Water Demand in Europe – Insights from a Cross-Country econometric Analysis of EU-28 countries. JRC Technical Reports.

Rinaudo, J., Neverre, N., Montginoul, M., 2012. Simulating the impact of pricing policies on residential water demand: a Southern France case study. Water Resources Management, 2012, 26 (7),2057-2068. https://hal.archives-ouvertes.fr/hal-00796075/document

Rudolph, K.U., and Block, T., 2001. Der Wassersektor in Deutschland: Methoden und Erfahrungen. UBA.

Statista (2015): Wasserverluste in ausgewählten europäischen Ländern (in Prozent vom Bruttowasseraufkommen). http://de.statista.com/statistik/daten/studie/155692/umfrage/wasserverluste-in-der-wasserversorgung-in-europa/, accessed 19 November 2015.

Stavin (2011): Misconceptions About Water Pricing. The Huffington Post. http://www.huffingtonpost.com/robert-stavins/misconceptions-about-wate_b_175281.html

Strosser P. And Speck S. (2004), Environmental taxes and charges in the water sector, a review of European experiences. Final report of a study for the Water Agency of Catalonia (Spain).

Svenskt vatten (2014) *Värt att veta om vatten* Retrieved 150916 from: http://www.svensktvatten.se/Documents/Kategorier/Dricksvatten/Information/V%C3%A4rt%20att%20veta%20om%20vatten.pdf

UBA (2015): Monitoringbericht 2015. Zur Deutschen Anpassungsstrategie an den Klimawandel. Dessau.

UBA (2015b): Umweltschutz in der Landwirtschaft kommt zu langsam voran. https://www.umweltbundesamt.de/presse/presseinformationen/umweltschutz-in-der-landwirtschaft-kommt-zu-langsam

UBA (2015c): 30 Jahre SRU-Sondergutachten „Umweltprobleme der Landwirtschaft'' - eine Bilanz. Dessau. UBA- TEXTE 28/2015.

UBA (2015d): Bericht des Bundesministeriums für Gesundheit und des Umweltbundesamtes an die Verbraucher und Verbraucherinnen über die Qualität von Wasser für den menschlichen Gebrauch (Trinkwasser) in Deutschland (2008 - 2010). UBA Umwelt & Gesundheit 02/2015, Dessau.

UBA, 2014. Wassersparen in Privathaushalten: sinnvoll, ausgereizt, übertrieben? Fakten, Hintergründe, Empfehlungen. Hintergrund, September 2014.

Umesh, V., Nagaraj, S., 2014. Hydraulic performance of faucet aerator as water saving device and suggestions for its improvements. International Journal of Research in Engineering and Technology 03:07. http://esatjournals.net/ijret/2014v03/i07/IJRET20140307041.pdf

UN-ESC – United Nations Economic and Social Council (1997): Comprehensive assessment of the freshwater resources of the world. Report of the Secretary-General of the Commission on Sustainable Development, Document E/CN.17/1997/9, 4 February 1997. www.un.org/esa/documents/ecosoc/cn17/1997/ecn171997-9.htm.

Wackerbauer, J. (2009): The Water Sector in Germany. CIRIEC Working Paper, 2009/11.

Walker, A. 2009. The independent review of charging for household water and sewerage services. Independent Review. London: Department for Environment, Food & Rural Affairs.

WDD (Water Development Department) (2011). Cyprus river basin management plan. Ministry of agriculture, natural resources and environment, Republic of Cyprus.

WDD (Water Development Department) (2010) . Cost assessment and pricing of water services in Cyprus. Summary.

Withana, S., ten Brink, P., Illes, A., Nanni, S., Watkins, E., (2014) *Environmental tax reform in Europe: Opportunities for the future, A report by the Institutefor European Environmental Policy (IEEP) for the Netherlands Ministry of Infrastructure and the Environment*. Final Report. Brussels.

World Bank (2008) Practical Solutions to Water Challenges. Learning from the Spanish Experience. June 14 - September 14, 2008, p.20.

Worthington, A. and Hoffmann, M., 2006. A state of the art review of residential water demand modelling, University of Wollongong, 380 School of Accounting and Finance Working Paper Series, 27, 2006.

Zetland, D. (2016). The struggle for residential water metering in England and Wales. Water alternatives 9(1): 120-138.

Websites

Agència Catalana de l'Aigua - ACA. Vocabulario del Agua. Available on: http://aca-web.gencat.cat/aca/appmanager/aca/aca?_nfpb=true&_pageLabel=P1211454461208200805645&profileLocale=es

Decreto Sblocca Italia: http://www.gazzettaufficiale.it/eli/id/2014/09/12/14G00149/sg (last access: December 4th, 2015)

HQE – Association reconnue d'utilité publique: http://www.assohqe.org/accueil/?rubrique74 (last access: March 8th, 2016)

Investopedia : www.investopedia.com (last access : February 20th, 2016)

Romanian Water: http://www.rowater.ro/sites/en/default.aspx (last access: March 10th, 2016)

WaterHero Website: http://www.hofor.dk/skole/ (last access: February 19th, 2016)

Sardegna Ambiente: http://www.sardegnaambiente.it/index.php?xsl=612&s=72451&v=2&c=4798 (last access: March 8th, 2016)

Annex I – case study fisches

The fiches below include the following information:

- Area and water operator.
- Data coverage: number of municipalities, number of customers, time period.
- Description of the models applied, especially on what concerns the variables included in the model.
- For price and other variables with a significant effect on water demand, two parameters are provided: (i) elasticity coefficients: how water demand reacts to price changes; and (ii) P-value: if P-value is >0.05, the model is not significant or, in other words, the variable included in the model do not explain the observed changes in water demand.
- When necessary, the F-value is also provided. While R-squared provides an estimate of the strength of the relationship between your model and the response variable, it does not provide a formal hypothesis test for this relationship. The overall F-test determines whether this relationship is statistically significant. If F-value is > 0.05, the model is not significant or, in other words, the tested variables do not explain changes in price.
- In order to compare results with findings at the national level, the fiches also include the elasticity coefficients estimated in Reynaud (2015).

Table X Case study fiches – Summary of case study findings (Sources: mostly water supply companies – more details provided in the case study templates in the following link (Link))

DE	**Berlin Wasserbetriebe**		
Area	City of Berlin (whole city) 891.7 km²	**Operator**	Berliner Wasserbetriebe (public agency – Anstalt des öffentlichen Rechts)

Data coverage	1 municipality 3.4 million customers in Berlin in 2009 (roughly 256,000 houses connected) Time period: 1997-2014 (missing data for 1997 and 2003, for 1997 used data from 1996, for 2003 used data from 2002)
Price structure	Fixed part and per-unit volume charge, fixed part introduced in 2007

Model 1		**Model 2**	
The mean delivered volume per household is regressed on the average price a household will pay for a yearly consumption of 120m^3 of drinking water (the price includes both fixed and variable costs for drinking water).		In addition to price, the model also includes all other variables that were available: income per capita, share of individual houses (detached houses), the number of hot days and the number of rainy spring and summer days.	
Elasticity coefficient	**P-value**	**Elasticity coefficient**	**P-value**
-0.202	< 0.01	**Not significant**	All variables: 0.08 < P-value < 0.96
Price is a significant determinant of water demand in Berlin. *Water consumption per capita is inelastic to price.*		The regression returned high p-values for the additional variables, suggesting the latter were not significant, and neither were price.	

Country-level results from Reynaud, 20	Price elasticity: -0.45; -0.44 Income elasticity: 0.08, 0.14

DE	**Stuttgart – EnBW Energie Baden-Württenberg AG**

<table>
<tr><td>Area</td><td>City of Stuttgart (whole city)
207.36 km²</td><td>Operator</td><td>EnBW Energie Baden-Württemberg AG</td></tr>
<tr><td>Data coverage</td><td colspan="3">1 municipality
607,841 (Oct 2015) (main residence: 601,045, secondary residence: 6,796) (total served area of the operator)
Time period: 1980-2015</td></tr>
<tr><td>Price structure</td><td colspan="3">Fixed part + per-unit volume charge</td></tr>
<tr><th colspan="2">Model 1</th><th colspan="2">Model 2</th></tr>
<tr><td colspan="2">The mean delivered volume per household is regressed on the average price a household will pay for a yearly consumption of 120m^3 of drinking water (the price includes both fixed and variable costs for drinking water).</td><td colspan="2">In addition to price, the model also includes all other variables: income per capita, share of individual houses, the number of hot days and the number of rainy spring and summer days.</td></tr>
<tr><th>Elasticity coefficient</th><th>P-value</th><th>Elasticity coefficient</th><th>P-value</th></tr>
<tr><td>-0.311</td><td>< 0.01</td><td>Not significant</td><td>All variables: 0.07 < P-value < 3.5</td></tr>
<tr><td colspan="2">Price is a significant determinant of water demand in Stuttgart. A double-log regression was used. Water consumption per capita is inelastic to price.</td><td colspan="2">The regression returned high p-values for the additional variables, suggesting the latter were not significant.</td></tr>
<tr><td colspan="2">Country-level results from Reynaud, 2015</td><td colspan="2">Price elasticity: -0.45; -0.44
Income elasticity: 0.08, 0.14</td></tr>
</table>

<table>
<tr><th>DK</th><th colspan="3">Denmark – Country-level</th></tr>
<tr><td>Area</td><td>Denmark – Whole country</td><td>Operator</td><td>350 utilities - All utilities extracting in excess of 200 000m^3 per year are included.</td></tr>
<tr><td>Data coverage</td><td colspan="3">98 municipalities, 5.5 million inhabitants
Price data for 2010-2013</td></tr>
<tr><td>Price structure</td><td colspan="3">Fixed part + per-unit volume charge</td></tr>
<tr><th colspan="2">Model 1</th><th colspan="2">Model 2</th></tr>
<tr><td colspan="2">The consumed yearly volume per household is regressed on the total price for a typical household consumption of 83m^3 per year.</td><td colspan="2">Water demand per household is regressed on the same price variable used in model 1 in addition to share of individual houses, share of summer houses, population, income per capita and two dummies (region and year).</td></tr>
<tr><th>Elasticity coefficient</th><th>P-value</th><th>Elasticity coefficient</th><th>P-value</th></tr>
<tr><td>-1.089</td><td>0.00</td><td>-0.804</td><td>Price: 0.00
Share of individual houses: 0.00
Other variables: > 0.005</td></tr>
<tr><td colspan="2">The estimated price parameter is significant and larger than 1, implying that demand is elastic to price. However the explained variance, as measured by R^2, is also quite low at around 12 % indicating that other factors explain a great deal of the variation in water demand over Danish municipalities.</td><td colspan="2">The estimated price parameter is significant but smaller than 1, thus water is inelastic to price - water demand decreases less than proportionally with price increases. The share of individual houses are significant, but with a low coefficient (-0.013). The other variables are not significant. The overall explanatory power of the model is 23,5% as measured</td></tr>
</table>

	by R^2, still relatively low given the explanatory variables included.
Country-level results from Reynaud, 2015	Price elasticity: -1.00; -0.33 Income elasticity: -0.37; -0.50

ES	**Aguas de Barcelona**		
Area	Catalonia, metropolitan area of Barcelona (over two-thirds of the territory of the metropolitan area of Barcelona) 425.4 km^2	**Operator**	Aigües de Barcelona (AGBAR)
Data coverage	23 municipalities, 1,209,027 domestic customers in 2014 Time period: 2008-2014		
Price structure	Fixed part + volumetric part		
Model 1		**Model 2**	
The mean delivered volume per household is regressed on the average price a household will pay for a yearly consumption of 144m^3 of drinking water.		In addition to price, the model also includes the median income per capita.	
Elasticity coefficient	**P-value**	**Elasticity coefficient**	**P-value**
-0.142	0.004	**Price: -0.149** Income: 0.435	Both variables: < 0.001
*Water consumption per capita is negatively and lowly inelastic to price***.** However, whereas price could be a determinant of water demand in the Metropolitan Area of Barcelona, its R^2 value (4%) does not show a significantly strong correlation.		Price and income per capita explain 39% of the variations in water demand. This shows that the combined influence of these two variables is a better and more significant determinant of water demand in the Metropolitan Area of Barcelona. *Water consumption per household is elastic to price***.** Moreover water consumption per household is also positively influenced by income but with variations lower than the increase of income (elasticity inferior to 1).	
Country-level results from Reynaud, 2015		Price elasticity: -0.21; -0.00 Income elasticity: -0.30; 0.05	

FR	**Eau de Grenoble**		
Area	City of Grenoble (whole city) 18.13 km²	**Operator**	Eau de Grenoble (Public company)
Data coverage	1 municipality managed by the operator, composed of 10 districts – data per district 47 514 domestic customers / 2 753 big consumers (includes domestic buildings) / 875 municipal infrastructures customers / 24 fire hydrant / 22 bulk customers Time period: 2002-2014		
Price structure	Water: Fixed part + Volumetric part + Fees and taxes Sewerage: Volumetric part + Fees and taxes		
Model 1		**Model 2**	

The mean delivered volume per household is regressed on the average price a household will pay for a yearly consumption of 120m^3 of drinking water (the price includes both fixed and variable costs for drinking water and sewage as well as fees and taxes).	In addition to price, the model also includes the median household's income and the mean household's size.

Elasticity coefficient	P-value	Elasticity coefficient	P-value
-0.614	< 0.001	**Price: -0.613** Household size: 0.787 Household income: 0.697	All variables: < 0.001
Water consumption per household is inelastic to price.		*Water consumption per household is elastic to price.* Moreover water consumption per household is positively influenced by income but with variations lower than the increase of income (elasticity inferior to 1). Household's size also partly determines water demand, but the difference in water consumption between a one-person household and a couple is lower than a factor 2.	

Country-level results from Reynaud, 2015	Price elasticity: -0.43; -0.10 Income elasticity: 0.07; 0.26

IT	Viveracqua – Verona province		
Area	18 municipalities scattered across the Verona province in the Veneto region – mostly rural municipalities 610,1 km^2	**Operator**	Viveracqua – Consortium of 14 public water operators, covering the entire Veneto region
Data coverage	18 municipalities – Elasticity was assessed for 16 municipalities (unsufficient data for 2 municipalities) Customers water supply: 61 449 (2014) – Customers wastewater collection and treatment: 51 366 Time period: 2008 - 2015		
Price structure	Fixed part + Volumetric part		

Model 1		Model 2	
The mean delivered volume per household is regressed on the average price a household will pay for a yearly consumption of 120m^3 of drinking water (the price includes both fixed and variable costs for drinking water and sewage as well as fees and taxes).		In addition to price, the model also includes the median household's income and the mean household's size.	
Elasticity coefficient	**P-value**	**Elasticity coefficient**	**P-value**
Not significant	0.08	Price: **Not significant** Household size: 1.649 Household income: 1.458	Price: 0.11 Household size: <0.001 Household income: <0.001
From the regression results it might be concluded that price is inelastic to price, as the coefficient is -0.51. However, P-value is > 0.05, and the critical F-value is > 0.05, revealing that the model is not significant		This model is significant in explaining the determinants of water demand. Water price, however, is not a significant determinant of demand (coefficient= -0.320; P-value > 0.005). In contrast,	

or, in other word, that the *price is not a significant determinant of water demand.*	*household size and household income are significant determinant of water demand, and a positive correlation is observed* (household size, coefficient= 1,649; household income, coefficient= 1,458).
Country-level results from Reynaud, 2015	Price elasticity: -0.58 Income elasticity: 0.31

RO	**Regional Water Company Bacau (CRAB)**		
Area	CRAB services 20 localities - only 4 municipalities studied here	**Operator**	Regional Water Company Bacau (CRAB) – public operator
Data coverage	4 municipalities, 264371 inhabitants Time period: 2011-2015		
Price structure	Fixed part + Volumetric part		
Model 1		**Model 2**	
The mean delivered volume per inhabitant is regressed on the average price of drinking water and sewage.		Data on additional variables were not available.	
Elasticity coefficient	**P-value**	**Elasticity coefficient**	**P-value**
-0.738	0.009		
It can be concluded that price is significantly correlated to water demand in CRAB but due to the higher level of consumption in some municipalities, *this correlation cannot be interpreted to explain a potential causal effect of price on water demand.*			
Country-level results from Reynaud, 2015	Price elasticity: -0.58 Income elasticity: 0.26		

RO	**Somes Water Company – Cluj and Salaj counties**		
Area	Somes Water Company operates in the counties Cluj and Salaj, but it does not completely cover the area of the two counties. 4 municipalities studied here.	**Operator**	Somes Water Company – public operator
Data coverage	184 localities, 628268 inhabitants Time period: 2009-2014		
Price structure	Fixed part + Volumetric part		
Model 1		**Model 2**	
The mean delivered volume per inhabitant is regressed on the average price of drinking water and sewage.		Data on additional variables were not available.	
Elasticity coefficient	**P-value**	**Elasticity coefficient**	**P-value**
Not significant	0.62		
The model is not significant (P-value > 0.05; significance of F value > 0.05) – i.e. *the variations of*			

price cannot explain (even partly) the variations of water demand.	
Country-level results from Reynaud, 2015	Price elasticity: -0.58 Income elasticity: 0.26

SE	**Sweden – Country level**		
Area	Sweden – Whole country	**Operator**	Municipal utilities
Data coverage	290 municipalities. Due to some missing data only 190 were included in the assessment. Year: 2014		
Price structure	Fixed part + Volumetric part The volumetric parts is not however metered in all cases but rather based on typical consumption of a representative household.		
Model 1		**Model 2**	
Water consumption is regressed against price.		Water consumption is regressed against price, share of individual houses, income per capita and a regional and coastal (i.e. house on the coast or inland) dummy.	
Elasticity coefficient	**P-value**	**Elasticity coefficient**	**P-value**
Not significant	0.631	Not significant	All variables: > 0.05
With cross sectional data and no time serie, elasticity cannot be analyzed through this case study but only the correlation between price and demand through the different municipalities in Sweden. That no significant relationship exists between the two variables is confirmed by a very low R^2, an insignificant F-value and an insignificant parameter estimate. The conclusion from this must be that price is a very poor determinant of Swedish water consumption.		This development of the model does improve the explanatory power, but only marginally so. The f-test cannot reject the hypothesis that all estimated parameters are simultaneously equal to zero. It is interesting, and quite surprising, that a model that controls for living conditions, price level, income level and geographical location should have this *low explanatory power*.	
Country-level results from Reynaud, 2015	Price elasticity: -0.58; -0.28 Income elasticity: 0.37; 0.40		

UK	**England – Essex and Suffolk Water**		
Area	Center, Suburbs and near rural areas of the towns of Chelmsford and Southend Chelmsford = 144km2; Southend = 72km2	**Operator**	Essex & Suffolk Water (private company)
Data coverage	2 municipalities Time period: 2000 - 2013		
Price structure	Fixed part + Volumetric part		
Model 1		**Model 2**	
The mean delivered volume per household is regressed on the average price a household will pay for a yearly consumption of $120m^3$ of drinking water (the price includes both fixed and variable costs for drinking water and sewage).		In addition to price, the model also includes the median household's income and the mean household's size.	

Elasticity coefficient	P-value	Elasticity coefficient	P-value
Not significant	0.03	**Not significant** (none of the variables)	All variables > 0.05
Price is not a significant determinant of water demand in Essex.		*None of the variables are significant determinants of water demand.*	
Country-level results from Reynaud, 2015	Price elasticity: -0.18; -0.20 Income elasticity: 0.26		

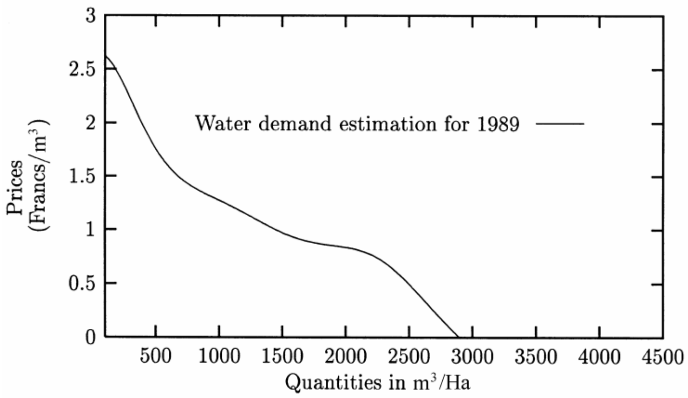
Annex II – Case study for the agricultural sector

Price elasticity of water demand in agriculture

A *review of 11 case studies* of price elasticity of *irrigation water demand* was conducted. Although the focus of this study is on the domestic sector, this review was included in the elasticity assessment to provide a more complete overview of price elasticity of water demand. A complete review is provided in the following link (https://forum.eionet.europa.eu/nrc-eionet-freshwater/library/other-reports-and-assessments/water-management-europe-price-and-non-price-approaches-water-conservation/supporting-documents/). The result of this is a complementary analysis, based on the review of existing cases and is not discussed further in the paragraphs below, which refer only to the case studies developed for the domestic sector.

The estimation of price-demand elasticity has some particularities in the case of agricultural water use. The reason for this is that the price or charge of agricultural water is rarely determined in the market. Thus, the hypothetical effectiveness of pricing as a demand management tool needs to be derived from modeling exercises, which will provide pairs of prices and demanded amounts of water, that can be demonstrated in water demand functions (see Figure 15) and thus demand elasticities[32] for different levels of price. Given the resources accorded to this analysis, modeling from primary data was not possible and water demand elasticities were derived from models already implemented and published (abundant in the literature).

Figure 15 Irrigation water demand curve in the South west of France in a dry year



Source: Bontemps and Couture, 2002.

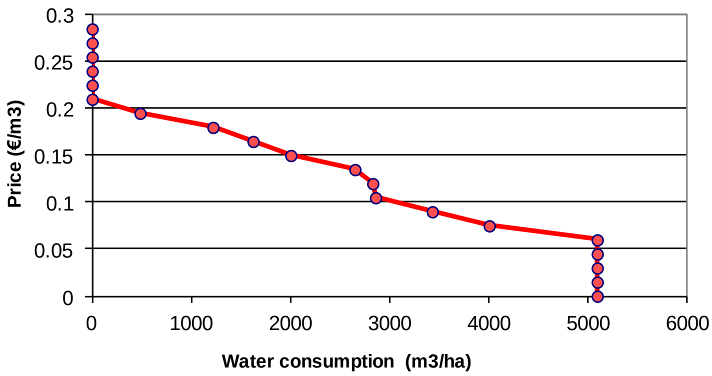
Fifteen studies were reviewed to analyze water price elasticity at the irrigation district scale, mainly in Spain (11 case studies) but also in France, Italy and Portugal. The selection of the case studies has been based on data availability and different other criteria, such as number of irrigators, source of water, average water consumption, irrigation technology, etc.

[32] The demand elasticity being equal to the variation of water consumption in percentage divided by the variation of water price in percentage.

In most of the cases, *irrigation water demand is rather inelastic*, ie the percent change in demand is less than the percent change in price, especially when prices are low or high, *with price elasticity ranges between -0.1 and -0.5*. For the lowest and highest prices, water demand is even sometimes perfectly inelastic (price elasticity is equal to 0), see Figure 16.

Many cases also show that for mid-range prices, price elasticity of irrigation water demand tends to be more elastic, i.e. demand is affected to a greater degree by changes in price, with price elasticity values sometimes greater than one.

Figure 16 Irrigation water demand curve in Vegas de Saldaña y Carrión



Source: Blanco and Varela, 2007.

The analysis shows that irrigation water demand is rather inelastic, especially in those irrigation districts were water is scarce or permanent crops are predominant. Some other reasons for finding generally inelastic irrigation demand are the following:

- Very often elasticity varies along the demand curve: in regions with abundant and cheap water the elastic segment will be found at lower prices, followed by more inelastic segments in the upper price range. A contrary situation is found when price is high and resources are limited (many situations of groundwater or semi-arid areas): the demand is inelastic at the relatively lower prices, up to a point where demand is completely choked off. This is the point where water use becomes completely unprofitable.
- Long-term estimations, considering variable capital scenarios, will in general reveal more elastic water demand. But this does not mean that the price signal will necessarily stimulate capital investment in irrigation. Other reasons may explain the investment: reduced management costs, more precise applications and water control, better crop yields and quality.

In most circumstances the amount of water use is constraint by entitlements or rights. Therefore, if farmers tend to use them in full, and water prices are low, then demand will be in general inelastic. If lower used volumes are identified, this may be due to reduced deliveries instituted to cope with drought situations.