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Water Pricing and Cost Recovery: Practice, Experience and Feedback in Europe

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Water Pricing and Cost Recovery: Practice, Experience and Feedback in Europe

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RESUME

Dans le cadre de l'eau à usage agricole et l'eau à usage industriel, l’application des principe Pollueur/Payeur et le Recouvrement intégral des Coûts, qui font l’objet de l’article 9 de la Directive Cadre Européenne sur l’eau (DCE), n’est pas assurée dans la plupart des pays de l’UE.

Cette synthèse essaie d'aborder les difficultés expérimentées dans ce cadre par certains pays de l'UE, soumis à étude. Dans l'industrie, le fait que la plupart des usagers réalisent des prélèvements directs de manière indépendante entraine des difficultés pour favoriser un usage plus efficace de la ressource à l'aide des tarifications. Dans l'agriculture, les types d'usagers sont plus variés, mais d'autres variables, liées à la gestion des infrastructures de distribution et à l'activité agricole (techniques d'irrigation, subventions sur les cultures, manque d'instruments de comptage, …), rendent difficile la comparaison entre pays ainsi qu'un usage efficace de la ressource en eau.

Mots clé: Tarification de l'eau, Directive Cadre Européenne sur l'eau, Recouvrement des coûts, Principe Pollueur/Payeur, Irrigation, eau à usage industriel, UE.

ABSTRACT

Within agricultural water and industrial water the Full Cost Recovery (FCR) and the Polluter-Pays principles and which are the subject of article 9 of the Water Framework Directive (WFD), have not been achieved in most EU countries.

The aim of this report is thus to address the difficulties experienced by some EU countries. In industrial water, the fact that most users carry out direct abstractions from the resource has associated difficulties to promote an efficient use of water resources through water pricing. In agricultural water more types of users exist. But other variables, related to the management of supply infrastructures and to agriculture (irrigation techniques, grants for certain crops, lack of metering devices, …) make it difficult to carry out comparisons between countries as well as to achieve water efficiency.

Keywords: Water Pricing, Water Framework Directive, Full Cost Recovery, Polluter/Pays, Industry water, Agricultural water, EU.

SUMMARY

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INTRODUCTION

Human activity is one of the main factors affecting environmental conditions on the earth. Current economic practices, coupled with an increasing global population, are still not sufficiently ambitious in terms of sustainability, causing scarcity in resources such as water. In recent years, governance and management plans, designed to allocate resources among users and encourage an efficient use of those resources, have been implemented.

For water, a management policy appeared in 2000 with the promulgation of the Water Framework Directive (WFD). The WFD introduces the policy responses needed to regulate water use, one of these policies being water pricing. The use of such instruments brings additional social and political variables to the already complex field of water management.

In accordance with the WFD, ***recovering the full costs*** related to water supply, through a price paid by users, is now required. It is necessary to calculate a price that reflects the real value of water. The price should take into account water scarcity and the value of the aquatic ecosystems and, at the same time, has to ensure a good-quality service. The price contributes to the long-term sustainable management of water resources by ***promoting a more efficient and responsible use of water*** (however full cost recovery and promoting a better use, are not always compatible as will be demonstrated). In this context let us examine Article 9 of the WFD.

Article 9 of the WFD and Cost Recovery

Article 9 introduces the principle of cost recovery in accordance with the Polluter/Pays principle. In addition, it establishes all the services related to water use for domestic, agricultural or industry use*:*

- *Water abstraction, water storage, water treatment and water supply of both surface water and ground water.*
- *Water collection and treatment of wastewater and sewage before discharge.*

Currently, 14 years after the promulgation of the WFD, the point, for domestic use, is to know if the price actually reflects the real cost of water services. In agriculture and industry the point is to evaluate if water pricing actually encourages a more efficient use of water and if the correct pricing mechanisms have been implemented. Actually grants are considered to be a problem in the agricultural use of water. At the same time, in some European countries, such as Spain, Italy or Greece; pricing mechanisms do not always reflects water scarcity.

This document is structured in three main parts. 1. The understanding and analysis of the different pricing mechanisms implemented in the agricultural and industrial use of water, in some European countries. 2. The analysis and evaluation of cost recovery. 3. A global evaluation of the possibilities and limitations of water pricing in agriculture and industry.

WATER COSTS

WATER COSTS AND COSTS RECOVERY

In order to better understand the pricing mechanisms, which are used to achieve cost recovery, it's necessary to define the costs of water services. The WFD introduces three costs:

- Financial costs: Include all the costs of providing and administrating water services, which concern capital costs (investments and interest payments) and operation and maintenance costs.

- Resource costs: In the same water resource the use of a quantity of water by an upstream user means the impossibility to use this water for downstream users. This opportunity cost that is lost is called resource costs.

- Environmental costs: In a certain water resource, the use of a quantity of water may have an impact in the environment and in the aquatic ecosystems of this resource; these impacts are the environmental costs. A very clear example is the loss of ecological value in an aquatic system due to water abstraction.

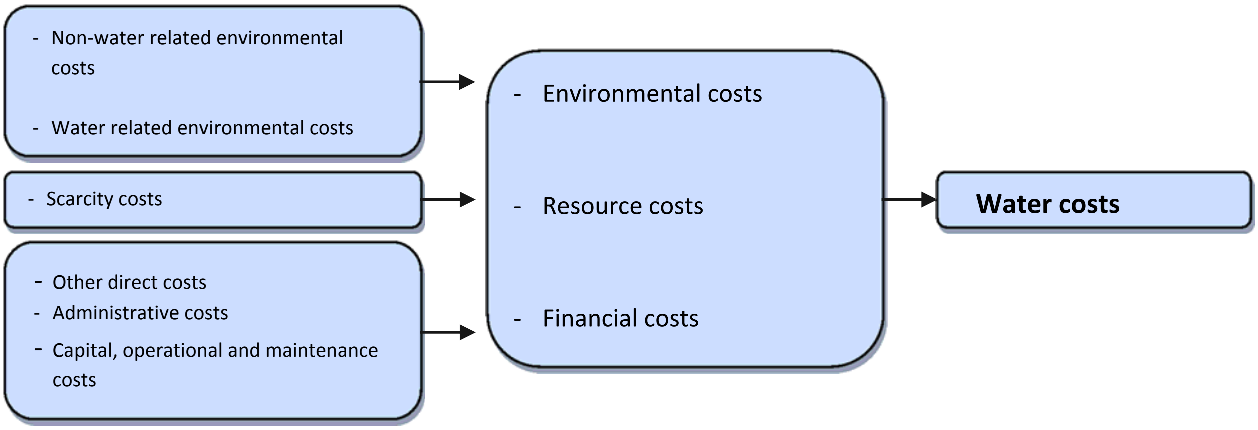


Figure 1.Water costs. Source: Wateco (EC, 2003)

These are the costs that should be paid by users and through these payments cost Recovery will be evaluated. In order to facilitate the evaluation recovery costs are broken down into three groups:

- C&I (Capital and Investment costs)
- O&M (Operational and Maintenance costs)
- E&R (Environmental and Resource costs)

Nevertheless the definitions of costs are limited:

Firstly it's quite difficult to give the exact monetary value to E&R costs. So the price of these costs is calculated, more or less subjectively, through estimations.

In addition, some economical costs related to the use of infrastructures, such as marginal or replacement costs, are not included in the WFD. So users do not pay the replacement costs by the time that the infrastructure is no longer useful the flow of paid charges would never be enough to build a new one. Furthermore, concerning cost recovery, in multi-purpose infrastructures (for example dams used for irrigation and domestic water at the same time) sharing costs between uses is not established in the WFD. So, how do we establish the quantity to recover by each use? And then, which price of water and pricing mechanism should be paid by each user?

Finally as every country is free to implement the pricing mechanisms that it considers most appropriate to achieve cost recovery, it's difficult to perform comparative analyses across countries' tariffs and cost-recovery rates.

WATER PRICING

When calculating the correct price that users should pay, it should be necessary to establish two parts, (a) a fixed rate to recover infrastructures costs and (b) a certain amount per unit of water consumed (which is not always the case). In any case the price of water is going to be calculated, for each use (drinking water, irrigation water and industry), as the sum of the price of each water service (water abstraction, water distribution, water treatment, …). Because each service can be charged in many different ways, the table below shows the most common water pricing mechanisms used for each water service.

Water service	Pricing mechanism	Cost types covered ([b])
Water abstraction	Tax or charge	E&R
	Water trading	E&R
Water supply/consumption	Water price/tariff	C&I; O&M
	Tax on water use	E&R
Sewage	Sewage charge	C&I; O&M
Wastewater treatment	Wastewater charge	C&I; O&M
Water pollution	Water pollution charge/tax	E&R
Quantitative water management	Water system charge	C&I; O&M

Figure 2. Pricing mechanisms for water service. *Source: EEA*

It's important to notice that the table shows just the most common pricing mechanisms but as has already been pointed out each service can be charged in many different ways, so the table does not represent all the possible water pricing mechanisms that could be implemented, the aim of the table is to facilitate a better understanding of how water pricing is usually implemented.

WATER PRICING IN INDUSTRY

In so far as water pricing in industry is concerned, there are two main services that determinate the final price of water and the water pricing mechanisms implemented - the supply and discharge of industrial water.

- **Source of water supply**

Industrial water can be supplied by the public network (which enables the implementation of to implement hybrid water pricing mechanisms, with a flat rate and a volumetric price) or by direct abstraction (in which case users will only pay an abstraction tax). Table 1 shows that the majority of water used by industry is abstracted and the public network plays a minor role. Three main elements can explain why most industrial water is abstracted (Baker et Tremolet, 1999) :

1. Water quality can be different from drinking water.
2. Direct abstraction can be the simplest and cheapest method when surface water is close by and where little treatment is required.
3. Abstraction taxes are generally quite low.

As table 1 shows, industrial water does usually come from surface water (except for Denmark) and represents between 70% to 90% of total abstractions. Normally the technologies necessary to abstract groundwater can be very expensive, however, surface waters may need a more intensive treatment before being used. Non-treated, reused or salt water can also be exploited; these waters are mainly used for cooling.

	% direct abstraction	% groundwater	% surface water	% salted water	% reused water
Germany	92	15	85	-	-
Austria	nd	28	72	-	-
Belgium	95	7	93	-	-
Denmark	nd	100	-	-	-
Finland	98	0	57	43	-
France	nd	42	58	-	-
Luxemburg	33	21	79	-	-
Netherlands	95	8	24	68	-
United Kingdom	64	19	81	-	-
Sweden	94	1	73	26	-

Table 1. Supply in industrial water. Direct abstraction part (Baker et Tremolet, 1999) and source of water abstraction for manufacturing industry (Wieland, 2003)

Despite these rather old figures (1999 and 2003), these are considered representative because of the high trend registered (more than 90% are water abstractions in many cases) and no changes in terms of trend have been highlighted in recent years. Only for reused water, figures may not be taken into account.

As most abstractions are carried out directly by users, there are significant difficulties to collect adequate data at the lowest possible scale to analyze the grade of cost recovery achieved through water pricing in industrial water. At the same time this makes it difficult to analyze the possible impacts that water pricing may have in the industrial demand of water (incentives), which is not the case for drinking or irrigation water.

For industries connected to the public network, the water pricing mechanisms used are similar to those applied to domestic users. Which means a two part bill with a fixed price or flat rate and a volumetric price (that covers all financial and E&R costs). This bill is levied by the water companies in charge of the service. But as industries are major users special schemes may be applied with decreasing or increasing prices.

Industries which abstract water directly from the environment can't be subject to pricing mechanisms covering financial costs (when building their own abstraction infrastructures they have already paid the amount of financial costs) so they are subject to an abstraction tax that is based on the permitted capacity or on the volume of water actually abstracted. These charges can vary according to the source abstracted (groundwater or surface water), the use of water, the season or local scarcity of water.

As financial costs are already covered by users, the aim of this tax is to cover the E&R costs, so revenues generated from water abstraction charges are mainly earmarked for environmental funds and/or basin authorities, and therefore regularly used for investment in infrastructure. Therefore a first question can be asked - how can the efficient value of the abstraction tax be calculated, in order to recover the environmental costs, if the real volume abstracted by industries is normally not known? And if we do progressively increase the value of this tax what impact will it have on industrial water consumption?

The table below shows the different pricing mechanisms implemented in the supply and discharge of industrial water. It's important to notice that in water rich countries (Scotland or Nordic countries) industries may not be subject to abstraction tax, so water pricing does not encourage a more efficient use of the resource (Speck et al, 2001).

- **Industrial wastewater discharge**

A part of the discharge of organic pollutants and most toxic discharges (heavy metals or persistent organic pollutants) are caused by industrial activity. Industrial effluents can be discharged into the public sewage network or directly into the environment. To discharge directly into the environment a permit is compulsory and the quality of the wastewater discharged is regulated and fines are applied when quality is not respected, so some industries are equipped with wastewater treatment plants to treat their wastewater before discharging (physico-chemical or detoxifying treatment).

When effluents are discharged into the public sewage network, companies have to pay 'wastewater charges'. Wastewater charges are sometimes included in the water charges. In those countries where sewage charges are independent from water charges, the pricing scheme can be composed of a fixed element (based on size, the value of the propriety or on the size of the water meter,…) and/or a volumetric part.

This charge can include a ***'pollution charge'*** which is calculated with the volume and the amount of pollutants in the industrial effluent. Slovenia, the Netherlands and the United Kingdom have defined 'pollution units', based on specific equations for each pollutant and the volume of effluents. A surtax on those pollutants which are difficult to treat can be added.

The cost of treatment of rainwater can be included in the water charge (as in Germany) in a specific sewage water (Denmark) or covered by the State budget.

Industries discharging their effluents into the environment have to pay a discharge charge which is close to the pollution charge. Revenues generated by the discharge charge are collected and given to the environmental funds or the state.

A question can again be asked: how reactive would be the quality of the discharges to an increase in the price for discharging into the environment (discharge charge)?

Water supply						
	Public network			***Direct abstraction***		
	Pricing schemes	**comment**	**price (€/m3)**	**Pricing schemes**	**Use of revenues**	**price (€/m3)**
Slovénie	Fixed part + volumetric part volumetric part		0,19 – 1,48			0,03 (Public service) (REC, 2000)
Allemagne	Fixed part + volumetric part	Decreasing prices for big consumers	1,80 (EEA, 2012)	Source, use, region, abstracted volume	Administrative costs	Surf. : 0,005 – 0,05 Ground.: 0,15 – 0,5 (OCDE, 1996)
Espagne	Various schemes mainly increasing with 2 sections		0,72 (NUS, 2002)	Use, region, granted capacity	Basin water board administrative and environmental costs	
France	Connection + fixed part volumetric part	**Decreasing** prices by sections, Contractual special prices	1,09 (NUS, 2002)	Source, use, region abstracted volume, granted capacity	Water board	Surf. : 0,002 Ground.: 0,004 (Ag. Rhin-Meuse, OCDE, 1997)
Ecosse	Fixed part (pipe diameter) Volumetric part		0,96(scottishwater.co..uk, 2012)	Inexistante	-	-
Pays Bas	Connection Fixed part (meter size) volumetric part	Special prices according to schedule of operation	1,15 (NUS, 2002)	Use, volume	Environment (provinces) General Budget (State)	Ground. : 0,12 (REC, 2000)
Angleterre y Gales	Connection Fixed part (pipe diameter) Volumetric part	Decreasing prices for big consumers	1,335 (OFWAT, 2012)	Source, use, loss factor, season, granted capacity	Environment Administrative costs	

Table 2. Pricing schemes in water supply. *Table 3. Pricing schemes in industrial wastewater discharge. Source REC* in *Speck and al, 2001* *Source OCDE* in *Baker and Tremolet, 1999*

Industrial wastewater discharge					
	Public sewage network			**Direct discharge**	
	Pricing scheme	**price €/m3**	**'Pollution charge' ?**	**Pricing scheme / List of pollutants**	**Use of revenues**
Slovénie	Fixed part + volumetric part volumetric part	0,28 (REC, 2000)		Pollution Unit Objective : incite with investment in sewage infrastructure	Central budget
Allemagne	Connexion tax? Water volume or propriety surface Decreasing price if volume smaller than consumption	1,75 – 2,47 (OCDE, 1997)		COD, P, N, halogenated organics, Hg, Cd, Cr, Ni, Pb, Cu, toxicity Charges paid only if the amount of each pollutant per year is over the standards	municipalities
Espagne	Operation charge + treatment charge		Pollutant charge expressed in Equivalent Habitant	nd	
France	Include in the water bill (%) Contractual special prices	0,47 (ONEMA, 2011)	Quality of effluent	Suspended solids, COD, BOD, P, soluble salts, halogenated hydrocarbons, heavy metals, N	Water board
Ecosse	Fixed part + volumetric part	1,61(scottishwater.co.uk, 2012)	yes		
Pays Bas	Based on pollutants quantity		Pollution unit. Counting for big users	Quantité et qualités des rejets émis à partir de modèles d'intrants/extrants. Mesures réelles pour les gros pollueurs	Infrastructures liées à l'eau
Angleterre y Gales	Volume of water supplied moins un 5%. Rain water evacuation. Special schemes for big users.		Formule MOGDEN selon teneurs en polluants	Volume, teneurs en polluants, nature des eaux réceptrices	

IRRIGATION WATER ECONOMY

Irrigation water has an influence and is also influenced by another economic activity - agriculture. So water pricing is not the only variable that can have an impact on irrigation water management. Water demand in irrigation banks on other agricultural variables (such as the type of crops, subsidies for certain crops, irrigation systems,…). Agriculture may also have an impact on water resources, even when water is not used (diffuse pollution caused by rain-fed surfaces and greenhouse surfaces). At the same time water pricing may impact agricultural activity (labour market and GNP).

All these notions have been subject of numerous studies carried out by experts in order to better understand all the factors and constraints of the irrigation water economy.

WATER PRICING IN IRRIGATION WATER

In so far as the irrigation water situation is concerned it is quite different across EU countries, actually there are two main groups:

- On the one hand in ***northern countries,*** characterized for not having water scarcity problems, farmers do usually carry out direct abstraction from the environment individually. So the situation is similar to industrial independent users, as they have built their own infrastructures only an abstraction charge can be implemented in order to recover E&R costs.

- On the other hand ***southern countries*** like Spain, the south of France, Greece or Italy; do experiment with water stress and water scarcity. Water availability is limited and water needs in agriculture are more important. So in order to ensure water availability, for all users all year long, large scale infrastructures have been built. For these users water pricing may have a more important impact on water management and tries to cover not only E&R but also C&I and O&M costs.

In comparaison with southern countries the evaluation of cost recovery for irrigation water in northern countries does not seem relevant, for several reasons: (a) Irrigation water consumption does not represent such an important part of total water consumption (drinking and indrustrial water), (b) As users are commonly independent only an abstraction charge can be implemented so the impact of water pricing in these countries is considerably reduced.

Types of users in agriculture In most cases, it's important to distinguish the ***users or community of users that are owners of the infrastructures*** (irrigation districts) from the ***users or community of users***[1, 2] ***that are not owners of the infrastructures*** (users that share and, in some cases, manage the same supply infrastructure, in other cases infrastructures are managed by private enterprises). Investment costs in this case have been commonly co-financed by public entities. Currently these subsidies have been reduced and in some countries like Spain, grants may be limited to economically depressed areas in order to promote their development and are known as social projects.

1. *Annex 1 shows the particular case of Spain in what type of users, pricing mechanisms and grants for infrastructures in irrigation water concerns.*
2. *Annex 2 shows some governance examples in Europe.*

As mentioned before, panorama in irrigation water is quite heterogeneous, the table bellow shows some of the pricing schemes and orders of magnitude implemented in EU countries with water scarcity.

Table 4.Pricing schemes in irrigation water.

	Irrigation water		
	Type of supply	**Pricing schemes**	**Price (€/m3)**
France	Water distributed (Loire-Bretagne)	All-in tariff Dual tariff (Sur. +Vol.) Dual tariff (discharge + Vol)	0,09 81 E/ha + 0,06 E/m3 38 E/m3/ha + 0,06 E/m3 (Gleyses, G. 2004)
	Water distributed (Adour-Garonne)	Dual tariff (Sur. + Vol)	157 E/ha + 0,082 E/m3 (Arcadis, 2012)
	Direct abstraction (surface water)	Abstraction charge	0,0015-0,03
	Direct abstraction (underground water)	Abstraction charge	0,002-0,003
Spain	Water distributed (Guadalquivir)	Volumetric tariff	0,026
		Flat rate	62,71 E/ha (Arcadis, 2012)
Cyprus	Water distributed	Volumetric tariff	0,15-0,17 (Arcadis, 2012)
Greece	Water distributed	Volumetric tariff	0,002-0,7 (Arcadis, 2012)
		Flat rate	73-210 E/ha (Arcadis, 2012)
Italy	Water distributed	Volumetric tariff	0,04-0,25 (Arcadis, 2012)
		Flat rate	30-150 E/ha (Arcadis, 2012)
Portugal	Water distributed	Volumetric tariff	0,002 (Arcadis, 2012)
		Flat rate	120 E/ha (Arcadis, 2012)

COST RECOVERY

As has been demonstrated by Berbel et al. (2005), we have to correctly estimate cost recovery in what O&M costs concerns. When evaluating cost recovery according to the Spanish Water Law (water tariff calculated by basin water boards adding a deprecation of the infrastructures) results show 99% of cost recovery. Nevertheless, when using accountability criteria with a higher depreciation and an interest rate of 5%, the estimation of the cost recovery is 71%.

INDUSTRIAL WATER

- **Financial costs**

Operational, maintenance and depreciation costs and capital return are covered in nearly all northern countries. By contrast this is not the situation in southern countries where financial help still exists as direct subsidies or as loans with a low interest rate (Davy and Strosser, 2001) in wastewater management. European funds play a major role, in particular in Greece and in Portugal where they contribute to water and wastewater projects (Roth, 2001).

- **Environmental and resource costs**

As a whole, environmental and resource costs are hardly included in the price of water. Environmental damages are internalised mainly under abstraction and discharge charges. The objective of these charges is seldom to protect the environment directly but to generate revenues used afterwards to protect the environment (Davy and Strosser, 2004).

In any case, for both uses (industrial and irrigation water), water pricing is not the only way to correctly manage the impact that the use of water has on the environment and the resource. Even if water pricing is important to ensure the necessary funds for building all appropriate conservation and sanitation infrastructures, it should act in conjunction with the regulatory standards which will impose limits.

The lack of information on industrial water (most users are “self-service”) does not allow us to correctly evaluate the level of cost recovery.

- **Incentives for more efficient use**

Water demand in industry is almost inelastic.

In contrast to the tendency experimented between 1999 and 2004 when environmental protection expenditure (funding allocated by industries to environmental protection such as wastewater and waste treatment activities) decreased (Olsson, 2005), EU countries should increase such expenditure, or at least maintain them.

IRRIGATION WATER

It’s important to note that water pricing in irrigation may have an impact in the labour market or even in the GNP of a region or a country. A clear example is the study performed by Castellano et al (2008), in an application of a GIS and social accountability matrices in the region of Navarra (Spain) they find the environmental value, which results from the average environmental cost that internalizes the value of all the externalities generated by irrigation water consumption. Then when increasing the water price in the half of the environmental costs calculated (optimal social price) means the internalization of 66% of the environmental costs, whereas an increase of the total environmental costs calculated guarantees the total internalization of costs but means a loss of 200 jobs. Finally an increase of 1, 5 environmental costs would result in a variation of -0, 31 in regional GNP and the loss of 400 jobs.

- **Financial costs**

The more heterogeneous situation in irrigation water results in having different levels of cost recovery across countries or regions, so the level of the cost recovery will rely on the type of users or community of users and on the way that the infrastructure has been financed (which will determine a certain pricing scheme).

The simplest situation would be for the farmer or the community of farmers who are owners of their own infrastructure (which is commonly the case for underground water), when talking about independent users, as happens in industry, they have built their own infrastructures so only E&R costs can be recovered through water pricing; when talking about irrigation districts they internalize themselves, their financial costs, but even if some efficient water pricing mechanisms could be implemented (such as a dual tariff) users most commonly pay a flat rate which does not incentivise more efficient use (per hectare rate).

With regard to large scale infrastructures (that have usually been co-financed) cost recovery level is far from what would be desired. As mentioned in annex 1 most infrastructure investment funds are non-repayable subsidies and can reach up to 60 % of total investment costs, so logically C&I are not recovered. The level of O&M costs recovery in some countries, such as France is total, and the following table shows the common values in the case study countries:

Pays	Niveau de Recouvrements de coûts financiers
France	Coûts O&M: 100% (Arcadis, 2012)
	Coûts d'Investissement: 15-95 %
Espagne	54 - 98 %
Chypre	51 % (Arcadis, 2012)
Grèce	54 %(Arcadis, 2012)
Italie	20 – 30 % (Sud) (Arcadis, 2012)
	50 – 80 % (Nord) (Arcadis, 2012)

Table 5.Level of irrigation water financial costs recovery.

- **Environmental and resource costs**

In agriculture two bills can be implemented in order to recover E&R costs. An abstraction charge and a pollution charge (which is not implemented in all countries). However the difficulty to estimate the monetary value of pollution results in a low influence of water pricing in pollution practices.

As mentioned in the ***Blueprint to Safeguard Europe's Water Resources (2012)***, the European Commission should introduce an official definition of E&R costs in order to calculate the optimal price of these charges (impact of pricing increase in common agriculture practices) and to achieve a more efficient use through water pricing schemes.

Calculating the optimal price of these charges is the objective of some authors who propose the convenience of carrying out an "***emergy***" analysis (Brown, Amaya and Uche, 2010). This type of analysis is quite interesting when calculating the value of resource costs in relation with the loss of energy, within two aspects: (a) the loss of water potential chemical energy (Gibbs free energy, chemical quality of water) and (b) the loss of geopotential energy; then these energy values are turned into monetary values (energy-emergy conversion factor and emergy-money ratio).

- **Incentives for more efficient use**

In any case, even if calculating the correct value of the costs is important to promote better use, it's necessary to establish the potential impact that water pricing may have in agricultural practices.

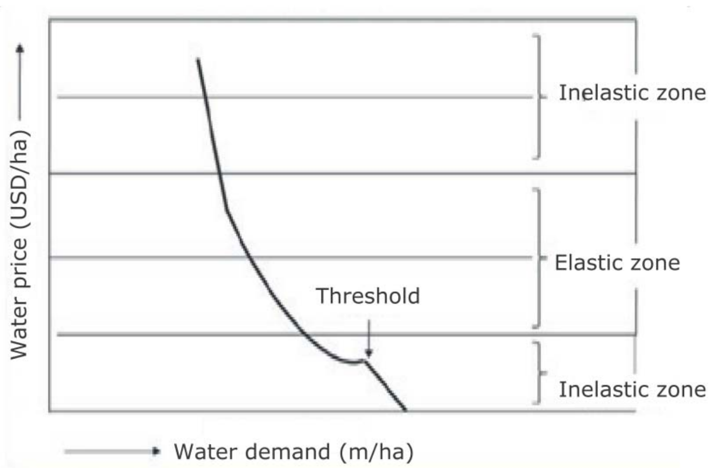
1. *Reducing water consumption. Volumetric tariff, water price and modernization of the irrigation system.*

Garcia Molla's (2002) analysis, in the region of Valencia (Spain), shows that water use variability can be explained by three factors: (a) the type and the institutional arrangement of irrigation districts (type of users), the origin of the used water and the type of pricing scheme. The lowest consumption levels, in Garcia Molla's results, are found in traditional districts supported by state projects with two part tariff systems (Vol. + Sur.).

As mentioned above in agriculture flat rates (per hectare rate) are commonly used among irrigation districts, which do not represent the scarcity of water, so a volumetric tariff could mean a decrease in water demand. The point then is to estimate the elasticity of water demand in relation to volumetric pricing and pricing increase.

As has been shown by various authors (Fraiture and Perry, 2007) irrigation water demand is quite inelastic in relation to price increases, though three ranges are found: (a) firstly, while increasing price, demand is inelastic, (b) when reaching a certain value demand becomes more elastic but (c) as price continues to increase demand becomes more inelastic (farmers are going to need a minimal quantity of water to grow their crops). The following figure illustrates demand behavior.

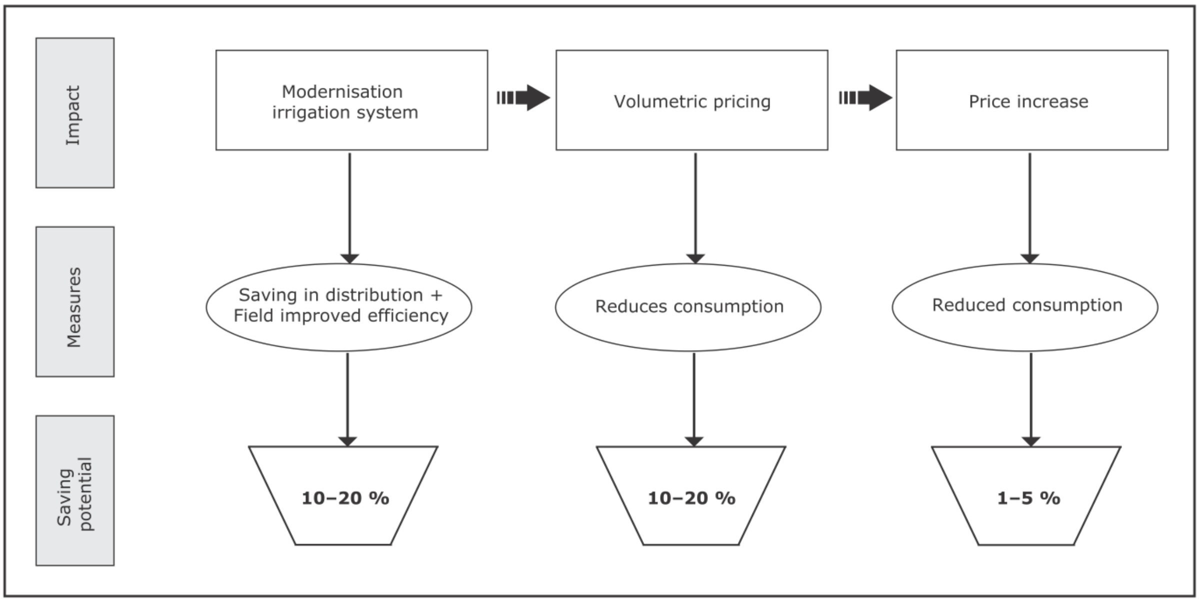
However, other factors may influence water demand, when water does not represent an important cost in total agricultural costs or when the irrigation system is already relatively modern demand's elasticity is lower. So even if demand is quite inelastic, water demand is not stable and may vary in relation to the modernization of the irrigation system and in relation to the volumetric pricing as shown by figure 4 below (Strosser et al, 2007).



Source: EEA based on de Fraiture and Perry, 2007.

Figure 3. Elasticité de la demande

Nevertheless it's important to be careful when evaluating the saving potential of the modernisation of the irrigation system, Garcia Molla (2002) has shown that a modernisation of the irrigation system has resulted in a decrease of water consumption. The same tendency has been found in the Guadalquivir basin, the explanation being that the modernisation of the irrigation system encouraged farmers to plant more water demanding crops and which are more profitable (Berbel et al., 2005).



Source: Strosser et al., 2007.

Figure 4. Potential saving of water demand

2. *Reducing water consumption. Farm subsidies.*

Many authors have established a relationship between water demand and farm subsidies in Spain (Sumpsi et al., 1998; Gomez-Limon et al., 2002; Arriaza et al., 2003). These subsidies encouraged farmers to plant more water demanding crops, causing a disequilibrium between water availability in a region and water demand. Indeed the results of these studies established that removing water subsidies has a larger effect on the farmers' choices than increasing prices.

3. *Reducing diffuse pollution. Pollution charges, agricultural markets and public regulation.*

Agriculture is the main cause of nutrient pollution in Europe (including rain-fed and greenhouse surfaces). Indeed the impact caused by rain-fed and greenhouse surfaces is more important than the impact caused by irrigated lands in most basins. Examples of the effects of these pollutants have been found in France (Adour-Garonne), in Spain and in some vulnerable parts of Greece.

Some countries, such as France or the Netherlands, have attempted to internalize these costs by introducing an "ecotax", although the level of cost recovery achieved through this tax is low.

Indeed, some authors disagree with the use of this kind of water pricing incentive (Martinez and Albiac, 2005), because reducing diffuse pollution is more effective by targeting the source of emissions than by imposing pricing incentives. Nevertheless, even if the impact of water pricing incentives in reducing pollution is more reduced than the impact of agricultural markets and policy measures (Bartolini and al., 2007); a certain charge, even symbolic, is important to make farmers conscious of the actual value that water has for society (Seeman et al., 2007; Riesgo and Gomez-Limon, 2006).

In any case a more rational use of water resources means a decrease in diffuse pollution (Dinar and Letey, 1991; Calatrava and Garrido, 2001). So water pricing incentives, such as an ecotax, should be developed in parallel with public policies and regulations to limit the negative impacts of pollution in rural surfaces.

ANALYSIS OF STUDY CASES

In all EU countries subject to analysis, none is in conformity with all current directives (WFD, nitrates directive, urban waste water directive,…). Nevertheless each country has a particular situation in relation with the type of infrastructure funding, type of irrigation districts and the efforts being made.

SPAIN

Even if Spain is the country where the impact of water pricing in agriculture has been most studied, water stress is quite important in Spain, and Spain certainly can't not be consider as a good case in point.

In so far as infrastructure financing and irrigation users are concerned, in Spain 70% percent of water resources are distributed by irrigation districts and 90% of water costs are controlled by private enterprises, what could represent a favorable scenario to correctly manage water resources through water pricing.

Although two are the main factors that have contributed to the over-exploitation of water resources:

- The lack of metering devices promotes a fixed tariff. 82 % of irrigated surfaces in Spain are present a per hectare rate and only 5 % present a dual tariff.
- EU funds and subsidies have encouraged the planting of more water demanding crops that do not match with the water availability resources in the regions.

PORTUGAL

In terms of water availability Portugal presents a healthy situation, nevertheless important differences between northern and southern regions do exist. In any case most regions do not present an over-exploitation of water resources. Irrigation water represents 61 % of total water consumption in the country.

The particularity of Portugal is that the State role in promoting irrigation projects has been quite reduced. Public irrigation projects are focused mainly in the southern regions and make up only between 19 to 25% of irrigated lands in the country. Although the particularity of the situation a very complex pricing mechanism is usually implanted in Portugal: the ***TEC***[3] (Taxa de Exploraçao e Conservaçao). This pricing mechanism is positive and encourages a more efficient use of water resources.

Nevertheless as E&R costs have not been evaluated, Portugal has traditionally allowed water abstractions without implementing any charge, in many cases diffuse pollution has not been considered. This practice is in clear nonconformity with the WFD (resulting in convictions by the European Court in 2006). Currently institutional and legal progresses have been made, but only in public projects.

GREECE

Greece is also relatively well endowed in respect of its water resources. The agricultural sector represents 35 % of total GNP. According to the FAO water used in Greece represents only 10 % of total renewable resources.

The main points of Greece are the initiatives combining irrigation management and environmental objectives. The law 3199/2003, that tries to adapt WFD to the Greek legal system, establishes the main environmental objectives in water management. Greek law has also established a method to evaluate E&R costs and create water management agencies.

Concerning irrigation infrastructure development, the irrigated surface has increased by 65 % over the last 20 years as a result of political commitments and private initiatives (60 % of Greek irrigated acreage). The remaining 40 % of Greek irrigated lands is composed of co-financed irrigation projects managed by TOEVs and GOEVs. So Greece's water economy is currently approaching maturity, with water demand tending to stabilize (Margat 2002) and public investment decrease.

Despite this progress, Greek water management through water pricing presents two main negative aspects:

- As water resource access has not been yet totally regulated, and as the water management agencies and water suppliers are mainly regulated by the civil code; it's not been possible to establish the main water pricing mechanisms implemented in the country.
- No effort has been introduced in order to make farmers pay for the maintenance and rehabilitation costs of the infrastructures, which is quite important due to the weight that agriculture has in the national economy. (resulting in convictions by the European Court in 2008)

ITALY

Water resources are unequally distributed in Italy (abundant in the north, but scarce in the south). Water demand has decreased in recent years but is now tending to stabilize (Massaruto, 2001, Margat 2002). In efficiency terms Italy is far from objective:

- 50% of water used in Italy is distributed by infrastructures managed by CBI, (Consorzi di Bonifica e Irrigazione). Pricing schemes implemented for the users of these infrastructures is composed of an abstraction tax and tariff, though, these charges do only cover partially O&M costs which results in poor maintenance of the infrastructures (AAVV, 2001).

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3. Annex 3 explains TEC's (Taxa de Exploraçao et Conservaçao) components.

- 38 % of the irrigated area is irrigated by flooding or watering techniques (Eurostat, 2005).

FRANCE

As in Italy, in France water resources are unequally distributed. In the north users are mostly independent while the south experiences more water scarcity. According to Rieu (2005) in 54,6 % of irrigated areas water is supplied by direct abstractions, in 23,6 % water is supplied by infrastructures managed by irrigation districts and the remaining 20% combine both types.

Despite this heterogeneity France is to be admired in terms of water efficiency. The Water Law of 2006 is behind this good track record because it:

- obliges the installation of metering devices in all irrigated surfaces which enables the implementation of volumetric tariffs (85% of the irrigated are do dispose the such devices ; CGGREF, 2005)
- Defines the types of charges that can be implemented by the 6 Water Management Agencies.
- Requires an abstraction authorization for any user that can be temporally or permanently reduced or revoked by the prefects.

The only negative point in France irrigation water management is diffuse pollution (non-conformity with nitrates directive, resulting in convictions by the European Court in 2013), though, water pricing efforts have been made via the introduction of the “Ecotax”.

CONCLUSION

On the one hand the several studies completed since the WFD promulgation, have highlighted various general conclusions that are commonly linked to the WFD. The major conclusions are (Molle and Berkof, 2007; Tsur et al., 2004):

- Water pricing schemes are important to ensure a good-quality service, however, their importance while managing water resources (water demand, environmental effects and cost recovery level) is limited. Politicians and practitioners should be conscious of these limitations and lower their expectations.
- Cost recovery level evaluation is a challenging task due to poor cost definitions (especially for E&R costs).
- Water supply costs are difficult to evaluate and subject to crucial assumptions, linked to (a) replacement and marginal costs are not taken into account and (b) multipurpose infrastructures costs recovery are not defined.
- From an accountability point of view O&M costs evaluation it’s not clear (Berbel et al., 2005). Full O&M cost recovery do not ensure appropriate maintenance and management.

Other conclusions linked only to irrigation water may be extracted from various expert studies (Molle and Berkof, 2007; Tsur et al., 2004):

- Water demand is quite inelastic (in relation to the water price), but is quite responsive to (a) the type of crop planted (subsidies and CAP directives influence), (b) the modernisation level of the irrigation system and (c) to the implementation of a volumetric tariff.
- Diffuse pollution is not very responsive to water pricing incentives.
- A more efficient use of water resources leads to a reduction of diffuse pollution.

On the other hand, the main conclusions extracted during the elaboration of this paper are:

INDUSTRY

As most users in industry do abstract water directly from the environment they actually pay for all the financial costs for their own infrastructures, but at the same they are not subject to other pricing mechanisms other than an abstraction or a pollution charge, so the impact of water pricing in industrial water management is reduced. In any case it's important to fix the correct monetary value of these charges in order to promote more efficient use (E&R costs).

During the preparation of this paper no adequate data about the impact of water pricing on industrial water demand or on industrial activity was found, so no adequate incentives can be defined, although, it's logical to conclude that the impact, concerning a more efficient management of water resources, of public regulations or directives may be much more important than the impact of water pricing.

AGRICULTURE

Conclusions extracted from experiences and feedback in irrigation water in the EU are:

- The least water demanding scenario is one in which the infrastructure is co-financed by the state and is managed by an irrigation district that imposes a dual tariff (flat rate + volumetric tariff).
- Large scale infrastructures have been mainly subsidised.
- Per hectare rates do not represent water scarcity, so metering devices should be installed in all irrigated areas in order to reduce water consumption through a volumetric tariff.
- Users do not always pay all the O&M costs required to ensure a good-quality service.
- Modernisation of the irrigation system may not decrease water consumption but increase it (farmers choosing to plant more profitable but more water demanding)crops
- EU subsidies for crops have led to a water demand which fails to correspond to water availability in some regions.
- Even if the decreasing potential of diffuse pollution through water pricing incentives in irrigation is low, it's recommended to implement them in order to make famers more aware of the value that water actually has for society.
- And a final question, as investment cost are not recovered in irrigation, when the infrastructures become no longer useful, are users going to become "self-service" users?, In which case will irrigation practices become totally unresponsive to water pricing?

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ANNEXES

ANNEX 1. TYPE OF USERS AND PRICING SCHEMES IN IRRIGATION WATER (Spain)

Resource management and the rate structure applied in the Spanish irrigation sector can vary significantly from one river basin to another. River basin authorities may allocate water rights to end users directly or via irrigator communities (comunidades de regantes) who then administer the resource to the users (Arcadis et al., 2012). In its integrated report on Article 5 and Annex III of the WFD published in 2007, the Spanish Ministry of Environment (MMA) recognised the existence of the following modalities of irrigation communities in the country.

- ***Traditional Irrigator Community.*** Created before the District Agricultural Development Plans implementation, these irrigator communities are the owners of the infrastructures that they actually use. State action works towards an investment in maintenance and in the irrigation network renovation. These communities are classified Depending on water availability:

  • Surface water available is usually sufficient for a normal year's needs, only during drought periods other resources are needed.
  • Surface water available is not sufficient for normal year's needs and need to be completed with ground waters abstractions.
  • Water is stocked in dumps run by private enterprises.
  • Other situations.

- ***Irrigator Community subject to state plans (new irrigation networks).*** Infrastructures have been built with state funds, so the dumps and main canals are manage by the state. Farmers do usually use, at the same time, ground waters and the surface waters distributed by the state infrastructures.

- ***Entities that only use ground waters.*** Groundwater users do usually build their own infrastructures, so when building their own abstraction infrastructures they have already carried with the amount of financial costs, so they are only subject to an abstraction tax.

And the modalities of pricing for irrigation water in the country are:

- The user pays a yearly amount based on the area of land irrigated, independent of the volume of water used. This fee covers all the costs of the irrigator community. This model is commonly applied by traditional irrigator communities.

- The user pays fixed amounts per unit of land which provide them with irrigation rights. These fees commonly cover maintenance, vigilance, administration and other fixed costs, but no variable costs. The latter are recovered through variable fees which are calculated as a function of the number of hours of irrigation, and in some cases, of the volume of water used.

- The user pays per application, regardless of the volume of water used. This model is applied in some communities which use surface water for irrigation.

- The user pays using a theoretical flow rate during a designated amount of time. This model is applied in the majority of entities managing groundwater.

- The user pays for the volume of water used. This model is only applied in entities using drip irrigation (MMA, 2007).

Lack of metering devices carries that the most common modality for pricing in irrigation (per hectare rate) does not represent water scarcity in the country.

Il est intéressant ainsi de noter que quand les investissements sont réalisés par l'état, ils sont à fond perdus dans la plupart des cases, et pourtant ne sera favorisé le recouvrement des coûts financiers par les usagers.

With regard to infrastructure financing, the values of funds for financing in the National Irrigation Plan Horizon 2008 (Plan Nacional de Regadios Horizonte 2008) are:

Scale	Organisation/Origin	%Funding
General National Administration	Ministry of Fisheries and Agriculture	19,98 %
Autonomous Administration	Agriculture Regional Ministry	19,98 %
European Development Funds	FEOGA-Orientation	20,10 %
Private	Irrigation communities	39,95 %

Table 6.Infrastructures financing in Irrigation water

ANNEX 2. EXAMPLES OF INFRASTRUCTURES FINANCING AND MANAGEMENT IN IRRIGATION WATER

In ***Italy*** distribution networks are managed generally by the CBI (Consorzi di bonifica e Irrigazione), Which are commonly managed by owners associations. These entities are controlled through public law. 90% of irrigation water is actually distributed by these entities in Italy. CBIs are in charge of the operational and maintenance costs, though the investments costs are funded by the state.

In ***France*** the Associations Syndicales Autorisées (ASA) are users associations with a reduce size. The Sociétés d'Aménagement Rural (SAR) are private associations that manage the infrastructures.

In ***Portugal***, agricultural water tariffs are levied by users' associations in accordance with very complex mechanisms and formulae. The complexity arises because WUAs sometimes supply municipal water as well, property size affects the water charges.

In ***Greece***, the cooperative irrigation Projects result From the joining of the Local Land Improvement Boards (TOEV) and the National Land Improvement General Boards (GOEV), being the former the responsible of running the collective irrigation schemes.

ANNEX 3.TEC (Taxa de Exploraçao e Conservaçao)

TEC is composed by three out of these 5 pricing mechanisms:

Pricing models	Bragança, 1998 (OECD study) (USD)	DGADR, 2005 (EUR)	DGADR, 2007 (EUR)
Fixed rate per ha improved	18 to 270	16.21 to 215.48	16.21 to 221
Fixed rate per ha irrigated	31 to 146	16.21 to 45.45	18 to 115
Volumetric rate per m^3 used	0.01 to 0.028	0.0107 to 0.065	0.011 to 0.092
Drainage rate (per ha)	19 to 67	19.3 to 197	38.9 to 210
Rate per ha of irrigated crop	16.9 to 87.3	10 to 203.3	13 to 210.9

Table 7. TEC (Taxa de Exploraçao e Conservaçao)

AgroParisTech
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