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Determining a socially fair drinking water pricing policy: the case of Kozani, Greece

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Abstract

The Water Framework Directive (WFD) 2000/60/EC clearly indicates that all member states should develop and apply water pricing policies to recover the Full Water Cost (FWC) (including the direct cost, the environmental and the water resource costs). Drinking water pricing policies set by the water utilities today do not comply with the WFD basic principle. They are rather determined locally, without taking into consideration environmental (e.g. river basin water balance) or economic issues (e.g. socially fair allocation of the water cost). This paper proposes a new, socially fair drinking water pricing policy, taking into consideration the FWC recovery and socially fairness. This methodology is applied in the water utility of Kozani, in Greece.

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Keywords: Water price; full water cost; Water Framework Directive; socially fair water pricing policy

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1. Introduction

Efficient and sustainable water systems management toward worth living development contributes to social, economic and environmental balance, in a global level. With this respect, the Water Framework Directive (WFD) 2000/60/EC has established an institutional framework, providing guidance for common approach, objectives and shared principles regarding water resources and water supply management, in a European level. Furthermore, water pricing policies developed by governments are recommended to allow full cost recovery of water services, including direct, environmental and resource costs. As water pricing is a crucial issue both for decision makers, water utilities and consumers, it is imperative that socially fair prices should be set, especially for drinking water. It is a fact that water pricing policies differ a lot not only among different countries but also within the same country among the water utilities. Most of the times water use is being metered and there are many water pricing structures, such as inclining block rates, declining block rates, uniform rates and seasonal-peak rates. When the water use is not being metered, the customers are being charged a flat rate equalized for each customer or taking into consideration its individual characteristics [1]. Tariffs' structures in most European countries include a fixed charge whose value varies a lot. It is also a fact that Non-Revenue Water (NRW), water volume not generating revenues because it is provided for free from the water utility or it represents commercial (apparent) or/and real losses, is a big part of the water entering the distribution network (System Input Volume-SIV). So, the main question is who has to pay for this NRW volumes? The authors taking into consideration the full water cost (FWC) recovery principle, propose a methodology for the estimation of a socially fair average water price, including also the allocation of the water use the consumer has to pay for. This methodology allocates different water uses (consumers' water use, water theft, meter errors, real losses, etc.) to the two basic water users: the consumers and the water distribution network (WDN). A new higher mean water price is estimated tending to fluctuate due to the water price elasticity of demand. Finally, the optimum mean water price is found by simulating its fluctuations.

2. Drinking water cost and pricing policies: a review

2.1. The Full Water Cost

WFD 2000/60EC has introduced guidelines for the FWC estimation and the FWC recovery calculation based on the current water pricing. The innovative feature of the WFD lies on the fact that it defines the river basin as the basic spatial and environmental framework for calculating environmental and resource costs regarding the water sector. WFD is governed by the "principle of sustainability", the "polluter pays principle" and the "principle of proportionality". The necessary steps to calculate water utilities' FWC is to calculate its three components (Direct – DC, Environmental - EC and Resource – RC costs). In a river basin many users and non-users of water may be involved, affecting directly or indirectly the quantity and quality of water used by a utility's consumers. The definition of environmental damage will lead to the definition of EC. Environmental damage during human activities is caused when their results decrease the level of environmental quality [2]. Environmental cost is considered to be any damage caused to water with subsequent quality degradation. Environmental damage may suffer other human activities dependent on good water quality (recreation, fishing, etc.). In case of the quantitative damage of water resources by human activities, both economic impact of water users' activities and potential new costs for water utilities must be calculated. This cost is conceptually defined as the damage created to natural stocks which took hundreds of years to be created [2]. Many ECs and RCs have been incorporated by water utilities and are counted as DCs. According to the WFD, these costs should be clarified and incorporated to EC and RC. The proper separation of FWC in its components will lead to the correct Full Water Costing and therefore to the proper Full Water Pricing.

The calculation of the three FWC components is expected to increase the current cost of water but may also cause a reallocation of costs between the components. For example, costs considered today as direct costs, such as energy costs, can ultimately be resource costs due to groundwater over-pumping by farmers. Thus, this kind of cost should be paid by them. The water costs should be calculated on a monthly step as they depend on many different variables, such as seasonal water consumption, water abstraction sources (springs, boreholes), energy costs, etc. The water distribution network should be considered as a distinct water user and the costs due to poor water distribution network management should be calculated. Poor water pressure management and non-implementation of NRW reduction strategies reflect to high revenue loss and increased water price for the consumers. The calculation of Economic Annual Real Losses (EARL) which is the optimal economic level of leakage will act as a guide for implementing NRW reduction strategies which should reduce the FWC. In the long run the correct FWC calculation, the application of the "polluter pays principle”, the implementation of NRW reduction measures and the application of the full water pricing will result into system’s sustainable balance.

2.2. Drinking water pricing policies

Although, several EU member states have made significant progress, more specifically 25 out of the 27 of them have completed the task (fully or partially) to develop appropriate water pricing policies (towards FWC), other member states such as Portugal and Greece are far behind this goal [3]. Moreover, the level of environmental and resource costs integration into pricing policies through economic instruments varies not only by Member State [4], but also by region or River Basin District [5] (Fig. 1).

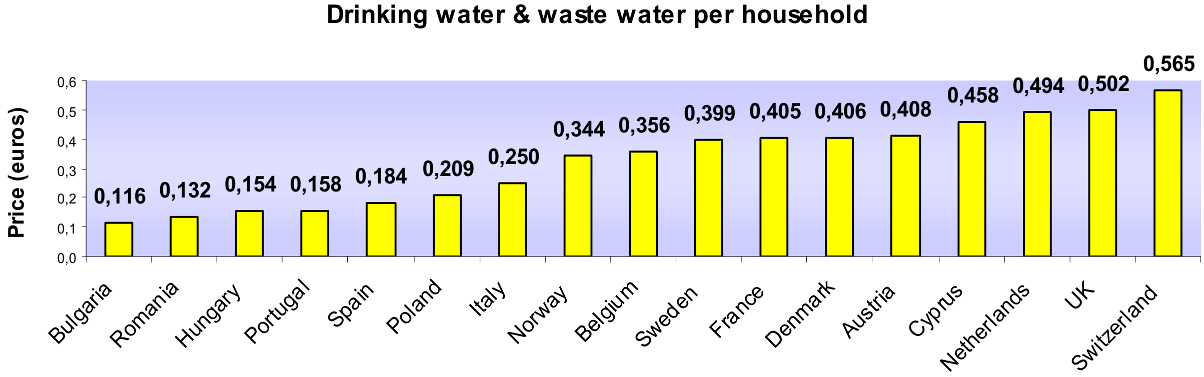

Fig. 1. Drinking Water & Waste Water prices per household in EU member states [4]

Even in more developed countries, the price of water differs by region, partly because of structural differences and partly because price components vary between several water utilities. In Denmark for instance, a number of water utilities have chosen to charge a fixed annual charge for water and/or waste water and a price per cubic meter for water consumed, whilst others charge only for the water used [4]. Additionally, although water pricing structures in selected European countries (England and Wales, Scotland, Netherlands, France, Germany, Slovenia, Croatia, Serbia, Spain) are a combination of fixed and volumetric charge [5], in a number of OECD countries, the structure of prices for public water services are volumetric oriented rather than fixed charging [6]. For instance, several countries such as Hungary, Poland and Czech Republic have already adopted water pricing policies based only in volumetric pricing with a trend in moving towards increasing-block tariffs. In Greece, a fixed charge is also used additionally to a volumetric water pricing model. A recent study [7] showed that there is no common pricing policy between the Greek water utilities. Each water utility charges different fees and tariffs to their water bills. The mean payable amount does not display great variation between low and high consumption while high consumption and water wasting are not discouraged [7].

Looking at the nexus between all specific parameters, reliable metering systems of water consumption are also a precondition for the application of efficient water pricing policies. Safeguarding both transparency and fairness of water pricing policies based on reliable water metering and improved cost-benefit assessments to ensure cost-recovery is one of the basic principles of the EC.

In conclusion, the development of “appropriate water tariffs” is influenced by a number of factors, such as local characteristics, different geological and climatic parameters and different institutional and regulatory framework [7]. With this respect, water utilities should adopt a more strategic approach that could be cost effective and could be used to signal water scarcity and to create incentives for efficient domestic water use. The overall objective is to implement an appropriate water pricing policy in Greece, better designed tariff structures and targeted measures, in order to implement the EU guideline regarding FWC recovery.

3. Determining a socially fair drinking water pricing policy – The methodology

Socially fair drinking water pricing policies should include a fair fixed charge, representing the opportunity cost the consumers should pay and a fair FWC allocation to the users. The fixed charge is part of the pricing policy but today it is not calculated on a socially fair basis. In a socially fair water pricing policy, the fixed charge should only represent the opportunity/access cost, as both the water utility and the infrastructure it daily manages simply exist to supply its customers with adequate quantity of good quality water [8]. The socially fair fixed charge should only include the fixed costs not related to the water volume the customer consumes (i.e. water meters' and service pipes' maintenance cost, water connection fee, firefighting, public use costs etc.). Fixed costs (proportionally) related to the water volume each customer consumes, such as water mains' (and not service pipes) repair costs, pipes and tanks washing costs, etc. should be appropriately incorporated in the unit selling price of the water use (of the first block in cases of inclining block rates applied) as they relate to the "water network percentage of use" index [8]. Apart from the fixed charge, socially fair water pricing policies should allocate the FWC to the water users, including the water utility as the network itself is one of the main water's users. The water utilities' practice is to charge all the NRW related cost to the consumers although they are not fully responsible for it. For example, if a water distribution system experiences a NRW level of 50% of the SIV, the water utility will charge twice the price of water to recover the cost of the NRW. A socially fair cost allocation of the water uses among the users is developed by Kanakoudis & Tsitsifli [8]. When designing a socially fair allocation of the costs related to the water volumes consumed in the water distribution network, the consumer has to pay for (Table 1): (a) The actual water volume he consumes which is the Revenue Water (Q_{RW}); (b) The unbilled consumption (Q_{UNB}) which is authorized including washing the mains and the tanks, firefighting, public buildings' consumption etc. All these consumptions aim at the consumers' quality of life improvement and provide services to him; (c) The water volume not recorded because of the meters' errors (Q_{MER}) since this volume is actually consumed by the users (including leakage within his property); (d) The optimum level of the Unavoidable Real Losses ($QUARL_{opt}$) as the opportunity cost. The role of the water distribution network is to serve the users with water at their taps; and (e) A part of the difference between the Unavoidable Real Losses and the Economic ones ($Q_{EARL\text{-}UARL}$), proportionate to the part of the water volume entering the network that the customer consumes. The water volume $Q_{EARL\text{-}UARL}$ can be recovered using technical solutions but it is not economically effective since the recovery cost is higher that the revenues from selling the water. The level of this water volume depends on the cost of the techniques used and especially from the water price. Thus, the cost of this water volume should be shared proportionally among all consumers [8].

On the other hand, the water distribution network (the water utility) has to pay for (Table 1) [8]: (a) The water volume corresponding to the recording errors (Q_{RER}) since it is the utility's responsibility to record and transfer correctly the water meter recordings; (b) The water volume consumed illegally (Q_{WTH}) e.g. water theft, illegal connections etc. as it is the utility's responsibility to perform audits and impose measures to avoid unauthorized uses; (c) The difference between the Current level of Real Losses and the Economic ones ($Q_{CARL\text{-}EARL}$) as a kind of penalty because of the bad infrastructure and the fact that the utility does not implement any water losses reduction measures; (d) All the difference between the Unavoidable level of Real losses and their optimum ones $Q_{UARL\text{-}UARLopt}$. The water utility must improve the performance level of its distribution network and take all the necessary measures (active leakage control; pressure management; speed and quality of repairs) to achieve the optimum level of unavoidable real losses; and (e) The attributable part to the utility (the part it uses being (1-a)) of the difference between the unavoidable real losses and the economic ones ($Q_{EARL\text{-}UARL}$).

To estimate the socially fair pricing policy for drinking water the authors propose the following methodology, consisting of 5 steps:

1. FWC estimation;
2. Estimation of the unit water cost based on the FWC recovery (eq.1).

$$UWC = WP_0 = (FWC/SIV) \tag{1}$$

where: UWC and WP_0 both represent the unit water cost; FWC is the full water cost (€); and SIV is the system input volume (m^3).

3. WP_0 is the average unit water cost if the whole SIV was sold to the consumers. As only a part of the SIV is sold to the consumers (and this is the RW), then a new unit water cost must be calculated. The new unit water cost (WPA) is calculated by charging the whole cost to the consumers based on their consumption. If Revenue Water is b% of the SIV, then the unit water cost the consumers will pay is:

$$WPA = (FWC/SIV)^* (1/b) = WP_0^*(1/b) \quad (2)$$

4. Responsibility allocation and estimation of the percentage of responsibility the consumers have. Based on the methodology by proposed Kanakoudis & Tsitsifli [9], it is socially fair that the consumers will pay a% of the SIV (as calculated in Table 1).
5. Calculation of the socially fair average water price, WP_1 (eq.3).

$$WP_1 = (a/b)^* WP_0 \quad (3)$$

Table 1. Responsibility allocation of water cost recovery [8]

Water quantities per use in the distribution network				Customer	Water Utility
				$\boldsymbol{Q_{CUST} = a \times Q_{SIV}}$	$\boldsymbol{Q_{DN} = (1-a) \times Q_{SIV}}$
Q_{SIV} (100%)	Q_{RW} (60%)	Q_{RW} (60%)	Q_{RW} (60%)	100% x (60%)	-
	Q_{NRW} (40%)	Q_{UNB} (5%)	Q_{UNB} (5%)	100% x (5%)	-
			Q_{WTH} (2%)	-	100% x (2%)
		Q_{AL} (15%)	Q_{MER} (10%)	100% x (10%)	-
			Q_{RER} (3%)	-	100% x (3%)
			$Q_{CARL-EARL}$ (5%)	-	100% x (5%)
		Q_{RL} (20%)	$Q_{EARL-UARL}$ (5%)	a% x (5%)	(1-a)% x (5%)
			$Q_{UARL-UARLopt}$ (2%)	-	100% x (2%)
			$Q_{UARLopt}$ (8%)	100% x (8%)	-
				$Q_{CUST} = (0.83 + 0.05 \times a) \times Q_{SIV}$	$Q_{DN} = (0.17 - 0.05 \times a) \times Q_{SIV}$

4. The case of Kozani, Greece

4.1. The case of Kozani – the current pricing policy

Kozani is the capital city of Kozani Regional Unit, in the North-Western Greece, with a population of approximately 71,000 people (according to the 2011 census). Ermakia natural resources and two groups of boreholes located in Vathylakos are used for water supply of the city of Kozani. DEYAK is the municipal water utility of Kozani, responsible for drinking water supply and sewerage services.

The actual DEYAK's water pricing tariffs are separated by type of consumption (residential; commercial; public sector) and by certain social criteria in residential tariff, i.e. social tariff for families with more than 3 children, patients suffering from nephropathy, etc. DEYAK total revenues are composed of: the value of water volume consumed, the fixed charge of 17€/4 months (billing period), the fixed maintenance fee of 2.06 €/4 months, the special fee which is equal to 80% of the water value and the sewerage charge which is equal to 85% of the water value. Table 2 presents the current structure of the DEYAK's water pricing policy.

The analysis of the pricing policy (base year 2013) resulted in the following outcomes: (a) residential consumption is 87.8% of the total consumption, while residential water meters represent 96.5% of the total water meters and the residential revenues represent 87.05% of the total revenues; (b) 10.71% of the total residential water meters do not register any consumption (Fig. 2); and (c) The value of water represents only 23.15% of the total revenues derived from the pricing policy (Fig. 2).

Table 2. DEYAK's 2015 water pricing policy

Residential		Multi-child families		Social tariff		Commercial tariff		Public sector tariff	
scale(m^3)	value (€)	scale(m^3)	value (€)	scale(m^3)	value(€)	scale(m^3)	value(€)	scale(m^3)	value(€)
0-20	0.38	0-60	0.38	0-20	0.19	0-80	0.60	0-80	1.68
21-40	0.46	61-100	0.60	21-40	0.23	81-500	0.99	81-160	1.90
41-60	0.60	101-160	1.25	41-60	0.60	>500	1.11	>160	2.12
61-80	0.76	>160	3.05	61-80	0.76				
81-100	1.01			81-100	1.01				
101-120	1.25			101-120	1.25				
121-160	1.53			121-160	1.53				
>160	3.05			>160	3.05				

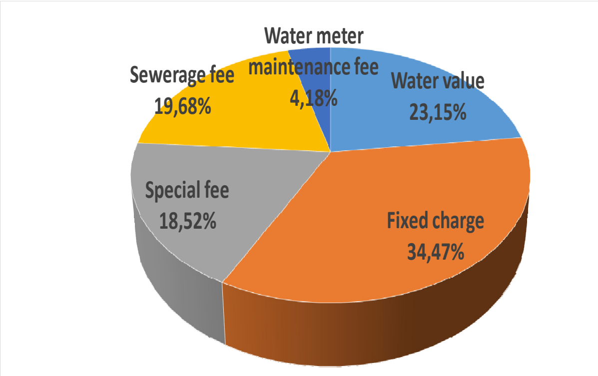

Fig. 2a. Water revenues allocation

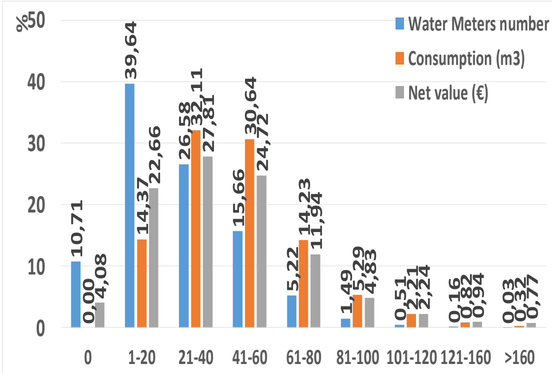

Fig. 2b. Water meters number; consumption; & net water value (%) per consumption blocks

4.2. Estimating the FWC for Kozani Water Distribution System

The first step toward the formation of a socially fair pricing policy is to estimate the FWC. To estimate the environmental and resources costs, the processes deteriorating the quality and reducing the quantity of water resources and generally the environment were investigated. This procedure took into account all the 7 processes of urban water's cycle including abstraction, supply, treatment, storage, distribution, administration and water drainage. The FWC calculation method used is a combination of original calculation definitions of the 3 FWC components [2] and the segmentation of the analytical balance sheet of DEYAK. Initially the balance sheet was decomposed in 11 operation and maintenance sub costs and 3 capital sub costs, each of which is then divided in the 7 abovementioned processes of urban water. At the end, each minimum cost segment (emerged from the analysis) was checked in order to be identified to what extent is part of DC, EC or RC. DEYAK's FWC calculated equal to 7,827,794 € and is fully recovered by the current pricing policy. There was a reallocation between the three FWC components and was found that the RC is equal to 863,760 € for the year 2011. This is due to lignite mining activities of DEI (Public power Corporation) in "Sarigkiol" area which caused a drop in the aquifer level. The result was an increased abstraction and supply cost of abstracted quantities from Vathylakkos new boreholes, the cost of new infrastructure and the residual value of obsolete infrastructure in aquifer "Sarigkiol" which will not be depreciated. These costs are considered as RC. DC was equal to 3,793,315 € and EC equal to 3,170,719 €.

4.3. Developing a socially fair pricing policy for Kozani

The second step of the proposed methodology is to estimate the average unit water cost. As the SIV (water volume entering the network) is 6,921,387 m^3, the unit water cost is estimated as:

$$UWC = WP0 = \frac{FWC}{SIV} = \frac{7827794}{6921387} = 1.13€/m^3 \tag{4}$$

The new unit water cost (WPA) by charging the whole cost to the consumers based on their consumption, is:

$$WP_A = \frac{FWC}{SIV} \cdot \frac{1}{b} = WP0 \cdot \frac{1}{b} = 1.13 \cdot \frac{1}{0.3692} = 3.06€/m^3 \tag{5}$$

Table 3. Responsibility allocation of water cost recovery

Water quantities per use in the distribution network				Customer	Water Utility
				$Q_{CUST} = a \times Q_{SIV}$	$Q_{DN} = (1-a) \times Q_{SIV}$
Q_{SIV} (100%)	Q_{RW} (36.92%)	Q_{RW} (36.92%)	Q_{RW} (36.92%)	100% x (36.92%)	-
	Q_{NRW} (63.08%)	Q_{UNB} (2%)	Q_{UNB} (2%)	100% x (2%)	-
			Q_{WTH} (1%)	-	100% x (1%)
		Q_{AL} (4.69%)	Q_{MER} (3.69%)	100% x (3.69%)	-
			Q_{RER} (0%)	-	100% x (0%)
			$Q_{CARL-EARL}$ (35.48%)	-	100% x (35.48%)
		Q_{RL} (56.39%)	$Q_{EARL-UARL}$ (12.67%)	a% x (12.67%)	(1-a)% x (12.67%)
			$Q_{UARL-UARLopt}$ (5.06%)	-	100% x (5.06%)
			$Q_{UARLopt}$ (3.19%)	100% x (3.19%)	-
				$Q_{CUST} = 52.44 \times Q_{SIV}$	$Q_{DN} = 47.56 \times Q_{SIV}$

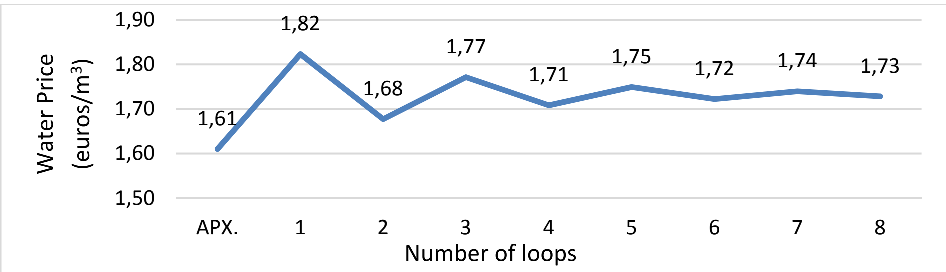

Fig. 3. Water price fluctuations and balance point

The responsibility allocation and the estimation of the consumers' percentage of responsibility is done for Kozani water distribution network (WDN) (Table 3). The Water Balance methodology has been applied for the Kozani WDN and the results are presented as percentages of SIV in Table 3 [9]. The value of a is estimated to be 52.44%. This means that consumers should pay only for 52.44% of the water volume entering the system (SIV) and not for all of it. Thus, the socially fair average water price is:

$$WP1 = \frac{a}{b} \cdot WP0 = \frac{0.5244}{0.3692} \cdot 1.13 = 1.61€/m^3 \quad (6)$$

Consequently, the new price should be 42% higher than the initial one (WP_0). The current net average price is 1.99€/m^3. The current net average price excluding the revenues derived from the fixed charge of the water meters registering zero consumption, gets to 1.91€/m^3.

However, this is not the final water price. The authors [10] proposed a methodology to estimate the balanced average water price, based on the water price elasticity of demand. Thus, by simulating the application of the new water price (1.61€/m^3) to the consumers they are expected to increase their water consumption, increasing at the same time the SIV and the FWC and thus a new higher water price will be calculated. The application of a higher water price will result in reduced water consumption and so on (Fig. 3). The system balances at a new average water price of about 1.73€/m^3. However, these loops did not take into consideration any possible measures the water utility will take to reduce NRW and water losses.

5. Conclusions

The WFD requires the member states to develop and apply appropriate pricing policies to recover the FWC. Water utilities are therefore obliged to develop new pricing policies taking into consideration the FWC recovery principle. On the other hand, big water volumes are lost in WDNs and their cost is not allocated on a socially fair basis. The paper presents a solid methodology to estimate a socially fair average water price taking into consideration both the FWC and the WFD's requirements and also a socially fair allocation of the responsibility of each water user (the consumers and the water utility). The methodology is applied in Kozani, where after simulating the water price fluctuations due to the water price elasticity of demand, the final average water price is 1.73€/m^3. The current average water price is 1.99€/m^3. The next task is the estimation of a socially fair fixed charge representing only the "opportunity cost". As other charges are included in the water pricing policy of DEYAK, the authors also investigated the incorporation of the special fee of 80% of consumption into the water tariffs. Toward this task, 13 different scenarios of modifying tariff values and ranges were developed and tested to calculate the scenarios' efficiency.

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