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D6.3 Comparison on the economic efficiency of different pricing schemes

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Executive summary

This report details the analysis of the economic efficiency of different pricing schemes. More specifically, it reports on differentiation on water tariffs and its associated consequences. In doing so, it evaluates the effects of using the dynamic pricing model.

We summarize the results by listing to major analyses.

1. The first analysis was focused on using the tariffs as a tool for demand management. This instrument, however, has quite limited applicability and the associated consequences seem to be not affordable due to political and social reasons. The reduction of water demand by 20% requires an increase in the average price by 87% in the best scenario, and by 190% in more realistic scenarios.
2. The second analysis was geared towards an increase of the net income of the water operator. An increase by 10% in the income, would require an increase by 16% in the average price of water. This will typically hurt the most sensitive of all clients.

Table of contents

1. Introduction

This report details the analysis of the economic efficiency of different pricing schemes using the dynamic pricing decision support system (DSS) as part of the Integrated Support System for Efficient Water Usage and Resource Management (ISS-EWATUS) project. The software can be found at http://www.math.vu.nl/~sbhulai/issewatus. It is part of work package 6 (WP6) of the project. The goal of this work package is to develop and simulate adaptive water price systems.

2. Terminology

The term *tariff* means a set of water prices. Such a set consists of typical prices defined in €/m^3, but additionally the water tariff consists of some fixed charges (usually per client per certain period of time). If there is more than one price (which is possible when the price depends on the amount of consumed water), and if there exist one or more fixed charges the *average price of water* is calculated as the total expenditure for water purchase divided by the amount of billed water. Such an average price exists in two formats: *net* – before value added taxation and *gross* – after such a taxation. From the point of view of a water operator, the net prices are crucial because such an operator is in charge for VAT collection, but in the next step it is also obligated to pay this tax to the government. From the point of view of consumers, the gross prices are substantial, because the final users (households) are obligated to pay the gross price for water – the demand reaction reflects the gross price.

The *expenditure for water purchase can be calculated per client* (usually the fixed charges are calculated per client) or *per capita* – only in the case when the number of inhabitants per client are known. The database describing the region of Skiathos includes such data, therefore both indicators can be calculated.

The affordability of hypothetical changes of tariffs was calculated in several formats:

a) increase of expenditures in €/y (per each client);
b) increase of expenditures in % (per each client);
c) increase of expenditures for the average household.

The second format (in %) is more appropriate for some generalization, because the calculation was made on the sample of clients and some values in € can be different using the whole population. The extreme changes were highlighted in two ways – the *maximum increase of expenditures in the analyzed sample* (in € and %) and *the upper decile of clients sorted by size of the changes* (also in € and %). This last indicator give us the picture of the 10% of clients that are most affected by the analyzed changes. The term "average, typical household" refers to a household consisting of 2.6 people (calculation on the basis of data provided by the water operator) consuming 16.7 m^3 of water per trimester (the same source of data). The terms "high and low elasticity" are described in detail in the Section 4: "Effects of changing the tariffs".

3. Choice of the scenarios

For the purpose of this report, over 200 scenarios were reviewed. Only the most representative cases of these are presented in the report. The number of variables consists of:

a) number of brackets for different prices (possible values 1-10);
b) the size of each bracket (possible values 0-n[1]);
c) prices per each bracket (possible values 0-n, with an accuracy up to 3 or 4 decimal places);
d) fixed price (possible value: 0-n, with an accuracy up to 3 or 4 decimal places);
e) value of the demand price elasticity index, per each trimester (possible values: -1:0);
f) value of the demand price elasticity index – depending on the amount of water consumption (possible values for demand index -1;0, two values one below and the second over the break point, value of break point 0-200 m^3/trimester/client).

Almost all[2] combinations are possible – the number of hypothetical combinations is enormously high (in the billions). Therefore, the review of the variants was prepared focusing on the output (like the drop in water consumption or the increase of the income of the water operator) with a very clear assumption that the same output can be obtain by millions of different combinations of the specified above variables. Especially the choice of the increase of the volumetric prices versus the fixed prices was important for the allocation of the consequences between the different clients.

The variants presented in this report can be divided into 4 groups. The first one (V1-V6) includes single minor changes of a few variables (for example, 1 to 3 of 8 existing volumetric prices). Such small changes give us the rough picture of how important such a differentiation is. There is no special analysis of such cases – in fact, there were no sophisticated targets and the variables were chosen randomly. The next three groups of variants are output oriented and the output details are included in Annex 1. Depending on the type of expected targets, the variants are developed in the separate coming sections. The second group is demand management oriented (V7-V10), the third – income oriented (V11-V14). The last set of variants give us the picture of how the hypothetical switch to single volumetric prices (V15-V17 + V18) look like.

4. Effects of changing the tariffs

The basics principles of changing the tariffs were specified in previous deliverables. These are:

T1. Direct – sustainable water balance due to the reduction of the total volume of water consumption using demand reaction on the rise of average prices;
T2. Direct – increase of the income of water operators and spending such extra profits at minimization of the water losses (leakage) and as a result of the reduction of total water consumption (indirect) or better balancing of the demand by limited supply.

Due to the extended utilities of the prepared model some additional verifications seem to be possible. First of all, the fit of the present tariffs to the cost structure is possible. All water providers face the majority of constant costs (regardless of the amount of provided water) and significant political pressure to connect the prices with the amount of consumed water (volumetric prices). In such a case, the consumers who use a small amount of water (second houses) create serious costs

[1] In theory $n = \infty$, however, in reality there is no sense to prepare very high number of brackets.
[2] There are some conditions concerning consistency of brackets for water consumption, the brackets altogether have to cover all possible values of consumption.

(ability to provision water services) with very low return rate. In such a case, the Users Pays Principle is met only on a high aggregated level. The present model enables the analysis of incomes in disaggregation into incomes from constant charges (maintenance charges) and volumetric charges. The real structure of costs usually is sensitive information – however, the present simulation gives a clear picture of the structure of incomes and enables the comparison to the structure of costs.

The possibility of demand management due to changes of the set of prices (tariffs) depends on the demand price elasticity. In many papers, the index of demand price elasticity is assumed as constant over the seasons and over the clients. In case of touristic resorts, such an assumption seems to be not proper. There are many places at Mediterranean basins where in the high season the number of tourists exceeds the number of the local population. This subpopulation is not sensitive to water prices, because they are charged per night and many of them do not understand the indirect correlation of exploitation costs of the tourist infrastructure and a price of a single night. Therefore, in case of modelling such a situation (tourist areas) a more sophisticated model seems to be necessary. The situation is more complicated when the hotel infrastructure is supplemented by single rooms or houses for rent. In such a situation also the household segment has lower demand price elasticity during the tourist season. For better fitting of the model in such touristic cases two alternative solutions were implemented:

a) The first one was related to differentiation of the demand price elasticity index across the low and high tourist season. Such an approach roughly describes the situation because during high season part of the local population that is not involved in rental of the houses or rooms still is sensitive to price incentives. On the other hand, during low season also some tourist activity exists – which is skipped in the calculations. This solution will be described as “high elasticity”.
b) The second approach assumes differentiation of the demand price elasticity index between two subpopulations: clients not engaged in room/house rental and others clients. The criteria of qualification is monthly water consumption per capita. The quality of this approach depends on the credibility of data describing the number of people living in each house provided by the operator. This solution will be described as “low elasticity”.

Both versions were taken into consideration during the scenario modelling. All analyzed variants will be recalculated according to the mentioned high and low elasticity. It is necessary to highlight that this short name is related to the modelling assumptions more than to the value of demand price elasticity index.

4.1. Demand management

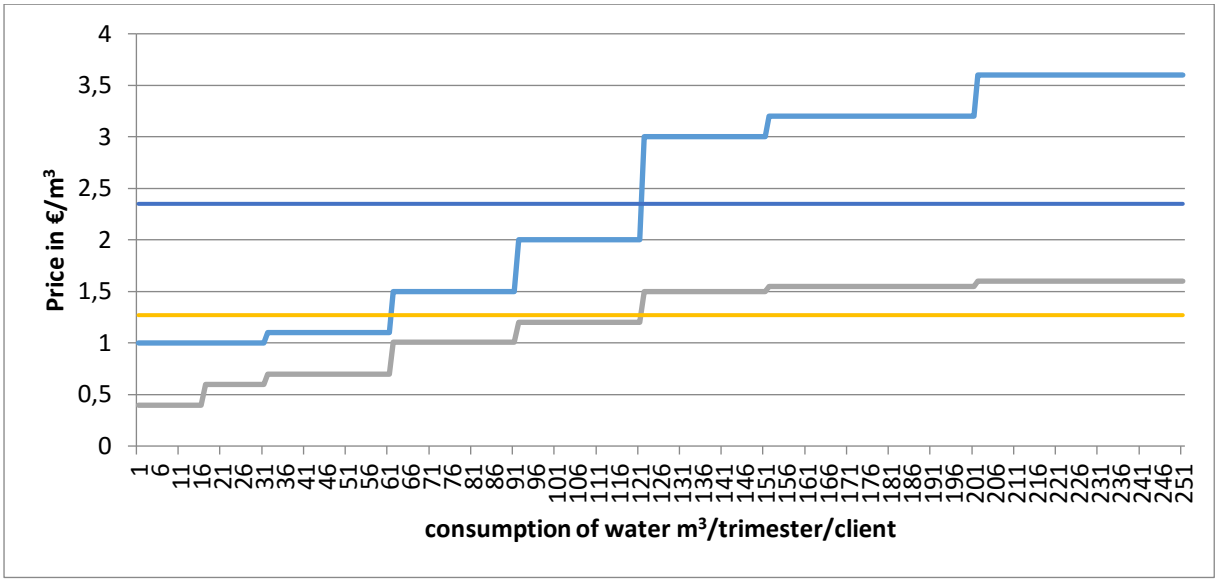
The first approach was focused on using the tariffs as a tool for demand management, i.e., the reduction of the total water consumption. The tariffs change was aimed at the reduction of the total annual water demand by 20% and 30%. Such a reduction seems to be substantial in the water balance. The demand reduction of 20% assuming the first conception of demand price elasticity index requires a serious increase of the incremental changes. The necessary changes (one of possible solution) is presented in the Table 1 and in Figure 1.

Table 1 Necessary increase of the tariff for reduction of the demand of water by 20% - high elasticity assumption.

Amount of water consumed per client (family or legal entity) in period of 3 months (in m^3)	Price (net) in €/m^3	New price (net) in €/m^3
0-15	0.396	1.00
15-30	0.60	1.00
30-60	0.70	1.10
60-90	1.01	1.50
90-120	1.20	2.00
120-150	1.50	3.00
150-200	1.55	3.20
200+	1.60	3.60
Fixed charges €/client/trimester	12.00	20.00

Source: Own calculation.

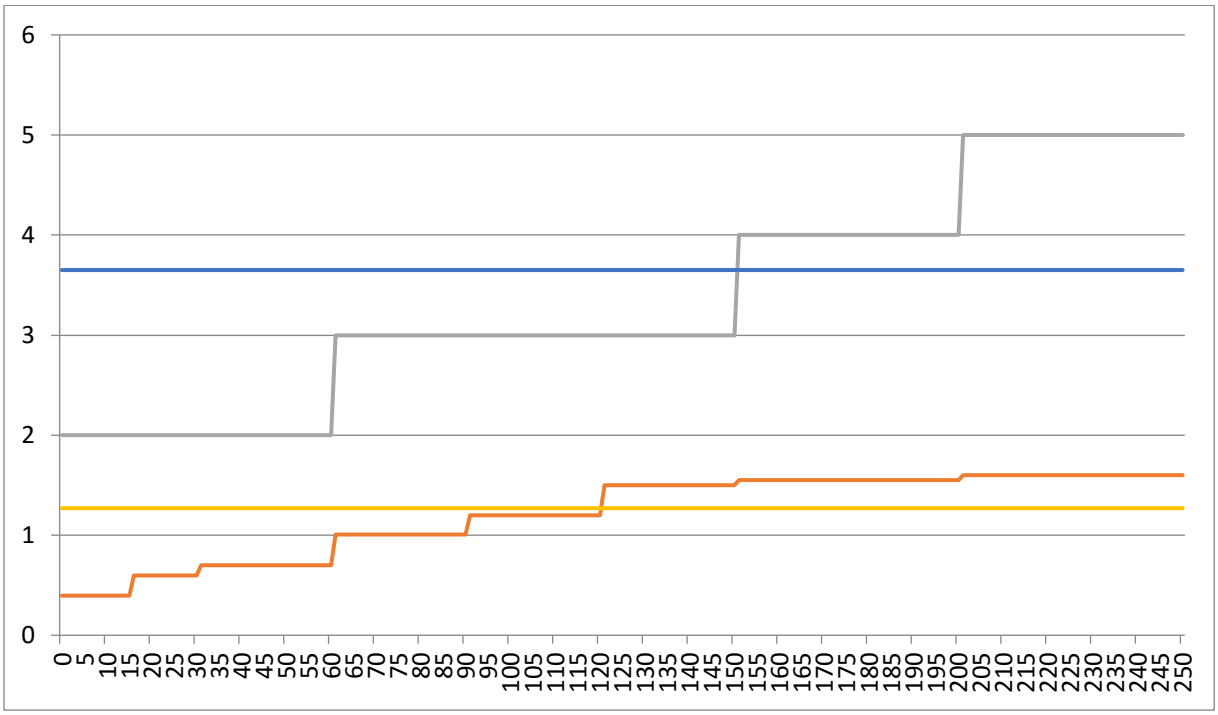
Figure 1 Comparison of the baseline scenario and the hypothetical tariff which caused the drop of demand for water by 20% - high elasticity assumption.



Source: Own calculation.

More conservative assumptions related to the demand reaction (called “low elasticity”) reflected in the second approach indicates only an 8% reduction in water demand using the above specified tariff. For such precautionary assumptions related to the demand reaction – much higher prices are necessary to meet the target of 20% demand reduction. The hypothetical tariff is presented in Figure 2. The average gross price is almost tripled in comparison to the base scenario.

Figure 2 Comparison of the baseline scenario and the hypothetical tariff which caused the drop of demand for water by 20% - low elasticity assumption.



Source: Own calculation.

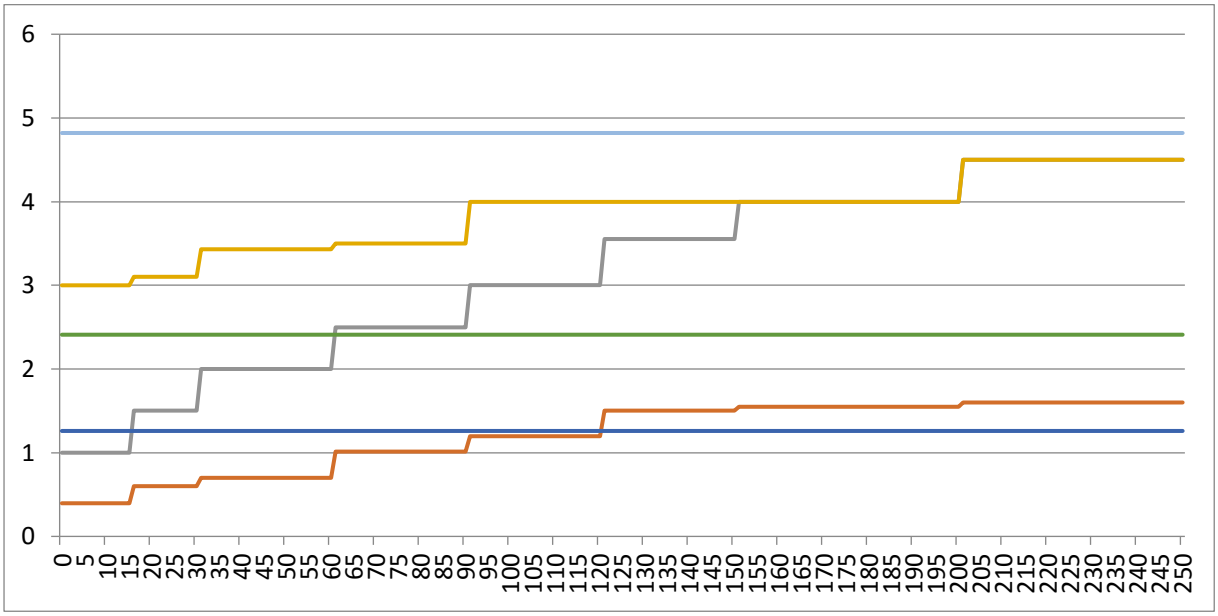
Table 2 Necessary increase of the tariff for reduction of the demand of water by 20% - low elasticity assumption.

Amount of water consumed per client (family or legal entity) in period of 3 months (in m^3)	Price (net) in €/m^3	New price (net) in €/m^3
0-15	0.396	2.00
15-30	0.60	2.00
30-60	0.70	2.00
60-90	1.01	3.00
90-120	1.20	3.00
120-150	1.50	3.00
150-200	1.55	4.00
200+	1.60	5.60
Fixed charges €/client/trimester	12.00	24.00

Source: Own calculation.

Similar calculations aimed at 30% of demand reduction are presented in Figure 3. The necessary increase of the prices seems to be not affordable. The average values presented in Figure 3 are gross and include also fixed payments, therefore, the average price in the figure can be above all incremental net prices. In such a scenario 30% of demand reduction caused the increase of the average water price by almost 4 times!

Figure 3 Necessary increase of the tariff for reduction of the demand of water by 30% -high and low elasticity assumption.



Source: Own calculation.

Table 3 Necessary increase of the tariff for reduction the demand of water by 30% - high and low elasticity assumption.

Amount of water consumed per client (family or legal entity) in period of 3 months m^3	Price (net) in €/m^3	New price (net) in €/m^3	New price (net) in €/m^3
		High elasticity	Low elasticity
0-15	0.396	1.00	3.00
15-30	0.60	1.50	3.10
30-60	0.70	2.00	3.43
60-90	1.01	2.50	3.50
90-120	1.20	3.00	4.00
120-150	1.50	3.55	4.00
150-200	1.55	4.00	4.00
200+	1.60	4.50	4.50
Fixed charges €/client/trimester	12.00	12.00	22.00

Source: Own calculation.

The short comparison of affordability indicators between the analyzed variants are presented in Table 4.

Table 4 Affordability indicators describing the demand reduction of the variants of tariffs increase.

	Unit	Baseline scenario	Demand reduction by 20%		Demand reduction by 30%	
			V7	V8	V9	V10
			High elast.	Low elast.	High elast.	Low elast.
Average price of water, gross	€/m^3	1.26	2.35	3.65	2.41	4.82
	%*	0%	87%	190%	91%	283%
Annual average expenditure per capita	€/y	51.64	76.45	119.79	68.66	137.57
	%*	0%	48%	132%	33%	166%
Annual average expenditure per client	€/y	134.21	198.71	311.34	178.44	357.56
	%*	0%	48%	132%	33%	166%
Annual expenditure of typical household	€/y	82.69	146.42	220.81	117.03	253.02
	%*	0%	77%	167%	42%	206%
Maximum increase of expenditures per client	€/y	-	279.60	699.66	296.14	893.57
	%*	-	74%	166%	52%	209%
Upper decile of clients by changes in expenditures	€/y	-	104.45	372.07	112.86	517.27
	%*	-	71%	160%	48%	202%

* increase in comparison to the baseline scenario
Source: Own calculation.

Interpretation of the data presented in table 4 is not obvious. The discussion is focusing only on the first target "demand reduction by 20%" but described method is the same for other targets.

In the first step, the tariffs were changed to obtain a drop by 20% of the total water consumption. The choice was made with the assumption of high demand elasticity. The following variables were changed (in comparison to the baseline scenario):

a) prices per each bracket;
b) fixed charge.

The details are attached in Annex 1 (see data for variants V7 – V10). The output (changes of the price, expenditures, etc.) is presented in Table 4 in column V7 – Demand reduction by 20%-V7-High elast. In the next step, for the same set of prices, charges – the assumption concerning elasticity was changed from high – to low. Such an approach is justified by little knowledge of how the elasticity for this local community looks like, therefore, the second output (also Table 4, column V8 – Low elast.) gives us the picture what can happen in case of lower demand elasticity. The result of the introduction of such a tariff can be described as follows:

a) the average price of water will increase by 87% (high elasticity) and 190% (low elasticity), in monetary format the average price will increase from 1.26 €/m^3 to 2.35 €/m^3 or 3.65€/m^3 depending on the elasticity assumptions;
b) the annual expenditure for purchasing water services will increase by 48% (high elasticity) and 132% in case of low elasticity. Both figures are lower than the price increase due to the demand reaction (drop of water consumption due to higher water prices);
c) the increase of typical households (2.6 people, only consumption for own purposes, without room rentals) will increase by 77% up to 167% depending on the elasticity assumptions (high versus low);

d) the maximum increase in the reviewed sample is 74% (high elasticity) and 166% (low elasticity);
e) the most sensitive 10% of all clients will face an increase of the expenditures by a minimum of 71% (up to 74%) in case of high elasticity and minimum 160% (up to 166%) in case of low elasticity.

The increase of water tariffs has limited influence on the water demand. This instrument has quite limited applicability and the associated consequences seem to be not affordable due to political and social reasons. The reduction of water demand by 20% requires a serious increase of prices for water. The average price should increase by 87% in the best scenario and by 190% in a more realistic scenario. The upper decile of clients exposed at extremely high expenditure increase indicates an increase at 71% in the best scenario and 160% in a more realistic scenario. Such a price increase seems to be not acceptable.

4.2. Income effects

Due to the low price elasticity of water demand other options of balancing the demand with supply should be taken into account. One of possible options is reducing the water leakages by differentiation of the hydraulic pressure in the network and by replacement of the water network. Especially, the network maintenance and replacement is expensive and usually the capital outlays has low rate of return. As a result, very often a possibility of financing such investments faces problems concerning available financial sources. In this section, the model was used as a tool for verification of the hypothetical tariff schemes aimed at gathering additional income. In many cases, the profitability of water operators is regulated, therefore, the main assumption that the additional incomes are spent on the maintenance is crucial. In such assumptions, the additional income (in comparison to the baseline scenario) is the main variable, however, other effects like the increase of the prices, the demand reaction, and the social affordability are also taken into consideration.

The basic review of hypothetical consequences includes changes in the tariffs causing the increase of the operator's income by 10, 20, 30, and 40%. The calculations include the demand reaction. Because the model enables different assumptions concerning quantification of the subpopulation sensitive on the price changes – the estimations were repeated according to the previously described options; high and low elasticity. Therefore, the tariff causing an increase of the income by 10% under the assumption "high elasticity" creates another effect using the assumption "low elasticity", this is the reason why the increases by 10, 20, 30, and 40% are accompanied by other figures.

Of course, the proposed variants are taken from many possibilities causing the increase of incomes by assuming 10-40%, this is just a rough view on the hypothetical consequences of such a solution.

Table 5 Affordability indicators describing income oriented tariffs' variants.

	Unit	Baseline scenario	Increase of the income by							
			V11		V12		V13		V14	
			10%	13.1%	**20%**	34.4%	**30%**	47.1%	**40%**	71.5%
			High elast.	Low elast.	High elast.	Low elast.	High elast.	Low elast.	High elast.	Low elast.
Net income of the operator	1000 €/y	**28,451.79**	31,296.84	32,173.95	34,145.87	38,235.41	36,988.32	41,846.92	39,840.35	48,796.2
Average price of water, gross	€/m^3	1.26	1.47	1.46	1.74	1.79	1.97	1.99	2.44	2.43
	%*	0%	16.7%	15.9%	38.1%	42.1%	56.3%	57.9%	93.7%	92.9%
Annual average expenditure per capita	€/y	51.64	56.8	58.39	61.97	69.39	67.13	75.95	72.31	88.56
	%*	0%	10.0%	13.1%	20.0%	34.4%	30.0%	47.1%	40.0%	71.5%
Annual average expenditure per client	€/y	134.21	147.63	151.76	161.07	180.36	174.47	197.39	187.93	230.17
	%*	0%	10.0%	13.1%	20.0%	34.4%	30.0%	47.1%	40.0%	71.5%
Annual expenditure of typical household	€/y	82.69	85.15	85.41	87.17	87.48	99.47	101.05	113.81	118.43
	%*	0%	3.0%	3.3%	5.4%	5.8%	20.3%	22.2%	37.6%	43.2%
Maximum increase of expenditures per client	€/y	-	82.16	102.41	245.28	418.57	271.52	413.40	298.16	524.74
	%*	-	20%	27%	43%	78%	48%	77%	53%	91%
Upper decile of clients by changes in expenditures	€/y	-	36.39	36.39	77.28	131.53	94.60	161.63	125.76	242.70
	%*	-	16%	20%	28%	47%	35%	58%	49%	85%

* increase in comparison to the baseline scenario

Source: Own calculation.

Interpretation of the data presented in Table 5 is similar to the data from Table 4. The discussion focuses only on the first target "the increase of operator's income by 10%", but the described method is the same for other targets.

In the first step, the tariffs were changed to obtain 10% of income increase. The following variables were changed (in comparison to the baseline scenario):

a) prices per each bracket;
b) fixed charge.

The details are attached in Annex 1 (see data for variant V11 – V11). The choice was made with the assumption of high demand elasticity. The output (assumed income, the changes of the price, expenditures, etc.) is presented in Table 5 in column V11 – 10%-High elast. In the next step, for the same set of prices and charges the assumption concerning elasticity was changed from high to low. Such an approach is justified by little knowledge of how the elasticity for this local community looks like, therefore, the second output (also Table 5, column V11 – 10%-Low elast.) gives us the picture what can happen in case of lower demand elasticity. The result of the introduction of such a tariff can be described as follows:

a) the average price of water will increase by 16%, with minor differences between assumptions: high and low elasticity;
b) the annual expenditure for purchase of water services will increase by 10% (high elasticity) and 13% in case of low elasticity. Both figures are lower than a price increase due to the demand reaction (the drop of water consumption due to higher water prices);
c) the increase of expenditures of typical households (2.6 people, only consumption for own purposes, without room rentals) will reach 3%;
d) the maximum increase in the reviewed sample is 20% (high elasticity) and 27% (low elasticity).
e) The most sensitive 10% of all clients will face an increase of expenditures by a minimum of 16% (up to 20%) in case of high elasticity and a minimum of 20% (up to 27%) in case of low elasticity.

5. Simple volumetric price for water

The tariff consisting of a fixed charge plus eight different volumetric prices for water belongs to the most complex across Europe. The prepared model enables answering the hypothetical question concerning simplification of such a tariff to a single volumetric price plus a fixed charge. The single price should be, of course, an equivalent for the existing eight different prices from the point of view of a constant annual income. The above remarks do not aim at forcing such changes – this is just the discussion of hypothetical consequences possible for modelling by preparation in this project tool. In many cases, such decisions have a strong political context – but all discussion should be supported by creditable and transparent arguments.

Using such an assumption the equivalent price was calculated, with all affordability indicators (variant V5). The value of the equivalent single price is 0.71 €/m^3 (net), the fixed charge remains at the same level (12 €/trimester/client) and the consequences are as follows:

a) the maximum increase of expenditures in analyzed sample of clients is 21% (high elasticity) or 24% in case of the low elasticity assumption;
b) in monetary values the increase does not exceed 22-27€ per client in the whole year;

c) the typical households will face additional expenditures ranging between 19-20 €/y;
d) such small households belong to the subpopulation of the most sensitive to the projected changes;
e) the most sensitive subpopulation (upper decile) of clients will pay at least 18-20% more for water (depending on the assumption high versus low elasticity).

Taking into account that the hypothetical simple volumetric price causes additional financial burdens in the subpopulation of small households, it is possible to smooth such an allocation due to the reduction of the fixed charge and increase the volumetric price. This solution protects the households with small water consumption because in such a situation the fixed charge plays a major role in the incremental cost structure. The next two variants (variants V16 and V17) describe such a possibility. The results are summarized in Table 6.

Minimizing the fixed charge causes smoothing of the extra financial burdens allocated in small households. For example: introduction of the single volumetric price associated with the present fixed charge causes the increase of annual payments by small typical households from 83 to 102 €/y/household. But the change of the fixed charge from 12 to 7 €/client/trimester associated with the equivalent increase of the single volumetric prices causes also an increase of such annual expenditures but from 83 to 96 €/y/household.

The reasonable compromises between simplicity, social reasons, and proper reflection of the cost structure can be obtained by implementation of the tariff consisting of:

a) fixed charge at the present level (12 €/trimester/client);
b) double volumetric tariff; present value 0.396 €/m^3 in first shorter bracket (up to 10 m^3/trim/client) and over 10 m^3 – 0.808 €/m^3.

All prices are specified as net prices, the bracket 10 m^3/trimester/client reflects the median consumption calculated across all four trimesters and the whole sample. The details are also presented in Table 6 (V18). This variant offers the lowest increase of the annual charges for the average household.

Table 6 Affordability indicators describing single volumetric price variants.

	Unit	Baseline scenario	Different combination of fixed charge and single volumetric price caused the same annual income							
			V15		V16		V17		V18	
			High elast.	Low elast.	High elast.	Low elast.	High elast.	Low elast.	High elast.	Low elast.
Fived charge, net	€/client/ trimester	12	12.00		10.00		7.00		12.00	
Volumetric price, net	€/m^3	8 prices	0.71		0.801		0.934		0.396 up to 10m^3 over 0.808 €/m^3	
Net income of the operator	1,000 €/y	**2,8451.79**	28,444.12	28,586.84	28,460.14	28,756.91	28,463.51	29,064.65	28,459.09	28,625.23
Average price of water, gross	€/m^3	1.26	1.28	1.27	1.29	1,29	1.32	1.31	1.28	1.28
	%*	0%	1.6%	0.8%	2.4%	2.4%	4.8%	4.0%	1.6%	1.6%
Annual average expenditure per capita	€/y	51.64	51.62	51.88	51.65	52.19	51.66	52.75	51.65	51.95
	%*	0%	0.0%	0.5%	0.0%	1.1%	0.0%	2.1%	0.0%	0.6%
Annual average expenditure per client	€/y	134.21	134.17	134.84	134.25	135.65	134.26	137.1	134.24	135.02
	%*	0%	0.0%	0.5%	0.0%	1.1%	0.0%	2.2%	0.0%	0.6%
Annual expenditure of typical household	€/y	82.69	101.68	103.04	99.24	100.6	95.95	97.26	91.72	92.47
	%*	0%	23.0%	24.6%	20.0%	21.7%	16.0%	17.6%	10.9%	11.8%
Maximum increase of expenditures per client	€/y	-	22.11	27.34	29.59	37.57	40.04	53.27	40.04	53.27
	%*	-	21.0%	24.2%	19.4%	23.4%	21.1%	27.7%	21.1%	27.7%
Upper decile of clients by changes in expenditures	€/y	-	20.00	23.69	22.13	27.01	30.91	39.01	30.91	39.01
	%*	-	17.5%	20.4%	16.9%	20.3%	19.8%	24.0%	19.8%	24.0%

* increase in comparison to the baseline scenario

Source: Own calculation.

6. Incomes from water tariffs in the context of fixed and variable costs

The problem of the obligatory ability for the provision of the service and associated with such ability costs exist in all network services with different intensities. The cost recovery is usually realized by selling the services. The problem grows in case of serious differentiation of demand across time (tourist season, weekends, etc.). The network services are not flexible in the context of their maximum capacity, therefore, the infrastructure has to be prepared for the maximum demand which means that the off peak is only partially used. Because the majority of the costs of water provision is fixed (regardless to the amount of provided water) – the problem of summer houses or second houses is important in the context of cost recovery. Such an infrastructure generates serious constant costs and in case of aperiodic purchasing of the services, the principle "user's pays" is only partially implemented. A better implementation of such a principle is possible using a combined tariff consisting of a fixed charge and supplemented by a volumetric charge. From the position of the water operator, the income structure divided into fixed and volumetric parts of the tariffs should reflect the real structure of the costs (constant and variable). On the other hand, there is strong political pressure on the increase of the importance of volumetric prices – because only this price has an incentive impact on water savings. The elaborated model gives us the transparency of how the current and predicted tariffs work in the context of the income structure. The aim of this section is not to discuss and prove which solution is proper or better but to provide transparent information about the relation between the income from fixed charges and the volumetric part of the tariffs. Therefore, the next table presents the structure of incomes for all analyzed variants. The comparison of all variants is controversial – different tariffs have different targets and associated with it different financial consequences, therefore, the table is important only to get the picture about possibilities of the prepared model. The proper comparisons should be conducted across more homogenous sub-groups of variants like V15-V17 – all limited by assuming the same annual income.

Table 7 Income structure for analyzed variants.

Variant	Elasticity assumption	Total annual income (gross)	fixed	variable	fixed	variable
	-	€/y	€/y	€/y	%	%
Baseline		28,452	11,092	17,360	39.0%	61.0%
V1	HE*	31,053	11,092	19,961	35.7%	64.3%
	LE**	31,812	11,092	20,721	34.9%	65.1%
V2	HE	34,284	11,092	23,192	32.4%	67.6%
	LE	35,879	11,092	24,787	30.9%	69.1%
V3	HE	31,217	11,092	20,125	35.5%	64.5%
	LE	32,061	11,092	20,969	34.6%	65.4%
V4	HE	29,520	11,092	18,428	37.6%	62.4%
	LE	30,377	11,092	19,285	36.5%	63.5%
V5	HE	27,415	5,546	21,869	20.2%	79.8%
	LE	28,489	5,546	22,944	19.5%	80.5%
V6	HE	36,028	15,713	20,315	43.6%	56.4%
	LE	38,043	15,713	22,330	41.3%	58.7%
V7	HE	42,126	18,486	23,639	43.9%	56.1%
	LE	46,836	18,486	28,349	39.5%	60.5%
V8	HE	48,061	22,184	25,878	46.2%	53.8%
	LE	66,003	22,184	43,820	33.6%	66.4%

V9	HE	37,829	11,092	26,737	29.3%	70.7%
	LE	48,327	11,092	37,235	23.0%	77.0%
V10	HE	37,381	20,335	17,046	54.4%	45.6%
	LE	75,802	20,335	55,467	26.8%	73.2%
V11	HE	31,297	11,092	20,205	35.4%	64.6%
	LE	32,174	11,092	21,082	34.5%	65.5%
V12	HE	34,146	12,016	22,130	35.2%	64.8%
	LE	38,235	12,016	26,219	31.4%	68.6%
V13	HE	36,988	14,789	22,199	40.0%	60.0%
	LE	41,847	14,789	27,058	35.3%	64.7%
V14	HE	39,840	15,713	24,127	39.4%	60.6%
	LE	48,796	15,713	33,083	32.2%	67.8%
V15	HE	28,444	11,092	17,352	39.0%	61.0%
	LE	28,587	11,092	17,495	38.8%	61.2%
V16	HE	28,460	9,243	19,217	32.5%	67.5%
	LE	28,757	9,243	19,514	32.1%	67.9%
V17	HE	28,464	6,470	21,993	22.7%	77.3%
	LE	29,065	6,470	22,594	22.3%	77.7%
V18	HE	28,459	11,092	17,367	39.0%	61.0%
	LE	28,625	11,092	17,533	38.7%	61.3%

HE – high elasticity,
LE – low elasticity,
Note: both statements reflect calculation assumptions not the direct value of the price demand elasticity index
Source: Own calculation.

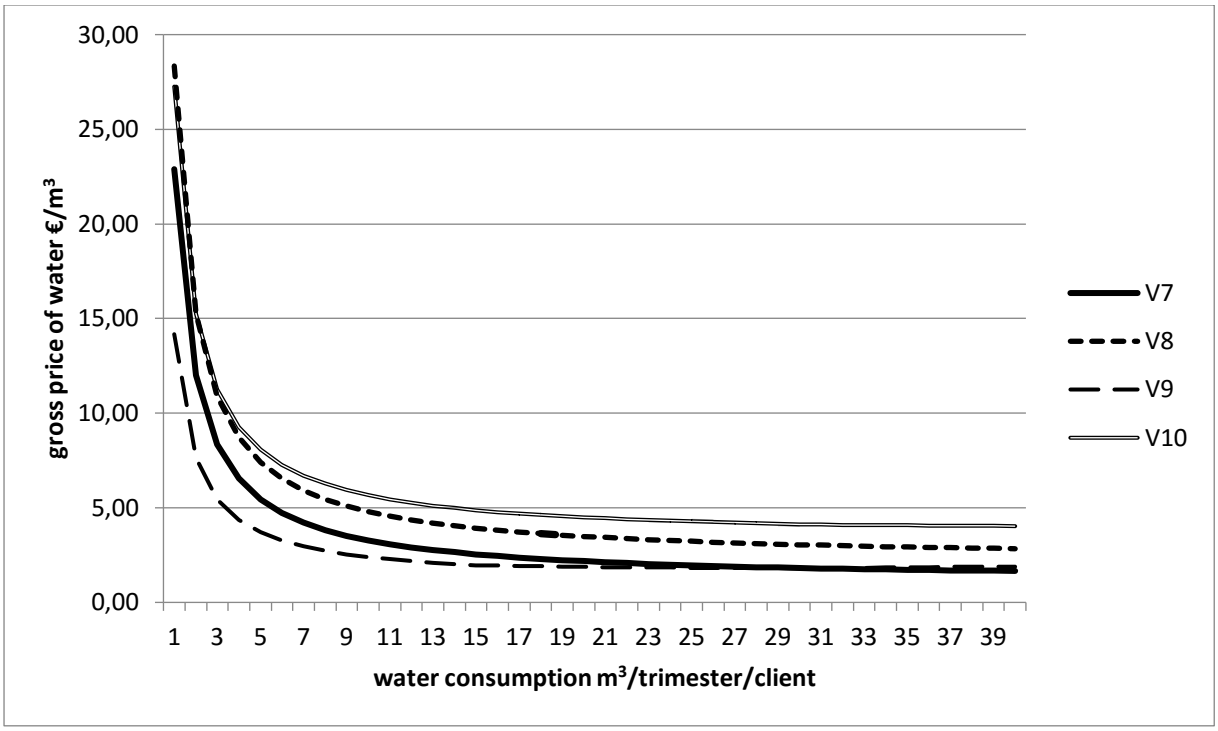
The income from fixed charges varies from 20 up to 54%, which suggests high flexibility during the tariff construction. It is worth to state that the highest result – 54% – still does not reflect the typical structure of the fixed and variable cost of water operators. This statement does not correspond with the sensitive data of the Skiathos water operator but is formulated on the basis of literature review.

The more creditable comparison across the "single volumetric price" variants shows us that the same target can be obtained not only with a different split of the financial burdens but also the structure of the incomes (fixed versus variable) can be different. In the presented variants V15-V17, the difference ranges up to 17 percentage points. Higher differentiation seems to be also possible using more extreme variables (higher fixed charges).

7. In-depth analysis of the real price of water in context of the reviewed tariffs

The analysis in this section was conducted in three different groups of variant. The first one consists of variants V7-V10 oriented at demand management. These variants are characterized by substantial volumetric price increase. The changes (increase) of the fixed price was included in two of four variants. Each variant consists of eight brackets of water consumption, however, in single cases some brackets were unified. Because the volumetric prices in consecutive brackets were increasing (see Figures 1, 2, and 3) the typical expectation of consumers was the same. The detailed analysis indicates a huge influence of fixed charges. The visualization of the marginal prices per each m^3 of water across variants V7-V10 is presented in Figure 4.

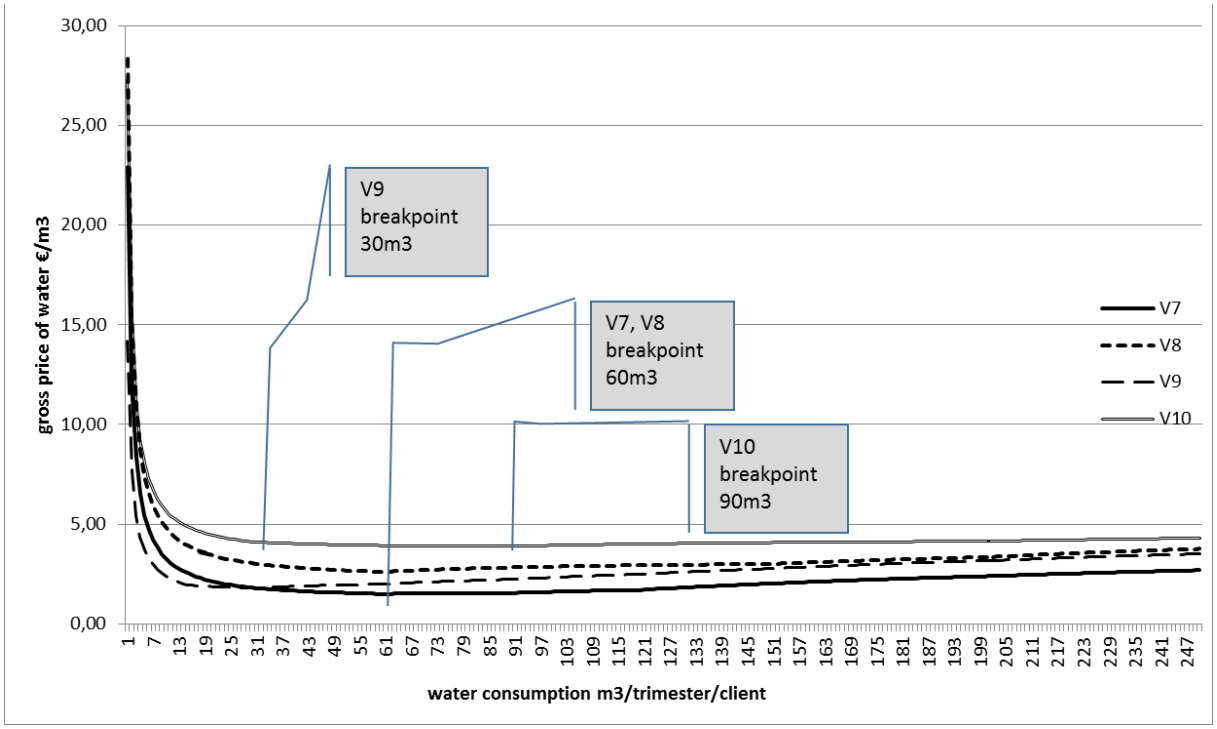
Figure 4 Marginal price of water for tariffs V7-V10.



Source: Own calculation.

In contradiction to common expectations, the prices are decreasing at the first, serious part of consumption. The break point (the moment where the prices again start to increase following the increase in volumetric prices) is different for the analyzed scenarios, in case of V7 and V8 the marginal prices are decreasing up to consumption 60 m^3/trimester per client, for V9 this is 30 m^3 and for V10 the prices are decreasing up to the consumption of 90 m^3/trimester. These breakpoints are shown in the next figure (Figure 5). Due to the necessity of using full scale up to 250 m^3 of water consumption, the decreased effect of fixed charges is not transparent as in the previous Figure 4. Taking into account that the median of water consumption is 10 m^3/trimester, the effects of water consumption in first brackets are much more important that on the full scale.

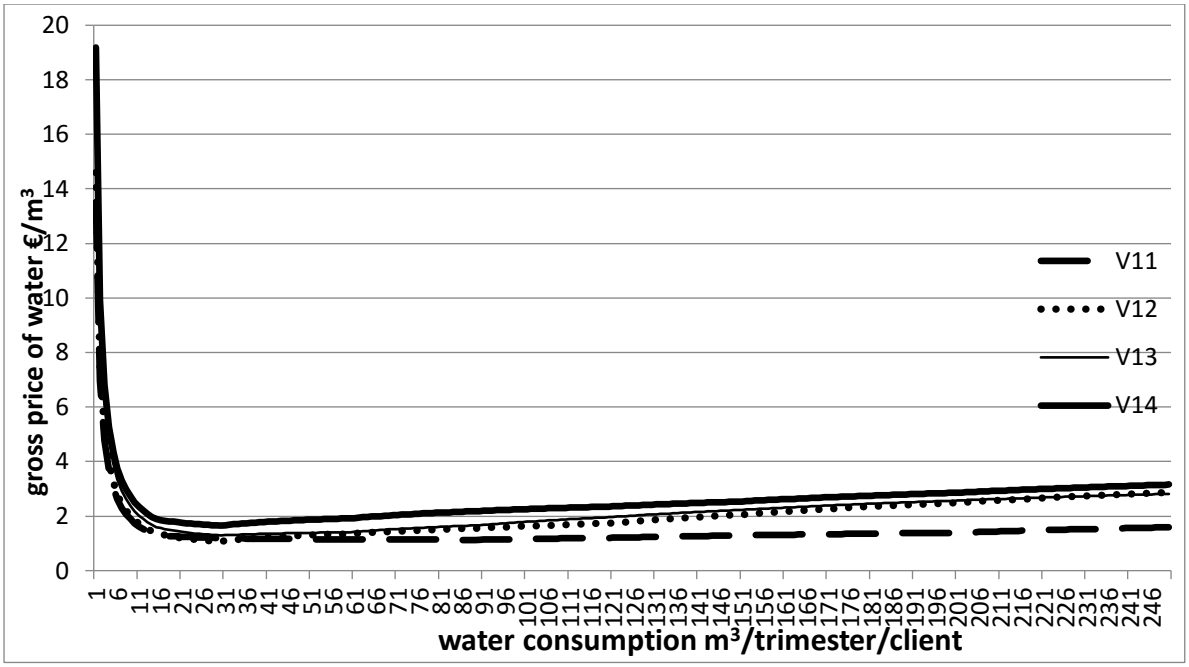
Figure 5 Marginal price of water for tariffs V7-V10 – full scale of water consumption.



Source: Own calculation.

The income-oriented variants (V11-V14) have similar characteristics, however, the allocation of breakpoints is quite surprising. The variants generating increases of income by 20, 30, and 40% with different values of fixed charges have the same breakpoint – 30 m^3/trimester. Of course, it is possible to make a different choice of the set consisting of eight volumetric prices plus a fixed charge, but in each separate case the distribution of additional costs among the clients will be different.

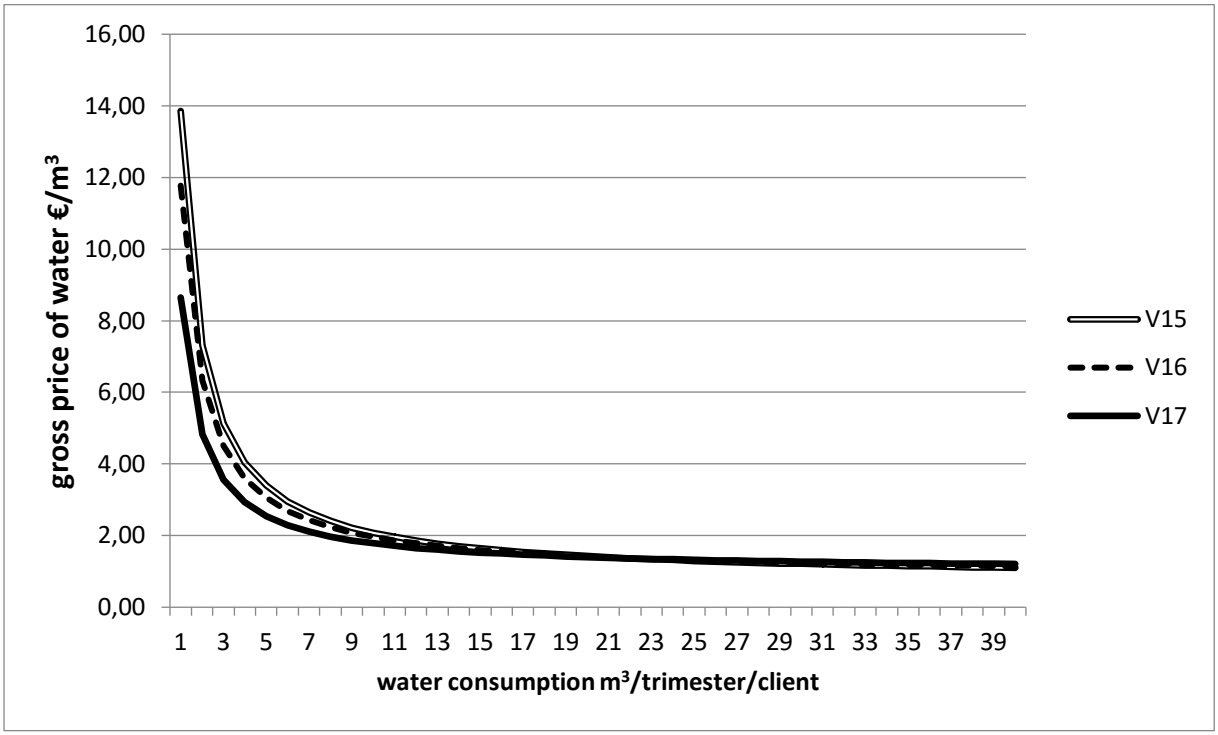
Figure 6 Marginal price of water for tariffs V15-V17.



Source: Own calculation.

The comparison of all three variants focusing on a single volumetric price and binding by the same income from selling the water is on the first view not very complicated. With the consumption above of 20 m^3/trimester the prices look quite similar. It is necessary to repeat that half of the clients consume below 10 m^3/trimester, therefore, small discrepancies in the range 1-10 m^3 are also important.

Figure 7 Marginal price of water for tariffs V15-V17.



Source: Own calculation.

Annex 1 Details for presented variants.

Part 1 - Variables

Scenario	Brackets	Pricing scheme											Demand elasticity scheme						
		Unit	Variable								Fixed	VAT	differentiation across trimesters – „high elasticity"				across amount of billed water – "low elasticity"		
		-	1	2	3	4	5	6	7	8	€/trim/client		1st	2nd	3rd	4th	break point, m^3/month	below	over
Baseline	Size	m^3/trim/client	**0**	**15**	**30**	**60**	**90**	**120**	**150**	**200**									
	Price	€/m^3	**0.396**	**0.6**	**0.7**	**1.01**	**1.2**	**1.5**	**1.55**	**1.6**	**12**	**1.09**							
V1	Size	m^3/trim/client	0	15	30	60	90	120	150	200	12	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	0.396	1	1	1.01	1.2	1.5	1.55	1.6	12	1.09					5	-0.4	-0.1
V2	Size	m^3/trim/client	0	15	30	60	90	120	150	200	12	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	1	1	1	1.01	1.2	1.5	1.55	1.6	12	1.09					5	-0.4	-0.1
V3	Size	m^3/trim/client	0	15	30	60	90	120	150	200	12	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	0.396	1	1	1.01	1.2	1.5	1.55	2.2	12	1.09					5	-0.4	-0.1
V4	Size	m^3/trim/client	0	15	30	60	90	120	150	200	12	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	0.396	0.6	0.7	1.01	1.2	3	3.11	3.2	12	1.09					5	-0.4	-0.1
V5	Size	m^3/trim/client	0	15	30	60	90	120	150	200	6	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	0.6	0.7	1	1.01	1.2	3	3.11	3.2	6	1.09					5	-0.4	-0.1
V6	Size	m^3/trim/client	0	15	30	60	90	120	150	200	17	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	0.6	0.7	1	1.01	1.2	3	3.11	3.2	17	1.09					5	-0.4	-0.1
V7	Size	m^3/trim/client	0	15	30	60	90	120	150	200	20	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	1	1	1.1	1.5	2	3	3.2	3.6	20	1.09					5	-0.4	-0.1
V8	Size	m^3/trim/client	0	15	30	60	90	120	150	200	24	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	2	2	2	3	3	3	4	5	24	1.09					5	-0.4	-0.1

V9	Size	m^3/trim/client	0	15	30	60	90	120	150	200	12	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	1	1.5	2	2.5	3	3.55	4	4.5	12	1.09					5	-0.4	-0.1
V10	Size	m^3/trim/client	0	15	30	60	90	120	150	200	22	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	3	3.1	3.43	3.5	4	4	4	4.5	22	1.09					5	-0.4	-0.1
V11	Size	m^3/trim/client	0	15	30	60	90	120	150	200	12	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	0.396	1	1	1.01	1.3	1.5	1.55	2.2	12	1.09					5	-0.4	-0.1
V12	Size	m^3/trim/client	0	15	30	60	90	120	150	200	13	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	0.396	0.7	1.5	1.8	2.1	3	3.5	4	13	1.09					5	-0.4	-0.1
V13	Size	m^3/trim/client	0	15	30	60	90	120	150	200	16	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	0.4	0.9	1.4	2	2.6	3	3.3	3.5	16	1.09					5	-0.4	-0.1
V14	Size	m^3/trim/client	0	15	30	60	90	120	150	200	17	1.09	-0.4	-0.2	-0.2	-0.4			
	Price	€/m^3	0.6	1.3	2	2.5	2.6	3	3.5	4	17	1.09					5	-0.4	-0.1
V15	Size	m^3/trim/client	0	15	30	60	90	120	150	200	12	1.09	-0.4	-0.2	-0.2	-0.4	5	-0.4	-0.1
	Price	€/m^3	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71	12	1.09	-0.4	-0.2	-0.2	-0.4	5	-0.4	-0.1
V16	Size	m^3/trim/client	0	15	30	60	90	120	150	200	10	1.09	-0.4	-0.2	-0.2	-0.4	5	-0.4	-0.1
	Price	€/m^3	0.801	0.801	0.801	0.801	0.801	0.801	0.801	0.801	10	1.09	-0.4	-0.2	-0.2	-0.4	5	-0.4	-0.1
V17	Size	m^3/trim/client	0	15	30	60	90	120	150	200	7	1.09	-0.4	-0.2	-0.2	-0.4	5	-0.4	-0.1
	Price	€/m^3	0.934	0.934	0.93	0.934	0.93	0.934	0.934	0.93	7	1.09	-0.4	-0.2	-0.2	-0.4	5	-0.4	-0.1
V18	Size	m^3/trim/client	0	10	30	60	90	120	150	200	12	1.09	-0.4	-0.2	-0.2	-0.4	5	-0.4	-0.1
	Price	€/m^3	0.396	0.808	0.808	0.808	0.808	0.808	0.808	0.808	12	1.09	-0.4	-0.2	-0.2	-0.4	5	-0.4	-0.1

The changes in comparison to the baseline scenario are marked in grey.

Part 2 – Outputs.

Variant	Elasticity	Total annual income (gross)				Total water consumption	Average price	Affordability analysis						
			changes	fixed	variable			Expenditures per capita, annual, average	Expenditures per client, annual, average	Max increase of expenditures per client		Upper decile of clients by changes in expenditures		Expenditures of average households
		€/y	%	€/y	€/y	m^3/y	€/m^3	€/pc/y	€/c/y	€/c/y	%	€/c/y	%	€/c/y
Baseline		**28451.79**		**11091.84**	**17359.95**	**22494.00**	**1.26**	**51.64**	**134.21**					**82.69**
V1	he	31052.52	9.1%	11091.84	19960.68	21436.56	1.45	56.36	146.47	40.98	20%	34.20	16%	
	le	31812.45	11.8%	11091.84	20720.61	22095.70	1.44	57.74	150.06	57.18	27%	44.70	20%	
V2	he	34283.88	20.5%	11091.84	23192.04	20266.67	1.69	62.22	161.72	65.87	39%	59.78	36%	
	le	35878.66	26.1%	11091.84	24786.82	21672.34	1.66	65.12	169.24	91.85	49%	79.38	45%	
V3	he	31216.82	9.7%	11091.84	20124.98	21382.66	1.46	56.65	147.25	79.96	20%	35.61	16%	
	le	32061.26	12.7%	11091.84	20969.42	22074.54	1.45	58.19	151.23	99.67	27%	49.04	20%	
V4	he	29520.08	3.8%	11091.84	18428.24	22046.52	1.34	53.58	139.25	184.39	32%	10.72	3%	
	le	30376.79	6.8%	11091.84	19284.95	22296.80	1.36	55.13	143.29	275.12	53%	18.44	6%	
V5	he	27415.10	-3.6%	5545.92	21869.18	21879.41	1.25	49.76	129.32	189.26	33%	20.01	8%	
	le	28489.49	0.1%	5545.92	22943.57	22237.36	1.28	51.71	134.38	274.71	50%	31.45	11%	
V6	he	36028.17	26.6%	15713.44	20314.73	20332.36	1.77	65.39	169.94	221.87	42%	49.63	42%	
	le	38042.96	33.7%	15713.44	22329.52	21649.02	1.76	69.04	179.45	316.68	59%	70.80	42%	
V7	he	42125.86	48.1%	18486.40	23639.46	*17928.95*	2.35	76.45	198.71	279.60	74%	104.45	71%	146.42
	le	46835.58	64.6%	18486.40	28349.18	20731.70	2.26	85.00	220.92	429.13	84%	162.52	78%	153.24
V8	he	48061.44	68.9%	22183.68	25877.76	11048.18	4.35	87.23	226.70	290.66	120%	161.31	113%	191.26
	le	66003.20	132.0%	22183.68	43819.52	*18104.11*	3.65	119.79	311.34	699.66	166%	372.07	160%	220.81
V9	he	37829.21	33.0%	11091.84	26737.37	*15729.11*	2.41	68.66	178.44	296.14	52%	112.86	48%	117.03
	le	48327.14	69.9%	11091.84	37235.30	19842.71	2.44	87.71	227.96	582.68	102%	255.25	92%	122.80
V10	he	37381.23	31.4%	20335.04	17046.19	4831.32	7.74	67.84	176.33	321.32	119%	91.48	106%	191.56

	le	75801.99	166.4%	20335.04	55466.95	15739.70	4.82	137.57	357.56	893.57	209%	517.27	202%	253.02
V11	he	31296.84	*10.0%*	11091.84	20205.00	21353.91	1.47	56.80	147.63	82.16	20%	36.39	16%	85.15
	le	32173.95	13.1%	11091.84	21082.11	22062.27	1.46	58.39	151.76	102.41	27%	49.81	20%	85.41
V12	he	34145.87	*20.0%*	12016.16	22129.71	19606.63	1.74	61.97	161.07	245.28	43%	77.28	28%	87.17
	le	38235.41	34.4%	12016.16	26219.25	21323.59	1.79	69.39	180.36	418.57	78%	131.53	47%	87.48
V13	he	36988.32	*30.0%*	14789.12	22199.20	18818.10	1.97	67.13	174.47	271.52	48%	94.60	35%	99.47
	le	41846.92	47.1%	14789.12	27057.80	21020.80	1.99	75.95	197.39	413.40	77%	161.63	58%	101.05
V14	he	39840.35	*40.0%*	15713.44	24126.91	16360.85	2.44	72.31	187.93	298.16	53%	125.76	49%	113.81
	le	48796.20	71.5%	15713.44	33082.76	20078.77	2.43	88.56	230.17	524.74	91%	242.70	85%	118.43
V15	he	39840.35	*40.0%*	15713.44	24126.91	16360.85	2.44	72.31	187.93	298.16	53%	125.76	49%	113.81
	le	48796.20	71.5%	15713.44	33082.76	20078.77	2.43	88.56	230.17	524.74	91%	242.70	85%	118.43
V16	he	28444.12	0.0%	11091.84	17352.28	22265.07	1.28	51.62	134.17	22.11	21%	20.00	18%	101.68
	le	28586.84	0.5%	11091.84	17495.00	22448.20	1.27	51.88	134.84	27.34	24%	23.69	20%	103.04
V17	he	28460.14	0.0%	9243.20	19216.94	22010.26	1.29	51.65	134.25	29.59	19%	22.13	17%	99.24
	le	28756.91	1.1%	9243.20	19513.71	22350.17	1.29	52.19	135.65	37.57	23%	27.01	20%	100.60
V18	he	28463.51	0.0%	6470.24	21993.27	21603.11	1.32	51.66	134.26	40.04	21%	30.91	20%	95.95
	le	29064.65	2.2%	6470.24	22594.41	22193.59	1.31	52.75	137.10	53.27	28%	39.01	24%	97.26

The main results of this report can be summarized by assuming two different viewpoints. First, one can focus on using the tariffs as a tool for demand management. This instrument, however, has quite limited applicability and the associated consequences seem to be not affordable due to political and social reasons. The reduction of water demand by 20% requires an increase in the average price by 87% in the best scenario, and by 190% in more realistic scenarios. The second viewpoint can be focused on an increase of the net income of the water operator. An increase by 10% in the income, would require an increase by 16% in the average price of water. This will typically hurt the most sensitive of all clients.