Assessing the Water Pricing Policy (for domestic uses) The InnWater Micro-Simulation Model

Michel PAUL (CEMOI – University of Reunion Island)

InnWater Summer School

Friday, 26 September, 8:30–11:00 a.m. CET, remote mode

I – Introduction

As part of the InnWater project, development of 3 digital tools including:

- 1 CGE Model (focused on the WEFE nexus on Reunion Island)
- 1 Micro-Simulation Model to assess the socio-economic performance of a (specific) water pricing policy for domestic uses.

Remark: part of the tool is uploaded at https://innwater.eurecatprojects.com/msm/home.

The content of this session:

- introduce the MSM (that can be used on line)
- discuss (some of) the difficulties faced by water managers with the setting of water and wastewater tariff.

Please, note the MSM :

(1) is based on French Regulation;

(2) can be replicated with some adjustments (related to national regulations, but not only) that may be more or less significant,

(3) implements an evaluation methodology based on :

- an econometric model of **local** household water demand
- some indicators commonly used in the field of public policy evaluation,

which is reproducible / regarded as "innovative" by stakeholders / basic from an academic point of view. But first of all …

II – Basics

2.1 Drinking water and wastewater services: a brief description

See :

(1) the infographic "*The small water cycle*" at https://www.ofb.gouv.fr/le-petit-cycle-de-leau

(2) The 3 principles:

(i) **"Water pays for Water"**: the cost of providing the service is borne by the users (and not the taxpayers).

(ii) **Cost recovery** in the **full** sense of the term, i.e. including the **environmental cost** defined as "the costs of actions for maintaining the good status of water bodies and ecological services" (https://economie.eaufrance.fr)

(iii) "**Water must return clean to nature**": applies to "new" pollutants ("Towards zero water pollution" (Green Deal)).

(3) The human development issues linked to poorly performing services:

- Pasteur: "We drink 90% of our diseases" and the list of water-related diseases...
- SDG1, SDG6
- "water chores" burden …

2.2 The Primitives tab in MMS

In the MMS, you are asked to provide:

- the amount of fixed costs (F)
- the unit variable cost of a unit of service (c)
- the number of households / domestic subscribers (n),

for (1) the Drinking Water service ("EP") and (2) the Collective Sanitation service ("A").

In addition, you are also asked to enter:

- the environmental cost (c_e) defined as the cost of **complete** depollution (of one m^3 of drinking water used by a household)
- the excise duties (r_{EP} and r_{A}, in $€/m^3$) collected by the Water Agency (to fund some actions set by the local Water Parliament)
- VAT rates on drinking water (5%) and collective sanitation (10%) to feed the state budget,

and "social data":

- the **monetary poverty threshold** (threshold value for the standard of living below which a household is considered poor)
- the **water poverty threshold** as defined by **CAR** (weight of the bill in household income)
- the **water poverty threshold** as defined by **PAR** (proportion of household income spent on covering basic needs)

for identifying affordability issues when the household's expenditure exceeds the threshold value entered by the user (typically 3%).

Remark Given the modelling of depollution technology (see the technical documentation (fairly strong assumptions)), unrecovered environmental cost set to:

$$\max\left[c_e - c_{\mathrm{A}} - r_{\mathrm{EP}} - r_{\mathrm{A}}, 0\right] \times q_i$$

$$\max\left[c_e - r_{\mathrm{EP}}, 0\right] \times q_i$$

according to the household is connected or not to the collective sanitation network.

2.3 The "TBSE"

The point Drinking Water and Wastewater Services are:

- a network industry with relatively high fixed costs (60 to 80% of service costs)
- a market with a natural monopoly structure (in the long run, only one company will be active in the market)

and the usual response of Public Authorities (market regulation):

- Entrust the service to a local (e.g. France) or national (e.g. Madagascar) public company

and **question**:

"*What about the objective function ?*"

Answer In the domestic water sector, the tariff system (in the broad sense) has to meet 5 objectives:

- **Affordability**: households have to cover their basic water consumption at reasonable economic conditions.
- **Incentive effect**: the tariff must induce households to water-saving behaviours
- **Equity**: the tariff must be equitable/not inequitable in the sense that... ?
- **Economic efficiency**: the tariff must maximise (minimise as much as possible) the aggregate surplus (loss of surplus).
- **Cost recovery**: implementation of the "water pays for water" principle (including environmental costs).

Implementation …

Implementation In an "ideal" world (with some additional technical assumptions (("Quasi-linear framework")):

(1) Operator applies the "TBSE" ("Structurally Balanced Two-Part Tariff") with:

- a subscription fee to cover fixed costs $\Rightarrow F_{\text{EP}} = \dfrac{CF_{\text{EP}}}{n}$ & $F_{\text{A}} = \dfrac{CF_{\text{A}}}{n_{\text{A}}}$
- marginal cost pricing $\Rightarrow \pi_{\text{EP}} = c_{\text{EP}}$ & $\pi_{\text{A}} = c_{\text{A}}$

(2) Water Agency sets an eco-tax equal to the (marginal) cost of depollution:

$r_{\text{EP}}^{1} = c_e$ for households not connected to sanitation network (G1)

$r_{\text{EP}}^{2} = c_e - c_{\text{A}}$ & $r_{\text{A}} = 0$ for households connected to sanitation network (G2)

(3) State set VAT rates equal to 0 (when depollution technology is "perfect").

(4) A system of **personalised** lump-sum transfers:

$\left(T_1, T_2, \ldots, T_n\right)$ with $\sum_{i=1}^{n} T_i = 0$

to deal with the affordability issues encountered by some households.

Problems …

Problems In practice:

- the (necessary) transfer system may be (very) costly to implement (management costs)
- its targeting could be irregular (in light of the current law)
- the principle of equality before public services may constrain the eco-tax system
- the high level for the fixed part may (*i*) generate household inattention (close to a lump sum) and (ii) contribute to precariousness (high level of captive expenditures) ...

so that :

- TBSE is no longer an ideal way of pricing water (in fact, part of an ideal system)

but:

- a benchmark pricing ("maximisation of aggregate surplus")

on the basis of which the gains and losses of other pricing policies can be assessed, such as:

- Two-part Tariffs other than TBSE
- Increasing Block Tariffs
- Social pricing (with differentiated prices for various income categories) …

Illustration …

Illustration 1/3 – Tables : Service Costs and "TBSE" parameters (EP / A / EPA)

EP	Coûts Fixes	Nombre Abonnés	CFM	F TBSE EP	CVM_EP
	9000000	45800	196,51	49,13	0,6

A	Coûts Fixes	Nombre Abonnés	CFM	F TBSE A	CVM_A
	5000000	21000	238,10	59,52	0,5

TBSE EP		Prix HT Op	Redevances	Prix H TVA	Montant TVA par unité de service	Prix TTC	Taux de TVA (en %)	2,1	Redevances (accise, en euro / m3)	0,12
Abonnement		49,13	0	49,13	1,03	50,16				
Prix unitaire (au mètre 3)		0,6	0,12	0,72	0,02	0,74				

TBSE A		Prix HT Op	Redevances	Prix H TVA	Montant TVA par unité de service	Prix TTC	Taux de TVA (en %)	10	Redevances (accise, en euro / m3)	0,04
Abonnement		59,52	0	59,52	5,9524	65,48				
Prix unitaire (au mètre 3)		0,5	0,04	0,54	0,0540	0,59				

TBSE EPA		Prix HT Op	Redevances	Prix H TVA	Montant TVA par unité de service	Prix TTC			Redevances (accise, en euro / m3)	0,16
Abonnement		108,65	0,00	108,65	6,98	115,63				
Prix unitaire (au mètre 3)		1,1	0,16	1,26	0,07	1,33				

Illustration 2/3 – Water demand Function (back to the tool)

Based on the information entered by the user, the tool:

(1) calculates:

household water consumption,

bill amounts,

PARs (the proportion of the bill related to the provision of basic services in the household's income) …

for each household in the Population module (representative sample of the customer population) making use of an econometric demand model:

$$\ln q_i = \ln q_{0,i} + \alpha \ln\left(R_i - F\right) - \beta \ln \pi + \varepsilon_i,\ i = 1, \ldots, n$$

for the reference tariff system ("TBSE EP/EPA") next

(2) displays a certain amount of (basic) information on the performance of this reference pricing policy.

Remark *On the household water demand function*: see technical documentation for detailed information on:

Functional form

Captive consumption, basic consumption, economic (variable) part (of water demand)

interpretation of coefficients (that have an economic meaning) with, in particular, price-elasticity (see **question Q4**) … and the impact of the fixed part:

$$\eta_{q_i^d,F} = \frac{\partial q_i^d}{\partial F}\frac{F}{q_i^d} = -\frac{\partial q_i^d}{\partial R}\frac{R_i}{q_i^d} \times \frac{F}{R_i} = -\left(\alpha \times \frac{R_i}{R_i - F}\right) \times \frac{F}{R_i} = -\alpha \times \frac{F}{R_i - F} \simeq -\alpha \times \frac{F}{R_i}$$

on household *i*'s drinking water consumption, $i = 1, \ldots, n$.

Illustration 3/3 – Initialisation phase : TBSE Findings:

(1) TBSE Consumptions are (often) quite high (compared, in particular, to "First-best values")

	IBT	IBT PP	TBSE	First Best
% de Ménages	***	***	***	
Moyenne			51,471	29,616
Médiane			48,804	28,773
Min			10,353	6,625
Max			115,353	72,702
Q1			38,109	22,043
Q3			62,771	35,330
D1			27,619	16,578
D9			77,726	43,896
F (Moyenne)			57,2	55,2

(2) Unrecovered environmental cost is (often) quite significant.

Moyennes TBSE	unit	Population	G1	G2	Poor	Non Poor
Coût non récupéré	en € / trim	239,86 €	198,35 €	275,02 €	214,56 €	262,46 €
Consommation	en m3 / trim	51,471	45,703	56,356	46,135	56,234

and …

(3) TBSE Unaffordability

3-1 Incidence Headcount ratios (% of households, individuals…) facing an affordability issue (in the sense of PAR), are large

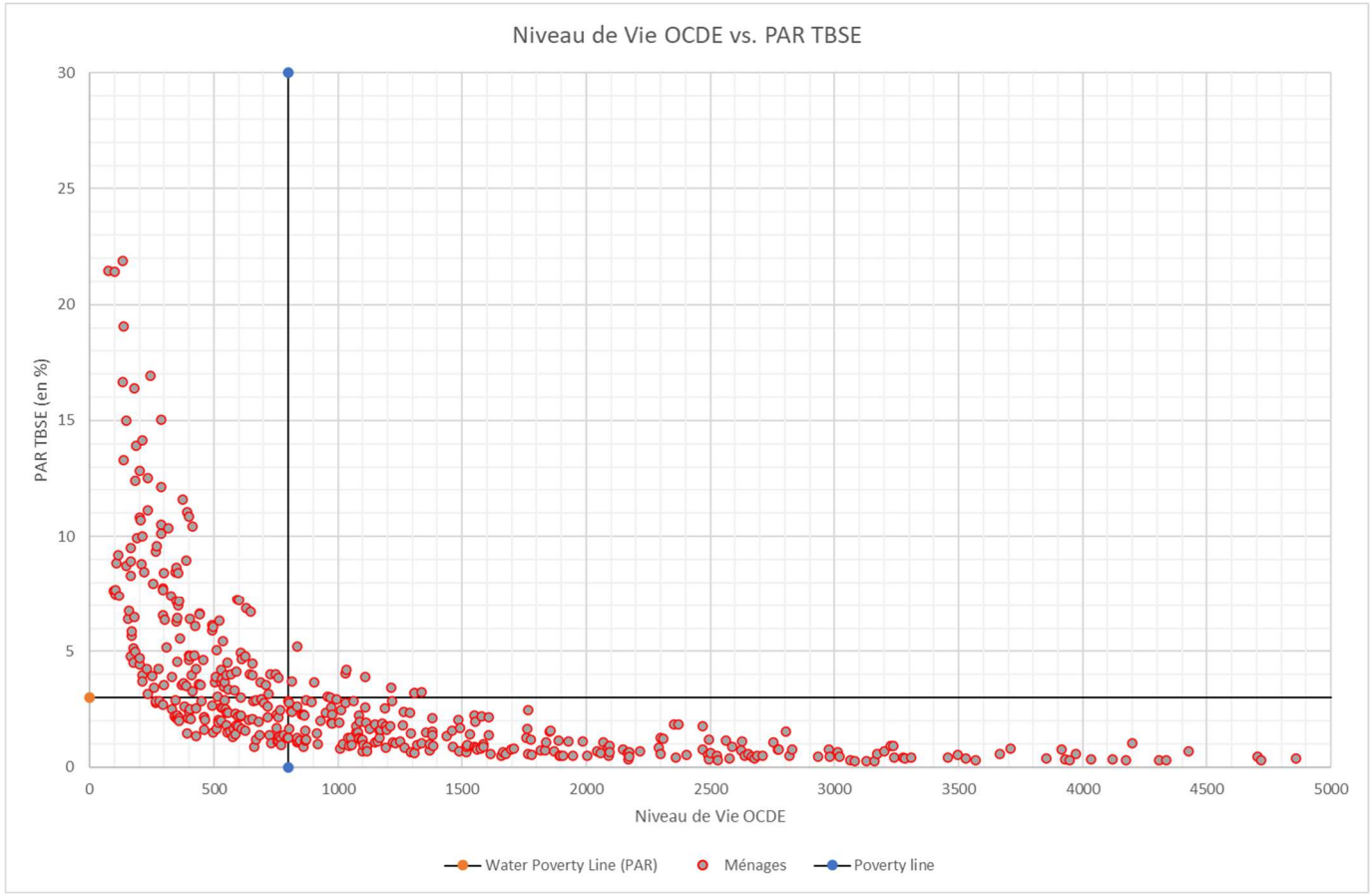
	En %		En points de %
Headcount ratio	PAR IBT	PAR TBSE	Delta PAR
Ménages		32,1	
Individus		30,5	
Enfants		33,2	

3-2 Intensity Apparent and Effective TBSE Affordability deficit are high

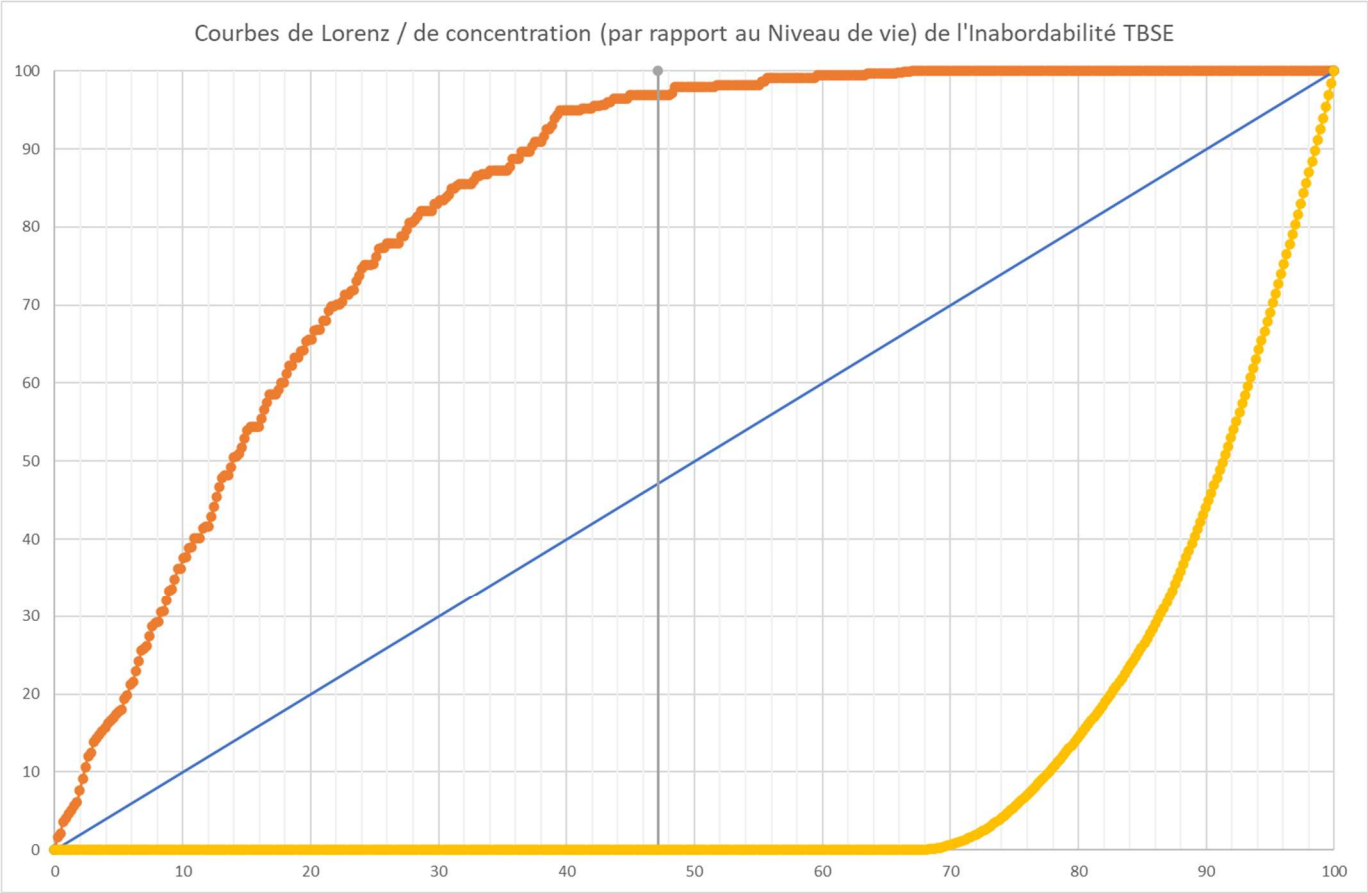
Déficit Apparent	PAR IBT	PAR TBSE	Delta PAR
Moyenne		**17,05 €**	
Médiane		0,00 €	
Variance		**993,6658**	
Ecart-type		31,52 €	
cv		1,85	
MAPE		24,06 €	

Déficit Effectif	PAR IBT	PAR TBSE	Delta PAR
Moyenne		53,13	
Médiane		41,90	
D1		9,72	
D9		102,43	
Variance		**1179,3496**	
Ecart-type		34,34	
cv		2,01	
MAPE		30,41	

3-C Inequality (Unaffordability Concentration) : Poor households are (often) much more exposed (1/2)



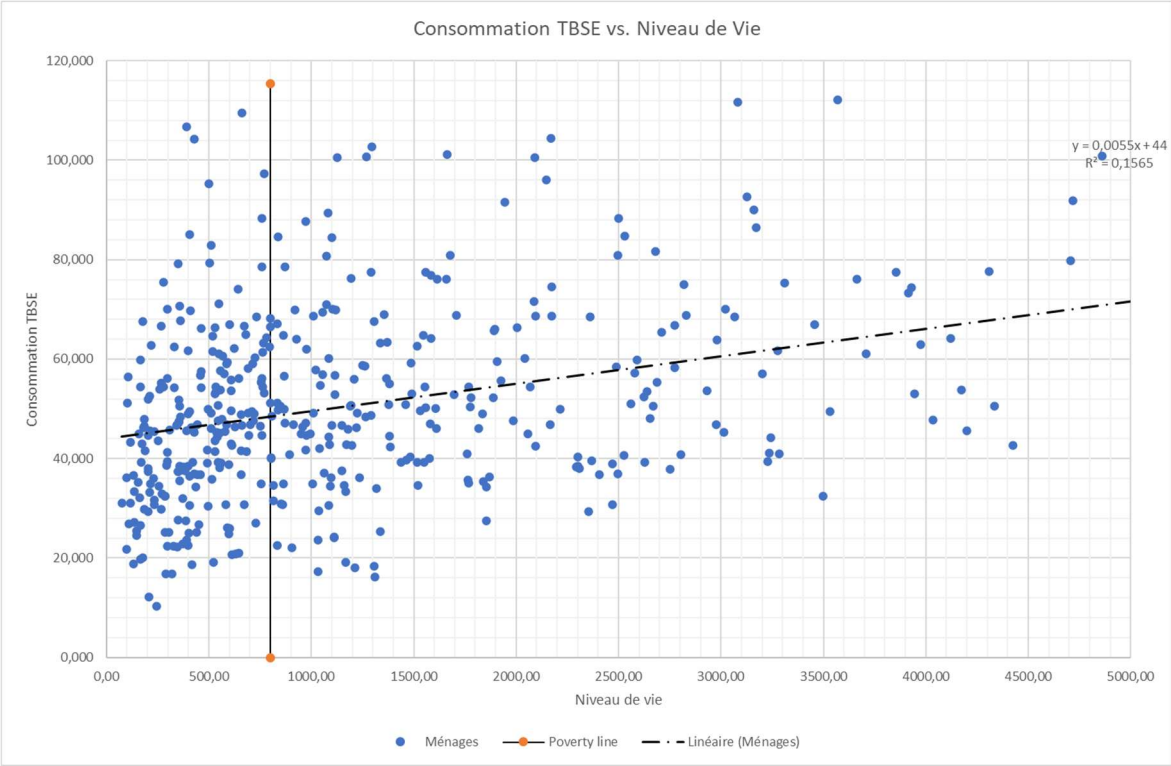
3-C Inequality (Unaffordability Concentration) : Poor households are (often) much more exposed (2/2)



(Gini Index : 79.7 – Quasi-Gini index: - 65.9)

(4) Stylized fact: The empirical correlation between water consumption and standard of living is positive but weak

i.e. "*There are many rich households that use small amounts of water, and many poor households that use large quantities of water*" (Nauges and Whittingthon [2017]).



(Coefficient de détermination : 0.157 ; coefficient de Spearman : 0.387)

In view of these findings :

What can be done?

End of Part I & **Break**: 10 minutes.

III – Progressive pricing (IBT)

3.1 Motivations

(1) Commitment No. 42 of François Hollande's presidential campaign (2012):

"**I will introduce a new progressive pricing system for water**, electricity, and gas in order **to guarantee access to these essential goods for all and to encourage responsible consumption**."

(2) Water Plan (Mars 2023) – French President Macron:

"We need to introduce **a pricing system** that I would describe as **progressive** and **responsible** in terms of water. […]

The aim of the plan must be to **guarantee all French people access to high-quality drinking water for their essential needs**. […]

The first few cubic meters are billed at a modest price, close to cost. […]. This corresponds to the water we all need for drinking, washing, and everyday domestic use.

Then, **above a certain level**, **the price per cubic meter will be higher to encourage moderation**."

(3) …

3.2 Real Example

Tarif EP		Prix HT Op	Redevances	Prix H TVA	Montant TVA par unité de service	Prix TTC	Taux de TVA (en %)	2,1	Redevances (accise, en euro / m3)	0,12	
Abonnement		32,2	0	32,2	0,6762	32,8762	**N° Tranche**	D de Nordin Op	D de Nordin H TVA	D de Nordin TTC	**Vérification**
k0	0	0,2813	0,12	0,4013	0,0084	0,4097	**T1**	0,0000	0,0000	0,0000	0,0000
k1	25	1,4694	0,12	1,5894	0,0334	1,6228	**T2**	29,7025	29,7025	30,3263	30,3263
k2	50	3,6972	0,12	3,8172	0,0802	3,8974	**T3**	141,0925	141,0925	144,0554	144,0554
k3	100	5,6804	0,12	5,8004	0,1218	5,9222	**T4**	339,4125	339,4125	346,5402	346,5402

TBSE EP		Prix HT Op	Redevances	Prix H TVA	Montant TVA par unité de service	Prix TTC	Taux de TVA (en %)	2,1	Redevances (accise, en euro / m3)	0,12
Abonnement		49,13	0	49,13	1,0317	50,16				
Prix unitaire (au mètre 3)		0,6	0,12	0,72	0,0151	0,74				

Tarif A		Prix HT Op	Redevances	Prix H TVA	Montant TVA par unité de service	Prix TTC	Taux de TVA (en %)	10	Redevances (accise, en euro / m3)	0,04	
Abonnement		32,54	0	32,54	3,2540	35,794	**N° Tranche**	D de Nordin Op	D de Nordin H TVA	D de Nordin TTC	**Vérification**
k0	0	1,3	0,04	1,34	0,1340	1,474	**T1**	0	0	0	0
k1	25	2,12	0,04	2,16	0,2160	2,376	**T2**	20,5	20,5	22,55	22,55
k2	50	2,21	0,04	2,25	0,2250	2,475	**T3**	25	25	27,5	27,5
k3	100	3,5	0,04	3,54	0,3540	3,894	**T4**	154	154	169,4	169,4

TBSE A		Prix HT Op	Redevances	Prix H TVA	Montant TVA par unité de service	Prix TTC	Taux de TVA (en %)	10	Redevances (accise, en euro / m3)	0,04
Abonnement		59,52	0	59,52	5,95	65,48				
Prix unitaire (au mètre 3)		0,5	0,04	0,54	0,054	0,59				

3.3 IBT Design

Q1 Apart from fixed parts, this municipality subsidises the drinking water service but taxes the collective sanitation service. What do you think about this?

- Yes, only the drinking water service should be subsidised.
- No, both drinking water **and** (collective) sanitation services should be subsidised.
- I don't know

Q2 Can you justify your answer to the previous question? **Open question**.

Questions 1 and 2 – diapo 1/2

Tarif EP		Prix HT Op	Redevances	Prix H TVA	Montant TVA par unité de service	Prix TTC	Taux de TVA (en %)	2,1	Redevances (accise, en euro / m3)	0,12	
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Abonnement		49,13	0	49,13	1,0317	50,16				
Prix unitaire (au mètre 3)		0,6	0,12	0,72	0,0151	0,74				

Questions 1 and 2 – diapo 2/2

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k1	25	2,12	0,04	2,16	0,2160	2,376	**T2**	20,5	20,5	22,55	22,55
k2	50	2,21	0,04	2,25	0,2250	2,475	**T3**	25	25	27,5	27,5
k3	100	3,5	0,04	3,54	0,3540	3,894	**T4**	154	154	169,4	169,4

TBSE A		Prix HT Op	Redevances	Prix H TVA	Montant TVA par unité de service	Prix TTC	Taux de TVA (en %)	10	Redevances (accise, en euro / m3)	0,04
Abonnement		59,52	0	59,52	5,95	65,48				
Prix unitaire (au mètre 3)		0,5	0,04	0,54	0,054	0,59				

Questions 3 and 4 We are initially **interested in the fixed part** (subscription amount).

We have operator's subsidies on the access fee amounting to 16.93 euros per trimester for the Drinking Water service and 43.91 euros per trimester for the Water and Wastewater service.

Q3 Do you consider these subsidy amounts to be significant in a context where 47.2% of households are poor (the percentage of households in group G2 (connected to the collective sanitation network) is 48.6%)?

- Yes, they are excessive
- No, they are at the levels they should be
- No, they are insufficient.
- Personally, I would have subsidised the Access fee for Drinking Water more and reduced the one for (Collective) Sanitation.
- Personally, I would have reduced the subsidy for Access Fee for Drinking Water and increased the one for (Collective) Sanitation
- I don't know
- Other: please specify.

Survey responses are displayed and:

Q4 Ultimately, what do we do?

- Leave it as it is
- We increase the (two) subsidies
- Reduce both subsidies
- Increase the EP subsidy and reduce the A subsidy
- Reduce the EP subsidy and increase the A subsidy
- I don't know

Preliminary information for Q5

Sub EP		Sub HT Op	Sub Redevances	Sub Hors TVA	Sub TVA	Sub TTC
Droit d'Accès		16,93 €		16,93 €	0,36 €	17,28 €
k0	0	0,32 €		0,32 €	0,01 €	0,33 €
k1	25					
k2	50					
k3	100					

Tax EP		Sub HT Op	Sub Redevances	Sub Hors TVA	Sub TVA	Sub TTC
Droit d'Accès						
k0	0					
k1	25	0,87 €		0,87 €	0,02 €	0,89 €
k2	50	3,10 €		3,10 €	0,07 €	3,16 €
k3	100	5,08 €		5,08 €	0,11 €	5,19 €

Subsidy & taxation on Drinking Water service

Sub A		Sub HT Op	Sub Redevances	Sub Hors TVA	Sub TVA	Sub TTC
Droit d'Accès		26,98 €		26,98 €	2,70 €	29,68 €
k0	0					
k1	25					
k2	50					
k3	100					

Tax A		Sub HT Op	Sub Redevances	Sub Hors TVA	Sub TVA	Sub TTC
Droit d'Accès						
k0	0	0,80 €		0,80 €	0,08 €	0,88 €
k1	25	1,62 €		1,62 €	0,16 €	1,78 €
k2	50	1,71 €		1,71 €	0,17 €	1,88 €
k3	100	3,00 €		3,00 €	0,30 €	3,30 €

Subsidy & taxation on Wastewater service

Sub EPA		Sub HT Op	Sub Redevances	Sub Hors TVA	Sub TVA	Sub TTC
Droit d'Accès		43,91 €		43,91 €	3,05 €	46,96 €
k0	0					
k1	25					
k2	50					
k3	100					

Tax EPA		Sub HT Op	Sub Redevances	Sub Hors TVA	Sub TVA	Sub TTC
Droit d'Accès						
k0	0	0,48 €		0,48 €	0,07 €	0,55 €
k1	25	2,49 €		2,49 €	0,18 €	2,67 €
k2	50	4,81 €		4,81 €	0,24 €	5,04 €
k3	100	8,08 €		8,08 €	0,41 €	8,49 €

Subsidy & taxation on Drinking Water & Wastewater services

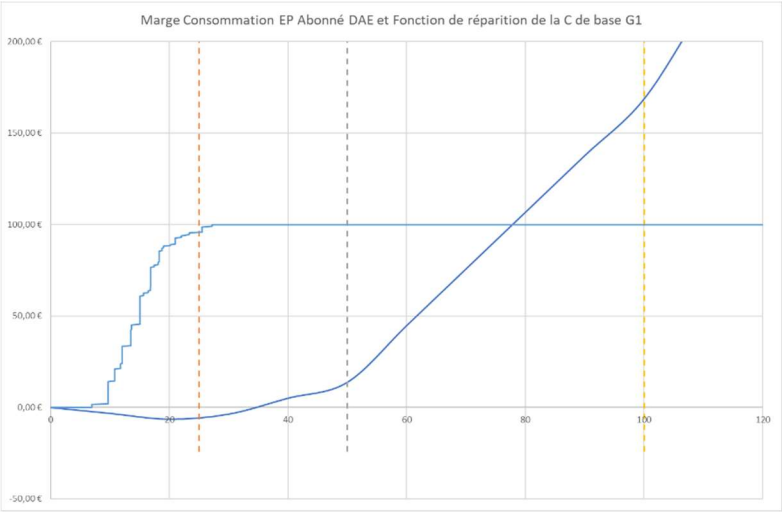
Q5 With regard to the distribution functions (Group 1 and Group 2) of basic consumption, do you think the subsidised volumes are sufficient?

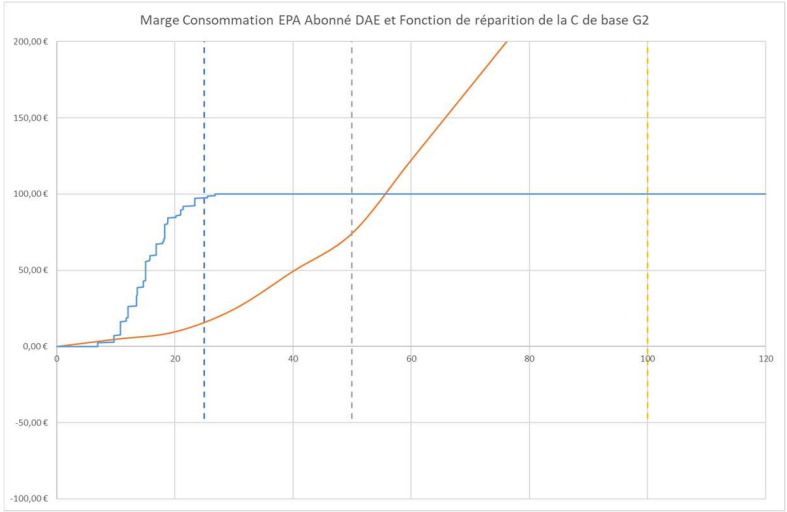
- Yes, they are
- No, it is not enough. It needs to be increased.
- No, it is too much. It needs to be reduced.
- I don't know

Q5-bis (depending on answer to Q5) By how much should we vary the threshold for the first consumption block for drinking water services?

Answer: numerical (cubic metres per quarter), open-ended.

Elements Q5:





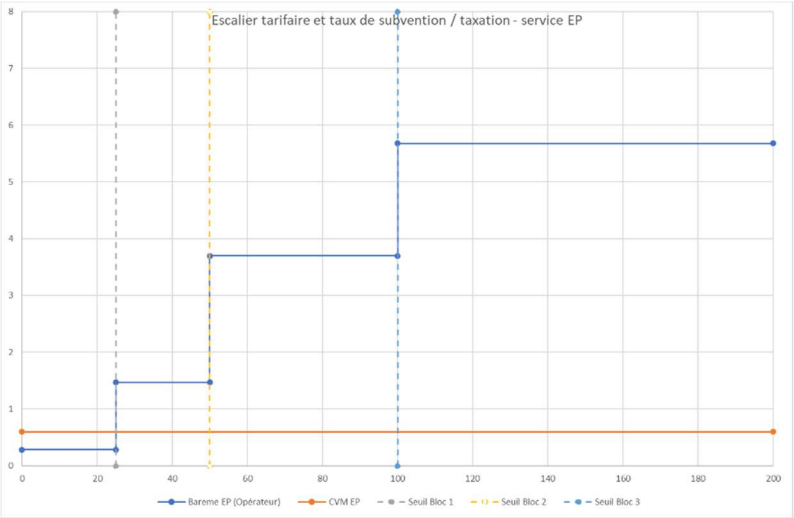
Q6 Looking at the Drinking Water tariff scale graph, do you think the subsidy rate applied to drinking water for Group 1 households alone (not connected to the collective sanitation network) is sufficient?

- Yes, it is
- No, that's not enough. It needs to be increased.
- No, it's too much. It needs to be reduced.
- I don't know

Q6-bis (depending on answer to Q6) By how much should we vary the EP subsidy rate for the first block?

Answer: numerical, open-ended.

Elements Q6

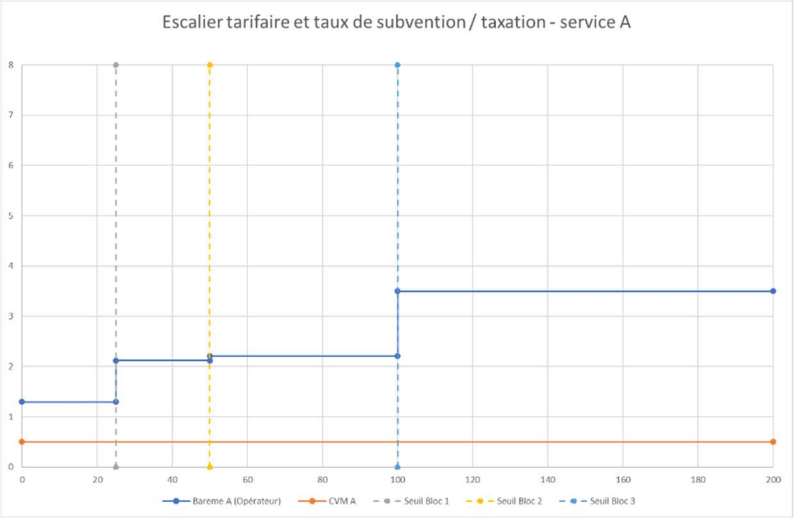


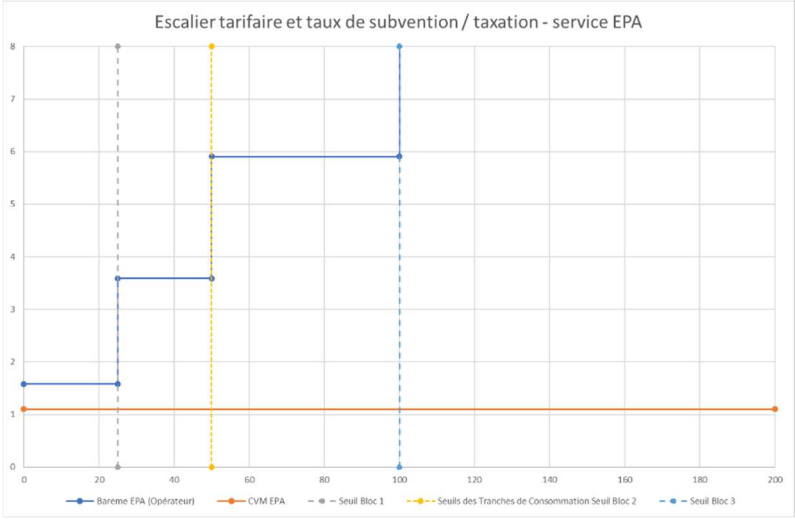
Q7 Looking at the EPA tariff scale graph, do you think the taxation rates applied to drinking water and sanitation service units, for Group 2 households only, are convenient?

- Yes, they are !
- No, it is not enough. It needs to be increased.
- No, it is too much. It should be reduced.
- No, units in the first block should be subsidized.
- I don't know

Q7-bis (depending on answer to Q7) By how much should we vary the Drinking Water and Wastewater rate(s)?

Answer: numerical, open-ended.





Finally (on the calibration of increasing block pricing) and limiting ourselves to equiproportional variations:

Q8 What do we do for Drinking Water prices of blocks 2, 3 and 4?

Answer: numerical, open-ended.

Q9 What do we do for Wastewater prices for blocks 2, 3 and 4?

Answer: numerical, open-ended.

Before running the simulation (and displaying a number of (initial) results), what do you think about the impact of the new pricing policy on:

Q10 the level of service?

- Overall consumption is expected to increase
- Overall consumption is expected to decrease
- Consumption is expected to remain stable
- I don't know

Q11 Operating profit?

- The accounts should remain roughly balanced.
- I expect a deficit.
- I expect a surplus.
- I don't know.

Q12 The affordability deficit?

- It should decrease, significantly.
- It should decrease, slightly.
- I wouldn't rule out an increase.
- I don't know.

By the way (on REX values) :

Service EP / EPA (consolidé)					
Charges		Montants		**Produits**	
Coûts Fixes		14 000 000,00 €		R Fixes (Abo)	8 632 400,00 €
Coûts variables		6 036 214,57 €		R variables	11 294 601,89 €
Total Charges		20 036 214,57 €		Total Produit	19 927 001,89 €
Résultat net		**-109 212,68 €**	**-0,5**	En % du coût du service	
Redevances		1 028 522,57 €			
TVA		1 033 571,92 €			

and …

				Abonnés		Niveau de service	
Service Eau Potable				45800		7578130,62	
Charges		Montants		Par abonné		Par unité de service	
Coûts Fixes		9 000 000,00 €		196,51 €		**1,19 €**	
				CV par Abonné		CVM	
Coûts variables		4 546 878,37 €		99,28 €		0,60 €	
				C par Abonné			
Total Charges		13 546 878,37 €		295,78 €		1,79 €	
Résultat net		**-1 013 462,55 €**		-22,13 €		-0,13 €	
Redevances		909 375,67 €		19,86 €		0,12 €	
TVA		282 298,62 €		6,16 €		0,04 €	

				Abonnés		Niveau de service	
Service Assainissement				21000		2978672,39	
Charges		Montants		Par abonné		Par unité de service	
Coûts Fixes		5 000 000,00 €		238,10 €		**1,68 €**	
				CV par abonné		CVM	
Coûts variables		1 489 336,20 €		70,92 €		0,50 €	
Total Charges		6 489 336,20 €		309,02 €		2,18 €	
Résultat net		**904 249,88 €**		43,06 €		0,30 €	
Redevances		119 146,90 €		5,67 €		0,04 €	
TVA		751 273,30 €		35,77 €		0,25 €	

IV – Additional information ("To go find out more")

A) Other items (covered by the tool):

- The issue of overconsumption linked to misperception of IBT
- Fairness: subsidies often benefit the wealthiest households more
- Exclusion and inclusion errors (in volume and value) related to the proper calibration of the tariff
- The dependence of funding on large consumers (what poses a risk of the service)
- …

B) The advantage of "knowing" water demand functions …

Please note:

(1) (water-) demand functions exist;

(2) data can be used to infer (water-) demand functions;

(3) knowledge of (water-) demand functions provides useful information

for (in particular) calculating the indicators that need to be calculated.

On this last point, see the practices of consultants, companies, certain stakeholders … for:

- measuring affordability
- measuring incentive effects

versus academic practice/what the tool allows.

C) Dissemination

- The tool will be uploaded to the InnWater project platform with presentation materials, an AI, a Q&A …

and (warning) be aware of the replication conditions:

- Local demand function (water demand econometrics);
- Socio-economic composition of the population
- Adaptation of the Tariff module
- ...

(Open Code Source Strategy).

D) Governance aspects (and the tool):

- The Dashboard and the Stakeholders
- The prioritisation of objectives (show answers to **Q5**)
- Agreement on the diagnosis
- Quantification of trade-offs (moving away from "fénoir")
- …

and the combination of instruments (aid programmes, behavioural interventions) for which there are gains … and losses (decrease in consumption tends to destabilise the financing of the service).

In any case:

- Calibrating properly the water and wastewater tariffs is challenging

but the academic knowledge and methodology that are passed through the tool should support water price setting (and the related public political decision-making process). ■