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Is Individual Metering Socially Sustainable? The Case of Multifamily Housing in France

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ABSTRACT: Before generalising water metering and billing at the apartment level for consumer equity reasons, and alleviating the burden of water bills for poor families through increasing block tariffs (IBTs), Paris Council asked for some expert advice. The pros and cons of two separate issues – IBTs efficiency and justice; and individual household metering – were mixed. Our research first summarises various studies of the redistributive effects of tariff changes, first from flat rates to metering, and then from uniform prices to IBTs. We address the particular case of multifamily housing, where it is possible to retain collective billing, while relying on sub-metering to allocate the bill. The limitations of classical econometric surveys on large samples (in terms of understanding households' strategies with tap water) support the need for supplementary detailed sociological surveys at neighbourhood or building levels, if only to check the unexpected redistributive effects of tariff changes in practice. We review the specific French situation, peculiarly in Paris, to show that individual apartment billing is more costly and tends to have regressive effects. Like other cities in France, Paris abandoned the implementation of Art. 93 of the 2000 law, which encouraged individual billing; and we explain why.

KEYWORDS: Water tariffs, metering, increasing block tariffs, multifamily housing, redistributive effects, France, Paris

INTRODUCTION

Since World War II, economists who studied water utilities supported the evolution towards a commercial service, covered by water bills rather than by taxes or rates. They usually proposed to generalise metering at the household level, which was supposed to foster efficient user behaviour. The argument in favour of 'full cost pricing' of water services is now accepted in the water policy communities of rich industrial countries; but it increasingly raises concerns about the important tariff increases induced and their socio-political acceptability. While connections to water supply are universalised, metering is not generalised and remains debated. Additionally, until recently, it has not been used to encourage efficient or environmentally friendly behaviour, but to cover utilities' costs: if water volumes sold increase with population and with household wealth and comfort, then every year utilities increase their incomes, which allows them to invest in extensions or in modernisation. Consumer billing also reduces the risk of political interference.

If the issue is global cost recovery, there is no need to generalise meters at housing unit level: indeed in large cities like Boston, New York, and Berlin, the urban tradition is to have only one meter per building. Frequently in France, properties, not housing units, are metered, so that, while single-family homes have their separate meter, in downtown areas and in dense neighbourhoods, it is common to have only one meter per building. The collective water bill is then allocated according to each apartment's surface area.[1] Collective billing usually reduces both potential conflicts between the utility and the residents, and the percentage of bills in arrears. In many cases though, building managers and public housing companies hope to reduce internal conflicts with and between residents through metering each apartment; usually the building managers read the sub-meters and allocate the single bill sent by the utility according to volumes used rather than surface area (or other criteria), but still adding the cost of water to the monthly rent. This is cheaper than billing residents separately. But the objective of efficient water use might be lost, since individual households are not directly confronted with a bill: this argument is frequently heard. However, if water consumption is not elastic to price, collective metering could be a better trade-off between the two targets (efficient use and cost recovery).

There is a third dimension to consider: affordability. With water becoming a global issue, metering and tariff policies in developed countries are impacted by the controversies that developed when neo-liberals claimed that privatisation and liberalisation were the best ways to improve water services in developing countries. European utilities discovered what had previously been ignored: water bills could become unaffordable for the poor. This was first evidenced in England and Wales, which were experiencing a radical and debated privatisation (Fitch and Price, 2002). In that situation, increasing block tariffs (IBTs), which were initially considered by economists as tools to curb consumption, were reassessed as potential social tariff systems. In response to Dublin's principle of considering water as an economic good, the 1992 Rio conference initiated the theme of 'rights to water', supporting, in turn, the idea of a cheap or free initial volume of 'essential water', balanced by IBTs design, so that utilities could still cover their costs.

Altogether, these new developments placed water utilities in the midst of the more complex debate on sustainable development: can they design a tariff system that induces water conservation (environment) while still allowing them to cover their costs (economic sustainability) and remaining affordable to the lowest incomes (social dimension)? This paper develops several case studies to support the argument that individual metering plus IBTs is not obviously the best universal solution.

In France, supporters of individual metering coalesced with a few public housing companies that wished to remove the duty of allocating water charges to tenants, and they lobbied government and the (then left wing) Parliament into voting for article 93 of the 2000 SRU law (*Solidarité et Renouvellement Urbain*; Solidarity and Urban Renewal). This article allows building (co-) owners and the building manager to compel the water utilities to meter each household and to send separate bills to the tenants. Some water utilities and academics, like myself, however, were suspicious about this 'ideal' tariff structure. One of several reasons is because the French experience with metering teaches that it is costly: obviously, if two families share the same meter, they reduce the fixed cost of meter operation and renewal, particularly in billing.[2] Since I had expressed some doubts (Barraqué, 2005), I was asked by the (socialist-green) Paris municipality for advice before they would implement Art. 93 of the SRU Law. Research was conducted with my colleagues of the LATTS – ENPC.[3] We first gathered international information on the redistributive effects of tariff system changes and on other means to alleviate the impact of water charges on various users. Turning to France, we analysed why some public housing companies wanted water companies to take over the charging of water and sanitation services through direct household billing, and what were the possible outcomes of this change. In Paris, we conducted

[1] For example, in Paris, there are approximately 80,000 residential building meters for a population of 2.2 million inhabitants, which means there are an average of 27 persons, or 13 families, using one meter. In Berlin, separate billing is more widespread but not systematic: the average number of persons per meter is 8 (on average, 5 families, given de-cohabitation).

[2] French water companies developed some skill in metering and billing; in other words, a capacity to reduce transaction costs with water users. They know that collective billing is much easier, from a commercial perspective. Boston Water and Sewer Commission also refused to bill apartments separately, and preferred to keep collective metering – they, however, turned to smart meters.

[3] Laboratory Technology Territories and Societies, École Nationale de Ponts et Chaussées, University of Marne la Vallée (see Barraqué et al., 2007).

what we termed a before – after survey in a few cases where individual metering and billing was introduced. The survey questions were: how did collective consumption 'react' to the new tariff, and how much money individual families paid before and after the tariff change? The results convinced Paris not to proceed with the project but rather to generalise smart metering at the building level, so as to attain knowledge of what makes water consumption increase or decrease,[4] and to provide real-time information to building managers about unusual consumption (i.e. leaks).

In the following pages, we illustrate the chief findings of our survey in several developed countries and of our fieldwork in France. In water supply, consumer justice is different from social justice, and it is not easy to design a tariff system that gets large consumers to assume the cost of their water use while usage remains affordable for low-income users. More precisely, while it is possible to design such a tariff, the information needed is costly to acquire and could well exceed the expected benefits. And, in any case, IBTs can have negative distributive effects. Indeed, many water utilities prefer to keep a simpler existing tariff, or would accept to introduce some changes, but they prefer that support to low-income families be provided "outside the bill" (AWWA, 2004).

We first present the general debate on consumer/social equity issues in water tariffs, in particular the pros and cons of IBTs. Then we present our findings on the redistributive effects of tariff changes, taking into account the diversity of initial situations:

- In England and Wales, the issue was to move from a supposedly outdated rating system to metering, but the generalisation of meters has been postponed;
- In New York City, analyses made by urban planners led the Water Department to introduce metering, but only at building level, and with no IBTs;
- In Barcelona, Belgian Flanders, and Wallonia, IBTs were introduced but had counter-intuitive effects.

Subsequently we turn to the French situation, and we summarise some of the case studies we made, focusing on condominiums and public housing. These microanalyses are useful to understand why billing water at the household level is not a good idea in French downtown areas, and probably not in other cities either. Building managers should remain responsible for allocating the collective water bill among residents, either through an apartment surface indicator or through sub-meters they operate themselves. We conclude that sociological analyses of water tariff redistributivity are still in their infancy, and need to be developed before the tariff changes take place; and the consumption and the charges paid need to monitored before and afterwards.

While a full review of the economic literature on water pricing is beyond the scope of this paper, it is useful to present some of the arguments by economists who expressed doubts about IBTs. This information is in the text box below, titled, *Household metering, IBTs and water demand management*.

METERING, IBTS, AND EQUITY: CONSUMER OR SOCIAL JUSTICE?

The first rationale for introducing volumetric payment of water, and additionally IBTs, is efficiency in use and demand management. But there is another argument: equity. One can indeed argue that even if elasticity of consumption to price is small and that IBTs may have complex impacts, they may still be justified in terms of utilities getting higher revenues from users who generate a costly peak demand; and, on moral grounds, most people support that water wasters should be the payers: metering and IBTs would be advocated in terms of consumer justice. Some also consider social justice: initial cheaper volumes would make water less expensive for the poor. Mention must be made of the Organisation for

[4] In particular, water consumption decreased by 25% from 1991 to 2005 in the 20 *arrondissements*, without any explicit conservation policy or pricing mechanism. It is the consumption decrease that forced the mayor to increase the unit price to cover the costs.

Economic Co-operation and Development (OECD) survey on social issues in water pricing (OECD, 2003). Among other things, the OECD reviews various methods to cover bills in arrears or to support bills of the poorest families in various countries. But the OECD supports full-cost pricing of water services, and its commercial or private law status. *Social Issues in the Provision and Pricing of Water Services* (OECD, 2003)

But most of the book is devoted to the *affordability* of water services prices. Indeed, water prices rose drastically in the 1990s, and this trend is estimated to continue, so that the social issue will necessarily continue. The OECD taskforce tried to develop an indicator of what it called macro-affordability, based on the ratio of average water charges to the mean aggregated household revenue, or to the mean aggregated household expenses. It also developed an indicator of micro-affordability, this time looking at the impact of water expenses on various income groups, family sizes, and regions. But the priority remained economic rationalisation:

> The trade-offs between efficiency and equity objectives in the provision of household water services typically occur when moving from an unmeasured to a metered charging structure, when rebalancing tariffs away from fixed charges towards volumetric charges, and when increasing fees and tariffs towards full cost pricing. There is considerable experience in OECD countries with policy measures to address water affordability for vulnerable groups, while attempting to make water pricing reveal the full economic and environmental costs of water services (OECD, 2003: 12).

Supporting measures for the poorest families can be grouped in two broad categories: those supporting revenues of targeted households, and preferential tariffs. The first group of measures include social subsidies, vouchers, fractioned payments, and debt forgiveness.[5] In the second group, preferential tariffs are meant to keep water bills below a certain fraction of revenue (e.g. 4 %). They include keeping water charges under a threshold, and increasing block tariffs. Though the OECD admits that some metering plus IBTs may have regressive effects on large poor families, they deem that "the design of increasing block tariffs can be adjusted in several ways to make the sizes and prices of tariff blocks deliver the intended distributive effects" (ibid).

But is this evident? Boland and Whittington think that:

> this type of tariff deserves more careful attention. Even at first glance, the consensus appears somewhat curious because, although IBT structures were first designed in industrial countries by providing revenue-neutral cross-subsidies, only a small minority of water companies in countries like the United States now use them. Water and sanitation conditions may help explain the fact that IBTs are increasingly popular in developing countries… but this is not obvious. In many cities in developing countries, most poor households do not have private metered connections to the water distribution system, and thus IBTs do not help them (Boland and Whittington, 2000: 215-216).

After careful examination, they concluded, "IBTs introduce inefficiency, inequity, complexity, lack of transparency, instability, and forecasting difficulties… Every claimed advantage of an IBT can be achieved with a simpler and more efficient tariff design: a uniform price with rebate" (ibid). This is the formula they support: rebates can be targeted to low-income customers, provided the information is available. Komives et al. (2005) also draw from their experience in developing countries that IBTs have, in fact, regressive effects, because poor households are often large ones, so their consumption ends up in the upper blocks.

One however could argue that these conclusions may not be valid in developed countries. Indeed, in parts of Europe, almost all households are connected to the water supply system, so that collective

[5] Concerned about the high potential water supply price increases, the American Water Works Association (AWWA) recently published a guide for low-income water customers, the title of which shows their preference for this approach: "Thinking Outside the Bill" (AWWA, 2004).

consumption charging problems identified by Boland and Whittington (e.g. villages depending upon stand pipes, or connected subscribers reselling water to poorer neighbours) do not occur. There are, in fact, three situations in Europe. In the first, in England, Wales, and Ireland, there is no tradition of metering, and until recently all households paid by flat rates linked to the renting value of the homes. In the second possibility, in Mediterranean countries like Portugal and Spain (and also in Belgium), each household – including those living in condominiums – is metered and billed separately by water utilities; in such cases, IBTs can be introduced. The third possibility occurs in countries like France and in parts of Germany, in which metering was installed at the building level. Subsequently, building owners or managers can opt for sub-metering the apartments to allocate the total bill; if they don't want to sub-meter, they use to spread the bill in proportion to the number of household members, or (more frequently) to apartment sizes. In that case, it is difficult to introduce IBTs, though not impossible.[6] In the United States, metering is widespread, but some very large metropolises like New York and Chicago (which have a large proportion of condominiums) are only introducing metering now, and they do it at the building level.

There are few analyses on the socially distributive effects of tariffs on representative samples of families (size, type of housing, income, etc). We, however, found five such studies conducted in Europe and in the United States between 1993 and 2010. They illustrate the effects of changing from flat rates to meters (England and Wales, New York) and from uniform prices to IBTs (Barcelona, Belgium). When examining the following case studies, the reader should keep in mind that when utilities have separate water/wastewater budgets from the general budget, and must balance their costs with receipts, any internal cross subsidy scheme in favour of some customers results in higher water charges for other customers, all things being equal. Additionally, reforms were always considered or taken in particular situations, such as a crisis generated from outside the water utilities.[7] These new tariffs were usually thought to have positive distributive effects, which turned out to be incorrect.

ENGLAND AND WALES: TO METER OR NOT TO METER?

In England and Wales, the generalisation of metering was obviously considered as part of the full privatisation of water and waste water services, but also in the context of the replacement of local taxes by the poll tax: replacing a tax based on rental housing values by a uniform tax on all citizens of voting age. This new taxation was particularly regressive, and stirred hotter debates than those over water industry privatisation. The poll tax was abandoned, unlike the metering project. Yet the targeted full metering date of 2000, set by the privatisation law, is far from being met in 2011: two-thirds of English homes remain unmetered. The rating system is increasingly outdated, because the rates' fiscal base has not been updated since the 1990s. Water charges are less and less representative, which gives a strong argument to the supporters of metering.

Adviser to the OECD cross-country analysis, Paul Herrington is one of these supporters. He drew up a synthesis tuned with the quest for a new water tariff that would take advantage of this elasticity, however weak it may be (Herrington, 2007); introducing meters reduces global drinking water consumption by 10% to 15%. However, elasticity to price variations remains unclear. Yet Herrington still advocates metering with IBTs because in the south-east of England, water abstractions have reached the sustainable yield of the resources, so wastage must be penalised so as to postpone very costly investments in additional supplies. But Herrington agrees that sustainable tariffs should also meet the

[6] If the first block is calculated per person, like in the Flanders case reviewed below, there can be a fair IBT structure, even with collective metering. Yet it will obviously be difficult to keep a precise record of the number of people using a collective meter. Boston Water and Sewer Commission did introduce IBTs after installing collective and smart metering at the building level. Unfortunately, there is no distributive analysis (e.g. who pays how much for water).

[7] This might give additional credence to the endogeneity hypothesis of Hanemann (1998) (see box 1).

social target, and he finds the solution: IBTs could be designed to protect access for essential uses, and if so, they could help reduce the government's reluctance to make metering compulsory.

Yet, back in 1993, the Fiscal Studies Institute tried to assess how different households might be impacted by the shift towards full metering (Rajah and Smith, 1993). They gathered evidence that large poor families would be impacted negatively by the change,[8] but apart from that, full metering would only be slightly regressive compared to the existing rating system, notwithstanding the costs associated with metering and billing.[9] They also explored banded charges. Interestingly, they found that a fair charging system could be based on family size: given the inelasticity of water consumption in the area, family size could provide the best proxy to volumes used without having to meter; excessive costs to poorer households could be handled through the existing benefits system. However, it might mean developing and updating a costly register of households' sizes. The Fiscal Studies Institute, in fact, feared the administration costs of full metering. This study probably did not influence the debate much, but the message about the costs to administer any charging system was heard; in the end, metering was made compulsory only for non-residential buildings, large residential single family housings (those with swimming pools and/or automatic lawn sprinklers), and for all new housing. Metering is progressing slowly.

The debate continues. Water companies usually support metering as an essential quality of a commercial service. But if various conservation measures result in a reduction of volumes sold, they lose money,[10] so water companies would like to obtain a financial bonus from OFWAT[11] (Office of Water Services) if they are successful with conservation measures. Some economists argue that even in the absence of meters, per capita consumption in England and Wales remain quite low at 129 litres/cap/day (lcd), which is below the European average, even though more people live in single-family or row houses with small gardens in Britain than on the continent. Reversing the idea, it means that the potential for residential water conservation remains small. Why generalise metering at housing unit level if metering and billing bear a significant cost? Generalising meters would cost as much as £1.4 billion; the water companies argue that this money would be better spent on asset renewal. One could, for instance, imagine installing one smart meter for a street of row houses, which would suffice to identify high consumption, usually due to leaks in the area. European operators know that controlling leaks is the first and easiest water conservation option.

NEW YORK CITY: FROM FRONTAGE RATES TO COLLECTIVE METERING

In New York City, replacing the frontage rates charging system[12] with metering at the building level was considered in the 1990s, so as to reduce water use and, thus, waste water volumes discharges, as mandated by the Environmental Protection Agency (EPA). Additionally, the New York City Department of Environmental Protection (DEP) wanted to Implement a council decision to stop the on-going subsidies for water services through a modernisation of management, including a long-term reduction of service costs (Netzer et al., 2001). But this reform was proposed at the time of a serious housing

[8] The Fiscal Studies Institute did not take into account the possibility of a consumption reduction. In fact, they considered that the total costs of the utility would stay unchanged, so that if some paid less, others would have to pay more, all things being equal.

[9] They did not take into account the extra costs associated with metering. Maintenance and depreciation of the meter, reading, and billing are costly operations, as we describe below in the French case. If Rajah and Smith had added these costs, the shift to metering would have been more regressive.

[10] Through an association called Waterwise UK, United Kingdom companies and the government encourage water-conserving technologies. Rainwater harvesting turns out to be much more expensive than the public supply.

[11] Office of Water Services is the economic regulator of water companies.

[12] The frontage rate is a water charge set in proportion to the width of the building façade on the street. In New York City, the rates were improved, thanks to surveys taken of the number of water-using fixtures in each building. However, updating the fixtures information has been costly.

crisis. Many building owners had declared their inability to pay local taxes and their properties had already been mortgaged. Some had even been seized by the City. In that situation, a dramatic increase in water charges linked with metering would have had regressive effects. The poorer neighbourhoods with a heavy proportion of modest rental apartments would be hit the worst, since they could not invest in water saving technologies (and they were not owners).

The DEP asked a university planning department to create a simulation of how metering might impact consumption and charges. First, Netzer et al. (2001) surveyed buildings that were already metered, but that were still paying by the frontage rates system, to assess the short-term impact of shifting to meter-based bills, with consumption deemed equal. They found that, on average, the change to metering would not increase the average water charges, but that the range of bills, from smaller to larger usage, would expand, with increases greatest in the areas with higher poverty rates. A second analysis was made of some buildings in the borough of Queens, buildings that had long been metered, to estimate what households would pay if using the frontage rates system. The authors symmetrically found that the rating system would reduce the span of water charges.

They concluded that a small, though still significant, portion of buildings with modest-sized families would be negatively impacted by metering, and that, apart from leak reduction and replacing wasteful water appliances, the potential for bill reduction after metering introduction would be limited. They advocated that some form of transition procedure was needed to make metering socially more acceptable. They imagined 3 classical possibilities: free initial volumes; rebates for poor households; and topping the bills at a certain level.

Finally the DEP opted for the third transition system. Since smart meters spot leaks much faster, they were proposed to building owners and/or managers. If owners/managers of leaky buildings opted for metering, their bills were capped at the level of the previous rates for a few years. During the transition period they were offered subsidies to help replace leaky pipes and fixtures. Buildings with unidentified leaks also received water bill rebates. However, in New York City it is illegal to differentiate water tariffs or to offer lower prices according to income levels. Instead the city developed a *Multiple Dwelling Conservation Program* where targeted buildings have to install separate meters in commercial spaces and to replace at least 70% of fixtures with water-conserving ones, in exchange for subsidies. On a total of 100,000 collective buildings of 6 or more flats, 40,000 flats were still in this transition phase in 2009, and half of the renters would pay less if their building shifted to metering. New York City had hoped to complete the suppression of frontage rates by 2010, with the assistance of a new subsidy program for toilet flush replacement in all apartments of a building. In any case, the City abandoned developing individual household metering and billing.

BARCELONA, FLANDERS, AND WALLONIA: REGRESSIVE EFFECTS OF IBTS?

After two case studies comparing flat charges to metering, let us consider the introduction of IBTs in cases where metering was already practiced. In Barcelona, a 'water war' took place in the 1990s (Tello, 2000; Domene and Sauri, in press): between 1987 and 1993, water prices more than doubled, due to inclusion in the tariff of waste water collection and treatment and of an abstraction tax linked to water scarcity. In addition, the garbage collection tax was also included in the water bill (as frequently occurs in Iberian countries). To alleviate the impact of this dramatic price increase, an IBT scheme was adopted, but with cheap initial volumes per meter, not per person. Due to the lack of preparation of the public, and given the obviously negative impact on households with several children, consumer NGOs and the federation of neighbourhood associations started a payment strike on the supplements introduced by the Catalan Government. The strike included up to 80,000 families, some of whom went to court; they won the case on the basis of large and poor families, but also single persons, having to pay much more, while industry paid 4 times less. Golf courses paid the irrigation tariff, which is very little money. The Catalan Government had to abandon many of the new taxes, and even had to introduce (in 1996) a 'social tariff' for large and poor households. Ten years later, the issue is still there, with additional price increases being considered by the Water Framework Directive of the EU, because of the new downward trend in water volumes sold by water utilities.

In Belgian Flanders, the 1997 pricing reform was triggered by an earlier decision to charge sewage collection and treatment closer to the real costs within the water bill (which actually doubles the price per m^3). After two previous tariff reforms were rejected, it was decided to implement one item of Agenda 21, adopted in Rio de Janeiro in 1992: a free initial volume of drinking water of 25 lcd to 40 lcd. It translated into an initial free block of 15 m^3 per capita per year, compensated by a strong increase for volumes above that level to allow water utilities to meet their costs. An analysis of distributive consequences was performed at the request of the Economic and Social Council of the Region (Van Humbeeck, 2000), which discovered that the effects were slightly but clearly regressive, despite the introduction of exemptions for some particularly fragile target groups. Frédéric Varone (2004) later showed that it was regressive partly due to the local characteristics of households: upper-income Flemish families statistically have more children and are advantaged by the free per capita volumes; they pay less than before,[13] while low-income families pay more because consumption above 15 m^3 is charged at a much higher rate. Unfortunately, it was the third such reform since 1991, and the regional government, and even the water suppliers, decided to retain this tariff system (without changing the blocks' spans) and to keep its effects undisclosed. Only workers' unions protested.

In 2004, Wallonia, the other Belgian region, adopted a water tariff reform with simultaneous objectives: (1) getting close to full-cost pricing, in particular for waste water services; (2) reducing the number of different price structures across water supplies; and (3) promoting rational water usage, consumer equity, and social access to water. In the region, 82% of homes are single family, and almost all households have a separate meter. It was then possible to set up a complex tariff system comprised of a fixed part (to fund the needed investments in sewage treatment), and of three increasing blocks (but no free volume like in Flanders); additionally, water supplies were allowed to offer limited rebates to very large customers. A survey has just been completed by the Association of Walloon Water Supplies (Aquawal, 2010). The overall result was, of course, a major increase in average bills (more than 40% between 2004 and 2009). But the variation among categories of population (size, education level, etc) would not exceed +/- 2% around this average. What worries the author of this article, however, is the number of people using an alternative supply source, which is much higher than previously expected. Average and median household consumption are very low, respectively 93.6 and 82 lcd. But for 49% of families who harvest rainwater and/or (more seldom) use a private well, average consumption goes down to 71.6 lcd. If this trend continues, and, additionally, if industries that use large amounts of water leave the system and directly pump groundwater, utilities might end up bankrupt. With a forecast price of 5 to 6 euro/m^3 (sewerage included), utilities fear the development of conflicts and bills in arrears. Domestic abstraction from alternative water sources was estimated at 11 million m^3/year; that is, 6% to 7% 'losses' in water sales. Some observers have asked if it was a good idea to even introduce IBTs, when water usage was already so modest.

These various case studies highlight that:

- Paying water according to the renting value of the house is socially fair, and might be a good choice in areas where there is no water scarcity and where consumption remains moderate and inelastic to price;

[13] Indeed, an additional child in a family uses less water than his/her siblings. If a free volume per capita is introduced and compensated by a higher price for higher volumes, then a larger family pays less than before. To give an illustration, in a family of three, where each member uses an average of 40 m^3, if an additional child uses 30 m^3, at 1€/m^3, the additional bill is €30. If this extra child gets 15 m^3 for free, and the price in the above block rises to €1.6, the child's part of the bill reduces to 15x1.6 = €24. The family of four pays €144 versus €150. But a family of three uses 120 m^3, so the new bill is 25x3x1.6 = €120, just like the previous one.

- Moving from rates to metering is usually a good idea, but there is no need for water utilities to separately meter each household in a condominium building. There are possibilities to support low-income customers under collective metering, but usually utilities will not include IBTs;
- When individual metering and billing is adopted, it is possible to use IBTs, but then the blocks need to be carefully designed so as to reach the target. The size of each family must be taken into account; otherwise large, low-income families will be badly hit.

Box 1. Household metering, IBTs, and water demand management.

Economic analysis of residential water consumption developed more than 40 years ago in the United States (Howe and Linaweaver, 1967); it usually showed a weak and negative elasticity to price (wide range around -0.3), and more important for outdoor uses than indoor. I do not expand on this literature here: readers will find an excellent presentation in Baumann et al. (1998), in particular in the chapter by Hanemann (1998): after introducing the types of charging systems (flat or variable, with or without blocks), and describing the criteria for designing water rates, he presents the complexities of water supply costs. He explains that the heavy initial investment leads to support marginal cost pricing, but the long run one, and eventually two-part tariffs (fixed/variable) and multiple block rates. He also covers the issue of seasonal rates, or peak load pricing, and provides examples of IBTs. He recommends balancing the administrative costs of designing a complex tariff system with the efficiency gains that can be expected. He concludes that:

IBTs have been used by several utilities to reshape the distribution of consumption by discouraging end-uses…. If designed so that every customer pays the marginal cost of service for at least some of their consumption, they can mimic the efficiency properties of marginal cost pricing. The heterogeneity of customer demands, however, makes this exceedingly difficult to accomplish. More typical is a block-rate structure that results in some people paying a higher price for services than others. Unless there are cost-based reasons to do so, concerns about equity will emerge. (Hanemann, 1998)

This raises a serious issue: given the heterogeneity of water supply and household situations (let alone the problem of correct meter functioning, reading, and reporting) is it not necessary to improve the traditional econometric surveys linking only water consumption to the price structure and to income? Based on study of the intermittent water supply issue in Amman, Jordan, Rosenberg et al. (2007) contended that regression analyses should better incorporate the alternative options that water users can adopt, given "alternative sources, water availability, conservation behaviours, local storage, or interdependencies". They propose to develop models based on revealed preferences, generating plausible household strategies with a Monte Carlo simulation. Systems analysis seems to provide better insights into the possible strategies of the utility and water users to improve their access to piped water, and into the relationship between water uses/conservation, prices, and utility revenues. Even though the study was made only about Amman, this type of approach is valid for a utility with continuous supply, and it supports the idea that understanding water users' behaviour is essential.

On his web page, Michael Hanemann posted a recent PhD thesis on the elasticity of demand under uniform versus IBTs, addressing the complexity of the problem (see Olmstead et al., n.d.). Using a unique set of cross sectional data on water consumption, households characteristics, and price structures in 16 water utilities across the United States (1082 households), the authors built a model taking into account the nonlinearity in the block tariff systems, based on "the econometrics of piecewise linear budget constraints" (ibid). They explain that, on the whole, residential water demand remains inelastic but that elasticity is greater in long-run analyses, in studies based on summer data, and in areas with IBTs. However, meta-analyses, which were conducted comparing elasticity across different studies, "face many confounding factors that differentiate the studies in their samples…. These results have caused some to suspect that previous studies had underestimated price elasticity through incorrect modelling, or that IBTs themselves are responsible for greater sensitivity of demand to price" (ibid). Applying their "discrete continuous choice" model to the full sample, they found an elasticity of demand to price of -0.33, which is in the range of most studies. For the subsample facing IBTs, the elasticity rose to -0.64, and for the subsample facing uniform prices, the effect was again -0.33, but the result is statistically insignificant. The authors then raise the theoretical question: "Does price elasticity vary with price structure, all else being equal, or is something else going on"? (ibid). Indeed, they suspect that cities adopting IBTs usually face dryer climates, and so water conservation programs are developed, "which may also cause consumers to be more responsive to water price changes" (ibid). Despite the quality of their data, these authors cannot demonstrate that there is a real elasticity to the shape of supply, but they suspect that demand elasticity is sensitive to the variable characteristics of cities. In other words, apparent elasticities might well be due to endogenous city effects. "Results from our tests…do not eliminate the possibility of some kind of behavioural response to the shape of supply, in addition to the magnitude of the marginal price, but they cast doubt on this possibility as the sole explanation" (ibid).

These recent analyses in the United States challenge the belief that IBTs would entail important water demand reduction; additional and detailed case-by-case studies are needed before adopting IBTs. This is all the more important in Europe, where per capita water use is on average about three times less, meaning that the potential for demand reduction is smaller: elasticity appears to be weaker in Europe, usually less than -0.15. Analysing large samples, another PHD thesis (Boistard, 1993) had shown weak elasticity of water use to price, and the statistical correlations were not very significant. More recent studies in France (Nauges and Reynaud, 2001) show elasticity around -0.1: increasing water prices by 10% would lead to conservation of only 1%, and the results are less significant; in any case, studies must be designed carefully in order to reduce sampling errors. Rinaudo et al. (in press) are now developing such a complex survey in the Languedoc area: in a sample of 300 communes with all sorts of water price structures, they have already shown an average elasticity to price of -0.2, and they have a good discussion of the pros and cons of various incentive tariff systems. Seasonal tariffs seem to offer a good compromise between water conservation, cost recovery of the utilities, and equity. Rinaudo et al., however, are finding that pricing changes will not be sufficient to resolve the potential water scarcity with climate change and with population growth; meanwhile, changes may result in equity issues and in socially inefficient exit tactics by water users (e.g. drilling private wells).

THE INDIVIDUAL VERSUS COLLECTIVE METERING ISSUES IN FRANCE

In France, all properties are metered, but not all individual apartments. Single-family homes have meters, and homeowners receive bills. Each condominium building receives its own bill; roughly half of the owners split the bill according to apartments' surface areas, the other half through submeters, which are managed and read by building managers. It is often in older, urban centres (as in other European countries) that individual metering is less developed. This is partly due to the difficulty of refurbishing these buildings; additionally, it is costly to install meters when there are two or more water pipes serving the apartments. This is frequently the case in Paris.

Yet, in the 1990s rapid price increases placed water on the political agenda, and some public housing companies started advocating that water utilities should bill households directly, as gas and electricity utilities did. They thought it would reduce their own problems with unpaid rents. Supporters of water conservation and consumer NGOs pushed in the same direction, and they coalesced with advocates of residents of bankrupt *copropriétés* (buildings with shared ownership): due to the inability of some residents to pay their charges, water was cut off to all, but with the new structure, that would not happen. This coalition culminated in the Parliament, which voted an article of the SRU law supporting individual metering and billing when owners wanted it (but not tenants). Suspicion however quickly developed. A report by CREDOC,[14] a research institute on consumption (Maresca, 2005), showed that implementation of this project was lagging behind, and that there were serious difficulties with this new billing system. It proposed to make experiments before any generalisation. In another document, CREDOC authors report a regular decrease in consumption in the absence of official incentives to conserve (CREDOC, 2005);[15] they even mentioned that if households seriously conserved water, utilities would suffer from an imbalance in their budgets and they would be obliged by law to make up the difference by raising unit prices. In large French cities, like in the rest of Europe, downtown areas were experiencing a historical downturn in water demands (Barbier, 2000). This phenomenon added to the costly investments triggered by the Urban Waste Water Directive of the EU to raise the prices so drastically.

Consumption decrease can be due to many factors. For example, a large new housing project may oblige a utility to invest in additional water supply, which results in a higher price; meanwhile, new houses use less water than old ones, which could give the appearance of elasticity to price. More generally, replacing water appliances is not done as an immediate response to an increase in price, but later, such as when appliances wear out. Econometric surveys would be blurred by these time lags in responding to price. They also would be hampered by the simple fact that when households move, there is a period of vacancy, and then a different household (different size, usage) moves in. Depending on the turnover rate, this may influence water consumption more that water conservation practices.[16] It thus seemed necessary to run in-depth surveys on the causes of upward or downward water consumption in a given area, including controlling for in-house leaks. Like in the Belgian example above, single-family homes' water usage seems to show an elastic response to price, but this response may, in fact, hide the increasing use of alternative sources. In order to reduce drinking water consumption 'wasted' in non potable water needs, people increasingly dig a well, first to water their garden, but sometimes also to flush the toilet, or for other uses. Doing so, they partly disconnect from the public supply, but then often go on discharging the same amount of waste water into the sewers. The risk is that they save money at the expense of the utility's budget. Additionally, private wells are not necessarily well made: multiplying these private initiatives can lead to overdrafting and pollution of the aquifers, on top of utility budget problems (Montginoul et al., 2005). Lastly, if the utility is obliged to raise water prices to meet its costs, this will affect poor families harder, because they have no money to invest in private wells or cisterns. Meanwhile, the cost of the latter is often such that private water is far more expensive than public supply. Clearly this leads to situations which water supply authorities and operators want to avoid.

What is true at the level of a utility's territory is also true at the level of a multifamily building: if sub-metering, and even more so separate billing, requires investing in costly technology, it remains attractive for residents to share the collective bill on a simpler and cheaper basis. Water conservation potential in multifamily housing is limited, except for leak control, and the latter can be organised collectively.[17] In the research we developed for the City of Paris, we had no time or money to conduct

[14] Centre de Recherches pour l'Étude et l'Observation des Conditions de Vie.

[15] In Paris, CREDOC makes a yearly survey of water consumption on a random sample of 300 meters split into 9 categories (residential, office space, hotels and restaurants, etc.). It shows a small but significant decrease in consumption from 1994 to 2004, but the model cannot provide an explanation of why this is so.

[16] Water demand primarily correlates with household size, as seen above. Downtown renovations result in larger apartments for wealthier families; the resulting population reduction might be partly offset by densification. In any case, higher-income people use more water per capita. All this makes it difficult to understand the trend!

[17] Indeed, it is increasingly frequent in France for condominium owners to sign a temporary contract with a company specialised in finding leaks, which is a very valuable investment.

an extensive survey on a large sample of households. Additionally, in France, protection of privacy rules makes it very difficult to access data on water consumption at the household level and on household characteristics (revenue, size). In the context of disputes about the merits of metering, many building managers and some local water operators refuse to cooperate with investigators, either out of disinterest or, worse, out for fear of what they might discover. This is why the results we presented to the Paris council and to the Agence de l'Eau Seine-Normandie were partly masked: to protect actors involved in the cases. In the end, while we managed to do some of the before-and-after analyses at the condominium-building level, our results will appear somewhat imprecise to colleagues who are accustomed to quantitative studies on large samples. Yet this 'micro' approach provides valuable information on the reasons why individual metering should not be adopted, at least for economic reasons. As a matter of fact, we found that when it is adopted, it is largely for reasons linked to neighbours' distrust, or distrust between tenants and owners.

Household water billing in public housing

Charging tenants for the water they have used rather than in proportion to the size of their apartments has long been an issue in public housing, in particular when hot water is produced collectively. It extended more recently to cold water in the context of fears of global water scarcity, and of customers unwilling to pay for their wasteful neighbours. Many managers had already opted for sub-metering to split the water bill, so as to reduce conflicts among tenants, and to 'be left in peace'. Conversely, when tenants undergo the installation of separate meters, they often complain that it makes their water charges significantly higher. But studies are rare, in particular detailed ones, showing both the change in price paid and the eventual change in consumption. That is what we tried to do, despite the difficulty in obtaining reliable information.

We first chose the case of a public condominium in Toulon called *La Cigalière*. In 1992, the managing company, OPAC Var, a large county council public housing company, took the water company to court to force it to install individual meters and to bill customers directly; this case was several years before the vote for the SRU law. Upon losing the case, the utility (today a branch of Veolia) decided to experiment with separate metering and direct billing in this condominium building, which has 51 apartments. It installed 51 meters but retained the collective one in order to charge the difference for outdoor consumption and collective indoor spaces washing clean. At the time, the utility had no prior experience handling this set-up, and they offered to the building's tenants the same contract as it would for a single-family house. The problem was that any subscriber in that county had to pay a fixed part of €100, including for the meter operation and a contribution for the upkeep of a water system that has to be oversized to absorb peak summer demand (it is a busy tourist area). Before, the collective meter was charged a fixed part of €600, that is, roughly €12 per apartment. With the addition of individual meters, the total bill increase was dramatic, and raised tenants' anger. This had been investigated by CSTB,[18] a research centre on housing and building (Laumonier, 2000). Yet CSTB stopped its investigation even before the new meters were installed. When we arrived six years later, we were confronted by a lack of memory by both the housing manager and by the utility, but we found the initial data from the Laumonier report and obtained the most recent data on building occupation and water consumption. This helped us to discover what had happened since the introduction of the individual meters. We, of course, had to take into account that some families had moved, and, worse, that before being rented again, an apartment might have stayed empty for several months, which biases total water consumption of the condominium for that year.

Water consumption of those families that stayed had not decreased significantly over the years; yet, on average their yearly charges had increased by 30%, and one tenant told us that she paid much more than families who lived in the equivalent building across the street, which had kept its collective meter

[18] Centre Scientifique et Technique du Bâtiment (Housing Science and Technology Centre).

and joint billing (interview).[19] According to the water utility, the rate of bills in arrears after the change rose to 11%, which is greatly above the average. One family with several children was €900 in arrears, due to its inability to pay the bill. One might think that the housing manager had reached his goal which was to get rid of tenants' unpaid bills. Yet they also were losers: in the new arrangement, if the difference between the sum of volumes of water registered by the sub-meters and the volume registered by the collective meter was above 5%, the water company sent a bill to the manager.[20] In the years after individualisation, some tenants moved, and in the same period the collective consumption[21] unexpectedly increased significantly. We discovered that while the OPAC Var considered full occupation at all 51 flats, the water company operated only 43 household meters, which means that 8 flats' incoming tenants ignored their obligation to contract with the water company, and nobody checked. Ultimately, the OPAC Var paid for the water of these 8 flats within the difference at the collective meter. This example shows that individual billing does not always protect housing companies by controlling residents' consumption; in fact, we can infer that good management implies cooperation between the utility and the housing company. In this particular case, cooperation was impossible, since the whole thing started with a lawsuit between OPAC Var and the water utility. The most important outcome, however, is the negative impact on the tenants. Even if the fixed part of the new subscribers' bills had been reduced to 50 €/yr, which is the price proposed after careful examination by water companies in current individualisation projects, few households would pay less after the change; indeed, the average yearly consumption per household in that building oscillates between 118 and 107 m^3 (i.e. the yearly variable part of the bill is below €250). Tenants would have to reduce their consumption by 20% to offset the cost of the meter.

We also studied the case of public housing in Amiens, a city that has always kept its water utility under direct management, and it provides this service with a strong quality – price ratio. In Somme County, in which Amiens is the largest city, the tradition since WWII has been to install meters in each apartment in all new construction. In public housing, the utility would read all the meters and transfer the information to managers, who would then assess individual water charges. For an unknown reason, there was no collective meter, even though the utility had no responsibility to maintain the networks within the residences. Twenty years ago, facing relatively high unaccounted for volumes, the utility decided to install collective meters at the entrance of public housing properties, to bill the corresponding management companies, and to stop reading apartments' individual meters. Public housing companies then not only had to bear the cost of any leaks in the residences, but also the costs to read the meters in order to allocate water bills among the tenants.[22]

When we came back to study the case more in depth, there was a change, because the mayor of Amiens, G. de Robien, had become minister in charge of implementing the SRU law, when J. Chirac was re-elected as president. Even though this law had been voted by the previous socialist parliament, de Robien published the implementation decree for Art. 93, and requested Amiens to be among the early cities to implement individual billing.

The task was not very difficult because public housing companies had retained the meters already in use and paid specialised metering companies to maintain and read them; the managers then split the total bill according to volumes used in each apartment. Water customer management costs were not

[19] Unfortunately, we could not counter-check this information, because the public housing company was uncooperative.

[20] This item of the contract allows charging for collective consumption, like lawn watering, indoor collective spaces cleaning, and such, but the meters' reliability must be taken into account.

[21] Obtained by difference between sum of individual meters and collective meter readings.

[22] We had discovered this in previous research at the European level, where we assessed the sustainability of this direct management policy. Looking at the accounting over the years of the utility, we had found that the meters had suddenly decreased from 48,000 to 32,000 in number. This did not result in any significant change in water consumption of the public housing residents involved. The decrease in volumes of water used in Amiens was chiefly due to leaks control in the public network.

counted, assuming that it was only part of the general building budget. At the time of replacement of the utility by specialised metering companies, the change in price paid by tenants was insignificant, which may explain why there was no change in consumption over the years.

Public housing companies in Somme Country were, however, quite upset at the time and felt abandoned by the utility. No one did any follow-up to check whether the change resulted in better or worse management of water consumption and if there were any eventual arrears. The only residence built without sub-meters (where water consumption could be expected higher than in those with sub-meters) is managed by a company openly at odds with the utility; the managing company's president has repeatedly refused to cooperate in our survey. Housing companies complained that they had to support the cost of unpaid water charges, so they really wanted the SRU law to be enforced in Amiens.

The utility only partly implemented the mayor's decision; arguing that under law only the owner of the property can be billed, the water department proposed to housing companies to come back to the ancient formula, i.e. to maintain and read the meters again, and then to transfer them the information for water bills' allocation. It argued that this formula would be much cheaper than if they had to bill the tenants directly. The only change for the housing companies is that the utility would do the same work as the private metering companies, but for less. Only one public housing company decided to experiment in one building, but it had not started at the time of our visit.

We thus witnessed a clear lack of enthusiasm on the part of the various actors in the implementation phase of article 93. Interestingly enough, this was confirmed by the customer service departments at the Suez and Veolia water utilities, concerning private condominiums at national level. Fearing a strong increase in the number of billed customers and of litigation, the companies developed new contracts for specific cases of billing individual renters, including when only some of the residents accepted this change. Yet these contracts apparently remained unattractive, in particular in the private *copropriétés* (co-ops). The companies did not have to hire more personnel to handle an expected multiplication of meters which did not occur.

We also learnt that in one category of low-cost public housing (LQCM[23]), some public housing companies preferred replacing the individual meters for electricity and gas with a collective meter in each building (or in each staircase). If the apartments are of the same size, and are occupied by a similar number of people, then the consumption difference among apartments is less then the cost of sub-metering. The public housing company managers also argued that it was much easier for low-income families to pay a fixed sum every fortnight or month, rather than a bill arriving at random times with variable amounts (Kerhuel, 2000). Though bound to remain marginal, these cases tend to indicate that the social sustainability criterion does not necessarily fit with consumer justice.

These various case studies support the idea that (multifamily) public housing companies should not only retain the task of allocating water bills between residents, but should keep the payment on a monthly basis with the rent, with a regularisation at the end of the year. But above all, cooperation among public housing companies and water services operators is needed to find appropriate solutions, case by case, with residents. Unfortunately, this seldom happens. One can hypothesise that both French water utilities and housing operators largely ignore the social issue; they are mostly concerned with their economic balance, so they want to get rid of residents who cannot pay or who pay late. Yet recent studies (Smets, 2009) show that a small but significant number of French households end up paying more than 4% of their income on water services. Counties have the possibility to create a solidarity fund for housing (FSL) to cover rents, electricity, and, sometimes, water bills for families that cannot afford to pay its bills. But such aid is limited to families that receive a physical water bill, and a lot of poor families live in condominiums and so do not receive their own bills. Something has to be done beyond the social treatment of families in bankruptcy.

This is why a recent proposal by an NGO in the Ile de France Region attracted much interest: it argued that most families for which the water charges are largely above the threshold of 3% to 4% of

[23] Logement de Qualité à Coût Maîtrisé (quality housing with controlled cost).

the revenue are large, single-parent families living in condominiums. In that case, it is easy to add a bonus to the *allocations familiales* (family benefits) to compensate for high water prices. It would provide a more systematic support than the existing FSL (OBUSASS, 2009), and it would make installation of apartment meters unnecessary.

From the above reviews of international and national surveys, we could address the Paris situation: Was it indeed a good idea to propose the generalisation of individual household metering and billing, in particular in the context of a steady decline in water volumes sold? Since there is an ongoing quantitative survey by CREDOC on a sample of 300 meters, we chose instead to work at the microlevel of buildings, in order to find qualitative information on the reasons for water usage decrease or increase. For the few buildings that have adopted individual billing, the before – after method was based on four interrelated questions: How do average water charges in a building evolve after the shift to individual metering and billing (or after any tariff system change)? Which households pay more and which pay less? Does the change induce water conservation (and if so, when)?[24] What is the social impact, indicated by the evolution of water bills in arrears? This research has been difficult to develop, since it needs the cooperation of many actors at the same time; and since the effects often occur with some delay after the tariff changes, it requires following the cases over several years. This will result in changing the sample due to population change (families moving, new babies being born, adults changing living situations, etc).

No individual metering and billing in Paris

We first held a series of interviews with public housing managers operating in Paris and suburbia, and the interviewees indicated that support for individual billing largely fell, if it had ever been important. The operators acknowledged that refurbishing old buildings is costly, and that meters' operation costs are high; many understood that they cannot outsource their task in water bills' allocation between residents. Some argued that specialised metering companies charge too much for the job. One naively said: "Meters are ok but more expensive. You would think that meters bring an advantage, yet today it's not the case. It's crazy, we are in a system where it costs more to be modern"! (Barraqué et al., 2007).

Interviewees often think metering induces water conservation, but they do not check. Many of them already opted for sub-metering, and even though it neither solves all the residents' conflicts nor reduces the amount in arrears, the building managers are happy to keep the meters, since on the whole they feel more secure with submeters. They know that shifting from surface-based allocation to metering is unfair to large families and to residents with small apartments. However, they seldom mention the long-term average cost of sub-metering itself: they *de facto* include water as part of their rent-recovery task. What concerns them is not water conservation or consumer justice; what concerns them is having a charging system that allocates water bills in such a way that people would pay without complaining. Additionally, they are interested in quickly finding any leaks and learning about water wastage.

Within this exploratory research in Paris, we could not undertake diachronic surveys over several years, so we cannot check if individual billing would induce people to conserve water. In the few condominiums that implemented individual billing,[25] there has been no consumption reduction after two years. Indeed, the reason for individual billing was not water conservation, but what managers thought would be a fair and precise manner to allocate the water charges: each consumer would pay his water bill to the utility. But in the three first cases where we applied our method, for the same consumption, average water charges increased by 25% to 30% when shifted from allocation of

[24] This question can only be addressed at a collective level, unless sub-metering was already in operation in that building.

[25] Our experience is that it is very difficult to get the appropriate information; the new system has often been introduced at the request of some residents, who refuse to pay for their neighbours' wastage. We were often confronting a situation of distrust, in which building managers fear the intrusion of outsiders.

collective billing to individual billing. It could be expected that, given the moderate and inelastic water consumption in Paris, the new system would be more expensive for almost all residents; very few would pay less, and large families in a relatively small apartment would see their water charges treble. Sub-metering is the least-cost option to be used in large residences (where the risk of careless water use is higher), and it could even be made more equitable with growing block tariffs. A caveat is that a prior field survey would be needed to assess the levels of the blocks and to avoid the counter-intuitive effects seen in Belgian Flanders. And, of course, it is necessary to take into account the number of persons in households to avoid the Barcelona situation. This complex information is simply difficult to obtain and to update. All This results in collective metering and uniform pricing, but with smart meters, being preferable in downtown areas, both for the utilities and for the building managers who seek relatively simple rules to allocate the bill (plus early warnings of leaks or other sudden changes in consumption). The complexity of the billing issue led the Paris municipality to drop the project of metering individualisation, and it is now looking for indirect solutions to alleviate the water charges burden on poor families. This gives credence to the solution adopted by New York City: smart collective metering, plus a transition system where the utilities are concerned about leaky buildings, both for social and for water conservation reasons.

In our opinion, the largest potential water conservation in a dense city like Paris is to reduce building leaks and to replace water wasting appliances (e.g. open circuit air conditioning, old toilet flushes,[26] etc). This is why most of the decrease in water volumes sold from 1991 to 2004 is due to renovated large office spaces and hospitals, factory closures, etc.[27] Starting in 2006, a systematic replacement of old building meters by new smart (remote-controlled) ones was undertaken. This is indeed a very interesting innovation, since the new system can provide information in real time. Not only is it much easier to find leaks (every bill now lists the amount of water through the meter during the five minutes when consumption was the lowest), but the meters' data are obtained simultaneously (while previously the meters in all buildings were read only twice a year, at different times). Indeed, remote-control meters allow investigators to undertake new analyses, like checking the impact of the weather or the type of water use consumption. This new system could help forecast additional potential water conservation, but it still needs careful preparation to take into account the numerous elements identified here.

CONCLUSION

Looking at distributive effects of tariff changes, we addressed two apparently separate issues: volumetric pricing versus flat rates, and IBTs versus uniform prices. In practice, however, politicians, NGOs, and some utilities and building managers have linked the two, considering IBTs not only a fair way to curb water demands but also a way to make metering and volumetric pricing more socially acceptable. Economists have, however, expressed some doubts about the second argument, at least as it pertains in developing countries.

In Western Europe, metering is widely practiced, domestic water use is traditionally moderate, and elasticities to price are correspondingly lower than in the United States; IBTs are advocated for equity reasons – those wasting water should pay for additional services. But from our perspective, which is concerned with redistributive effects towards the poor, this deserves careful examination. We reviewed four European cases, plus New York City, and conducted surveys in condominiums in France to

[26] In one condominium in the 14th arrondissement, the manager convinced residents to change all the toilet flushes at the same time: observed water consumption went down by 40%. It is much higher than expected, but toilets lose more water when they are idle than when they are flushed.

[27] For a detailed account of potable water demand reduction in France, see Barbier et al., 2000. In particular, a contribution by Cambon-Grau (2000) shows a 16% water reduction between 1991 and 1997 in Paris: half was due to 51 large accounts only; the other half remained unclear.

evaluate: (1) shifting from flat rates to metering; (2) shifting from metering with uniform prices to IBTs; and (3) shifting from collective metering to individual metering.

Any charging system incurs specific administration costs that are often overlooked by economic analyses, which may modify the results. For instance, unless they are designed in a socially justified manner (but then costly in gathering information), IBTs end up having regressive effects, without generating much water conservation, per se. This is basically why French cities, and New York, do not much care for IBTs, all the more so because water demands are decreasing. But without IBTs, the benefits of shifting from collective to individual metering are much more limited. Our results comfort the position of public and private water operators, who think shifting is not a good idea, in particular if it is done for the sake of introducing bill rebates. In the city of Niort, which adopted individual billing, the head of the water department declared that he would not do it again, since "it does not reduce demands, [it] just increases the bills in arrears".[28] Amiens, which we analysed above, is now introducing individual metering and billing, but the head of the water department there is also worried that replacing monthly fixed payments with variable bills sent randomly will create social difficulties. Indeed, the Amiens condominium that underwent the first implementation of Art. 93 of SRU law revolted, and residents demonstrated in the streets upon receiving their first separate bills (Dias, 2010).

What can we gather from this analysis? Maybe the broadest understanding is the difficulty in reaching all the targets of sustainable management within the same tariff system: water conservation, cost recovery, consumer equity, and social justice. If long-term reproduction of infrastructure (plus investment driven by environmental policies, with no more subsidies) incurs heavy investment costs, which the utilities have to allocate among customers, then the water conservation by some will result in increasing shares of costs by those with limited conservation possibilities; correcting inequities will result in adding higher administrative costs.

In other words, even though the European Union's environmental and sanitary policy impacts the price of water services, the value of drinking water and elasticity of demand are still too low to legitimise such a refined payment system as individual billing in multifamily housing, at least as long as households agree to share the collective bill through a robust allocation mechanism. If there is distrust among residents about water wastage, then sub-metering can offer a partial solution. This is frequent in large multifamily housing units in France: sub-meters allow for the allocation of the collective bill in proportion to residents' specific consumption, and at much cheaper prices. The water bill can be paid monthly within the rent, with a correction once a year. Paying a set amount every month is much easier for poor families to schedule than paying a random amount only twice a year. Public housing managers know that inter-residents conflicts do not magically disappear with sub-metering, which is not always reliable, but it helps solve some problems, like household wastage and leaks, in particular if concerned managers take good care of their building's plumbing.

In France, direct household billing is the norm for electricity and gas; first, because these services are more expensive than water; and second, for security reasons: gas leaks and short circuits are dangerous. Electricity and Gas operators are responsible for all systems, up to the households' doors. Even in the UK, water metering is bound to develop because it is not that costly to install sub-meters in new buildings (in France, it is now mandatory). But one could predict that individual household billing will not progress in condominiums, and that collective meters will not be abandoned; conversely, collective billing will not be replaced by rates or local taxes.[29]

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[28] Interview, Marc Lambert, director of Niort water services, 2010.

[29] In France, water services are commercial services by law, and it would be illegal to return to covering costs with local taxes. It is only in the case where a needed investment would severely impact water bills that the municipality is allowed to subsidise the separate water budget with a transfer from the general budget, and it must remain an exception. Operation costs must be fully covered by water bills, including for waste water (but not storm water). Recently however, some members of the water policy community argued in favour of removing some items of the water bill and transferring them back into local taxes, which are supposedly more progressive (renting value of homes).

These predictions lead to a reflection on the nature of water services: they are club goods to a large extent. Joining the club is not compulsory, but the club is designed so that there is no rivalry in consumption (e.g. water runs from all the taps, at any time, not one tap after another). There is possible exclusion if a member does not pay his dues. In a way, this kind of 'impure public good' is the opposite of 'common pool resources', where there is no possibility of exclusion but only rivalry in consumption. In that case, institutional economists advocate for setting up institutions where people are more or less forced to cooperate over allocated water.

Water services in developed countries are specific clubs in which almost everybody is a member, which means that subscribers' prices are usually small. Consumers are bound together by the heavy cost of shared infrastructure; if some quit or use less, then others have to pay more. This is why efficient water use must be promoted, but together with a follow-up of its distributive and social impacts; hence, the need for in-depth before – after surveys of tariff systems changes and their consequences. That is also why it is dangerous to incite water users to behave as selfish customers (not paying for neighbours, reducing water bill through rain- or ground-water harvesting). The resulting private well-drilling syndrome taking place in some regions in France is both irrational and worrying (Montginoul, 2005).

It is possible to downsize this club good reasoning at the level of a block or a condominium, and to ask at which scale should the club's membership be set: is each family a club member, or is a member the whole building, or is a member all the families served by one staircase?[30] One could calculate, in the socio-political context of any given city in any given country, the optimal number of households to be grouped behind one meter, balancing the decreasing fixed cost of sharing a meter, on the one hand, with the rising transaction cost of having to cooperate with neighbours, on the other. In other words, the water meter must be seen not as a moral tool (one should not waste water in order to save the planet) but as a piece of information, which in some cases is more costly than the benefits it brings. Additionally, those who pay the bill are the club members, but behind the meter there is a need for a community-based allocation of water. The size of this community should ideally be proportional to the capacity of its members to build trust among each other. In France, with an average of 20 households per building, many co-ops are small enough to keep it manageable; people understand that having a separate meter is not in their interest, which is why article 93 of SRU law is little implemented.

To the argument that no incentive is given to conserve water with flat rates or collective meters, one could reply that decrease in water consumption took place in Paris without any particular incentive. If part of the reduction in water usage is due to large water users reducing their volume, another part may be due to the replacement of old appliances, especially washing machines and dishwashers, by people who may not even know that the new ones use less water. Some people do replace their appliances for moral and/or ecological reasons, without acting as economists (e.g. dual-flush toilets are expensive, and a comparison with the price of water conserved is not advantageous at the household level). Globally, it is important to conserve water where demand has reached maximum supply capacity, so then clearly the cheapest water to face increasing demand is conserved water. In other cases, if demand collapses, utilities will be in trouble to meet their costs, and in some countries they will be compelled by law to increase water prices. This may have detrimental social effects, as well as generate additional distrust. That is why instead of indulging in simplistic 'consumption elasticity to price', utilities must develop citizen information and participation. In California, for instance, where water scarcity is a serious issue, an efficient policy is to send 'waterwise' agents to homes where water

By contrast, in the Netherlands, sewage collection is still paid through taxes (rates) to municipalities, and sewage treatment is paid to the water boards on a family basis: each family pays for 2.5 or 3 people; single persons pay for themselves only. This simple type of arrangement resisted a recent proposal to replace waste water treatment taxes by increasing drinking water bills.

[30] Or, as we mentioned for English cities, could a whole street of similar row houses be the club member (only one meter for the street)?

usage is excessive, and to help residents find their leaks or to change to water-saving appliances. This provides ancillary benefits in energy conservation, and long-term direct benefits in shelving new and costly water supply projects (Totten et al., 2010).

In the end, the water policy community clearly needs to turn towards unprecedented forms of governance, inclusive of the water users. In the past, the municipal tradition in water services was to let people ignore everything beyond the tap, and to permanently upgrade the supply. The consequence was grave ignorance of the demand structure and evolution causes. Now the supply-side strategy has reached its limits, and demand-side management is needed to make water services more sustainable. Since drinking water is not a market good, but a club good, it is insufficient to relate to customers only with price signals.

In Paris, individual metering and billing in multifamily housing is not encouraged anymore. Instead, collective smart metering turns out to be a good solution, since it provides a possibility of almost real-time interaction between utilities and customers, as well as much more precise information for observers of water demand evolution. This seems to be validated by the New York City example, and even more so by the Boston case, where smart metering was introduced in 1996 and is, indeed, used in an interactive manner.[31]

Before adopting tariff changes, cities and their water utilities should undertake sociological surveys and simulate their consequences in the real context of indoor/outdoor water consumption, family sizes, and household incomes. An appendix below shows how micro-level analyses can be useful, but they remain insufficient. The scientific issue we now face is to bridge these condominium (or neighbourhood) level analyses with macroanalyses, so as to help water utilities and authorities design their medium-term strategy. Hopefully and eventually, microanalyses will help find out the few essential factors explaining recent potable water demand evolution; in turn, these factors could be analysed at upper territorial levels to design future evolutions in a sustainable development. Unfortunately, our one-year contract with Paris did not allow us to do much more than provide evidence of some counter-intuitive effects of billing formulas: evidence of the need for both a sociological survey before designing a new tariff system and for a permanent follow-up of domestic water users' responses to changes in water supply provision and pricing.

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APPENDIX

The first condominium that adopted individual billing is located at rue Lecourbe, in south-west Paris. It is a small, new eight-floor building with a two-bedroom and a three-bedroom apartment on each floor. The top floor is owned by a salesman and his wife; they have also a duplex on the ninth floor and a roof garden (their adult children live elsewhere). One of the other owners in the building, a retired engineer, is a member of a union that advocates for individual metering. He convinced his neighbours to vote for the change from collective metering (plus surface allocation) to individual metering. Unfortunately, the three-bedroom apartments were designed with two water connections (in the kitchen and bathroom), which means they have two meters. Additionally, the co-owners wanted the water company to check the meters 4 times a year because of a lack of confidence in the supplier. The company accepted this request, and installed the more expensive smart (tele)meters to make things easier. While the previous collective subscription was set at 75 €/year (with a standard meter), new fixed parts were 55 €/year for a two-bedroom; 69 €/year for a three-bedroom; and the large apartment on the top, having three meters, paid 85 €/year. The variable part, sewer included, was priced at 2.69 €/m^3.

After interviewing people in the building, collecting data on water consumption, and analyzing bills that indeed correlated with the number of people per apartment, we built a simulation of what would be paid by families of various sizes in 2- and 3-bedroom apartments before and after individual metering.[32] The following table shows the results:

Table 1. Charges paid according to the number of people and bedrooms.

# of bedrooms	# of people per unit	Water volume (m3)	Charges: collective metering (€)	Charges: individual metering (€)
2	1	45	155	53+2.69x45=174
3	1	45	207	69+2.69x45=190
2	2	80	155	53+2.69x80=268
2	2 + Baby	130	155	53+2.69x130=403
3	3	120	207	69+2.69x120=392
3	5	190	207	69+2.69x190=580
Top flat	2 + garden	130	517	85+2.69x130=435
Total	-	1,130	75+2.69x1130=3115	997+2.69x1130=4,037

[32] For protection of privacy, we cannot provide the exact figures, but this simulation suffices to let readers understand what happened.

Before individualisation, the distribution of the water bill between the residents followed the surfaces of apartments. So, all the 2-bedroom paid the same amount, and all the 3-bedroom paid the same too. Note that the consumption of the top flat was lower than expected. It turns out that this couple does not use much water on the roof garden, and is away on weekends. This explains the counter-intuitive results for this unit. Also note that there is another 'winner': the single person living in a 3-bedroom apartment. All families with children are 'losers', and some are big losers indeed. It would even be worse for the 3-bedroom apartments and for the top flat if the company charged the same price for each meter.

An additional helpful investigation would be to check how the new price structure has differential impacts on families of various income groups. We did not have access to this type of information.