Water Policy 16 (2014) 973–990

The transformative effect of the introduction of water volumetric billing in a disadvantaged housing area in Sweden

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Abstract

Domestic water payment schemes are often a product of their time, place and what is perceived to be customary. Aspects that payment schemes can take into account include resource conservation, equity, maintainability, and profitability. In contemporary Sweden profitable environmentally sustainable solutions are promoted, such as the introduction of volumetric billing of water in rental apartments. This paper describes the detailed consequences of this change in the payment structure for domestic water in terms of reduced resource consumption, direct impact on household economies and perceptions of the system's change process. By combining high-resolution quantitative data on water usage and socio-economic household characteristics with qualitative data from semi-standardized interviews with residents, it is possible to identify the different impacts of the system's change and how the process was experienced. It was shown that while water usage decreased by 30%, 63% of the households had increased monthly costs, and unemployed residents were further disadvantaged and closer to social exclusion. Focusing on making environmental sustainability profitable, as posited in ecological modernization theory, may shadow negative impacts on social sustainability.

Keywords: Domestic water; Ecological modernization theory; Equity; Social sustainability; Tariff policy; Volumetric billing

1. Introduction

Through the current discourse on sustainable development, the environmental and economic dimensions of sustainability tend to attract more attention than the corresponding social dimensions (Pullman *et al*., 2009; Geels, 2011; Vallance *et al*., 2011). Environmental sustainability can be used to motivate investments and changes that might negatively affect equal opportunity, social equity and other targets in the sustainable development framework (Lehtonen, 2004; Luke, 2005; Gasparatos *et al*., 2008;

doi: 10.2166/wp.2014.105

Gough *et al*., 2008; Bond & Morrison-Saunders, 2009; Kommadath *et al*., 2011; Jensen *et al*., 2012). The purpose of this paper is to present such a case in the introduction of volumetric billing of water in a disadvantaged housing area at Bredfjällsgatan, Gothenburg, Sweden, in 2011.

Hjerpe & Krantz (2006) presented the volumetric billing of water in a Swedish context. In Sweden water is abundant and regional systems for the treatment and distribution of drinking water as well as sewage treatment are in place. Owners of private houses pay for their water individually. In apartments the cost for water is usually included in the rent, even though billed volumetrically by water and sewage utilities to the real-estate owner. In Sweden there has been an accelerating trend to introduce water metering and individual volumetric billing in rental apartments (Ek & Nilson, 2011) since the early 2000s. The usual reason for this is availability of cheaper and more reliable wireless monitoring technologies and increasing environmental concerns. Recent studies (Emanuelsson, 2010) have, however, showed that profitability is too low in the new-built areas with a high environmental profile and, generally, a more well-off population, to motivate sufficiently reduced consumption. This paper analyses the introduction of volumetric billing of water in an economically disadvantaged housing area, which was profitable and decreased water consumption but which led to decreased social equity.

In epistemic research within the sustainability sciences it is common to start by defining targets: what is to be sustained, what is to be developed, and for how long (Kates *et al*., 2005; Dillard *et al*., 2009). Reduction of resource consumption (hot and cold water), equal opportunity and decreased social exclusion are relevant, sustainable development targets (Kates *et al*., 2005; Vallance *et al*., 2011) that are considered in this paper. More specifically, raised re-employment thresholds (Daly & Silver, 2008; Bäckman & Nilsson, 2011), an indicator closely linked to social exclusion, have been measured in this study. In path-dependency theory, unemployment thresholds are considered to have a lock-in effect on societies (David, 2001; Erhel & Zajdela, 2004).

The management and finance structures for domestic water consumption have varied historically and geographically (Herrington, 1999), often depending on how water is perceived. Water has many attributes and can be considered a human right (Meier *et al*., 2012), a commodity (Rogers *et al*., 2002; Loftus, 2005), a scarce resource, a source of conflict (Sultana, 2011), a cultural value, or a resource to be taken for granted. The varied perceptions of water affect the way we determine how a water system should be managed and financed (Perry *et al*., 1997; Salzman, 2006, 2012; Goldman, 2007).

Historically, there are points when these perceptions undergo change (Salzman, 2006) and, as a consequence, water-management systems undergo shifts (Huitema *et al*., 2011). A well-documented change in perception was the shift towards the management of water as a tradable commodity in order to secure cost recovery, maintenance and service provision in the 1990s (Rogers *et al*., 2002; Savenije & van der Zaag, 2002; Goldman, 2007), which was internationally recognized through the Dublin Statement (UN World Meteorological Organization, 1992). Water privatization was thought to attract financial capital, promote technical innovation, encourage economic efficiency, improve clients' service quality, and advance environmental conservation (Gialis *et al*., 2012). The perception of water as a human right sparked reactions to the privatization of water utilities around the world (Goldman, 2007) and was internationally recognized in the General Comment No. 15 of the UN Economic and Social Council (2002) after the Water War in Cochabamba, Bolivia, 2001, a notorious water privatization conflict (Salzman, 2006).

Another such change in perception can occur between environmental concerns for reducing water consumption and the perceived right to water of marginalized groups in society (Ruijs *et al*., 2008). In ecological modernization (EM) theory (Mol & Sonnenfeld, 2009) water can be seen as a commodity and a scarce resource in order to reduce consumption. EM theory has had a significant impact on Swedish policy debates. Consequently, there is a trend of introducing volumetric billing and changing how water is used and paid for (Ek & Nilson, 2011). Since the volumetric billing of resources with a high marginal cost is seen as a key for achieving sustainable resource management (Wijkman & Rockström, 2013), related social dimensions could be seen as barriers, which is sometimes the case in the practical implementation of EM theory (Mol & Sonnenfeld, 2009). This provides the study with a theoretical context by framing volumetric billing in relation to sustainability.

Volumetric billing of water is a practical means of ascribing resource consumption a price for the user, thus shifting from common to particular resource consumption, which discourages excessive usage (Westcott, 2008; Wu *et al*., 2011). However, volumetric billing cannot be said to internalize all externalities; volumetric billing typically provides the end user with a price that reflects the cost of production and not ecosystem attributes. The introduction of volumetric billing of water with variable price represents a commodification and commercialization of water (Gialis *et al*., 2012). Flexible pricing and temporal adjustment of pricing build environmental and economic resilience by making it possible for consumers to save money by reducing consumption during consumption peak hours and cost-intensive production phases (Perry *et al*., 1997; Strengers, 2009).

In the ideal case, it is theoretically possible for all parties to gain from the installation of volumetric billing of water by splitting the savings of reduced usage in a fair way (Barberán & Arbués, 2009). However, practical implementation presents several problems: economic incentives do not motivate all segments of the population (Emanuelsson, 2010), and it is difficult to provide an accurate account of household size, economic status and individual practice (Bithas, 2011). Varied household size and socio-economic composition can be addressed by incremental block tariffs and per-person-permitted consumption levels (Barberán & Arbués, 2009; Martins *et al*., 2013). Depending on the way water is perceived and the societal structure, different payment and subsidy systems have been used. Welfare effects of block tariffs and flat rates have been investigated in Mauritius (Madhoo, 2011), São Paulo (Ruijs, 2007) and Manaus (Olivier, 2010), while Gomez-Lobo *et al*. (2000) considered water-subsidy schemes in Latin America. Gawel *et al*. (2013) compared different approaches to measure affordability. In a European context García-Valiñas *et al*. (2010) investigated affordability with aggregated data in Spain, while Gialis *et al*. (2012) assessed the impacts of water privatization in Greece in relation to the market-environmentalist trends. Furthermore, water pricing in Europe is summarized in the Organisation for Economic Co-operation and Development (OECD) report from 1999 (Herrington, 1999).

In contemporary Sweden, EM constitutes a key part of the sustainability discourse on policy. EM methods are applied in industry, in local governance, and by other implementing agents for achieving environmental sustainability based on economically profitable means (Spaargaren, 2000; Jensen & Gram-Hanssen, 2008). EM was first introduced in the early 1980s as an optimistic school of thought in which economic benefit can be a result of a change driven by environmentalism (Mol & Sonnenfeld, 2009). EM theory has been criticized for building on the idea of sustainable growth, which can be considered a theoretical paradox (Mol & Sonnenfeld, 2009). EM theory has also been criticized for its disregard for social justice (Fisher & Freudenburg, 2001; Jensen & Gram-Hanssen, 2008; Pataki, 2009). Langhelle (2000) argues that EM and sustainability should not be conflated at a conceptual level. Indeed, this paper provides an example of the practical implementation of EM that resulted in changes in measured social-sustainability parameters. This paper also provides a practical example of the installation of resource- and cost-saving equipment in a non-emerging economic setting, much like Lettenmeier *et al*. (2012) but extending the work by adding indicators of social sustainability.

2. Materials and methods

2.1. Methodology

Studying a case in detail has several advantages, which have been exploited in this study. It provides a historical account of the system's change process. It makes it possible to alternate between deductive and inductive perspectives and to consider socio-economic impacts on a disaggregated level (Ragin & Becker, 1992; Yin, 2008).

Both qualitative and quantitative methods were used to gather data (Bryman & Bell, 2007). An overview of methods can be found in Table 1. A pragmatic approach was used to identify data requirements based on research focus, relevance to the issue, and data availability (Creswell *et al.*, 2003). Informant and semi-standardized interviews were used to highlight conflicting interests. Water-usage data and data on socio-economic status from the Social Welfare Services (SWS) were used to describe and evaluate the economic impact of the introduction of volumetric billing. A questionnaire study was conducted to describe the households in terms of detailed socio-economic status and water-usage practices. Triangulation of different quantitative and qualitative data was used to provide a diversified perspective on a sometimes opinionated issue (Flick, 2009).

Addressing residents' perceptions of water and behavioural aspects provides a more comprehensive description of the implications of the system's change. Such aspects have also been described by Troy & Randolph (2006) and Keramitsoglou & Tsagarakis (2011). In the applied mixed-method approach, priority has been given to quantitative data since most conclusions are derived from measurements of water usage and pricing (Bryman & Bell, 2007). Qualitative data were used to give the case study contextual depth.

The focus of this paper is to study the implementation process and the impacts of implementing volumetric billing of water. A statistical analysis was conducted on the merged three quantitative databases. Several multiple-regression models were estimated to identify predictors to an increased water bill and to explore the causal relationships between the predictors and water consumption. A special focus was given to the group of households having their water bill paid by SWS.

Table 1. Overview of quantitative and qualitative methods considered in this study.

	Quantitative data Sample size, no.	Response rate, %
Water meter readings	571	100
SWS information on socio-economic status	149	90
Questionnaire study	85	56
	Qualitative data Interviewee	**Interview type**
Inhabitant interviews	85 households	Semi-standardized interviews
Stakeholders interviews	SWS, real-estate manager, water company, resident organization, water-metering company	Informant interviews

2.2. Data acquisition

To assess the economic impact on the households and provide an economic summary of stakeholder incentives several data sets were collected and merged. Hourly readings of hot and cold water usage during 2 years were provided by the real-estate company for their flats from 1 October 2011 to 1 October 2013. Unfortunately, the quality of water-usage data, disaggregated to the household level, was found to be poor in the period between meter installation and initiation of volumetric billing. The real-estate owner had little interest in disaggregated reference data. However, aggregated data at the building level have been recorded for 6 years and the difference in usage before and after was calculated on an aggregated level.

In Sweden SWS provide unemployed people with basic monthly income based on family structure, on average 2,600 SEK (€296) per family member. In addition SWS cover the monthly rent and the cost for water. The SWS provided data on family structure and the financial situation of the most underprivileged inhabitants at Bredfjällsgatan. Furthermore, SWS are a non-decision-making stakeholder in the system's change process, as SWS pay the water bills for the underprivileged households in the area. Semi-standardized informant interviews were conducted with the local SWS management. Further interviews were conducted with the water utility, the residents' association and the real-estate owner and manager to map the various interests.

The sampling for questionnaire and interview subjects among the residents was designed following two criteria: the subjects needed to be from the 571 households with volumetric billing, and the subjects needed to be from the households that had meters installed first (to reduce metering errors). On this basis 152 households were selected where water meters had been installed for 2 months. Of the 152 households, 51 households refused participation and in 16 cases language barriers prevented participation. Remuneration was a lottery ticket, with a nominal value of 20 SEK (€2.28), received after participation. Thirty of the 85 households in the questionnaire study were part of the SWS register.

Semi-standardized interviews were conducted in the same 85 households that participated in the questionnaire study to reveal residents' experiences and opinions on volumetric billing. The interviewees were asked one initial question: 'What do you think about the new system for water payments?' This question was chosen in order to answer the direct research question of this study, as suggested by Flick (2009). Thereafter, confrontational questions were asked to affirm the interviewee's position, and the interviews continued until the interviewee was content with their answers. Interviews were recorded with a hand-held device. These interviews were used qualitatively to provide insight into the respective interests of residents and actors (Esaiasson *et al*., 2012). Interviews represent a snapshot and were conducted 2 months after the initiation of volumetric billing.

Interviews were conducted in Swedish, English, German, Spanish and Persian. A bias was the language barrier that sometimes existed in communication with native Kurdish, Vietnamese, and Arabic speakers. After completion the interviewees' statements were grouped thematically and characteristic quotes were translated into English. Flick (2009) mentions interpretation as a shortcoming of semi-standardized interviews. The selection of quotes and the translation are connected biases. The selection of quotes was addressed firstly by having a comprehensive account of statements by the research question directly corresponding to the initial question asked and the affirming confrontational questions, secondly by a subjective measure of exhausting the arguments of the thematic groups. The translation bias was addressed by cross-confirmation among fellow researchers.

2.3. Case-study background

Bredfjällsgatan is a multi-family-dwelling suburban area in Gothenburg, Sweden, with 956 flats. The buildings were constructed by a public real-estate developer at the end of the 1960s as part of the national programme to construct one million dwellings in one decade. A real-estate company had installed volumetric billing of water in 571 of the flats and these were the focus of this study.

The real-estate company started investigating volumetric billing of water as an alternative in 2010. The reason given was that water usage in their stock of low-income multi-family buildings was at a level above the national average. Reduced resource consumption and improved environmental sustainability were considered positive outcomes. The residents' association, where retired people and single households are over-represented, stated support for the installed system during a stakeholder interview held after the volumetric billing implementation.

Volumetric billing of water was introduced in the 571 flats at Bredfjällsgatan, with an average occupancy of 2.9 and a standard deviation (σ) of 1.9. According to the first of the poverty criteria identified by the European Commission as that of earning less than 60% of the national median income, 29.6% of the households at Bredfjällsgatan would be classified as being in poverty (Bradshaw & Mayhew, 2011). In the group of residents receiving welfare from SWS (26% of the households) the average occupancy was slightly higher at 3.1 ($\sigma = 1.7$), and the maximum number of registered residents in one flat was 11. These households are exclusively long-term unemployed which is the third European Commission (Bradshaw & Mayhew, 2011) criterion for poverty and social exclusion.

The tariff structure for water billing selected for Bredfjällsgatan was adopted without change from a neighbouring area where a municipal real-estate owner implemented volumetric billing of water in 2001, resulting in reduced water usage and company costs (Pavlovas, 2006). The tariff structure is linear with a fixed price per m^3: 13.78 SEK (€1.57) per m^3 for cold water and 43 SEK (€4.90) per m^3 for hot water. The monthly rent was lowered depending on the number of rooms, excluding bathroom and kitchen, in the apartment in order to compensate for the payment of water as illustrated in Table 2. According to the municipal real-estate company, the number of rooms was used as a proxy indicator for household size based on the 2001 average living space. New contracts were also signed by each tenant.

Recommendations and calculation methods for an appropriate level of disposable household income spent on water vary. The OECD study by Herrington (2003) mentions 3% of disposable income to be considered a particular burden threshold; this is used as a reference value in this paper. The World Health Organization (WHO) (2011) determined the optimal consumption amount as a range between 100 and 200 lpcd (litres per capita per day). In a Swedish context the Swedish Energy Agency has

Table 2. Description of tariff structure used at Bredfjällsgatan recalculated into equivalent person consumption based on the average water usage, 174 lpcd, presented by Levander & Stengard (2009).

Apartment [number of rooms]	Reduction of monthly rent [SEK (€)]	Equivalent water use [litre]	Equivalent expected occupancy [person]
1	169 (19.3)	205	1.18
2	190 (21.7)	233	1.34
3	291 (33.2)	356	2.05
4	359 (40.9)	438	2.52

measured the average water consumption in apartments to 174 lpcd, which was used as a reference in this paper (Levander & Stengard, 2009).

3. Results

3.1. Evolution of water consumption and water cost

Based on measurements at a building level, the area as a whole used 30% less water after the installation of volumetric billing, see Figure 1. Unfortunately, household specific measurements were not recorded before the implementation of volumetric billing of water. Since the focus of the paper is to analyse the system's change, it was decided not to cause possible bias by changing the process and by installing other meters than those the real-estate developer installed for billing purposes.

The information that water would be billed volumetrically had already been disseminated at the end of 2010. The process of implementing volumetric billing was done on the basis of one building, of *c*.30 households, at a time. This explains why water usage decreases before 1 October 2011. From 1 October 2011 the readings had stabilized enough for the entire case-study area to be usable for accurate analysis. In Figure 1 we can also see that less hot water is used during the summer months. The difference between the first and the second year after the implementation of volumetric billing of water is an increase of 2%.

Of the 571 apartments 37% achieved lower monthly costs, see Figure 2. However, average household monthly costs increased by 255 SEK (€29). Even though the average water usage after the introduction of volumetric billing is 176 lpcd, compared with the 174 lpcd Swedish-reference usage (Levander & Stengard, 2009), the occupants as a group are paying more per month than before. One explanation is that the apartments at Bredfjällsgatan have a significantly higher occupancy rate than the average number of people per flat expected by the tariff structure (Table 2). The average expected occupancy rate for the households in the database was 1.80 and the average actual occupancy found during the questionnaire study was 2.90. A consequence is the difference between the price of water usage and lowered rent, represented by the difference in areas above and below the x axis in Figure 2. The sum of changed monthly costs in the area, the integral of the graph in Figure 2, is positive even though 30% less water is consumed after the implementation of volumetric billing of water.

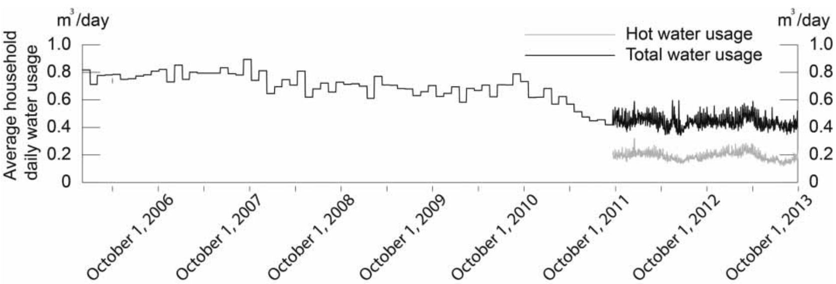

Fig. 1. Average water consumption of the households in the case-study area. For the first 6 years, only monthly readings of water consumption at a building level are available. After 1 October 2011, the readings of individual household consumption had stabilized.

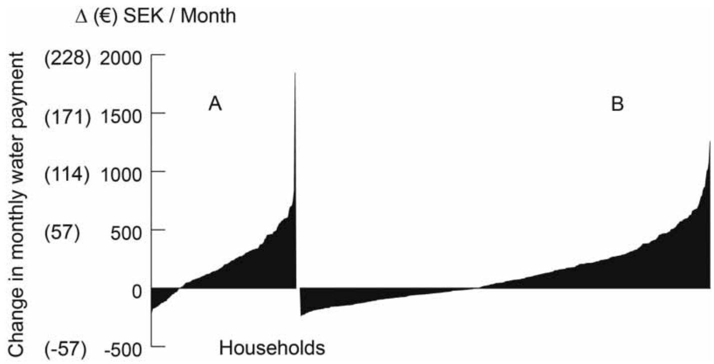

Fig. 2. The implementation of volumetric billing of water changed the monthly cost of households. This change in monthly cost is displayed here. A represents households receiving welfare from SWS ($N = 149$). B represents the remaining households ($N = 422$).

The relative difference for the intersection of the x axis between division A and B in Figure 2 can be explained by the higher average and lower standard deviation in occupancy in the households receiving welfare from SWS as well as other predictors described in the next section. The SWS database reveals that people living on welfare subsidies had an average water bill amounting to 6.85% of monthly income from welfare. Fifty-five per cent of these families consumed less than 174 lpcd even though these families lack the economic incentive to save water.

After the implementation of volumetric billing of water, the average monthly cost covered by welfare increased to 270 SEK (€31) per household in the area. If the household receives more welfare from SWS than employment would provide, then the household would be trapped in welfare dependence. The introduction of volumetric billing of water thus leads to a raised re-employment threshold (Schmieder *et al.*, 2012). This can be seen as a lock-in effect where the members of the household would decrease monthly income by taking employment and consequently losing the social welfare. A higher water bill increases the number of households in this category since a higher water bill increases the monthly welfare.

Even if SWS implemented per-person-permitted water usage, as suggested by Barberán & Arbués (2009), SWS would still continue to pay the water bill for most of this residential group since large households are over-represented and the real-estate owner has no permitted-per-person level, only a reduced rent depending on the apartment size. Furthermore, welfare receivers would still be at a higher risk of social exclusion, as the salary threshold for the first job, i.e. paying more than the monthly social welfare, would increase. Members of households run a high risk of being permanently socially excluded if employment is not economically beneficial (Daly & Silver, 2008; Bäckman & Nilsson, 2011). Social exclusion relates directly to equal opportunity and social capital targets set in the framework for sustainable development as described by Kates *et al.* (2005).

Using the data from the questionnaire study ($N = 85$), see Figure 3, we find that 26 of 85 households have a water bill higher than 3% of their income, 13 of these 26 consume less than the 174 lpcd Swedish-reference consumption (Levander & Stengard, 2009), and seven of these 13 do not receive welfare from SWS. These households have elevated water payments and are unable to receive support from SWS. In interviews at SWS a concern for the marginalized people who are not registered by SWS was expressed. These include illegal immigrants, mentally handicapped, and others who are not able to

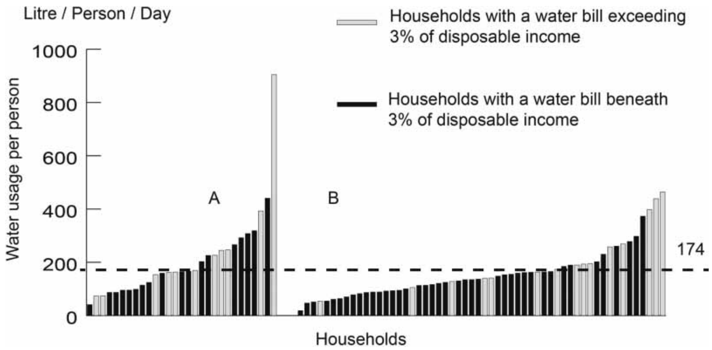

Fig. 3. The average water usage (sum of hot and cold water) per capita in the 85 interviewed households during the first year after the implementation of volumetric billing. A represents households receiving welfare from SWS ($N = 30$). B represents the remaining households ($N = 55$). The value 174 lpcd is the reference consumption of Swedish households (Levander & Stengard, 2009).

conduct the process of applying for welfare every month. This group will be the most negatively affected. It is difficult to identify this group and make them visible.

3.2. Understanding differences in water consumption

Water usage and water practices vary significantly among households. The statistical analysis was structured around behavioural practices and reported attitudes following the conclusion of Pullinger *et al.* (2013). Household characteristics, such as receiving monthly welfare from SWS, were also included in the analysis. The following hypotheses were posed:

- Households with more occupants use more water.
- Teenagers consume more water than other age groups.
- An understanding of the new billing system will decrease water consumption.
- People who spend more time at home use more water.
- Households having their water bill paid by SWS use more water.

The statistical analysis identified the four most significant factors of water consumption to be: number of occupants, presence of teenagers in the household, level of educational qualification, and the receiving of welfare from SWS. The relative importance of these variables to the water consumption level is presented in Table 3.

The hypothesis that people who understood the implications of the change in billing system would reduce their consumption was more difficult to find support for. Almost all households had understood that a new billing system had been implemented. However, some people were uncertain of how much water-consuming activities would cost. The level of education gives a significant negative correlation with the monthly bill, see Table 3. It is tempting to interpret this result by pointing to the lack of understanding of the actual cost associated with water-consuming activities, which would support findings from the semi-standardized interviews. The variable level of educational qualification is structured ordinally in four steps in the range: basic schooling not completed (less than 9 years), basic schooling completed (between 9 and 12 years), high school completed (12 years), and degree from university.

Table 3. Standardized regression coefficients β of predictors of average monthly water costs during the first year after the implementation of volumetric billing of water in multiple-regression models.

Dependent: Average water cost during the first year after the system's change	Model 1 β	Model 2 β	Model 3 β	Model 4 β	Model 5 β
Number of people in household	0.481[b]	0.316[b]	0.307[b]	0.309[b]	0.295[b]
Teenagers in household		0.369[b]	0.340[b]	0.341[b]	0.373[b]
Level of educational qualification			– 0.222[a]	– 0.234[a]	– 0.219[a]
Receives welfare from SWS				0.266[b]	0.253[a]
Hours spent home per day per occupant					0.112
Adjusted R square	0.219	0.319	0.358	0.422	0.425
R square change	0.231	0.109	0.048	0.071	0.011

[a]Coefficient is significant at the 0.05 level (2-tailed).
[b]Coefficient is significant at the 0.01 level (2-tailed).

Having the water bill paid by SWS decreases the financial incentive for saving water. This group of households have higher water consumption, as shown in Table 3. This may be due to the fact that people in this type of household are unemployed and are more likely to spend more time at home during the day. Confounding of the two variables also explained the non-significant relationship between time spent at home and water consumption. This assumption is also confirmed by the observed pattern in Figure 4.

Household income and saving water for economic or environmental reasons failed to produce significance above $p = 0.05$ in the regression analyses. An explanation is that household income is confounded with all other predictors in Table 3. A possible bias is that only one person from each household was interviewed, not always giving an exact account of motivation behind water saving for the household as a whole. The amount of time spent in the apartment per person did not produce significance

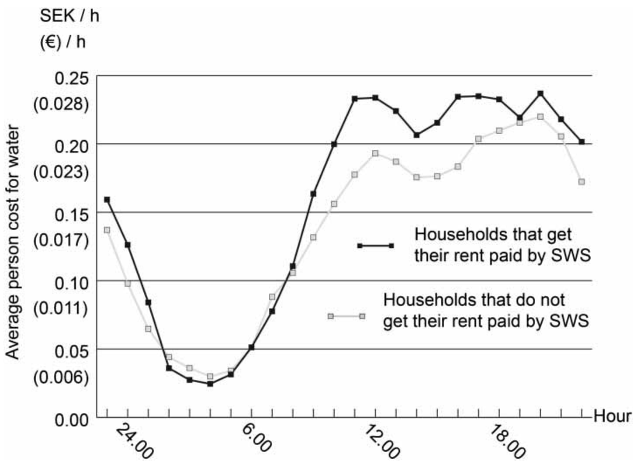

Fig. 4. The average water consumption, and thus price paid for water, varies during the day. Households that receive welfare from SWS have unemployed occupants and consequently consume more water at home during the standard working hours, 8 a.m. to 5 p.m.

above $p = 0.05$ in regression analyses, also seen in Table 3. Reasons for this might be: the difficulty for the interviewee to estimate the time people spend at home on average, the influence by household size when acquiring information, and the high level of confounding with other variables.

A positive difference between the actual and the expected occupancy of apartments makes it difficult for households to save money with the new system. There is a significant positive correlation $r = 0.45$ ($p < 0.001$) between this difference and water monthly consumption, but there is also a significant negative correlation $r = -0.35$ ($p < 0.001$) with water consumption per person. Larger households consume more water but the water consumption per person is lower in larger households. Explanations for these correlations are found in the assumption that some domestic water usage is shared in the household such as for cooking and cleaning. This difference can also be seen as a measure of crowdedness since expected occupancy is based on the amount of rooms in the apartment. Crowdedness might also cause people to spend time at home differently. Social welfare receivers are over-represented in the group of more crowded apartments, further emphasizing that the introduction of volumetric billing of water led to larger inequities.

3.3. Overall economic implications of the system's change

At an individual household level the heterogeneousness in water-usage patterns makes it difficult to make generalizations. However, at the aggregated area level it becomes possible to create an overview of financial flows associated with the system's change, see Table 4.

In Table 4 the reduction of water payment for the real-estate company can be identified as an economic incentive that was a driver for the system's change. It is important to note that it was possible to accurately estimate this decreased expense before installing volumetric billing based on known figures, i.e. monthly costs before implementation and reduced rental revenue. There is little financial risk for the real-estate company. However, while profit is a requirement for a system's change to take place when managed by a private investor, social equity and equal opportunity might be sacrificed for increased profit (Chomsky, 1999).

A further aspect is the reduced revenue to Gothenburg water and waste-water utilities as a result of decreased cold-water usage. The utilities charge users volumetrically at 13.75 SEK/m^3 (€1.57), of which 5.9 SEK/m^3 (€0.67) goes to waste-water treatment. The marginal cost of water production and treatment

Table 4. The change from paying a flat rate to paying volumetrically with a specific water tariff had several consequences. These benefits and disadvantages for different stakeholders are summarized here.

Benefactors/Benefits	Disadvantaged/Disadvantages
Smaller households are given the possibility to save water and reduce costs	Larger households have increased monthly cost
82 SEK (€9.35) increased monthly cost on average for single households	*325 SEK (€37) increased monthly cost on average for households with three or more occupants*
Real-estate company has decreased the yearly water costs	Social welfare receivers have an increased first salary threshold for re-employment
2,350,000 SEK (€268,000)/year	*270 SEK (€31)/apartment/month*
Environmental benefits by reduced resource consumption	Social Affairs Committee has increased costs
73 l/apartment/day for hot water	*480,000 SEK (€54,700)/year*
84 l/apartment/day for cold water	Gothenburg Water has reduced revenues and maintained expenses
Environmental benefit in system flexibility and possibility for temporally adjusted water and heating prices	*340,000 SEK (€38,800)/year*

Monetary values and water consumption in italics have been calculated from the database of 571 households.

is minor in comparison with the fixed costs. This form of overpricing of marginal costs makes it profitable for the real-estate company to install volumetric billing of cold water even though it results in a system's change with higher total cost on a societal level, if one considers the installation cost of meters. This consequence exemplifies practical problems in the EM process of pricing environmental loads. According to the Gothenburg sanitation utility, low flow rates constitute one of the larger problems in the combined sewage and storm-water system.

As can be seen in Table 4, and by the integral of A in Figure 2, a relatively large displacement of costs among stakeholders occurs between SWS and the real-estate company. SWS pay on average an increased amount of 270 SEK (€31) per month per apartment after the installation of volumetric billing. If SWS did not cover the cost of water bills, the most financially exposed households would be paying more than international recommendations, in some cases even more than the considered human-right level, 10% of disposable household income, for their water.

3.4. Residents' opinions

The qualitative semi-standardized interviews provide a snapshot of the sentiments among the occupants 2–3 months after the initiation of volumetric billing. The semi-standardized interviews confirmed that the introduction of volumetric billing is well known in the area and showed that the residents have diverging opinions about the new system. The opinions were divided into three groups: those in favour of the new system, those against it, and those who are less concerned. The representatives of the residents' association belong to the first group.

The arguments used in each group vary, as seen in Table 5. One of the residents stated: 'I live alone. Why should I pay for families that consume much more water?' Single households consumed less water than larger households, but the average monthly cost had also increased for single households, as seen in Table 4.

Table 5. Residents had varying opinions on the introduction of volumetric billing of water. This table shows quotes that represent the three categories found in the conceptual analysis of the semi-standardized interviews. The initial question of the semi-standardized interviews was: 'What do you think about the new system for water payments?'

The group in favour of volumetric billing ($N = 23$, 15 with negative change in monthly costs)
• I save money
• It is a more fair system. People are treated equally
• It is good for the environment
The group not in favour of volumetric billing ($N = 50$, 19 with negative change in monthly costs)
• I lose money
• It is unfair on people that are already struggling
• Water should be free. It is a human right
• The apartments are very run-down, other changes should be prioritized
• The water system is not working properly (it takes time for the water to get hot, and there are service stops) so I don't want to pay for the water system
• My water bill is higher than it should be
• The way the system was introduced felt forced – 'Sign a new contract or leave'
The less-concerned group ($N = 12$)
• I don't care/I have no opinion
• Social welfare pays my bill. Why should I care?

One interviewee also remarked that the system affects groups differently, stating that Muslims who pray at home will have larger water consumption as they practise ablution before praying.

Despite the fact that the residents understand that their water-usage affects their costs for water and that they have reduced usage following the introduction of volumetric billing, the semi-standardized interviews revealed that the residents lacked an understanding of the actual cost associated with water-consuming activities. This unawareness is perhaps also reflected in Figure 3 where the highest per person consumers also pay more than 3% of their disposable income for water. During the interviews the residents requested information about water-usage prices from the real-estate company.

It is also noted that the real-estate company had provided the residents with some of the water-saving appliances 1 year prior to the introduction of volumetric billing, such as low-flow faucets and plugs for sinks. Unfortunately, many of these appliances were removed before volumetric billing was initiated, since residents considered them a nuisance when they were not paying for water volumetrically.

4. Conclusions and discussion

While the implementation of volumetric billing fails to reduce water consumption in some more affluent areas in Sweden (Emanuelsson, 2010), this study demonstrated that implementation of the volumetric billing of water in an economically challenged area was profitable for the real-estate owner and that water consumption was reduced by 30%. However, households receiving welfare had an elevated average monthly cost covered by welfare. This elevated welfare increases the number of households in the group trapped in welfare dependence. This paper highlights the risk that marginalized groups are disregarded by decision-making stakeholders when there are economic as well as environmental motivations for the system's change. This suggests that alternative methods of implementing volumetric billing of water that include marginalized groups in the decision-making process should be investigated.

In the case study presented here, a single block tariff was adopted that assumed a lower-than-actual occupancy rate. As a consequence of the new payment model, 63% of the households had a higher monthly cost. Households receiving welfare had an average elevated monthly cost of 270 SEK (€31) to be covered. Incremental block tariffs and per-person-permitted consumption levels are ways to address varied water usages as well as household socio-economic status (Barberán & Arbués, 2009; Martins *et al*., 2013).

The actual environmental benefit of saving water should be considered in relation to other impacts of the system's change. It is questionable whether metering and charging for water volumetrically, especially for cold water, have any positive environmental impact in a Swedish context. Yet, from an environmental point of view, water is often considered underpriced. Van den Bergh (2010, p. 2051) writes that 'Without environmental externalities the problem of unsustainability vanishes', representing an environmentalist idea that fits well with the liberal notion of the aware consumer making calculated choices (Spaargaren, 2000; Lovell, 2004). In this research, additional dimensions of sustainable development are added to this line of thinking, such as that of social equity. It is easy to imagine a question of value ethics (Langhelle, 2000), trade-offs between environmental sustainability and social equity, and a value collision between anthropocentrism and ecocentrism (Kortenkamp & Moore, 2001). However, the implementation of volumetric billing of water at Bredfjällsgatan shows that, while this value collision does occur, economic prioritizations in the system's change process may further expose marginalized groups.

The implementation of the volumetric billing of water serves as an example of the practical implementation of EM theory. Another example has been investigated by Jensen & Gram-Hanssen (2008) who conclude that when EM theory is applied in practice, social dimensions are systematically disregarded in the Danish building industry. The EM paradigm builds on appreciating the environmental resources with a cost within the modern economic system, where profit is included as a bottom line. When the implementing agent of a system's change is more concerned with making profit than with the fate of the people affected by the system's change, decreased social equity and equal opportunity may be the consequence (Chomsky, 1999).

There are problems with the theoretical conflation of EM and sustainable development, but refraining from analysing sustainable development parameters when implementing EM systems in practice opens up the possibility of discrimination against already-disadvantaged groups by implementing agents since EM does not incorporate equity criteria (Langhelle, 2000). It is important to remember that it was the social dimensions of development and inter-generational fairness that preceded the Bruntland definition of sustainable development (Kates *et al*., 2005). Sustainable development has become a mainstream topic in the public debate and there is a problem if EM theory is proposed as a means for reaching sustainable development targets.

In order to address the implementation of volumetric billing with a nominal theoretical collision between environmental sustainability and social development, there is a need to contextualize since real-world examples involve practical limitations (Bithas, 2011), ethical considerations, and a range of stakeholders. Specifically for the volumetric billing of water, Barberán & Arbués (2009) have provided an overview of tariff alternatives including tariff structures that take socio-economic background and number of occupants into account. It is preferable for residents to be involved in the decision-making process or to at least be aware of the economic consequences of consuming water after the system's implementation. In the Bredfjällsgatan case the residents' varying perceptions of the system's change suggest that the decision-making process lacked accountability, much in accordance with other analyses showing that the consumer-inclusive impacts of water pricing are dependent on regulatory institutions (Sanz *et al*., 2011).

One relevant element of outlining strategies for the introduction of volumetric billing should be the creation of systems that protect people at risk. Stronger residential organizations and legal support could have aided residents who incurred higher monthly costs. A more thorough information campaign could avoid initial problems and disappointment (Pavlovas, 2006). In the Bredfjällsgatan case it was practically difficult for the real-estate company to consider occupants' socio-economic backgrounds; even the number of occupants per apartment was unknown. SWS compensate by providing protection for most of the underprivileged by registering socio-economic background and household size, along with payment of their water bill. However, in order to circumvent the problem of increased social welfare dependence, there is a need to extend the effort of SWS to decrease the actual economic problems of the clients.

Future research should consider alternative methods of implementing volumetric billing of water that include marginalized groups in the decision-making process. Such alternative forms could be via housing associations, cooperative rental organizations or even religious organizations (Mangold, 2008), where the residents themselves constitute the implementing agents and have a direct insight into the socio-economic composition and prerequisites. Such organizations also enable common resource usage in a more environmentally sustainable manner while also promoting social equity. Additionally, as often mentioned in other fields of academia, one could pose the question whether it really is the underprivileged who should reduce resource consumption, especially if they consume less than the average (Lettenmeier *et al.*, 2012). The underlying problem is the lack of debate on the outcome when environmental sustainability is used to motivate actions, investments or changes that have negative impacts on disadvantaged groups in society. Focusing on making environmental sustainability profitable, as posited in EM theory, may shadow the negative impacts on social equity.

Acknowledgements

The authors thank Krister Blixt, Susanne Brånalt, Farid Basill, Bjarne Öhman, Gunnar Tysk, Bengt-Axel Albertsson and Sven Christensen for technical assistance and helpful discussions. Furthermore, credit should be given to all residents who spent time talking with researchers. This work was supported by the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning – Formas, within the Homes for Tomorrow project.

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Received 4 July 2013; accepted in revised form 15 March 2014. Available online 8 April 2014