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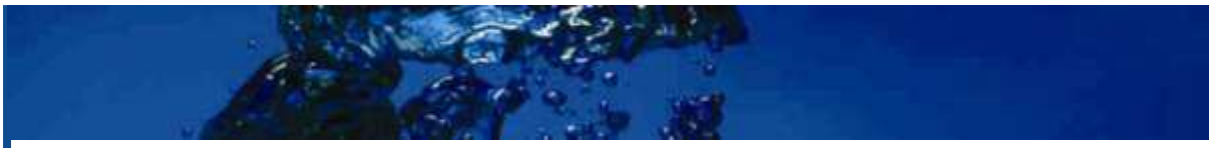

International experiences of sub-metering:

An analysis of four case cities to inform planning for domestic metering in the Greater London Area

Final report

Prepared for the Greater London Authority

December 2007

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We conduct our own research and also undertake work as consultants.

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1. Summary and recommendations

International cases of sub-metering initiatives were investigated and the associated failures and successes discussed in reference to the feasibility of sub-metering implementation in the Greater London Area. Initial results indicate that sub-metering presents challenges unique from conventional building-wide metering. Case studies revealed that implementation often precedes the establishment of necessary social, institutional, and technical frameworks, resulting in poor uptake and frustrations in debt collection. It is therefore recommended that sub-metering be approached with caution and that such frameworks be established prior to implementation. In order to produce these frameworks, it is recommended that metering at a building scale be achieved prior to the implementation of a sub-metering initiative. However, sub-metering pilot schemes in new build should be implemented alongside the initial building-wide metering programme to establish codes of best practice.

Socially, international experience shows that sub-metering initiatives are either driven or prevented by tenants, not authorities or water companies. Where sub-metering has proceeded, it has often been due to tenant associations requesting a fairer method of distributing water costs within a building. Where it has been blocked, it has often been due to those who experienced a rise in bills after indirect subsidies are removed and actual consumption signalled in charges. This is particularly a problem in high-occupancy, low-income units. Without the necessary safe-guards installed to protect vulnerable customers, sub-metering shall be met with resistance from tenants during installation, and may potentially lead to failure to collect debts post installation. These risks may be addressed through either a tariff-based subsidy or a means-tested state allowance in preparation for sub-metering initiatives. A programme of building-wide metering must precede sub-metering to establish a necessary tenant acceptance and trust of volumetric charging.

Institutionally, a clear definition of rights and responsibilities must exist between tenant, property owner, and water company. Responsibility for installation and maintenance must be established. Sub-metering removes property owner incentives to repair internal leakage and install efficient fixtures, as costs are transferred to the tenants. While there may be an incentive on the building owner's part to specifically repair leakage which damages the property, it was observed that these occasionally go undetected in common areas where metering may not be present.

Responsibility for billing must also be clearly defined. In some cases it was observed that the property owner divided a building-wide cost between tenants privately, and then forwarded these collections to the water provider. In others, it was observed that the relationship is direct between tenant and provider. Agreed billing procedures must be determined prior to sub-metering, and accountability for accuracy and water quality ensured.

Technically, clear standards and codes of practice must be established surrounding appropriate technology and installation in order to avoid disputes over reliability and accuracy. Sub-metering initiatives are often accompanied by technology which allows for the remote reading of meters through radio transmission, i.e. Automatic Meter Reading (AMR). The relative costs and benefits of AMR must be investigated further. Whilst initial capital costs of installation may be higher than

conventional meters, the flexibility of remote reading allows for metering in previously inaccessible units, as well as a reduction in operational costs associated with data collection time.

Finally, it should be noted that sub-metering may not be a realistic option in some older buildings where individual water supplies to each unit do not exist. In older buildings it is often the case that a unit shall have several points of entry or that several units shall feed off a common single pipe, raising the costs of sub-metering significantly. In such cases, a realistic judgement must be made as to the necessity of sub-metering.

Based on the findings in this report, the following recommendations are made:

- An initial focus should be placed on the metering of existing whole buildings. Metering of individual units should only procede afterwards.
- When sub-metering is pursued, clear targets should be set based on cost effective criteria.
- Safety nets for low income, high denisty units must be set prior to the pursual of any form of metering.
- Clear institional and legal frameworks must be set prior to the introduction of any form of metering.
- Sub-metering in new buildings should be pursued in parallel to the metering of existing whole buildings. Changes to the plumbing codes should be considered.

2. Introduction

This report was commissioned by the Greater London Authority. The feasibility of a sub-metering programme in the Greater London Area is explored via four international case city studies. The paper comments on the failures and successes associated with sub-metering, and provides initial guidance for further research and approaches to implementation in London.

2.1 Introducing metering

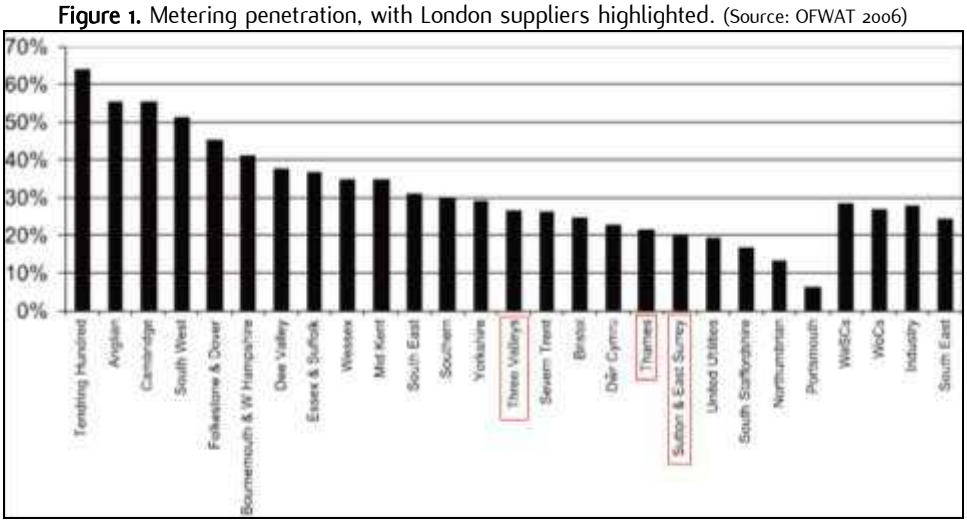
The metering of water resources encourages both economic and technical efficiency in water resource management. Economically, an efficient distribution of resources is achieved through the accurate signalling of marginal costs to the consumer. Meters provide a means for such signalling through a tariff system based on volumetric pricing: costs are signalled to the consumer, and consumer preferences and values to the provider, leading to more efficient supply-demand driven distributions.

Technical efficiency - or more specifically how efficiently water is consumed to gain benefit - increases when incentives to reduce consumption are introduced. Whilst being contingent on the tariff employed and the consumers' willingness to pay (collectively termed the 'elasticity of demand'), metering is generally acknowledged as a reliable means of demand management and incentive introduction (Inman and Jeffrey 2006). In the UK, the Environment Agency (EA) estimates a demand reduction of 5-15% in metered households (Stubbs 2007). The effect of pricing alone is difficult to disaggregate from consumption patterns: studies occasionally indicate an increase in demand due to volumetric pricing (Gunatilake *et al.* 2001), whilst others point to the social effect of customer awareness of being metered as the key determinant rather than the price paid (Koplow and Lownie 1999). The impact of metering is then dependent upon the context of implementation.

2.2 The UK context

Privatisation of water services in 1989 encouraged a perspective of water as an economic good and initially set forth an optimistic programme for 100% metering penetration of domestic properties by 2000. However, resistance from both consumer groups and water companies has resulted in much slower uptake of metering then expected (Bakker 2005). A study on the negative health effects of metering in low-income houses published by Save the Children (Cuningham 1996) and initial lobbying from consumer groups resulted in the introduction of the Water Industry Act of 1999, which now legally protects domestic customers' choice not to be metered. From a water company perspective, a metered household is less predictable in terms of revenue as well as additional capital expenditure. The result is national metering penetration of approximately 25% of homes (figure 1) (Ofwat 2006).

Figure 1. Metering penetration, with London suppliers highlighted. (Source: OFWAT 2006)



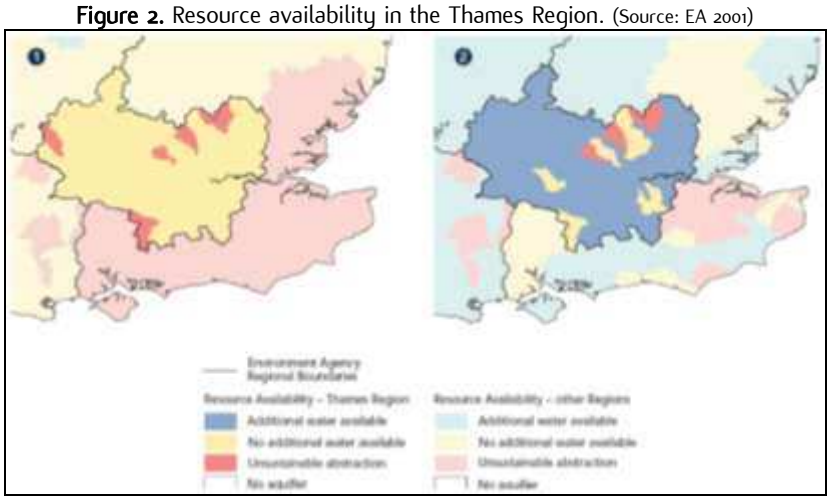
More recently, developments in policy and legislation have helped to encourage further metering uptake and to lay the grounds for sub-metering initiatives. The EA now considers surface and groundwater to be overabstracted or at least without room for further development in many areas of the UK, particularly in the South and South East regions (EA 2003). Defra's "twin track" policy for water resources now advises that the security of supply of freshwater should be ensured through a combination of resource development and demand side solutions. Under this context the role of metering in demand-side solutions has been acknowledged by the Water Savings Group's moves to extend metering in water stressed areas, building on Defra's *Consultation on water metering in areas of water stress* (Defra 2007). The government is establishing the ability of water companies in areas of water stress to mandate metering of customers as part of long term efficiency programmes in time for the 2009 price review.

Successive government ministers in recent years have also spoken publicly of the unsustainability of pricing by the decades old rateable value of property for 75% of homes, and advocated full metering as the way forward. Specific to sub-metering have been the calls for a change in billing systems to encourage efficient use. The *Report on Water Management* submitted by The House of Lords Select Committee on Science and Technology (Lords 2006) encourages volume-based tariff billing systems supported by an improvement in meter coverage and technology at a tenant scale. Currently, the economic and regulatory groundwork for universal metering are still being negotiated in preparation for the upcoming periodic review. As Water UK's response to consultations by Ofwat indicates, a significant barrier exists in the cost-benefit aspects of metering. Under the current regulatory framework, meter installation shall only prove economically efficient under specific circumstances. Unless cost-benefit analysis is placed in a long-term context or allowances for cost recovery are made in price reviews, significant economic barriers remain (Water UK 2007).

2.3 The London context

Greater London is experiencing a growth in the relative scarcity of water due to net demand for freshwater approaching the environmental limits of extraction (figure 2). 5,000 million litres of water are extracted per day (Ml/d) in the region, 85% of which is public, with household use accounting for approximately half of that (EA 2001).

Figure 2. Resource availability in the Thames Region. (Source: EA 2001)



High land prices and the politically contentious nature of reservoirs encourage demand side solutions alongside the current campaign to reduce leakage. Voluntary reduction in use, or behavioural change, is notoriously difficult to achieve as culture, perception and attitudes are very slow changing. Metering may provide a means through which to signal the growing scarcity of water resources and to curb per capita consumption in the region. This has been acknowledged in the Mayor of London's draft *Water Strategy*, which sets targets for full household metering by 2017, and all blocks of flats by 2027 (GLA 2007). Water companies have also begun to acknowledge the value of metering in the region. Thames Water, the key supplier in the London region, is now piloting a policy of meter installation upon change of tenancy (BBC 2006).

Due to London's high level of multi-dwelling buildings, increasing incidence of single tenant flats, and dominance of existing housing, an accurate volume-based signalling of costs to domestic consumers will require both retro-fitting existing homes and installing new homes with meters that can provide sufficient information on a tenant scale rather than a building scale. Sub-metering addresses this information gap and the loss of efficiency incentives which occur through the distribution of costs between multiple tenants.

2.4 Introducing sub-metering

Research on demand side management is limited, and this includes applications of sub-metering (Inman and Jeffry 2006). The few studies which do exist suggest that the drivers, implementation, and impacts of sub-metering initiatives differ from those of conventional metering. Drivers range from the need to establish a volumetric tariff at a tenant level for purposes of cross-subsidies and equity, the dominance of new build, visible scarcity of resources and hence public support, or relative scarcity and the ability of the state to command and control new building standards.

Criteria for successful implementation tend to revolve around the question of how new technology is implemented with the necessary institutional, financial and social frameworks to support them. Older buildings may have outdated drawings, making the identification of water pipes time consuming and expensive (Tamaki *et al.* 2001). Multiple entry points of supply may mean increasing the number of meters needed and hence cost (Starr and Judd 1992). Socially, sub-metering may be considered invasive and unfair by tenants, requiring prior notice and information in order to gain support (Koplow and Lownie 1999). In legislation there is often no clear definition of rights and obligations between tenant, landlord, and water company, leading to disputes (Wien and Harrak 2003).

The impacts of sub-metering are therefore potentially both positive and negative. The additional information afforded to water companies and building owners allows for a much more efficient management of assets, for instance the fast identification of leaks. Effects on demand from sub-metering tend to be more pronounced than from metering the building as a whole. Table 1 indicates the percentage reductions in demand observed when a transition from rent/flat rate tariffs to individual metered tariffs is made. As the spread of percentages indicates, initial conditions of implementation have a strong bearing on impacts.

Table 1. Reductions in demand due to sub-metering.

Study area	% reduction from sub-metering	Authors
USA: National study	15.39 +/- 9.3	Mayer *et al.* 2002
Brazil: University dorms, University of São Paulo	39	Tamaki *et al.* 2001
USA: California, Florida, Texas	18 - 30	Koplow and Lownie 1999
USA: City of Portland single terrace study	15	City of Portland 2000
USA: Seattle	27	Seattle Public Utilities 2002
USA: Mobile Home Community	7 - 12	Rosales *et al.* 2002

The most common negative impact is the possible increase in cost to low income families living in high occupancy units. In this case, the indirect subsidies afforded by a flat rate or building wide tariffs are removed; the high usage typical of these units is then reflected fully in the bill, affecting affordability, quality of life, and ultimately health. Such impacts may be addressed through tariff structures that reintroduce this subsidy; however, this topic lies beyond the scope of this study. For more information on possible tariff structures in the UK, please refer to Herrington 2007.

3. Case studies examined

The following section provides a brief summary of research conducted on four international cities where sub-metering initiatives exist. Each report addresses the drivers for sub-metering programmes, the necessary legal, institutional and social frameworks for implementation, and the observed impacts to date. The section concludes with an analysis of all cases and a comparison to the London context. Through this comparison recommendations for further research and the feasibility of sub-metering are made.

3.1 USA: New York City

Prior to the late 1980s, New York City metered industrial and commercial buildings only, charging residential owners through a frontage tariff based on factors such as the number of apartments, fixtures, and height of building. However, due to the growing population, drought, above average per capita consumption, and the steady decrease in federal and state funding since the 1970s, the need for full cost recovery and demand management arose. In 1988, New York City announced a 'Universal Metering Program'. The programme aimed to achieve 100% metering at a building scale within ten years. By the 1998 deadline, 90% of the planned meters had been installed and daily extraction from key reservoirs was observed to drop by 7% between 1989 and 1997 - despite population growth (Gandy 1997). Currently, 97% of accounts are billed through a volume-based tariff.

Building scale metering in multi-tenant flats has predominantly not been accompanied by a direct signalling of costs or savings to the multiple tenants within. In a limited number of cases (5-10%), cooperative buildings divide the whole building cost between them, based on a formula of ground space, number of fixtures, etc. and so are able to signal costs and savings. This system is referred to as a Ratio Utility Billing System (RUBS). For the majority of buildings, however, metered water costs are indirectly signalled in rent by the building owner who is ultimately responsible for payment. Should the building be under rent control, these costs are reviewed at the end of each year and limited allowances made for increases, with the remainder passed on as a loss to the building owner. Any saving made through reduced water costs is not signalled to the tenants through a reduction in rent, instead the building owner is the only party who stands to gain.

The transition from flat rate "frontage" rates to variable RUBS and in-rent charges has sparked controversy surrounding equity and fairness. In general it is the case that tenants will save money in comparison to flat rate tariffs; however, 10% of buildings with more than six units will incur additional costs. These 10% are most often those least able to pay, causing the metering initiative to add to an already growing issue of housing affordability, and to be met with resistance from many multi-family buildings. Additionally, errors in the billing system have lead to resistance founded on a belief that meter installation was complex and time-consuming. To address these obstacles, the city established a one year transition period in which billing continued at frontage rates with the option of transferring to meters. The program was unable to address the distrust from multi-family buildings, with the one year period being continuously renewed. A 2001 report showed that a majority of buildings with six or more units had elected not to make the transition from frontage to metered rates (Netzer *et al.* 2001) despite studies by the city water utility indicating a potential reduction in costs for 54% of current frontage buildings (Liebold 2007).

New York City's initial universal metering program had repercussions for the implementation of sub-metering. In some cases, a transition to sub-metering may either introduce or intensify the already observed distributional impacts of metering; vulnerable tenants already dependent on cross-tenant subsidies may face a further rise in water costs through the introduction of individual rates. However, an argument concerning "fairness" may side either way; whilst research comparing RUBS and sub-metered volumetric tariffs noted savings in both (Koplow 1999), the RUBS method of distributing whole-building costs between tenants has been criticised for failing to provide incentives for efficient use and not reflecting actual ratios of consumption

between tenants. One tenant's wasteful use of water can still be distributed across the building; whilst another's careful use goes unrewarded. The US Environmental Protection Agency (EPA) has seen this as its basis for encouraging sub-metering, arguing it is the only way to effectively encourage a reduction in demand and establish a fair charging system.

As a result, sub-metering in New York City is relatively scarce, the exception being cases where a high usage unit is situated in the same block as low usage units and tenants have requested to be metered separately. Retro-fitting existing apartment blocks is limited by engineering concerns such as the fact that older units have multiple points of entry for water supply, making meter location, installation, and access for reading complex and expensive. In addition, the standards for the class of water meter and its proper installation have been criticised as being vague and lacking in enforcement, leading to concerns over accuracy.

The institutional arrangements surrounding sub-metering were also found to be lacking prior to implementation. The EPA has recently had to address the status of property owners as suppliers of water, as sub-metering technically implies that landlords are water "sellers" and therefore subject to expensive quality tests. In an openly tactical response, the EPA announced landlords would be exempt from such quality tests in order to encourage up-take of sub-metering (Environmental Protection Agency 2003). This does not apply to the RUBS tariff, as it was deemed not to influence consumption levels, as mentioned a contested stance.

New York City's sub-metering initiative's success will be determined by the ability of the city to resolve its long standing issue surrounding tariff collection and equity. The current authority for bill collection (EPA) has been awarded limited powers to collect debts, which are lien against a property. Payment is therefore only guaranteed when a property is sold, refinanced, or changes hands. This has resulted in a large back-log of customer debt, which cannot be addressed through sub-metering, as liability for payment remains with the building owner, not the tenants. There is often no means for the building owner to transfer accountability for bill payment directly to the tenant due to rent regulation. Conversely, tenants who are privately sub-metered lack the consumer rights and protection afforded to public utility customers. The conclusion to be drawn from New York City's experience is that the basic structures and procedures necessary for efficient metering at a building scale must be in place prior to a sub-metering initiative. If and when sub-metering does proceed, a clear definition of rights and responsibilities must be set out before implementation.

3.2 Australia: Melbourne

Melbourne city is faced with a growing water scarcity problem with limited room for further resource development. Metering on a per-building basis has been central to Melbourne's demand management strategy since the 1950s, leading to widespread meter coverage. South East Water, one of three municipal bodies serving the city, currently has sub-meter coverage of approximately 93% of its 600,000 customer base. The remaining 7% are largely older developments in which plumbing prevents cost-effective sub-metering.

The drive for sub-metering has primarily been through tenant demand in multi-flat buildings. Awareness of scarcity is high in the city, and water is valued culturally. Due to this awareness and disputes over the fairness of distributing costs between tenants, there was a significant push for legislation to underpin sub-metering in condominiums. The result was the updated Residential Tenancy Act of 1998, which allows for the installation of sub-meters by the utility and the direct billing of tenants, with a small service charge sent to the property owner. Similar actions are being taken nationally with Queensland recently passing a bill according rights to landlords to meter tenants (Couriers Mail 2007).

To encourage retrofitting, the utility has established a free sub-meter installation scheme for existing buildings. However, the cost of the necessary plumbing to install the sub-meters is borne by the property owner, occasionally making retro fitting prohibitively expensive in older buildings. Currently, South East Water's retro fitting programme stands at 1500-2000 units a year, a relatively small number. New-build uptake is more rapid, with sub-metering of multi-unit developments now a requirement for the connection of new properties (South East Water 2007). Under these conditions, the developer pays a 120$ Aus (£51[1]) for meter installation, which covers for the provision of the meter and associated administrative costs.

Automatic Meter Reading (AMR), in which meters are able to be remotely read through a radio signal, has allowed the utility to work around cases where a standard meter would be inaccessible to read. AMR meters employed in Melbourne were quoted to last approximately 10 years after installation, however South East Water observes that after 13 years of operation, AMRs are still operating without battery failure and may eventually prove to be as robust as conventional sub-meters (lasting on average 15 years). South East Water has over 50,000 AMR sub-meters installed, with a large portion of these forwarding consumption data back to the utility on a daily basis. Where installed, it is required that the property developer pay for the additional cost of 210 Aus $ (£89.5[2]) per sub-meter for an AMR.

The ultimate aim in Melbourne is a 30% reduction in 1990s per capita demand values by 2020. Currently the reduction stands at approximately 22% and the introduction of sub-metering has been instrumental in proceeding towards this figure, supporting the signalling of costs to customers through the step tariff system, as well as providing significant data at a unit resolution, and an improved response time to leaks.

Melbourne's tiered tariff system provides an initial 440 litres per day at the lowest tariff, followed by progressively costlier tariff blocks. This has faced the common concern of affordability in high occupancy low income units. Interviewees mentioned that a metered tariff allowed for a much clearer assessment of debts and reduced disputes when negotiating alternative payment methods, as the ambiguity of shared water consumption costs are removed when properties are sub-metered.

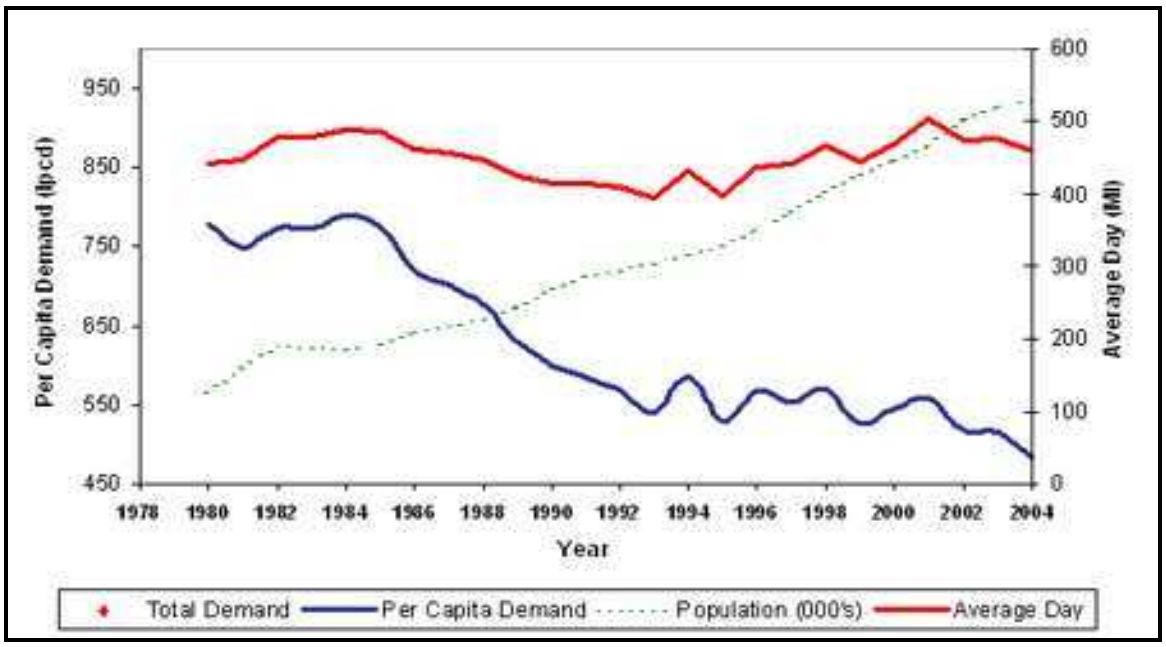
[1] Exchange value of 1 AUD = 0.426067 GBP on 17/12/2007

[2] Exchange value of 1 AUD = 0.426067 GBP on 17/12/2007

3.3 Canada: Calgary

Since the late 1950s, the city authorities of Calgary, Alberta, have had to work hard to gain public support for a universal metering programme. During 1959, 1966, and 1989 the public refused to approve programmes due to concerns over potentially increased charges. The city authority responded in 1991 with a compromise transition programme in which the voluntary installation of meters could be trialed for a year and, should additional costs accrue, they would be reimbursed by the city and the meter would be removed. By this time metering coverage stood at only 22%. The programme was of limited success mostly due to the cost ineffectiveness of water meter installation, resulting in a low uptake (Infrastructure Canada 2005). Since the 1970s, the city has seen a rapid population growth driven by growing oil and hi-tech industries. The city has since acknowledged this growth as a key threat to the security of water and sewerage services, and has focussed on reducing per capita demand (figure 3). After further campaigning, a universal metering bill was successfully passed in 2002 requiring meters to be installed in all new buildings and on change of tenancy in old buildings, concluding with all residential customers being billed on a metered basis by 2015.

Figure 3. Population growth, per capita demand and total demand. (Source: City of Calgary, 2007)



Universal metering was subsequently underpinned by a city Water Efficiency Strategy which set a 30% reduction in per capita demand by 2032 (City of Calgary 2005). Despite being cited as a component in the city's strategy, sub-metering has proceeded under purely private initiatives. The uptake of sub-metering has been on a voluntary basis, decided through condominium associations. Drivers for retro-fitting existing properties are mostly founded on issues of fairness in which tenants feel cross subsidies to a minority of high use units are unacceptable. Installation, billing, and collection through sub-metering are all handled by a private, third party consultant.

A key barrier to implementation in Ontario has been the unusually low price of water in Canada, which is significantly cheaper than in many OECD countries including the UK. Capital costs for retro-fitting projects are relatively high in comparison to potential paybacks through water savings, affecting available finance for installation, operation, and maintenance of sub-meters, as well as reducing incentives for installation. Consequently, private contractors report a large number of sub-metering projects to be in commercial buildings, new developments, and in limited cases, condominium association contracts. Total sub-metering coverage is estimated at 25% of flats.

A legal stumbling block to implementation in Calgary has been the necessary majority consent within condominium associations to install sub-meters, which effectively alters the original terms of tenancy agreements. In other Canadian provinces this issue has been addressed due to gas and electricity sub-metering initiatives. Recent improvements in metering technology have reduced operation and maintenance costs enough to encourage a spread in the sub-metering of gas and electricity in much of Canada, which in some cases has set out the legal and institutional frameworks necessary for water sub-meter retro-fitting on a commercial basis. Prior to 2007 the province of Ontario operated under an 80% consent provision, enforced through the Condominium Act of 1998. Legislation was subsequently updated in 2007 to support a programme of full sub-metering of electricity and gas by 2010, allowing for the licensed installation of sub-meters without majority consent and for the collection of utility bills. Interviews with contractors in Calgary suggested that such frameworks are currently lacking, creating legal uncertainty in implementation. Contractors have tended to take legal advice of a 75% consent rate for installation, however this a best guess and not stipulated in any legislation.

Calgary's failure to proceed with its stated sub-metering ambitions highlights an important distinction between water and other utility sub-metering initiatives. Internationally it has been acknowledged that water is often under priced, affecting the feasibility of initiatives which treat it as a conventional economic good. Without a tariff system which reflects the true costs of water and sewerage services, volumetric pricing becomes difficult to encourage and finance. In the absence of government subsidies to support retro-fitting initiatives, it is unlikely that a majority of tenants will feel the need to adopt sub-metering.

In light of the limited spread of sub-metering in Calgary, city authorities have adopted alternative avenues to provide incentives for water efficiency within multi-unit buildings. In 2006, an awareness raising initiative included the mailing out of 2000 water efficiency guides to building owners. An existing toilet retro-fitting programme was extended to multi-unit building residents, providing a CA$ 50 rebate on the purchase of a water efficient toilet, and bylaws concerning water efficiency of appliances and fixtures were updated to encourage efficiency in all new development.

In working towards the city's target of a 30% reduction in per capita consumption by 2032, Calgary has maintained progress through continuing a universal metering programme at a building scale, supplemented by promotion and incentive schemes to address inefficiency within the multi-tenant buildings (figure 4). Whilst metering at a building scale has been instrumental in per capita reduction (figure 5), the city's leaning towards alternative methods for demand management within buildings is indicative of the relatively low cost of water.

Figure 4. Calgary's per capita demand, 1986 – 2006. (Source: City of Calgary 2006)

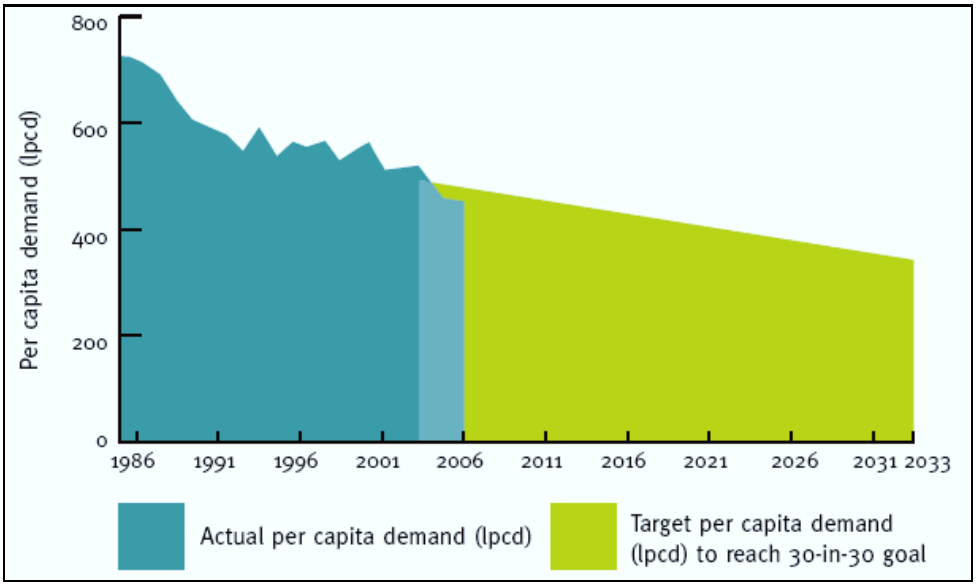
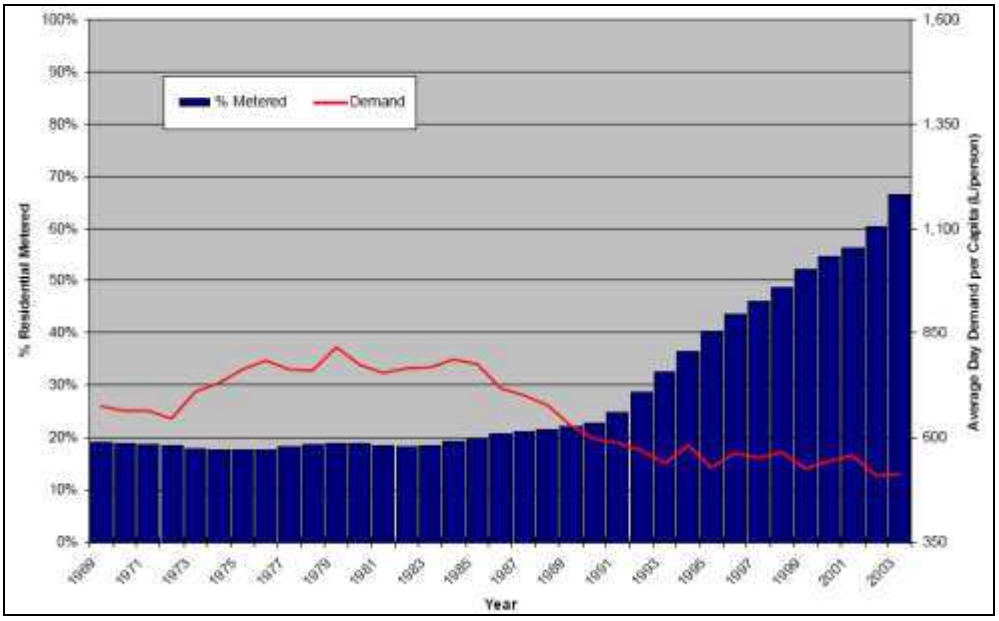


Figure 5. Metering and demand relationship in Calgary, 1989-2003. (Source: City of Calgary 2005)



3.4 France: Paris[3]

Paris introduced water metering at a very early stage in the development of its water services, and as such coverage now stands at almost 100% on a building scale. Until 2000, the method used for calculating bills in multi unit buildings was similar to the RUBS system employed in New York City. Responsibility for payment rested with the building owner, who in turn divided building–wide metered water costs between tenants according to floor space. Recently, pressure to

[3] Credit given to Bernard Baraque, Ecole Nationale des Ponts et Chaussées, for original data analysis and commentary (Baraque 2007).

make a transition to individual meters has risen from three distinct stakeholder groups. Owners of multi-tenant buildings and managers of social housing have pressed for individual metering as a means of transferring responsibility to tenants and therefore reducing the operational costs of managing their properties and removing liability for unpaid bills. Tenants on the other hand, complain of rising water tariffs and the perceived private water company profits resulting from them, and see sub-metering as a means of controlling costs through bills which reflect actual use. Finally, arguments for the potential of sub-metering to curb water consumption have been made in support of decreasing Paris's environmental footprint and promoting sustainability.

The legal provisions for individual metering of tenants were established in 2000 with the introduction of the "Solidarité et Renovellement Urbain (SRU)" bill, in which article 93 allows for tenants to choose to be individually metered. A number of housing projects outside the city have been used to examine the feasibility of expanding sub-metering under the new legislation. The results have so far not been very promising. A common theme throughout the implementation has been the issue of the transfer of responsibilities from landlord to tenant, the ensuing transfer of costs, and the resulting disputes.

With the transition to individual metering has come a transfer of liability for bill payment and maintenance of common areas. Disputes concerning responsibility for common areas focused on leakage. The law provides that a discrepancy of more than 5% between building wide charges and sum-total sub-metered charges due to leakage in common areas must be paid for by the building owner. Whilst this legally addresses the question of the effects of poor maintenance (leakage), it does not address the cause. The cause in the case of Paris is a general reluctance from all three parties of water companies, building owners, and tenants to assume responsibility for maintenance of common areas. This is even more of a pressing issue in buildings which were initially built with sub-meters already installed and so lack a building-wide meter. In such cases leakage cannot be detected through meter comparison and often go unfixed due to the resulting lack of liability for costs.

The transfer of costs and liability has also been a complex process. Tenants who have elected to be sub-metered have often found it not to be cost effective. In fact, average water bills have risen by approximately 30%, in addition to an initial €50 charge for installation. This additional cost rises from the relatively high cost of installation and maintenance in comparison to savings in reduced volume charges. This evidence raises doubt on the money saving potential of individual meters from the tenant's perspective, as they have inadvertently accepted operation and maintenance costs for water assets within the building. In addition, disputes over payments have been frequent in light of these unexpected rises is charges. Literature on sub-metering in Paris describes a legal case in which the municipal water supplier attempted to sue a building owner for failure of payment of water charges, subsequently loosing due to the argument that because sub-meters were present it was the tenant's responsibility. Liability for payment has therefore also remained a point of dispute.

There are two important lessons to be learnt from Paris's experiences with sub-metering. Firstly, in the presence of a private water supply industry and without government subsidies, the cost effectiveness and affordability of sub-metering initiatives will be severely limited. Those who do elect to be sub-metered and bear the costs of installation and maintenance will probably not

achieve a reduction in water bills due to the low cost of water, an issue which will remain in most countries. The transfer of costs to the tenant is accompanied by an obscure transfer of responsibility beyond the sub-meter and prior to the property boundary, which is then contested between the three parties of water company, building manager, and tenant. Secondly, results from studies into the impacts of sub-metering on long-term demand have shown that volumetric pricing alone cannot guarantee a reduction in demand. Preliminary results of pilot studies in several multi-tenant buildings in Paris indicate an initial drop, followed by the re-establishment of original consumption levels. A key message to acknowledge is that the effects are far from certain.

4. Conclusions

4.1 Foundations for sub-metering

Research indicates that a programme of metering at building scale is often already in place prior to the demand for sub-metering arising. Such programmes establish public acceptance of volumetric charging, develop technical expertise in metering technology, and provide building-scale data for leak detection purposes. These programmes can then subsequently be transferred to sub-metering initiatives.

Customer demand is a key driver for retro-fit sub-metering, which is more feasibly left to the discretion of the tenants rather than enforced upon them. The need to establish public acceptance for sub-metering is particularly pressing in the UK. Whilst Ofwat note that the current growth in meter coverage can in part be attributed to changing attitudes to metering, relatively low national coverage (approximately 25%) suggests that customer attitudes to meters in the UK will differ significantly to cases presented (Ofwat 2006).

The emerging pattern is one of tenants or landlords of multi-unit buildings initiating sub-metering installations whilst water companies and city authorities provide the necessary legal, financial, and technical frameworks to support them. The challenge in London remains that of generating demand for sub-meters and preparing the necessary frameworks to support that demand.

Recommendation 1:

Place an initial focus on metering at a building scale, establishing a public acceptance of metering and technical experience in meter technology.

Research indicates that sub-metering initiatives are often underpinned by a supporting universal metering programme for all buildings. A programme of universal metering at a building scale should proceed. In doing so, public acceptance of volumetric charging will be developed and the necessary frameworks for the adoption of new metering technology established.

4.2 Assessing feasibility and financing implementation

From a policy perspective, the mounting requirements on water companies to demonstrate a move towards efficient management of resources, and the increasing emphasis on sustainability in government policy, has meant that sub-metering has come to the attention of Thames Water as a possible solution in the future. However, the current regulatory framework is often unable to allow for the capital expediture and operational expenditure of a sub-metering programme. Currently internal metering only proceeds in cases where cost effectiveness can be demonstrated, in accordance with regulations. From the customer perspective, to voluntarily elect to pay for sub-meter installation and maintenance will also make little sense given the price of water.

Clear targets and criteria for retro-fitting existing flats with sub-meters must be established and adequate financing and incentives must be provided. Case studies show this may proceed through a city-sponsored incentive scheme in which costs are distributed between customers, city authorities, and water companies. Alternatively, Ofwat may need to revise its periodic review process in order to accept the water-saving aspects of metering as a valid economic benefit, as well as operational expediture savings through the use of AMR technology to reduce reading collection times. In some cases sub-metering may not be cost effective due to plumbing and accessibility; in such cases, alternative forms of demand management may be more effective.

Recommendation 2:

Establish clear targets for sub-metering based on cost-effective criteria.

Acceptable levels of cost for installation and maintenance must be decided, and the criteria for assessing feasibility of projects based on those costs established. Current regulatory allowances to water companies may be insufficient to promote significant coverage, meaning a supporting incentive and funding scheme may be necessary in which costs are distributed between the city, water company, and tenant.

4.3 Protecting customers

Of great concern to any expansion of meter coverage is the protection of high occupancy, low income units. With the exception of water scarce areas, domestic users currently reserve the right not to be metered, providing a necessary safety net. If sub-metering is to proceed to a significant coverage in the future, customers must be ensured affordability upon adopting sub-metering. In the UK a recent focus group study conducted by MTP revealed affordability to be a key reason to opt out of metering (MTP 2006). In addressing this issue, a recent WWF study has revealed weaknesses in traditional step-tariff systems which do not account for occupancy (Herrington 2007). The suggested altered version of the step tariff, in which allowances for occupancy are made in the initial step, may be feasible but further research is needed into the availability of data and methods for keeping this data up to date. Currently Ofwat's position on this issue is that subsidies should be sought through social security programmes external to the water sector, and not internally through cross-subsidising tariffs, in keeping with the principle of full cost recovery. This position may have to change in light of international experience in sub-

metering. Without a means to protect families which currently depend on flat-rate subsidies, a sub-metering initiative may prove detrimental to public welfare.

Recommendation 3:

Establish a safety-net for low income, high density units.

A common weakness in metering initiatives is the failure to accommodate for those who may experience a sudden rise in water charges and are unable to pay. This may result in non payment of bills or an unacceptable impact on those concerned. Solutions are divided between equitable tariff systems or means tested state allowances.

4.4 Ensuring accountability and transparency in installation, billing, and maintenance

Case studies indicate that the necessary legal and institutional frameworks required to support sub-metering often lag behind implementation, leading to disputes concerning accountability and transparency. Allowing landlords to divide building-wide water bills between tenants according to sub-meter readings (as in New York City) will require legislation to protect both parties and to ensure assets are appropriately maintained and installed. A lack of legislation in this case shall lead to disputes between tenants and landlords concerning transparency of the billing system and the reliability of meter readings. However, establishing a framework which allows for the landlord to do so may encourage uptake, as landlords may respond to tenant demand and consider meter installation a capital investment on properties.

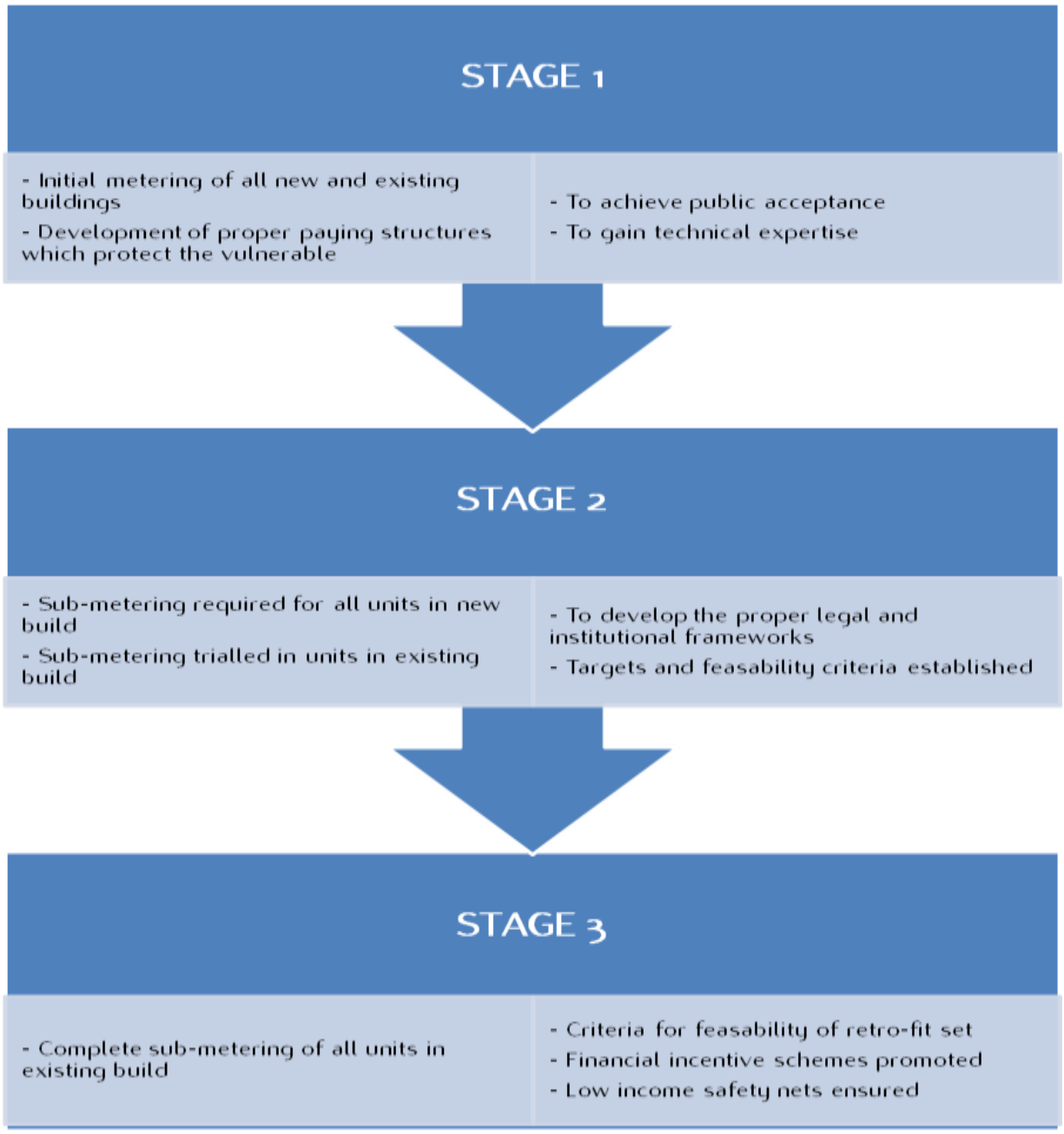
Currently Thames Water is responsible for the installation, maintenance, and direct billing of tenants on internal meters. Beyond the already discussed issue of capital expenditure and operational expenditure allowances needed to expand the sub-metering programme, a further issue arises concerning responsibility for maintenance of supply pipes inside the property line feeding the meters. These pipes have conventionally been outside water company responsibility. However the installation of sub-meters means that leakage in these pipes will not be signalled to customers in bills, occasionally requiring the water company to "adopt" the pipes in order to ensure adequate maintenance. This may prove to be a rising issue as efforts to cover more buildings continue.

Recommendation 4:

Establish clear institutional and legal frameworks to define responsibilities.

A distinction between sub-meters employed by landlords to subdivide building-wide water charges and those sub-meters used to directly bill tenants by water companies is necessary. Whilst this may not be an either/or case as each may be more appropriate in certain cases, both shall require clearly defined responsibilities to reduce uncertainty.

5. Proposed time-line for implementation



6. Proposed further research

Future research should investigate the realities of implementing tariff solutions which address the distributive effects of universal metering at a building-scale in Greater London. The results of Herrington 2007's study should be taken as a starting point upon which a strategy for implementation can be developed.

To support (Stage 1) and prepare the grounds for sub-metering, research should assess technology such as AMR and "smart" meters according to criteria of cost effectiveness, management implications, and social impacts. Once this has been completed, results can then be used to support the development of criteria for feasibility of retro-fit sub-metering projects.

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