Evaluation of
Potential Best Management Practices
-
Submetering of Multi-Family Residential Properties

Prepared for

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Submetering: An Effective Way to Conserve Water?

1.0 Background

Water consumption is usually master-metered in multifamily (MF) settings, with rent serving as the vehicle through which these and possibly other operational costs are transferred to the occupant, most of whom are renters[1]. The expense and administrative burden imposed by submetering has traditionally been considered too great relative to benefits to make it a worthwhile proposition. Many assert, however, that absence of submeters leads to significant water wastage since renters remain shielded from the economic consequences of their water-use decisions, and that this wastage is difficult to tolerate in an era of increasingly constrained supplies. While logical enough, this assertion represents only one side of the coin. A MF complex's total consumption is driven by decisions taken by both renters and owners. After all, a renter may decide how long to shower, but it is the owner that decides whether or not to install a low-flow showerhead. It is the owner's responsibility to ensure that plumbing fixtures remain in good working order, and that the inventory of these fixtures is steadily upgraded in a way that favors newer water-efficient technologies. Thus, while submetering would help in sending clear price signals to renters, it also would simultaneously weaken price signals received by owners. Or, in other words, it would switch incentives embedded in a master metered system.

How should we choose between these two billing options? How can we align renters' and owners' incentives such that together they take decisions that promote water-use efficiency? These are some of the questions that animate the discussion presented in this paper.

In some ways, the choice boils down to knowing whether the owner or the renter is more responsive to price. If price responsiveness (what economists call price elasticity) of the two actors differs considerably, then sending clear price signals to the more responsive actor ought to be preferred since that would reduce wastage the most. But if the two actors exhibit comparable levels of price responsiveness, then the choice is not so clear: In such a case, sending price signals to both actors instead of just one ought to produce better results in principle, assuming a simple enough system could be devised in practice to achieve this goal.

It is worth mentioning that several variants already exist for sending price signals to MF occupants. Complete submetering of each apartment is the most advanced method. Another, possibly cheaper, option includes submetering only of hot water consumption (or point-of use submetering when supply lines crisscross across units), which can then be used to proportionally divide a complex's total water bill across units. Finally, each unit can be billed on the basis of formulas, instead of measured in-unit consumption. The formulas can be simple or complicated, with the latter taking into account several factors,

[1] In multi-family complexes (e.g., condominiums), these costs are passed on to the occupant-owner through association dues or other similar billing mechanisms.

such as the number of occupants in a unit, type of fixtures in the unit, floor area of the unit, and so on. These formula-based bill allocation systems are generically called ratio utility billing systems (RUBS). When comparing the two approaches, it is obvious that complete submetering ties behavior to its economic consequences most directly, while RUBS do so only indirectly.

2.0 Water Savings Estimates

It is difficult not to lean considerably on the recently completed national submetering study[2] (hereafter referred to as the NSS) to assess the pros and cons of submetering. The NSS is both recent and comprehensive in scope, and also includes a thorough review of the literature that became available prior to the NSS's completion. Our goal is not to provide a detailed critique of the NSS's methods, but rather to alert the reader to the NSS's salient findings, compare these findings to those of previous studies reviewed and cited in the NSS, to assess the potential impact of submetering in California, and to raise questions for future analyses.

2.1 Price Elasticity

An obvious place to start our discussion is by examining water consumption's responsiveness to price, the very foundation of submetering. Ample literature suggests that indoor residential water use is less price-elastic than outdoor use. The intuition behind this empirical finding is easy to grasp. Indoor uses permit much less *behavioral* discretion. Under normal conditions, most individuals flush the toilet after every use, most take reasonable showers, and these essential end-uses are unlikely to react much to price. Dishwashers and clothes washers, on the other hand, are perhaps more responsive to price. In the absence of clear price signals one can imagine a higher likelihood of these appliances being run at partial loads. In the end, however, behavior-related price responsiveness comes mostly from outside end uses, such as irrigation, car washing, and so on. Water and energy differ considerably in the level of behavioral discretion each permits. It is far easier to accidentally leave a window open, or forget to turn off a light, or forget to alter the thermostat setting before leaving home, than it is to forget, say, a running faucet.

Apart from behavioral factors, of course, price responsiveness also has a *technology* component. A sufficient rise in the price of water or sewer can trigger a shift toward newer water-efficient appliances and plumbing fixtures (for example, low-flow showerheads, ultra-low-flush toilets, weather-based irrigation controllers, and so on), but this additional, and potentially greater source of price responsiveness falls mostly under the discretion of the property owner.

Because MF complexes generally have fewer discretionary end-uses than single-family (SF) residential settings, it is reasonable to expect the former to exhibit a lower level of behavior-related price elasticity. For example, few MF complexes have large landscapes.

[2] Mayer, P. W. et al., National Multiple Family Submetering and Allocation Billing Program Study, 2004, accessible at http://www.cuwcc.org/uploads/tech_docs/Submetering_Allocation_Billing_Fnl_Rpt.pdf

And compared to SF detached homes, far fewer have dishwashers and in-unit clothes washers. According to 2003 data from the American Housing Survey, in California approximately 47 percent of apartment units had a dishwasher and 25 percent had an in-unit clothes-washer compared to 69 percent and 93 percent respectively for SF detached housing units[3]. Thus, even the indoor price-elasticity of a MF occupant can be expected to be lower than the indoor price-elasticity of a SF occupant.

So what does the literature have to say about indoor price elasticity, and about how this parameter differs when MF complex owners pay for water versus renters? One of the NSS's key findings seems to address the issue, namely, that in MF settings *owners appear to be 70 percent more responsive to price than submetered renters* (NSS, pg. xxxvi-xxxvii). If not the exact estimate, we find this broad conclusion credible in spite of caveats included in the NSS about the submetered renter-elasticity estimate, which the authors state is based upon limited data.

2.2 Water Savings

Several studies have been conducted to estimate savings from submetering as well as from RUBS. The NSS compiles their results. Most of these previous studies derive savings by comparing water consumption of submetered or RUBS sites (test sites) to master metered sites (control sites). Only two studies published prior to the NSS, and now the NSS itself, offer before-versus-after comparisons.

Pre-NSS estimates

There is a striking pattern to the pre-NSS estimates. Savings estimates from the test-versus-control comparisons are invariably higher than the before-versus-after estimates, often by a factor of 3 or more (NSS, pg. 178). In real-world evaluations, a before-versus-after framework is likely to better preserve an apples-to-apples comparison. Thus, we are inclined to put more credence in these lower pre-NSS estimates. That the two methodologies can generate markedly different results, even when applied to the same data, can clearly be seen from the late 1990s study performed in Seattle (NSS, pg. 178).

NSS estimates

How do the NSS's savings estimates compare to these previous estimates? The NSS, to its credit, does not hang its hat on any single methodology. It presents estimates using several models spanning both a test-versus-control as well as a before-versus-after methodology. Unfortunately, the sample size available for the before-versus-after methodology ended up being very small (6 sites, NSS, pg. xxii) because reliable information about when a property switched to submetering or RUBS was unavailable to the NSS team[4]. Therefore, only the NSS's test-versus-control results are of any practical value. Based on a test-versus-control methodology, the NSS estimated submetered properties to have 15.3 percent lower consumption, and RUBS properties to have about

[3] Author's estimates derived from the 2003 American Housing Survey public use file (www.huduser.org/datasets/ahs/ahsnat2003puf.exe).
[4] Based upon personal communication with Peter Mayer, lead author of the NSS.

the same consumption as "in-rent" (that is, master metered) properties. The former estimate is within the previously published band of savings estimates, but the latter is bit of a surprise because prior evaluations have found RUBS to generate statistically significant savings.

Given our earlier comment about comparing apples to apples, the following facets of the NSS should be kept in mind while evaluating its results. Submetered properties were considerably different than the "in-rent" properties on several dimensions. For example, submetered properties were considerably newer—41 percent were built after 1994 compared to 7 percent of the "in-rent" properties (NSS, pg. 57 and 76). They were also larger (NSS, pg. 73), and had a higher prevalence of clothes washers and dishwashers (NSS, pg. 80) compared to the "in-rent" properties.

Although the NSS's statistical models attempt to account for all these differences, the relative newness of the submetered properties is of concern. The NSS (pg. 138 and 139) shows the relationship between total indoor consumption and the number of units per complex, by type of billing system, first for all properties included in the study, then only for those properties that were built after 1995[5]. While submetered properties exhibit lower consumption than "in rent" properties in both these graphs, the difference appears narrower when the comparison is only based upon post-1995 properties. This leads us to believe that if savings were to be estimated using only post-1995 submetered and master-metered properties (a tighter apples-to-apples comparison), the resulting estimates of water savings would be lower.

2.3 Income versus Price Effects

When a property switches to submetering or to RUBS, it is rare for the property owner to adjust rent downward as a way of keeping the tenant's total rental expense unchanged (NSS, pg. xxxi). This automatically leads to the question: do measured savings reflect a long-lasting price response, or a one-time rate shock (what economists call an income effect), that is likely to disappear when the affected tenant leaves and is replaced by a new one? Given the high turnover of residents in MF complexes, one would assume that savings detectable a year or two after the switch reflects a pure price response. It is also possible that when MF complexes switch to submetering or RUBS, the owners apply this new system selectively only to new tenants, minimizing rate shock by design. Previous studies, as well as the NSS, fail to describe clearly what process their respective study sites followed while switching either to submetering or to RUBS, as well as the number of years that had elapsed between the switch and the evaluation. Therefore, it is difficult to gauge how these factors might have impinged on the reported savings estimates. Interpreting previously published savings estimates as a definitive price response would seem reasonable were grandfathering of existing tenants a commonplace phenomenon. Grandfathering might also explain why the NSS found no savings, not even an income

[5] The 1992 Energy Policy Act mandates the use of efficient plumbing fixtures in buildings constructed after 1994, although to account for implementation delays, 1995 may serve as a better demarcation point. Properties built after 1995 can be expected to have lower per-capita consumption regardless of whether they are submetered or master metered.

effect, associated with RUBS. In the interest of clarifying these unknowns, we strongly recommend that future researchers compile longer time-series data covering several years before and after the switching point. We further recommend that they pay special attention to how tenants were actually eased into the new billing system, in order to permit a better differentiation between price and income effects.

2.4 Practical Feasibility

Promoting submetering or RUBS on a large scale may require public agencies (be they state legislatures, public utilities commissions, municipalities, or water districts) to set up a regulatory and institutional framework that clarifies each stakeholder's rights and responsibilities. The stakeholders include; (1) owners; (2) renters; (3) the water utility; and (4) companies that provide third-party billing services. Property owners often use third parties to install and read submeters, as well as to provide the monthly billing services[6]. The NSS discusses these regulatory issues in great detail, so we provide only a brief overview. The broad factors to consider include: (1) setting up a system for registering MF complexes that desire to switch to submetering or to RUBS; (2) requiring MF complex owners to fix leaks, and to upgrade fixtures to the latest water-efficiency standards since owners after the switch would have no incentives to do this; (3) instituting oversight mechanisms to both inform and protect consumers from unfair billing practices; (4) setting up technical standards for submeters; and (5) creating dispute resolution mechanisms. Water agencies wishing to promote submetering or RUBS will need to play at least a facilitating role, if not a leading one, in the creation of this regulatory infrastructure. We recommend that, at such time as these five factors begin to take shape in the marketplace or appear to be demanded by the marketplace, the Council's Utilities Operations Committee take an active role in addressing them.

3.0 California Conservation Potential

We use a combination of data sources to project submetering's statewide gross conservation potential. Since the NSS does not associate RUBS with any significant savings, we exclude this option from the calculation of conservation potential.

Table 1 shows the total number of apartment units in California by complex size, as well as the average number of residents per unit. These estimates are derived from two data sources, including; (1) the California Department of Finance; and (2) the American Housing Survey. The NSS (pg. xxiv) provides estimates of average indoor use (52.19 kgals per unit per year), which works out to roughly 143 gallons per unit per day. Normalizing this estimate by the average number of residents per unit in California (2.36), leads to a per-capita indoor consumption estimate of roughly 60 gallons per person per day, which appears to us as a reasonable estimate (AWWARF's *Residential End Uses of Water* study estimates indoor consumption to be roughly 69 gpcd.)

[6] Third party billing services companies have become increasingly important stakeholders in this arena. Their trade association's website (www.nsuaa.org) contains much useful information.

Conservation potential is derived as the product of the following four factors; (1) the number of apartment units; (2) the average number of residents per unit; (3) the average indoor consumption per capita (60 gallons per day); and (4) the potential reduction in consumption due to submetering (15.3 percent). The result shown in Table 1 is expressed in acre-feet per year.

Table 1 Submetering's Gross Conservation Potential in California

Size of MF complex	Total number of apartment units (as of 1/1/2004)	Average number of residents per unit	Gross conservation potential (acre-feet per year)
2 to 4 units	1,039,348	2.63	28,104
5 to 9 units	890,826	2.41	22,073
10 to 19 units	716,307	2.37	17,454
20 to 49 units	706,261	2.16	15,684
50 or more units	612,463	2.03	12,783
Overall	3,965,206	2.36	96,098

SOURCE: California Department of Finance (www.dof.ca.gov/HTML/DEMOGRAP/E-5a.xls) and the American Housing Survey public use file (www.huduser.org/datasets/ahs/ahsnat2003puf.exe)

One reason for estimating conservation potential by MF complex size is to permit reasoned judgments about what portion of this potential is realistically available. Submetering using automatic meter reading technology, the only kind considered by the NSS, not only involves costs associated with the purchase and installation of submeters, but also the purchase and installation of a central receiver, software, and computer to compile information from the submeters. Spreading the latter costs over a larger number of units obviously improves the overall economics of submetering. What is the minimum complex size below which submetering is not likely to be attractive? We do not know the answer to this question. And the answer is likely to change over time as the technology evolves and, potentially, hardware costs decline. But Table 1's data can help make some reasoned judgments. For example, if submetering were to be considered attractive, say, only in complexes with 20 or more units, then the available conservation potential would be about 28,000 acre-feet per year. And this estimate would have to be further scaled back to account for less-than-full penetration of this market by submetering, and for complexes that are already submetered (nationally, roughly 4 percent of multi-family residents are billed upon the basis of actual consumption, NSS pg. xiii).

4.0 Cost Effectiveness

As long as owners do not adjust the rent downward at the time of switching to submetering, the NSS shows that benefits of submetering to property owners will likely exceed their expenses (NSS, pg. 189). For utilities as well, water savings represent a clear benefit since utilities do not bear any of the submetering costs, unless of course utilities take it upon themselves to install or otherwise subsidize submeters and/or provide the associated billing services[7]. In such cases, a detailed assessment of costs and benefits from the utility's perspective would become necessary. Only the renter's expense increases. Certainly this is true in the short run, although the interplay of economic forces can mitigate some of these adverse effects in the long run. It is possible that competing pressures of supply and demand in rental markets may force submetered properties over time to accept slightly lower rents relative to comparable master-metered properties, which would render the owner's initial cost-effectiveness estimates as too rosy. Roughly 85 percent of apartment complexes are master metered at present (NSS, pg. xxi), so some amount of competition between submetered and master metered properties is inevitable. While it is worth analyzing how rental markets adapt to submetering in the long run, such analyses are not necessary for addressing the basic question—is submetering good or bad from a social perspective? The social perspective in some ways is the litmus test for judging whether or not to promote submetering. We assess this issue using the NSS's own estimates.

It is relatively easy to reinterpret the NSS's cost-effectiveness analyses for property owners (pg. 189) in a way that speaks to the social perspective. For example, the NSS, for its most optimistic scenario, shows that the present value of benefits to owners of submetered new construction is roughly $3,428 per unit (calculated at a combined water/wastewater price of $5.27/kgal, the average across all participating sites) while the present value of costs is roughly $675. In this analysis, benefits are calculated on the basis of the entire indoor consumption of the average apartment unit. From society's perspective, however, only the amount of water that is saved represents any benefit, which the NSS estimates to be roughly 15.3 percent of indoor consumption. Thus, societal benefit from submetering is only roughly $524 ($3,428 × 0.153) per unit, compared to the per-unit cost of $675. Based on this limited assessment of costs and benefits, submetering from a social perspective therefore does not appear to be cost-effective for the average agency, although it may be for those where the cost of water/wastewater is significantly greater than $5.27/kgal..

5.0 Conclusions

The above discussion shows that signaling the price of water to MF residents through RUBS is unattractive. It does not save water, and it shields owners from price signals almost entirely (since irrigation costs are also allocated), without simultaneously strengthening price signals received by tenants. Submetering, on the other hand, appears

[7] Utilities may need to modify billing programs to permit recording of submetered consumption in fractions of conventional billing units (hcf or kgals).

costly. And, since price responsiveness of property owners appears to be significantly greater than that of submetered renters, the wisdom of sending price signals to the less responsive party remains questionable[8]. The NSS recognizes this fact and recommends remedying the adverse incentives that owners would have in a post-submetering world by requiring them to upgrade plumbing fixtures prior to the switch. All of this requires the setting up of a new regulatory and institutional framework to protect consumers, to ensure compliance by owners, and to oversee the operations of third-party billing services companies.

When all is said and done, however, the realizable benefit may be small. The average apartment's indoor use is highly price-inelastic. We suspect that very high-end apartments, with several end-uses that permit significant behavioral discretion, are likely to make the best submetering candidates. Furthermore, unless utilities undertake or financially support submetering themselves, the economics of submetering appear to be such that third-party billing services companies will likely favor the larger complexes, leaving a large portion of the apartment portfolio (and its conservation potential) untapped.

In spite of the above observations, we realize that a water agency's actual position on submetering will likely depend upon market forces operating within its service area. If third-party billing services companies begin to rapidly introduce RUBS in a given area, it would be in the interest of the affected water agencies to get out in front of these trends and attempt to steer the market toward submetering and away from RUBS. Between the two, the former is clearly preferable. Other factors that will likely influence agency viewpoints on submetering include: (1) the prevalence of large versus small multi-family complexes in its service area; (2) the extent to which submetering or RUBS is seen as a way of incentivizing owners to undertake (one time) water-efficient fixture retrofits rather than tenant behavior modification *per se*; and (3) the extent to which submetering or RUBS is seen as a drought-management tool (anecdotal evidence suggests that tenants during droughts do not respond as well to requested water use reductions as do the bill-paying customers).

We expect much additional data to become available in the next 12-36 months from comprehensive submetering studies currently underway. These studies will significantly sharpen our understanding of costs, benefits, market trends, and other factors pertaining to submetering. It is recommended that at such time as these studies are completed and documented, the topic of submetering be revisited and re-evaluated as a PBMP and BMP candidate.

[8]An issue for utilities to consider is whether owners should be proscribed from allocating irrigation costs to renters in submetered complexes.