Policy Nook

Published 31 July 2020

Policy Note: A Universal Equity–Efficiency Model for Pricing Water

Janice A. Beecher
Institute of Public Utilities
Michigan State University
beecher@msu.edu

Drawing on theoretical, practical, and normative rationales, the analysis presented here calls for revisiting the prevailing water service paradigm, and the values and frames it reflects. As is increasingly apparent, current pricing policies may not be sufficiently responsive, pragmatic, or durable, particularly in reconciling competing objectives often cast as the equity–efficiency conundrum. Water is a social good that confers both private and public benefits. The proposed universal (all-inclusive) pricing model envisions five concurrent elements: recognize public functionality in cost allocation (scope economies), calibrate a minimum bill to property assessment (capacity value), provide an essential-use allowance for all households (public health), design cost-based rates for variable water usage (resource management), and prohibit disconnection and deploy service limiters instead (water security). The model advances meaningful structural progress toward social equity while comporting with generally accepted principles to fairly allocate costs and send economic price signals where they make sense.

Keywords: Utility paradigm; water pricing; cost-of-service; rate design; equity and efficiency; social goods.

1. Introduction

Water is intrinsic not just to human life but to the quality of life. It occupies the physiological base (along with air, food, and shelter) on [Maslow's \(1943\)](#) hierarchy of needs. It is difficult to conceive of a public service more important than water; the social imperative to provide safe drinking water and sanitation services to individuals, households, and communities should be noncontroversial.

When it comes to public infrastructure and utilities, low-income households pay more than what can be considered their fair share (Tomer 2018).¹ Like sales taxes, utility user fees are regressive and a form of structural inequity. A regressive cost takes a greater share of the low-income household budget; high fixed utility charges are particularly regressive as they are disproportionately burdensome and uncontrollable by the consumer. These affordability effects are cumulative across water, wastewater, stormwater, and other utility bills, accentuated by inequalities of income and living conditions.

Affordable access to essential water services has recently gained in position on the research, policy, and civil rights agendas, brought to light by high rates of service disconnection (water shutoffs) in cities like Detroit and Flint, Michigan, and into sharp relief by the COVID-19 pandemic. Lack of access exposes and magnifies intractable economic, social, and health disparities related to income, class, and race. Access to safe drinking water is not just a matter of convenience, but of public safety and welfare, inclusive of vulnerable populations and children who have little choice about their circumstances.

A motivation of this U.S.-centric analysis is to move beyond problem definition, the calculus of affordability, and blunt instruments, toward responsive institutions, pragmatic models, and durable solutions.² A new paradigm can advance progress toward the objectives of public health, universal service, ratepayer affordability, environmental stewardship, and distributive justice. This note provides an introduction to the water pricing challenge, an overview and critique of the prevailing world view, the elements and rationales for the proposed pricing model, illustrations and implementation ideas, and concluding remarks.

2. Prices under Pressure

Water prices are under pressure and rising much faster than the overall rate of inflation.³ Water system cost and price profiles vary substantially by system type, age, and location; public policies, economic regulation, and utility ownership also influence costs and prices. In the United States, public ownership of water utilities dominates; with relevant exceptions, state economic regulatory jurisdiction and

¹For a summary trends in the U.S. Bureau of Labor Statistics (bls.gov) data, visit the Institute of Public Utilities (ipu.msu.edu).

²The analysis may be informative but is not necessarily transferable to extreme cases in terms of costs or income conditions, or other development contexts.

³Date from the U.S. Bureau of Labor Statistics (bls.gov) available from the Institute of Public Utilities (ipu.msu.edu).

authority for utilities center on the private sector due to the potential abuse of monopoly power (Beecher 2016).⁴ Jurisdictional utilities find some cover from regulation in terms of raising rates to recover the cost of service.

Rising prices and customer bills relative to water usage are a function of various factors, including the impact of escalating capital and operating costs but also falling usage. Cost pressure stems from remedial investment in aging or inadequate water, wastewater, and stormwater infrastructures. Many older cities contend with legacy costs of their industrial heritage, including oversized assets, population loss, and pervasive poverty; these structural realities are beyond the control of households. For many communities, cost drivers include quality standards and the need to address environmental and health compliance issues, including lead service line replacement, in addition to infrastructure disrepair. Growing areas may experience water resource or supply capacity constraints.

In some cases, a history of forestalling spending and rate increases in the face of budgetary constraints, fear of backlash, or affordability concerns have jeopardized system integrity and viability, which necessitates catching up. Many water utilities are experiencing flat or declining usage associated with economic trends and efficiency gains; that is, fixed costs must be recovered over fewer unit sales, thus requiring higher unit prices to break even. Combined water, wastewater, and stormwater costs make for heftier bills that can be more difficult to pay, particularly if not synchronized with customer assistance.

Responsibility for water infrastructure is borne mainly at the local sociopolitical level. Funding for infrastructure (not to be confused with financing) comes from essentially two sources: taxpayers (federal, state, or local) or ratepayers (user fees and other charges), and they are not identical.⁵ Comparatively, in terms of distributional effects, taxes are or can be less regressive, and rates are more regressive.⁶ Beyond costs, rising prices correspond to the institutionalized movement toward “full-cost recovery” and “full-cost pricing” as a matter of fiscal necessity to close the infrastructure “funding gap” in the dearth of general revenues and federal grants that once played a prominent role. Although outside their domain, federal

⁴Economic regulation redresses market failure in the form of monopoly by holding utilities accountable and authorizing prices and profits. It is distinct from federal financial or securities regulation.

⁵The Organisation for Economic Co-operation and Development (OECD 2009; EurEau 2011) identifies three sources (“3Ts”) as tariffs, taxes, and transfers; transfers can likely be traced to other revenues. Debt and shareholder equity are methods of financing.

⁶Property taxes are generally less regressive than sales taxes, though not as progressive as income taxes. See Wiehe *et al.* (2018).

environmental regulators have pushed pricing at “true cost,”⁷ and practitioners have acquiesced to the simultaneously diminishing tax support.

While water prices do not accurately reflect the “true value” of public infrastructure and essential services, *neither do tax instruments*. Moreover, confining affordability metrics to households and prices deflects attention from metrics that represent the financial capacity of communities. While pricing can be delegated to bureaucracy, taxes require the hard work of democracy. Political and economic forces have conspired to fixate almost exclusively on *full-cost pricing* of utility services; the former argues for the “easier way to fund” (compared to raising taxes), and the latter argues for the “right way to price” (an efficiency criterion). The consequence is an either/or mentality based on a false dichotomy between user fees and taxes that favors pricing and forecloses other solutions.

3. The Prevailing Paradigm

The prevailing normative paradigm for water governance is manifested in the construct of a public utility, although how we think about community water service has evolved with time. With the industrial age came the desire to modernize urban drinking water and sanitation systems. In the early part of the 20th century, public health took priority. Water treatment to safety standards is considered one of the most salient social and scientific advances in modern history. Capital investment in systems followed, and the *public-health* construct morphed into a *public-works* construct that prevailed for decades. Federal funding for water infrastructure peaked in the mid-1970s, and total public funding peaked in 2010; capital investment has since waned (Eskaf 2015).

By perceived necessity and public policy, the water sector morphed again to embody the *public-utility* construct that dominates today. Bolstered by welfare, resource, behavioral, and regulatory economics, the construct emphasizes commercialization and commodification through markets or market-like structures and mechanisms, and has been perpetuated and diffused globally by various institutions. Economic regulation, when applied to utility monopolies, is accepted as an “imperfect substitute” for market competition. The utility construct is normatively technocratic and econocentric, with a discernible ideological undertone. It extols enterprise autonomy and the “depoliticization” of utilities, if not their privatization.

⁷“Pricing of water services should accurately reflect the true costs of providing high-quality water and wastewater services to consumers to maintain infrastructure and plan for upcoming repairs, rehabilitation, and replacement of that infrastructure” (U.S. Environmental Protection Agency, <https://www.epa.gov/sustainable-water-infrastructure/pricing-and-affordability-water-services>). For a broader perspective of “balancing the books,” see Canadian Water Network (2019).

It deliberately sets utilities apart from other public infrastructures and services, such as those related to transportation and public health. The transition to the present paradigm thus also marked a shift of emphasis from service to sales, and from social to economic equity (Bakker 2001).

The utility construct portrays water as a measurable, allocable, and priceable *commodity*. To many academics and influencers, “the idea of ‘water as an economic good’ is simple” (Briscoe 1996). Accordingly, the public interest is served by the “laws” of economics and a thus derived conception of social welfare, which in turn is served by “rational,” “dynamic,” and “appropriate” price signals reflecting “cost causality” to improve efficiency and reduce “waste.”⁸ Water is often characterized as “cheap” relative to other goods and “underpriced” relative to the full cost of service due to perceived subsidies as well as underinvestment. The “value of water” is expressed in monetary terms and invoked by the industry to justify spending and pricing. As new environmental “services” emerge, such as stormwater management, the impulse is to form a utility enterprise and set prices rather than raise taxes. Economists tend to regard departures from doctrine as “second best,” and policy institutions tend to embrace this narrative.

In theory and practice, seeing water only as an economic good is simplistic. Utility systems utilize commodities, but they provide obligatory services that confer both private and public benefits. These services are more accurately understood not as private or even public, but as social goods (also known as toll, common, club, merit, worthy, or even “political” goods). Having some characteristics of both suggests opportunities for hybrid approaches to governance and funding. Social goods are supplied through *public* infrastructures (regardless of ownership) with substantial positive network effects and spillovers. Economic analysis gravitates toward markets and pricing rather than concede to market failures. For monopolistic utilities and price-inelastic demand, pricing is insufficient to impose discipline toward capital or operating efficiency, calling for systems of public accountability (including economic regulation).

Defining welfare only in economic terms fails to capture social utility and the value of both individual and collective *well-being*. While economic goods call for market solutions and price measures that consider the *willingness to pay*, social goods call for governmental solutions and nonprice measures that consider the *ability to pay*. In the utility ratemaking context, the distinction between economic and social goods is paralleled by the distinction between economic equity and

⁸Economic efficiency might even commend Ramsey pricing, by which costs are loaded onto price-inelastic demand, contrary to the goal of affordability for essential uses. On the concern about waste, see Bonbright (1961: p. 55).

social equity.⁹ Unsurprisingly, despite institutional discretion, economic regulators adhere closely to the utility paradigm and economic conceptions of equity. Based on the purported cost of service, economic equity aligns burdens and benefits horizontally (within customer classes), vertically (across customer classes), and intergenerationally (given the long life of infrastructures).

In terms of utility rates and their design, economic equity promotes allocative *efficiency*; social equity promotes allocative *fairness*, that is, distributive justice.¹⁰ Thus, rates deemed by public utility regulators as “just and reasonable” according to economic criteria and methods may still be remarkably regressive and unfair. From a fairness perspective, water might be underpriced for some and overpriced for others. To overcome myopia, disciplines and principles beyond economics are needed to inform policy development and expand evaluation criteria beyond efficiency. Given the confines of the utility construct, a *public-service* construct could be restorative and allow for new framing.

4. Pricing Under the Construct

The utility paradigm entrenches full-cost recovery, full-cost pricing, and full-cost allocation. Although conflated, full-cost recovery refers to the financial self-sufficiency of utility enterprises in terms of deploying available resources (from combined rate or tax revenues, including tax-funded grants) to cover their full accounting costs (capital and operating) in providing an optimal compliant level of service over time.¹¹ Full-cost pricing refers to the recovery of all costs through rates and charges. Full-cost allocation assigns all costs to *cost causers*. By guiding production and consumption to achieve economic efficiency (and economic equity), rates that reflect the cost of service are accepted as “the basic standard of reasonableness” (Bonbright 1961).¹²

⁹The term economic equity has different meanings across fields of study; it refers here to the emphasis on economic principles in cost apportionment. Bonbright (1961: p. 110) questions the validity of the antithesis between “economic” and “social” principles.

¹⁰“Human rights to water and sanitation, and the tariffs that are applied to them, should not be addressed as technical problems but rather as social and political issues of justice” (Neto and Camkin 2020).

¹¹Financial viability also relates to credit quality and the cost of capital. Rating agencies have recognized the relevance of affordability to credit quality. See S&P Global (2018) and Fitch Ratings (2018).

¹²“The cost standard has the widest range of applications. Rates found to be far in excess of cost are at least highly vulnerable to a charge of ‘unreasonableness.’ Rates found well below cost are likely to be tolerated, if at all, only as a necessary and temporary evil” (Bonbright 1961: p. 67). Bonbright also acknowledges variations and limitations of the standard (p. 84).

In practice, the cost of network services can be fully socialized (postage stamps) or fully individualized (toll roads). Metering (and submetering) enable apportionment. Not all cost-sharing is unjustified subsidization. Cost-sharing in the postal and transportation sectors fosters social cohesion and development. Cross-nationally, in developed and developing economies, pricing models are evolving. Some countries outside of the United States are more comfortable with the concept of “social tariffs” and the use of demographics in ratemaking, although with mixed results (Martins 2020). A counterbalance to the prevailing paradigm is seen in the growing openness to structural and pricing approaches to ensure affordable access to essential services.

Public utility ratemaking begins with establishing revenue requirements (the utility’s budget), for a rate period, followed by cost allocation (to link costs and usage) and rate design (to specify tariffs). Revenues should be authorized only for prudent capital and operating expenditures. Rate design is *revenue neutral* and not engineering or enhancing revenues. Rate revenues are expected to meet but not exceed requirements, but both expenditures and revenues from sales will eventually diverge from expectations and trigger another rate review and adjustment.

Fixed (“customer”) and variable (“usage”) charges vary by customer class and are not necessarily matched to fixed and variable costs. Choices about charges involve several tradeoffs; uniform fixed charges by class provide revenue stability but they also send weak price signals and are regressive. Variable rates may be uniform or tiered by usage blocks in relation to costs. Traditional criteria for evaluating rates and rate structures prioritize revenue sufficiency, efficient use of resources, and equitable cost allocation defined in economic terms; “business principles” prevail over “so-called ‘social’ principles,” namely “ability-to-pay” and “diffusion-of-benefits” (Bonbright 1961). Early on, the possible role of value in ratemaking was acknowledged,¹³ but it remains at best an “ancillary” consideration relative to cost.¹⁴ Tension among ratemaking goals and practical constraints, such as understandability, feasibility, and defensibility, is persistent.

Pricing under the paradigm, as ingrained in the economic regulatory domain for more than a century of practice (and followed by many non-jurisdictional water utilities), can be rigid, formulaic, and process-heavy; strict adherence to

¹³“The uncertainties of cost (though narrower than the uncertainties of value) offer room for value to operate as a subordinate criterion, by fixing rates higher or lower within the range of cost; and some aspects of value do, and quite as many should, operate in that way” (Edgerton 1919).

¹⁴“The task of regulation is one of fixing values, not of finding them — of bringing the prices of public utility services into line with... the cost of production” (Bonbright 1961: p. 90).

methodologies may thwart policy pragmatism and innovation. Implied objectivity and exactness may not match reality. The assumption that book costs and thus prices are (or can be) undistorted is dubious in the first place. Costs and prices may embed government grants and loans, contributed capital for development, fees and other income, tax policy effects, and federal and state water projects (throughout the infrastructure investment and spending cycles); they may also allow for various tax payments and dividends (or their equivalents), as well as other transfers and non-revenue services. Cost allocation requires decision rules and subjective judgment, which have distributional consequences. Precision in allocation is elusive, as all costs and their causality may not be knowable or easily parsed. Grouping customers into classes (residential, commercial, industrial, and others) is a type of cost averaging that masks intraclass heterogeneity. Some key cost factors (such as proximity of production and consumption) are often intentionally disregarded. The renewability of water, and the resource value of wastewater effluent in terms of recoverable water, energy, and nutrients, are also unnoticed (Beecher and Gould 2018).

When they can overcome political, legal, and financial barriers, utilities address hardship and affordability through policies, programs, and prices. These compensate for unavailable or inadequate tax funding and typically rely on means-testing utilized for other forms of public assistance. Policies include budget billing, bill timing, flexible terms, and payment options; prepaid meters and user information; and rules for disconnection and reconnection. Customer assistance programs (CAPs) offer temporary or longer-term assistance that may be coordinated with not-for-profits and funded by charitable foundations or voluntary contributions, as well as assistance for upgrading plumbing and fixtures to improve end-use efficiency. Price tools include payment discounts, fee waivers, arrearage forgiveness, and lifeline rates with a below-cost first block usage for eligible customers. Pioneered in the United States by Philadelphia and Baltimore, income-based water bills, by definition, constitute a bold departure from conventions of cost-based ratemaking. Some view them as a way to stem disconnection (Swain 2020).

Income-oriented methods may have intuitive and political appeal but are incremental and not unequivocally equitable. As they are not inclusive of all households, they may not provide sufficient coverage of community needs. Targeting households may even be divisive, in some cases inviting resentment from nonqualifying ratepayers and legal or regulatory challenges asserting undue discrimination and cross-subsidies (interclass and intraclass). Utility-level support must rely on a defensible revenue mechanism. Ratepayers will likely support program costs, to regressive effect, and the near-poor subsidize the poor; both may move in and out of poverty

and, thus, eligibility for assistance. Increasing-block rate structures, even when re-fined, are highly nuanced with regard to equity and efficiency outcomes (Schoengold and Zilberman 2014; Nauges and Whittington 2017). They will also add to pressure on bills in circumstances that increase residential usage, as in the COVID-19 pandemic.

In terms of implementation, households must apply for assistance and meet applicable requirements, which can be cumbersome and raise privacy issues. Income may not correspond to burdens or accurately reflect the ability to pay in terms of wealth. Income can be unstable or inaccurate; at lower levels, it can be altered by public assistance. Affordability and eligibility thresholds (percentages and ratios) are arbitrary at any level. Programs can be complicated and costly to administer on a large scale (including audits and evaluation); adjusting for household size or occupancy requires documentation and verification. Legal and practice frameworks may limit the use of non-cost factors in ratemaking; resistance may also come from rate consultants, stakeholders, and policymakers.

As practiced, ratemaking is mostly detached from social equity. Affordability is regarded as a problem for other institutions to face, ostensibly to guard against “distorting” prices by “subsidies.” An insidious implication, reinforced by law and policy, is that utility advocates and utilities are compelled to make an aspirational “business case for compassion.”¹⁵ In other words, addressing affordability must yield tangible financial benefit to utilities in terms of avoiding costs, increasing revenues, and minimizing adverse ratepayer effects. Even though the business case can be made, this perspective may deflect from other solutions and desensitize policymakers to underlying structural inequities and possibilities for more impactful and durable reforms. Ensuring affordable access to essential services should rest not just on a *business case* for compassion but a *compassion case* on behalf of the human beings that utilities serve.

5. Proposed Pricing Model

Sustainable systems are bound by ecological, economic, and also *equity* tolerances. A new paradigm reflecting alternative decision frames can help overcome institutional inertia and inadequacy to actualize structural change. The aim is to solve

¹⁵“Frequent service shut-offs and resolving bad debt from customers who cannot afford their rates can be more expensive for a utility than... assisting customers in paying their bills... Utilities [could argue] that differences in rates based on income are justified, not only because it is socially responsible but because it helps the utility operate more efficiently... Utilities could argue, through a business case, in court if necessary, that [customer assistance programs] are an “essential cost of running a utility” (Mehan and Gansler 2017).

the equity–efficiency conundrum, that is, the dilemma of ensuring both household affordability and utility viability as levers of sustainability and resilience. The premise is that water service is a social good with positive social externalities, including protection of the public health and welfare of both the general and vulnerable populations. Water prices can be more value-reflective and fair while still comporting with the conception of utilities as self-sufficient enterprises and generally accepted ratemaking principles.

The proposed paradigm and pricing model draw on interdisciplinary and interrelated theoretical, practical, and normative rationales, a dozen each, as detailed in Appendix A. The pricing model builds on a realistic understanding of water system functionalities and cost structures, which in turn guides cost allocation and rate design. It also considers the financial capacity of the customer base to support the cost of service. The model is “universal” in its all-inclusive form as well as its furtherance of universal service. It can be applied to recover full accounting costs from rates, but can also be combined with other funding modes.

The pricing model comprises a set of instruments that address multiple policy objectives (in keeping with the Tinbergen Rule).¹⁶ Five concurrent and complementary elements (and how they are informed) are envisioned and elaborated in the remainder of this section:

- (1) Recognize public functionality in cost allocation (scope economies).
- (2) Calibrate a minimum bill to property assessment (capacity value).
- (3) Provide an essential-use allowance for all households (public health).
- (4) Design cost-based rates for variable water usage (resource management).
- (5) Prohibit disconnection and deploy service limiters instead (water security).

Illustrations of the rate design can be found in Appendix B. Simplified assumptions are applied to develop a hypothetical base case and scenarios meant to show relational patterns rather than specific options or outcomes. The potential improvement in progressivity that can be achieved by the model is apparent.

5.1. Cost allocation

Water utilities of scale achieve considerable scope economies by producing potable water for individual private use along with co-beneficial social goods, namely synergetic fire protection and sanitation services. Water utilities may also bear substantial costs of public road restoration following distribution work. System design and engineering incorporate average-day (minimum requirements or

¹⁶“For each and every policy target, there must be at least one policy tool” (Knudson 2008).

“reserves”), maximum-day, and maximum-hour demand (Howe and Linaweaver 1967). In the specialized and arcane language of ratemaking, cost-of-service analytical models functionalize, classify, and allocate capital and operating costs. Costs correspond to the provision of “base capacity” for general service and “extra capacity” for meeting coincidental peak demand (including a fire event) following established practices in the sector (AWWA 2017). Water utilities are particularly capital-intensive, meaning their cost profiles are heavily weighted by the fixed costs of production and distribution, especially in the near term. In other words, not all water system costs are usage-related or can be precisely allocated. Rates based solely or mainly on commodity procurement and usage send magnified but fictitious price signals, at least relative to short-run marginal costs.

Cost allocation and recovery methods can vary considerably in the treatment of the *joint* costs of producing water for private and public use, or for water and sanitation services. In the context of efficiency gains and declining sales, the time has come to rethink the methods for allocating proportionate costs of the social functions of water supply. Absorbing the costs of capacities for *public* fire protection is the U.S. water industry’s open secret. Water systems are designed and sized to meet codes and standards for the potentiality of suppressing fires; these specifications are drivers of system costs.¹⁷ According to one analysis, the cost of fire protection as a percentage of the total cost of service averaged about 18% for larger systems and 34% for smaller, running as high as 45%; related revenues averaged 21% of total (Wisconsin Public Service Commission 2016). Some costs (such as for hydrants) are direct, but many (such as for distribution assets and water pressure) are indirect. Still, fire protection has long been understood as secondary to drinking water, with the incremental costs of standby service sometimes recovered from separately classified private and public fire protection customers.

For jointly produced services, regarding one as driving the base (average) cost and another as driving the extra (marginal) cost, is subjective. Inverting the conventional perspective could reveal fire protection as a primary service, with requirements driving *base* costs.¹⁸ Baseload costs do not drive system peaks or the incremental cost of water production (Chesnutt *et al.* 2014; AWWA 2017). Continued improvements to indoor end-use efficiency allow even more headroom

¹⁷The issue of whether water systems are optimally sized for their various purposes is a relevant question but outside the scope of this analysis.

¹⁸Some larger water utilities experience maximum-hour demand that *exceeds* the sum of their general-service maximum day plus their fire-flow requirement (Wisconsin Public Service Commission 2016).

for fire suppression.¹⁹ The proposed approach recovers costs more accurately by linking the capacity and commodity costs of peak demand, not with potential fires but with actual discretionary (outdoor) water usage (Section 5.4). Not recognizing fire protection costs, or allocating only direct or “extra” costs, understates their impact on the water system and disregards the related private and public value. These concerns merit attention and deliberation (Ancel 2012).

Recovering fire protection costs from volumetric water sales also perpetuates a pricing fallacy. The same point can be made for wastewater, for which the connection between volumetric flow and the cost of service (collection and treatment) is also tenuous (Beecher and Gould 2018). These costs are unassociated with commodified consumption; with falling usage and increasing capital intensity, they may also take a bigger share of the base. Fire protection and sanitation costs can be recovered through taxes, rates, or both utilizing property values; communities should be allowed to choose. In cases where fire protection costs are billed and funded through taxes, these charges could be more accurately cost-reflective as part of comprehensive rate reform. When cost recovery is through rates, systems may be tempted simply to raise uniform fixed charges for general service, which would result in inequitable outcomes. The proposed pricing model suggests that cost-of-service modeling and rate design can be modified to recognize the joint functionality of water systems.

5.2. Minimum bill

Like many rate structures, the proposed model includes fixed (non-usage based) and variable (usage-based) components (Section 5.4), but the fixed component here is a differentiated minimum charge based on assessed property values. Property value implies functional levels of service or demand that determine system design and capacity requirements, and thus the minimal cost of service; it also reflects the relative utility or value of service to customers. The association between property value, water usage, and the cost of service is not only inexact but also unnecessary to the reasoning; the model reconsiders the derivation of service cost and value to more fairly apportion burdens in relation to both ability and willingness to pay.²⁰

The envisioned charge is billed by the utility and need not be characterized as a tax or defended as such; it is a payment for access and capacity (or “readiness to serve”) to maintain public infrastructure network capacity for all water uses,

¹⁹Systems might be able to augment water supplies during fire events with temporary service interruptions to select customers as specified by tariffs.

²⁰On rate structure options and value-of-service pricing, see Chesnutt *et al.* (2014).

including fire protection and sanitation.²¹ Revenues from the charge could cover a substantial amount of fixed costs. It also effectively “decouples” base capacity costs from water usage but retains a gross price signal in the form of a graduated rate mechanism that satisfies both equity and efficiency criteria in ratemaking. The minimum bill would supplant other fixed customer charges for connections (tied to meter size); usage would still be metered for pricing purposes (Sections 5.3 and 5.4).²²

Income, wages, wealth, and home equity are positively but not necessarily highly correlated (Keister 2019). Nonetheless, property value can provide an accessible, reliable, and stable proxy for the ability and willingness to pay as well as household activity (although it does not account for occupancy). The use of assessed value for public funding is familiar to homeowners and policymakers. This method is not without precedent in pre-metering ratemaking, and “rateable property value” is used to price the remaining unmetered water service in the United Kingdom.²³ Some U.S. water utilities already use property values in setting public fire protection charges (Wisconsin Public Service Commission, 2016). Taxes on property are unpopular but considered reasonably fair (Marlowe 2019).

The pricing model is suggestive of an insurance (or proportionate-benefit) model in terms of the private value and loss protection enjoyed by property holders. It also addresses lifestyle preferences that affect costs on a forward-looking basis, including choices about landscaping and swimming pools as well as second or seasonal vacation homes. Lower income or wealth does not necessarily mean lower water usage due to variations in household size, quality of fixtures, and leakage. In the United States, higher income and wealth appear more likely to drive peak demand (outdoor use) and associated system costs. The proposed approach is less regressive than conventional utility rate structures, especially those in the form of high and undifferentiated fixed charges.²⁴ While not a means of revenue enhancement, it would also improve revenue stability and predictability, thus

²¹This type of charge is distinct from usage-based “demand charges” (see Borenstein 2016). Some water utilities have explored alternative “base charges” (Eskaf 2014).

²²This solution appears to align well with an analysis of fixed-cost recovery in electricity networks and might be applicable in that context: “A monthly fixed charge based on the customer’s service capacity would more appropriately capture [upfront investment] costs... Recovering customer-specific fixed costs through fixed charges — calibrated to reflect cost differences in service levels — is quite appealing on both equity and efficiency grounds. But a fixed charge that is the same for customers with massively different demands will violate a common sense of equity...” (Borenstein 2016).

²³Water Services Regulation Authority (ofwat.gov.com).

²⁴Other forms of regressivity remain relevant in the context of economic recession or gentrification, calling for additional policy attention.

supporting investment and operations, and might be useful during economic crises that reduce household income, as during the COVID-19 pandemic.

The aggregate wealth of the utility's customer base is a relevant indicator of the financial capacity of the community to bear the obligation to sustain infrastructure services. A rate structure incorporating a measure of wealth (property) to approximate costs and benefits does not imply wealth transfer (or welfare loss). The calibration of the minimum bill would ensure the progressivity of the fixed charge, requiring both analysis and deliberation. The calibration could also be refined to recognize idiosyncrasies in property assessment, local economic conditions, and other potentially relevant factors or policies affecting fairness. Affordability can be further enhanced by eliminating any other fixed customer charges and exempting the minimum bill from any applicable sales taxes.

5.3. Usage allowance

In their residential service function, water systems capture scope economies by co-producing and delivering five products through one set of pipes: water for physical consumption (drinking and cooking), personal hygiene, home hygiene, and discretionary (outdoor) activity, in addition to fire protection. Differentiating usage is useful for water pricing. Generally, essential usage is less discretionary and less price-responsive; that is, consumer agency and control are limited.²⁵ Exorbitant prices for mostly inelastic usage of services supplied by monopolies do not promote appreciable end-use efficiency; they simply extract rents and may be punitive.

Water is essential for consumption and hygiene. Fundamental properties (namely, renewability and storability) make a usage allowance more appropriate for water than for energy services (with the caveat that water services are also energy-intensive). Water for essential usage can even be regarded as a secondary product (or byproduct) of base capacities, including the water commodity available for fire protection and sanitation. Under the model, an allowance applies to all residential connections; although effective prices vary, equal quantities convey the universality of essential needs, which may also help with political palatability.

The essential-use allowance included in the fixed charge constitutes the first block of household usage, which can be guided by public health, safety, and welfare standards. The amount could be adapted to verified household size. Informed by the World Health Organization (WHO) recommendations for human health, 50–100 liters (13–26 gallons) per capita per day would yield a baseline household allowance of about 1,000–2,000 gallons monthly (assuming 2.6 persons

²⁵The conception of essential use here contrasts sharply with the conception of “need” reflected in “water-budget billing” (Beecher 2012).

per household). Some households may never exceed the allowance. These levels also equate to hyper-efficient usage; amounts below this threshold suggest the possibility of uneconomic and unwholesome avoidance behaviors. Water used to ensure public health is not wasteful but worthy (a normative construct), and minimum system flows also ensure the physical health of water infrastructures by maintaining circulation and preventing stagnation. Water loss reduction could also yield a source of essential supply.

Indoor household usage in the United States varies but typically exceeds the WHO amount. Indoor usage has been estimated to average 58.6 gallons per capita daily (down from 15% from the finding reported in 1999) and expected to fall to 36.7 (DeOreo *et al.* 2016). Analysts have used 50 gallons per capita daily in affordability benchmarking (Raucher *et al.* 2019). For water not used for consumption and hygiene, some economies are realized from sharing a dwelling (including a single customer charge and some communal activities, such as laundry). A uniform monthly allowance at an agreed-upon level, such as 2,000 gallons per household (as a minimum), would be easy to justify and implement. Adjusting the allowance for occupancy (household size) would enhance equity from this perspective but complicate design and administration; other forms of assistance, including an adjusted usage allowance, could be offered to large households with utility affordability challenges.

5.4. Rate design

Economists, along with many policymakers and regulators, emphasize that price signals are necessary for the efficient use of water. Demand for indoor water and wastewater services, however, is particularly price-inelastic (Beecher and Gould 2018), which undermines the sensibility of behavior-oriented price signals. Remarkable past and prospective efficiency gains in indoor end uses appear to be induced more by standards and turnover than prices (DeOreo *et al.* 2016). For some households, high water rates for essential usage may do more harm than good to consumers and society, and efficiency programs may be more helpful in managing demand. Moreover, public supply is a subordinate category of U.S. water withdrawals that peaked in 2005 (Dieter *et al.* 2017).

The first block of usage (essential-use allowance) is included in the minimum bill (described in Sections 5.2 and 5.3). Water usage above the essential-use allowance typically becomes more variable, discretionary, and somewhat price-responsive. For additional blocks, the proposed rate structure applies cost-based uniform or tiered rates. Variable charges for more discretionary usage communicate value and imbue a degree of customer control over water bills, even if limited to

the margin. Convenient and timely information on metered usage and costs can enable households to monitor their water usage and bills, and prompt self-rationing once the allowance is approached or exceeded.

Second-block rates can be designed for “basic” usage above the essential amount and priced with a uniform volumetric rate; this usage remains relatively price-inelastic, particularly for water-efficient households. Third-block (or “tail-block”) rates can be designed for “extra-discretionary” usage and priced in line with economic principles by operationalizing long-run marginal costs. These rates can thus be more cost-reflective to satisfy economic reasonableness and maintain behavioral incentives in keeping with efficiency objectives and sound resource management. Pricing may be relevant under spatial or temporal conditions of scarcity, where supply and demand are mismatched and conservation is necessary. Rate design options for the third block include continuation of the uniform rate, another rate tier, or a seasonal rate. Tiered and seasonal rates can be designed generically or at the household level by using off-season meter data to model basic indoor usage, which accounts for occupancy; this method is utilized in wastewater pricing.

For many parts of the United States, seasonal outdoor water use is a key driver of system peaks and thus costs, including those corresponding to extra (sometimes excess) capacity. Incremental seasonal usage is both discretionary and volatile due to the influence of weather (precipitation). Metering technologies and data can be used to refine pricing according to peaking factors within and across customer classes and contributions to system loads and costs. Allocating more costs to price-elastic demand will have consequences for all ratepayers in terms of recovering costs over fewer unit sales, although income and wealth attenuate this effect (Wiehe *et al.* 2018). Low-income customers can be price-sensitive, and high-income customers can be price-insensitive, even for high-volume usage. While it may run against the grain, under some circumstances, and with sound stewardship, well-priced water usage by those with ample ability to pay can enhance system sustainability.

5.5. Service limiters

Perhaps nothing marks institutional failure or separates society’s haves and have-nots more starkly than shutting off water service. Denial of service is a draconian and deleterious response to payment difficulty that is obviously at odds with the human right to water and sanitation, as well as dubious public policy. Confronting the issue takes on urgency in an age of pandemic.²⁶ Of course, it should not take a

²⁶On U.S. state disconnection moratoriums and service restoration amidst the COVID-19 crisis, see Campbell-Ferrari and Wilson (2020).

pandemic to fathom the value of sanitary practices. Many utilities and policymakers contend that they must resort to disconnection to contain the “moral hazard” of chronic nonpayment and utility revenue deficits. Disconnection may be conditional based on special circumstances (such as a resident with a medical condition). However, an array of options is available, including payment methods, positive incentives (such as discounts or rebates) and technologies that avert shutoffs.

Disconnection is unlikely to reduce the cost of service as most near-term costs are fixed; the implementation costs incurred by the system and the household (including reconnection) may exceed any savings, and the cost to public health and public trust may be greater still. Prohibiting disconnection preserves household water security and service continuity to safeguard public and system health and may not necessarily lead to excessive usage.²⁷ An early analysis of the COVID-19 pandemic estimated the annualized marginal cost of water disconnection moratoriums in the United States at \$570 million relative to a net potential financial impact on the sector of \$13.9 to \$15.5 billion (Raftelis 2020).

Deploying service limiters (flow restrictors) is a humane alternative to absolute disconnection requiring recoverable investment in technology and labor as well as engagement with engineering professionals. More experience with flow restriction is found outside of the United States.²⁸ As one U.S. example, the San Francisco Public Utilities Commission (2019) provides for its use in rules and regulations. These devices are volume or time-limiting with the use of tamper-resistant valves or meters. An analogue in electricity is the use of a voltage limiter. A service limiter imposes discomfort and is a form of service-quality differentiation, but importantly, not in terms of water potability. It allows for personal safety (for hydration, baby formula, and meal preparation) and sanitation (intermittent flushing). The essential-use allowance and rate structure still apply, as well as exemptions.

A pricing model that ensures affordability with a permanent ban on service disconnection would focus the mind of the water policy community. The human right to water (and to energy and broadband services)²⁹ is elaborated elsewhere. It resonates with the ideals of security and dignity, freedom from want, and social and

²⁷Clark *et al.* (2017) found that “activation of a NSO policy increases natural gas consumption by between 4.7–4.8%, resulting in a total increase of between 66 and 67 billion cubic feet of natural gas consumed per winter season in covered states.”

²⁸A study of 28 European countries found eleven that allow flow restriction, five that prohibit disconnection and six that prohibit flow restriction (Ireland and the United Kingdom prohibit both); and five that allow disconnection but require utilities to supply water sufficient for safety (EurEau 2016).

²⁹In the United States, the goal of universal service is enshrined by federal law for telecommunications.

economic inclusion. The right to water can be operationalized by universal water service to all who want it without discrimination or threat of disconnection. The right to water should be universal but, like other rights, is not unqualified. Discretionary (nonessential) water use by anyone willing and able to pay for it can be priced to meet economic and environmental objectives.

6. Implementation

Ensuring household affordability and utility viability requires a workable mix of revenue sources, including but not necessarily limited to rate structures. All are easier to implement for systems of scale with broad and diverse (possibly regional) customer bases, higher levels of economic activity and property ownership, lower levels of poverty, and manageable costs of service. Such systems are well-positioned to cover the full cost of service, including prudent capital improvements, through rates. The proposed pricing model is feasible under these conditions and may help reduce the scope of customer assistance programs and make them more cost-effective. Compared to many alternatives, it requires less effort and expense by administrators and is less burdensome to utility ratepayers who already bear the weight of poverty (Moynihan and Herd 2019).

Public officials and public utilities should be joined in their efforts and engaged collaboratively to craft local infrastructure funding solutions, whether in the form of taxes, rates, or both. Community self-determination should be authorized and codified to confer legitimacy and legal protection. State public service commissions with primary or appeals jurisdiction could affirm that rates under the model are just and reasonable, and provide an effectual means of dispute resolution and affirmation. In some jurisdictions (including California and Michigan), legislative dispensation could help overcome barriers and deter challenges stemming from the model's perceived resemblance to taxation, and affirmatively allow for innovative funding.

Outside of pricing, other policy reforms are still needed, including federal and state grants for assistance to households and communities considering their respective financial conditions and capabilities (Raucher *et al.* 2019; Pierce 2020; Martins 2020).³⁰ Customer assistance may still be needed to protect low-income households with large families or in gentrified areas. Distressed areas with pervasive poverty, economic decline, and oversized and failing infrastructure call for intervention from various governmental levels. Reducing or eliminating transfers

³⁰This might include retooling federal and state energy assistance programs to address all household utility burdens.

to parent municipalities could offer immediate revenue or rate relief (depending on accounting treatment). In some circumstances, including widespread and chronic nonpayment, it may be necessary to move a portion of cost recovery from water bills to tax bills.

Implementing the model requires a process for deliberation and decision-making at the community level, including whether to recover the total cost of service through rates alone. The details of the model will determine its impact. Implementation strategies and tasks include the following:

- Engage local politicians, stakeholders, and professionals in open and participatory processes to build a political consensus and legitimize pricing policies.
- Establish revenue requirements and conduct a modified cost-of-service analysis that accounts for system scope economies as well as both private and public benefits.
- Specify criteria and parameters for the essential-use allowance, calibration of the minimum bill, and the usage-based billing determinants, informed by relevant metrics.
- Synchronize property assessment and water billing data to model rates and revenues, and (re)distributional effects of the rate structure relative to the baseline.
- Invest in technologies, including advanced meters that enable customers to monitor and control their usage, efficiency devices, and flow restrictors.
- Develop consumer education programs and incentive systems that reward participation in prepayment and budget-billing plans as well as automatic and timely payment over time.
- Prepare a preemptive legal brief for use in a regulatory or judicial proceeding to defend the model's legitimacy and consistency with generally accepted rate-making principles.

Depending on the design details, the proposed model may find support among key stakeholders in accordance with their primary objectives related to water utility ratemaking: utility investors and managers (revenue sufficiency and stability); ratepayer advocates (fair cost allocation); environmental advocates (resource management); engineering consultants (physical and operational integrity); policymakers (infrastructure improvement); regulators (pursuit of the public interest); and politicians (service to constituent communities).

Extending this research could provide additional context and expand on the rationales for the proposal. Empirical modeling requires data for an actual system and scenarios that test the impact of alternative rate policies, price elasticities, and cost-allocation factors. More work is needed on pricing options for the

multi-family (renters and owners) and non-residential (commercial and industrial) classes. In terms of interclass cost allocation and rate design, property values for non-residential customers could also be used to calibrate a fixed charge, but other tariff elements would require analysis. Given altered price signals, further research should address finding the mix of price and nonprice tools under scarcity conditions, particularly with respect to discretionary water usage. Hybrid funding for social goods is deserving of more attention, as are governance models that restore a measure of constructive democratic politics and public accountability in the utility realm. Technical guidance is beyond the scope here, but the model could eventually find support within professional associations and, as appropriate, manuals of practice for cost allocation and rate design. A critical step is to convince a first taker to adopt and pilot the pricing model as a policy experiment to demonstrate proof of concept and inform implementation and refinement according to outcomes.

Finally, the model can be implemented by any type of utility (publicly owned, privately owned, or not-for-profit) and adapted to local values and policy priorities. It might ideally be applied collectively to water, wastewater, and stormwater services as part of integrated governance and pricing reform. The model also is potentially relevant and transferable to other capital-intensive industries facing the need to equitably cover fixed network capacity costs of “grids” with low (and falling) marginal production costs, including a transforming energy sector and broadband communications.

7. Concluding Remarks

The responsiveness of institutions to social issues and prospects for reform are delineated by their guiding paradigms until disrupted. Evolving a public-service construct and ensuring affordable access to essential water and sanitation services could constitute a paradigm shift, and allow for alternative values and decision frames. The proposed pricing model might seem radical, but it is also principled, and thus potentially durable. Underlying theoretical, practical, and normative rationales proffer legal and political defensibility in the face of inevitable challenges related to cost allocation and rate design. Its universal applicability satisfies perceptions of fairness by avoiding discriminatory pricing or service quality. By reconciling equity and efficiency objectives, the model may appeal to if not appease both economic and political forces to advance reasonable and meaningful structural progress toward social equity.

The provision of safe water by viable and resilient utility systems expresses societal priorities. Water brings sustenance, security, and dignity to every human

life, and water used to better the human condition is not water wasted. The inalienable human right to water is settled law in some places and aspirational in others but is yet to be embraced globally or in the United States. In an overdue conversation, if we cannot agree that water is an inclusive right, perhaps we can at least agree that it should not be an exclusive privilege.

Acknowledgments

The author is very grateful to the editors for the opportunity to share this work in progress, and for their thoughtful comments and suggestions. Many thanks are also due to Andrew Burnham, William Knudson, Gregory Pierce, and Erika Rosebrook for their careful and insightful reviews. Errors of omission and commission are the author's alone.

References

- Ancel, S (2012). Public fire service water charges – on the water bill or on the tax roll? *Environmental Finance Center*, University of North Carolina. Available at efc.web.unc.edu.
- AWWA (2017). *M1 Principles of Water Rates, Fees and Charges*. American Water Works Association. Denver, CO.
- Bakker, K (2001). Paying for water: water pricing and equity in England and Wales. *Transactions of the Institute of British Geographers*, 26(2), 143–164.
- Beecher, J (2012). The ironic economics and equity of water-budget billing. *Journal of the American Water Works Association*, 104, 73–81.
- Beecher, J (2016). Potential for economic regulation of Michigan's water sector. Michigan State University Extension. Available at msu.edu.
- Beecher, J and T Gould (2018). Pricing wastewater to save water: Are theory and practice transferable? *Utilities Policy*, 52, 81–87.
- Bonbright, J (1961). *Principles of Public Utility Rates*. Public Utilities Reports Inc.
- Borenstein, S (2016). The economics of fixed cost recovery by utilities. *Electricity Journal*, 29(7), 5–12.
- Briscoe, J (1996). *Water as an Economic Good*. Washington, DC: The World Bank.
- Campbell-Ferrari, A and L Wilson (2020). The COVID-water disconnect: How statewide moratoriums are leaving people behind. A Report by the center for water security and cooperation.
- Canadian Water Network (2018). *Balancing the Books*.
- Chesnutt, T *et al.* (2014). *Building Better Water Rates for an Uncertain World*. Alliance for Water Efficiency and.
- Clark, DE, C Dybiz, A Hanson and F Nourzad (2017). No shut-off policies and natural gas consumption. *Resource and Energy Economics*, 48, 19–29.
- DeOreo, W, P Mayer, B Dziegielewski and J Kiefer (2016). *Residential End Uses of Water, Version 2*. Water Research Foundation.

- Dieter, CA *et al.* (2017). *Estimated use of Water in the United States in 2015*. U.S. Geological Survey. Available at www.usgs.gov.
- Edgerton, HW (1919). Value of the Service as a Factor in Rate Making. *Harvard Law Review*, 32(5), 516.
- Eskaf, S (2014). Less common base charge structures. Environmental Finance Center, University of North Carolina. Available at efc.web.unc.edu.
- Eskaf, S (2015). Four trends in government spending on water and wastewater utilities since 1956. Environmental Finance Center, University of North Carolina. Available at efc.web.unc.edu.
- EurEau (2011). *Methodological Guide on Tariffs, Taxes and Transfers in the European Water Sector*. Brussels.
- EurEau (2016). *Access to Water and Measures in Case of Nonpayment*. Brussels.
- Fitch Ratings (2018). U.S. Water and Sewer Rating Criteria — Effective November 29, 2018 to April 3, 2020. Available at www.fitchratings.com.
- Gorina, E (2018). City revenue structure and unfunded pension liabilities. *State and Local Government Review*, 50(3), 189–202.
- Howe, C and F Linaweaver (1967). The impact of price on residential water demand and its relation to system design and price structure. *Water Resources Research*.
- Keister, L (2018). Income and wealth are not highly correlated. Work in Progress, available at wipsociology.org.
- Knudson, W (2008). The environment, energy, and the Tinbergen Rule. *Bulletin of Science, Technology and Society*, 29, 308–312.
- Marlowe, J (2019). The fairest tax during a recession may be the least popular. *Governing* (governing.com).
- Martins, M (2020). Regulatory changes to Portugal's social tariffs: Carrying water in a sieve? *Utilities Policy*, XX.
- Maslow, AH (1943). *A Theory of Human Motivation*. RD Printing.
- Mehan, G and Gansler, I (2017). Addressing affordability as a necessary element of full-cost pricing." *Journal of the American Water Works Association*.
- Herd, P and D Moynihan (2019). *Administrative Burden: Policymaking by Other Means*.
- Nauges, C and D Whittington (2017). Evaluating the performance of alternative municipal water tariff designs: Quantifying the tradeoffs between equity, economic efficiency, and cost recovery. *World Development*, 91, 125–143.
- Neto, S and Camkin, J (2020). What rights and whose responsibilities in water? Revisiting the purpose and reassessing the value of water services tariffs. *Utilities Policy*, 63.
- OECD (2009). *Managing Water for All: An OECD Perspective on Pricing and Financing*. Organisation for Economic Co-operation and Development. Available at oecd.org.
- Pierce, G, N Chow and J Deshazom (2020). The case for state-level drinking water affordability programs: Conceptual and empirical evidence from California. *Utilities Policy*, 63, 101006.
- Raftelis (2020). The Financial Impact of the COVID-19 Crisis on U.S. Drinking Water Utilities. American Water Works Association and Association of Metropolitan Water Agencies. Available at awwa.org.

- Raucher, R, E Rothstein and J Mastracchio (2019). Developing a new framework for household affordability and financial capability assessment in the water sector. Available at awwa.org.
- Rogers, P (2002). Water is an economic good: How to use prices to promote equity, efficiency, and sustainability. *Water Policy*, 4(1), 1–17.
- San Francisco Public Utilities (2019). Rules and regulations governing water service to customers. Available at <https://sfwater.org>.
- S&P Global Ratings (2018). Affordable for Now: Water and Sewer Rates at U.S. Municipal Utilities. Available at www.spglobal.com.
- Schoengold, K and D Zilberman (2014). The economics of tiered pricing and cost functions: Are equity, cost recovery, and economic efficiency compatible goals? *Water Resources and Economics*, 7, 1–18.
- Swain, M, E McKinney and L Susskind (2020). Water shutoffs in older American cities: Causes, extent, and remedies. *Journal of Planning Education and Research*.
- Tomer, A (2018). Can people afford American infrastructure? Available at brookings.edu.
- U.S. Environmental Protection Agency (2019). Pricing and Affordability of Water Services. Available at: www.epa.gov.
- Wichman, C J, L Taylor and R von Haefen (2016). “Conservation policies: Who responds to price and who responds to prescription?” *Journal of Environmental Economics and Management*, 76, 114–134.
- Wichman, C J, L Taylor and R von Haefen (2016). Conservation policies: Who responds to price and who responds to prescription? *Journal of Environmental Economics and Management*, 76, 114–134.
- Wiehe, M, A Davis, C Davis, M Gardner, L Christensen and G Grundman (2018). Who pays? a distributional analysis of the tax systems in all 50 states. The Institute on Taxation & Economic Policy.
- Wisconsin Public Service Commission (2016). Investigation into the methods used by Wisconsin’s water utilities in allocating public fire protection costs. Final Staff Report. Madison, WI.

Appendix A. Rationales

A.1. Theoretical rationale

- Conventional methods of pricing are not as cost or value-reflective as purported and do not accurately account for joint production, scope economies, non-allocable commodity usage, and the social value of maintaining base capacities and readiness-to-serve across synergetic functions.
- Cost-of-service principles cannot be violated if they are not strictly followed in the first place; the cost of service cannot be known or allocated with certainty, including non-revenue water for system maintenance and public use.
- Raising uniform fixed charges across customers is a languid response to changing cost profiles; network costs can be equitably covered by a graduated

rate not tied to usage, made more imperative by potential “death spirals” in capital-intensive utility industries.

- Property value is a suitable attribute for associating the ongoing level of service and system capacities with a connection, and calibrating a minimum charge to property value satisfies conceptions of economic and social equity.
- Allocating capacity costs by property value for the entire residential class comports with prevailing principles of intraclass equity in ratemaking that disfavor undue price discrimination, cross-subsidies, and wealth transfer.
- Social goods and social equity argue for considering tax-emulating vs. market-emulating models given social utility and returns; subsidies and “below-cost” pricing for transportation and other local services are justified by the desire to enhance places and the quality of life, as well as local economies.
- Relevant price effects can be differentiated by usage; price elasticities for discretionary usage are not transferable to nondiscretionary usage.
- Behavioral incentives should focus on price signals for discretionary usage where they matter (“tail blocks”) in line with resource economics and marginal-cost pricing theory; economic equity calls for allocating relevant costs to the usage that drives system peaks and expenditures.
- The marginal value of essential usage is very high while its marginal cost can be very low; given inelastic demand, price-based incentives are less relevant than efficiency standards, practices, and programs for resource and demand management.
- Rate-design details (including fixed and variable charges) matter little to price-inelastic demand; neither overpricing nor underpricing results in inefficient usage or a “deadweight” economic loss, meaning that price can be reasonably used to address social equity.
- The water commodity is a renewable resource and public supply is subordinate use, and while no water should be wasted (especially given the water-energy nexus), usage should be optimized to the benefit of society and its members; risks and detriments derive from both overutilization and underutilization of water.
- Conserving water by pricing or other measures does not lower or avoid the near-term fixed cost of service; reductions in usage translate into lower capital and operating costs in the long term but also imply higher volumetric rates for service.

A.2. Practical rationale

- In the larger scheme of total withdrawals, including withdrawals for public use, the volume of water required to meet essential needs may be modest.

- By ensuring an affordable minimum charge, the model can help mitigate the effects of rising infrastructure costs, falling usage, consolidated tariffs, and increasing-block rate design, on low-income and low-volume users.
- Both rates and revenues are stabilized to support necessary capital investment and operations, assure regulatory compliance, and enhance the utility's financials and credit quality (lowering revenue risk and thus the cost of capital).
- The model is pragmatic and technically feasible and covers a broad spectrum without the administrative cost and complication of targeted programs requiring thresholds, application processes, and verification of income and other criteria.
- Property values are assessed and recorded for tax purposes, relatively stable over time, and easier to access than income for ratemaking purposes.
- Progressive pricing may be characterized as "tax-like," but usage metering and billing by the utility are retained to communicate the price and value of water service.
- The model does not interfere with conventions of ratemaking in terms of establishing revenue requirements, including regulatory review of utility prudence.
- The threat of disconnection may induce payment in some cases, yielding some revenues, but may also encourage gaming behavior; disconnection may lead to unsafe theft of service.
- Disconnection (and reconnection) does little to avoid system operating expenses and is actually costly to utilities, affected households, and all system ratepayers; it consumes personnel and other resources, and can disrupt flows needed to maintain system-wide water pressure and quality.
- Disconnection harms institutional reputation and trust, which in turn undermines utility-customer and utility-community relations.
- The model works for different types of water utilities and services; the various elements are adaptable as to details, although complexity adds costs and may invite controversy.
- The model is comprehensible as to purposes, potentially supported by a wide range of diverse interests, and possibly transferable to other network services.

A.3. Normative rationale

- Economics is informative but should not be determinative; not all value can be derived from economic metrics, including costs and prices, or accurately monetized with regard to network effects and social externalities.
- Social values can and should play a more explicit role in regulatory and rate-making policy; protection of public health and welfare should have a higher priority.

- Pricing should consider both the ability to pay for essential services (social equity) and the willingness to pay for discretionary services (economic equity); if higher prices can be used to help manage demand, lower prices can be used to help manage affordability.
- Pricing models can preserve individual responsibility, consumer agency, and ratepayer control over water bills, but in a fair and considerate way.
- A substantial amount of potable water (net of losses) resides continuously in the piped distribution network to meet total system requirements; withholding available water that could meet essential needs is negligent.
- Disconnection is fundamentally inhumane, inflicting physiological and psychological stress; usage allowances, self-rationing, and flow restriction are less draconian and preserve a modicum of personal dignity.
- Lack of water and sanitation services can lead to unhealthy behavior (such as less washing and open defecation) associated with disease and mortality, adversely affecting personal and public health.
- The dire and stigmatizing consequences of service disconnection include forced relocation (to avoid utility debt), property devaluation and seizure (liens and foreclosure), and possible loss of child custody due to uninhabitability.
- The model's pricing instruments are compatible with tax instruments at the local, state, and national levels to enhance the progressivity of solutions, including support for customer connection, payment assistance, and efficiency programs.
- Affordable access to essential services aligns with doctrines of social, environmental, and distributive justice (inclusive of the concept of universal basic income) that envisage equity and security for all of society.
- Universal service is consistent with the duty of economic regulators to ensure the provision of safe, adequate, and reliable service on just and reasonable terms.
- Civil societies bear core obligations and responsibilities, including toward the human right to safe drinking water and sanitation, and protection of the vulnerable; protection of children promotes intergenerational health equity.

Appendix B. Illustration

Rate design under the model is illustrated with simplified assumptions for a uniform rate with one tier (Figure B.1) and a block rate with two tiers (Figure B.2). Total water bills are shown for five monthly consumption levels (2,000 gallons for essential use, 3k, 6k, 9k, and 12k) and seven market-based (vs. assessed) property values (\$40k, \$60k, \$120k, \$160k, \$200k, \$400k, and \$800k; the U.S. median is about \$200k). The minimum fixed charge was calibrated using a uniform annual rate of \$.00015 (divided into monthly charges). Rate tiers were set for

Figure B.1. Universal Equity-efficiency Rate: Uniform Design (One Rate Tier)

Figure B.2. Universal Equity-efficiency Rate: Block Design (Two Rate Tiers)

Figure B.3. Illustration of Minimum Charges as a Percentage of Total Water Bills (Hypothetical)

Figure B.4. Illustration of Effective Prices Based on Total Bill \$/Gallons (Hypothetical)

the usage between 2,000 and 6,000 gallons and more than 6,000 gallons. Although rates remain regressive overall, households with lower property values would incur substantially lower bills, particularly for modest levels of water usage, compared to bills incurred by households with higher property values.

Under the proposed rate model, as illustrated, the minimum charge would comprise 100% of the bill for essential usage only (2,000 gallons); beyond from this amount, the fixed-cost proportion increases with increasing property values at the different usage levels under both rate structures (Figure B.3). Price signals for discretionary usage are preserved and strengthen with usage. However, they appear weaker at higher property values, where price response may be limited regardless due to income and wealth effects (both ability and willingness to pay).

Effective prices under the structure (total bill relative to gallons) illustrate the overall progressivity of the rate structure (Figure B.4). Prices fall with higher levels of usage due to the influence of the minimum-bill component. Finally, assuming a 2:1 relationship of property value to income (including the U.S. median income of about \$60 k relative to a property value of \$120 k), affordability from the income perspective is illustrated across the scenarios compared to the base case (Figure B.5).

Figure B.5. Illustration of Total Water Bills as a Percentage of Income (Hypothetical)