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The Struggle for Residential Water Metering in England and Wales

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ABSTRACT: The transformation of water services that began with the privatisation of water companies in 1989 extended to households with the implementation of water metering. Meters 'privatised' water and the cost of provision by allocating to individual households costs that had previously been shared within the community. This (ongoing) conversion of common pool good to private good has mostly improved economic, environmental and social impacts, but the potential burden of metering on poorer households has slowed the transition. Stronger anti-poverty programmes would be better at addressing this poverty barrier than existing coping mechanisms reliant on subsidies from other water consumers.

KEYWORDS: Water meters, collective goods, privatisation, regulation, England, Wales

COMMUNITY OR PRIVATE WATER SERVICES?

Water utilities around the world face pressure to reduce water use, improve services, and cover costs. A move from unmetered to metered water services can make it easier to address these pressures, but that move brings transition costs and – more importantly – an entirely different discourse over the role of water in the community (Bakker, 2001). The transformation from treating water service as a common pool good provided to all in the name of social equity into a private good provided to paying customers in the name of economic efficiency generates a variety of reactions, as can be seen in these examples from Dublin, Sacramento and Harare:

> Protests have taken place in different parts of the country, usually when contractors come to install meters for the new water-charging regime…"I don't think the government realises how much of a burden it would be to the people around this area who are already stretched financially – paying tax after tax after tax – and this is just one tax too far". …Those behind water charging also say it will help conservation – as people will be more careful in their usage (Fleming, 2014).

> About a hundred years ago, the city of Sacramento wrote protections from metering into its charter, vowing that residents would always have the right to use as much water as they needed. But a series of droughts in recent decades led to concerns that unmetered water use would slow down conservation efforts…"Half the city is still on a flat rate, and we have no way of knowing how much water they're using" (Bernstein, 2015).

> Currently, the City of Harare collects over 50% of revenue from rates and little has been done to address the challenges of water supply and availability. We are not convinced that any new revenue flows [from prepaid meters] will lead to improvements in water supply…There has not been a clear package for free water that can be easily managed by this system as demanded by the new Constitution (Nleya, 2015).

This paper will describe how the installation of residential water meters in England and Wales is part of a larger programme for privatising water services in the name of economic efficiency, environmental sustainability and social equity. The next section explains the theoretical rationale for managing water as a common pool or private good. The sections that follow describe how metering has been implemented, and the economic, environmental and social impacts of metering. The paper concludes with suggestions for improvement, i.e. fiscal transfers that could support metering by rebalancing individual and government payments for private and social goods.

WATER AS A COMMON POOL OR PRIVATE GOOD

Economics is known for its focus on managing scarce time, money, and other resources. The nonscarce nature of some goods (e.g. knowledge) led Samuelson (1954) to define 'public goods' as those anyone could access (non-excludable) and everyone could consume (nonrival). Private and public goods were quickly joined by common pool and club goods when it became necessary to explain the risk of exhausting non-excludable goods and the exclusionary means of making a potentially scarce good nonrival, respectively (Buchanan, 1965; Olson, 1965). Table 1 summarises these ideas in a simplified form.

Table 1. Water can be any of four types of goods, depending on its characteristics for rivalry and excludability.

	Excludable	Non-excludable
Rival	Private good	Common-pool good
Nonrival	Club good	Public good

Source: based on Cornes and Sandler (1986).

A good should be managed according to its nature (rival goods are consumed in use) and accessibility (people can be prevented from using excludable goods), but a good can move from one type to another if it is managed differently or a supply-demand mismatch grows. A move for either reason will affect consumers and producers of the good, but people tend to be more critical of impacts resulting from management decisions. A decision to restrict irrigation flows to farmers, for example, will be more controversial than a drop in supplies due to a drought. Potential controversy should not excuse inaction if business as usual will result private and social costs from misuse or destruction of the good (Hardin, 1968).

The need to match the characteristics of a good to its management can be dated to Pigou (1920) and Coase (1960) who discussed, respectively, the need to tax private activities that polluted the commons and the benefits of assigning property rights as a means of resolving disputes over use of the commons. Both authors made it clear that such moves – by 'internalising externalities' – would enhance both efficiency and equity, i.e. encouraging actions whose benefits exceeded their costs by assigning costs to those receiving benefits.

Water can take the characteristics of any of the four types of goods in Table 1, and changes in these characteristics can change a water's 'type'. A (club good) reservoir full of water shared among a few households can turn into a rivalrous (common pool) good if its level drops too much or other households are allowed access. The character of the reservoir as a clean (public good) recreational area might be put at risk if nearby residents 'free ride', i.e. they do not contribute to (common pool) measures to protect it from pollution (Olson, 1965). In each of these examples, rivalry or lack of cooperation reduce the flow of benefits from water.

Private and social funding for water services

Water utilities provide drinking and wastewater services to consumers in their service area. When water is abundant and costs are paid, then everyone can consume as much as they want. Revenues can come from tariffs (consumer money) or taxes and transfers (usually via governments taking money from others). Sustainable water services can be funded exclusively by either of these sources (private or social, respectively), but most utilities are funded by a hybrid mix of tariffs, taxes and transfers.

Water utilities usually run into problems when costs outpace available funding. In a purely private case, consumers will usually pay more because the value of reliable water services is so high. In a purely social case, outsiders may not pay additional costs, leaving consumers with a choice between paying or receiving less service. It is common in hybrid cases to have disputes over the relative contributions of revenue from tariffs, taxes and transfers, as each source would prefer to free ride on the others' contribution.

Switching funding sources

Water services have been financed through private, social and hybrid means over the millennia (Fagan, 2011; Salzman, 2012). Water users in different systems settle into different habits and expectations as they benefit from their systems. Changes in costs or services will be greeted with caution if seen as necessary but hostility if seen as harmful (Kahneman et al., 1990). Water users may not like using less water in a drought, but many will cut back if they see their neighbours doing the same (Cart, 2009). Users are more likely to oppose change that benefits others at a cost to themselves. A government regulation restricting water use during a drought, so as to leave more water for river flows, might not result in the same conservation as a programme directing savings to a drinking water reservoir.

The shift to residential metering water in England and Wales began in 1989 with a decision to rebalance the hybrid system from social to private funding. This move was driven by the need for greater spending on deteriorating infrastructure and an ideological desire to reduce free riding in the water sector. The shift in the water services model from a collectively financed common pool good to a user-financed private good was going to involve transaction costs (e.g. installing meters), but those were considered acceptable for the proposed efficiency gains (Matthews, 1992).

Although the move to metering promised net benefits in terms of improving operating efficiency and allocating costs to users, that net benefit masked the distribution of net gains to some and net losses to others. It was the prospect of those losses, especially to poorer families facing higher bills, that led many to attribute additional, perhaps unacceptable, costs to the change (Bakker, 2001).

Conventional definitions of economic efficiency tend to support a policy change if 'winners' can hypothetically compensate 'losers', but support for change will plummet if this 'Kaldor Hicks' compensation does not arrive (Hicks, 1939; Kaldor, 1939). The rest of the paper will explore how changes produced net gains but gave only weak compensation to losers. Although some have blamed metering for causing those losses, it turns out that metering merely called attention to *existing* problems of poverty – problems that meters (as a means of improving services) might help address.

THATCHER PRIVATISES WATER SERVICES

The 1974 nationalisations of water services were followed by policies designed to harmonise charges across the country by transferring funds from utilities with cheaper services to those with more expensive services, such that average household bills would converge, respectively, from below and above. These policies, in line with the theory on common pool goods, increased infrastructure decay, overstaffing and complaints of free riding. Margaret Thatcher's 1979 election brought cost-benefit analysis and efficiency targets back into use (Bakker, 2001).

Privatisation under the 1989 Water Act pushed utilities to improve their performance. The regulator used price and profit incentives to reward improvements and investments in repairing and improving networks to meet EU regulations on water quality (i.e. upgrading sewerage) and reduce environmental pressures (WFD, 2000). The Act also promised that consumers would pay metered charges, thereby severing links with their neighbours' wealth or consumption (Matthews, 1992; van den Berg, 1997). Incentives meant that new private water companies (PWCs) would profit if they exceeded expectations, just as consumers would pay less if they reduced their burden on the system. On the loss side, PWCs would be fined or face price reductions if they fell short of regulatory targets. Consumers, likewise, were expected to pay for waste from open taps or leaks. Although these incentives are similar in their reward/punishment structure, they were often criticised as favouring PWCs over consumers. Commodified water services, in the words of Bakker (2001), replaced 'social equity' (sharing water and costs) with 'economic equity' (payment for services).

Although routinely condemned as 'neoliberal' (Ogden, 1995; van den Berg, 1997; Bakker, 2005), it made good sense to stop managing household water as a rival, non-excludable common pool good and start managing it as a rival, excludable private good when both water and money were in short supply (EA, 2009; Ofwat, 2014a). Ostrom et al. (1994: 15) explain the rationale in terms of a common pool 'situation' turning into a 'dilemma' if potential rivalry turns into actual rivalry over a good – water services in this case. Although a dilemma can be resolved by strengthening measures against free riders and promoting cooperation, it can also be resolved by making the good excludable by, for example, installing meters to allocate costs and water to households as private goods.[1]

These options explain why each country in the United Kingdom has its own model for residential water and sewerage services. Northern Ireland Water and Scottish Water, both public corporations, provide free and at-cost services, respectively. Investor-owned PWCs in England and Wales provide services at regulated prices. Dwr Cymru/Welsh Water (DCWW) was taken over in 2001 by Glas Cymru, a private nonprofit that operates 'in the interest of Welsh customers'.[2] This paper focuses mainly on the English PWCs but refers occasionally to DCWW.

The 32 PWCs providing water services in England and Wales are regulated by the Department for Environment, Food and Rural Affairs (Defra), its subsidiary Environment Agency (EA), and the Water Services Regulation Authority (Ofwat, a nonministerial government department).[3] These agencies (or their Welsh equivalents) oversee metering requirements, environmental limits (e.g. classification of water stress) and metering implementation, respectively. The Consumer Council for Water (CCW) represents consumer interests. The Drinking Water Inspectorate (DWI) regulates the quality of drinking water.

Charges for residential water services were based historically on Rateable Value (RV), a measure of the 1990 rental value of a house.[4] The 1989 Water Act set out to replace RV with residential service charges that allocated costs according to metered consumption (90%of nonresidential consumers have meters), which meant that metering would have to increase dramatically from near-zero levels in 1989 if it was going to hit its year-2000 target of universal metering (Parliament, 1989; Ofwat, 2006; Owen,

[1] The service area of each PWC can be seen as a club good if it has adequate local water and funding. Operational or fiscal spillovers create a common pool dilemma on a national scale when they deplete the environment or government funds.

[2] Dee Valley Water Company supplies water to about 1.5% of the population of Wales. The services boundaries of Severn Trent and DCWW cross the Welsh-England border. See Owen (2013) for an excellent overview of DCWW's history and operations.

[3] According to Ofwat (n.d.b), 18 regional monopolies (including DCWW) provide water or water and sewerage services. The rest are smaller or provide water to larger consumers. Companies may have changed their names, policies, and service areas over the time period covered here.

[4] According to Ofwat (n.d.a), "Rateable value was a local authority's assessment of the annual rental value of an individual property. Rateable value assessments were carried out between 1973 and 1990. Each local authority took a number of factors into account when it set rateable values. These included the size and general condition of the property and the availability of local services. We have no specific details about how properties were assessed and cannot tell you why similar properties have a different rateable value. Rateable values were last updated in 1990 so any changes to your property since then will not be reflected in your rateable value."

2015).[5] The Act required that new residences have water meters. Existing residences would get meters if consumers (as 'optants') asked for them. Although the Act incentivised switching, progress was slow. The Water Industry Act of 1999 thus gave PWCs permission to install meters for consumers who changed houses, lived in water-stressed areas, or whose residences had 'heavy-demand characteristics' such as pools or lawn sprinklers (Ofwat, 2011b).

The materials and labour cost of installing a meter on the request of an optant or a change of occupancy meter is about £220. This cost would be 20-50% lower if meters were universal (EA, 2008; Walker, 2009). Although the installation cost is borne nominally by PWCs ('you pay nothing now'), it is shared among metered consumers, via 'differential charges' representing the higher costs of metered services. Recurring costs of approximately £30 per year (mostly in higher labour costs) per meter would drop by at least 20% with universal metering (Walker, 2009). Ofwat (2011b) defines 'universal' metering achieved at 90% penetration because residences with complex plumbing are expensive to meter, not inefficient water savings. Barraqué (2011) argues that meters are useful in single family homes when garden consumption is elastic to price, but inefficient in individual apartments because the extra annual cost of metering and billing far exceeds the benefit of water conserved. He prefers to meter an entire building with a smart meter so as to develop new customer relations (e.g. early leaks warning) while leaving the division of those costs to the building’s inhabitants. Such a system will work if tenants use similar volumes of water.

Residential metering penetration has grown from 30% in 2008 to 50% in 2015 (see Table 2). Most of the gains come from installations for new houses, changes in occupancy and water-stress designations (EA, 2008). Why have so few people opted for meters? According to MVA (2006), a majority of unmetered consumers do not care enough to switch while the rest worry about privacy or cost.

These concerns are not necessarily 'efficient' in their implications. Consumers asked for responses to water scarcity, for example, favour subsidies for saving water (e.g. rebates on water-saving appliances) and regulations on water use (e.g. bans on hosepipes) over volumetric charges (Opinion Leader, 2006). This answer leaves them with an admirable scope for action, but it ignores evidence that price incentives play a useful role in conservation (Loaiciga and Renehan, 1997; Reynaud, 2013; Ferraro and Price, 2013). Turning to cost, Dalziel et al. (2014) report that 72% of metered consumers (vs. 62% of unmetered consumers) found their bills to be affordable; 58% of metered consumers (vs. 50% of unmetered consumers) found their bills to be fair; and 61% percent of optants (vs. 52% of compulsory metered consumers) found their bills to be fair. These results may explain why meters are 'obviously necessary' to some, 'obviously mistaken' to others, and slow to appear in people’s homes. The following sections will examine the economic, environmental and social impacts of metering in an attempt to explain their contradictions.

ECONOMIC IMPACTS

The change in managing water as a common pool good to treating it as a private good will change the way water is consumed, the relation between the user and supplier of water, and PWC accounting, operations and investments.

[5] The cost of serving consumers always varies. Consumers at the end of a long road cost more to reach than consumers in the city centre. Consumers who dump chemicals in drains create more costs than consumers who do not. These disparities mean that water prices based on average cost ('postage stamp pricing') also result in cross-subsidies among consumers, but these subsidies are much smaller than they would be with fixed (RV-style) charges alone.

Table 2. Residential metering (%) by water company in regions of 'serious' stress (top) and 'not serious' stress (bottom).

Company	2008	2015-2016	2019-2020
Affinity	49	52	72
Anglian	57	80	88
South East*	33	72	90
Southern*	33	92	93
Sutton and East Surrey	23	49	60
Thames*	23	37	52
'Serious' stress (unweighed)	**36**	**64**	**76**
Bristol	27	49	65
Dee Valley	41	59	65
Dwr Cymru	25	40	47
Northumbrian	28	43	50
Portsmouth	8	28	37
SembCorp Bournemouth	46	68	76
Severn Trent	28	43	49
South Staffordshire (Cambridge)	38	42	
South West	55	79	84
United Utilities	21	40	49
Wessex	37	64	79
Yorkshire	31	50	60
'Not serious' stress (unweighed)	**32**	**50**	**59**

Sources: Meters from 2008 from EA (2008), 2015-2016 from Ofwat (2011a), 2019-2020 from Duff (2015); Stress EA and NRW (2013).

PWCs with '*' are implementing universal metering. 'Unweighted' averages give PWCs equal weights. Population-weighting would reflect national progress but obscure progress by PWC. NB: Northumbrian now includes Essex and Suffolk, which was previously listed as having 'serious stress'.

Rationalising demand

Demand for water can fall in two ways. In the first, an 'inward shift of the demand curve' results in less water use, regardless of the price of water. This shift can be caused by a change in tastes, income, technology, etc. In the second case, higher prices result in a 'slide down the demand curve', such that quantity demanded is lower.[6] Although academics debate the relative impacts of shifting and sliding, there is no doubt that these changes reinforce each other, i.e. higher prices call attention to use, which then result in a change in attitudes or technologies affecting use. It is this logic that makes meters an important part of demand management. Meters can shift demand in by calling attention to water use, but they definitely slide demand down by moving the unit price of water above zero.

These effects are hard to separate in practice because it is common to introduce meters with volumetric charges. The 1989-92 Isle of Wight field trials found that meters reduced demand by 22%,

[6] For a discussion of 'shift' methods and effects, see Zadeh et al. (2014); for a comparison of shift vs. slide effectiveness, see Loaiciga and Renehan (1997) and Reynaud (2013). See Zetland and Gasson (2012) and Hoque and Wichelns (2013) for reviews of water tariffs around the world.

with half the reduction coming from a fall in consumption and half coming from leak repairs (EA, 2008). In other studies of combined impacts, NAO (2007) reports that demand drops by 9-21 and 10-15% for optant and compulsory meters, respectively while Pymer (2012) concluded that the existence of meters and volumetric charges cut demand for 6,000 Wessex Water consumers by 15%. Looking at price effects alone, Dalhuisen et al. (2003) estimated a price elasticity of -0.35 in a meta-analysis of 64 studies while Zetland and Gasson (2012) estimate a price elasticity of -0.37 from a sample of 61 cities scattered around the world.

Volumetric prices encourage households to repair leaks, replace old appliances and reduce outdoor water use (a practice less common in the UK than regions such as the Western US where detached houses and lawns are common), but higher prices are more likely to result in higher bills than lower indoor use after some point. Such an outcome may be acceptable if volumetric prices are aimed at allocating costs rather than reducing demand, but that goal must be explicit if PWCs want to avoid accusations of morally inappropriate profiteering (Ferguson, 2014). Defra (2008) proposes reducing current consumption of 150 litres/capita/day (lcd) to 130 or 'as low as' 120 lcd by 2030. Those levels should not be hard to reach (many Europeans use less without suffering), but averages can distract attention from outlying, vulnerable groups – an issue addressed below.

Improving customer service

Water meters transform water users from passive *consumers* taking what (RV-funded) services they are given into active *customers* entitled to value for money. On the downside, meters turn water use into a financial obligation, increase financial risk via variance in charges, and increase costs to PWCs (installing and reading meters) and consumers (understanding and paying bills). On the upside, meters let users influence their water charges, reduce their responsibility for neighbours' behaviour, and make PWCs more responsive (whether by regulatory obligation or profit-maximisation) to customers.

These predictions, based on economic theory, might contradict consumer perceptions susceptible to bias ('free' services tend to be more popular than their paid equivalents), but Dalziel et al. (2014) report that metered consumers are more likely to be satisfied with their value for money than unmetered consumers (73 vs. 66%). Among the metered group, optants were more satisfied (77%) than those who moved into metered properties or had meters compulsorily installed (70 and 66%, respectively).

Impacts on PWCs

Meters may be unattractive to PWCs. Meters replace reliable fixed charges with fluctuating volumetric charges that discourage consumption. Charges for leaks and mistakes mean that consumers sometimes complain of 'shocking' bills in tabloid stories whose bad publicity disrupts managers' preference for a 'quiet life' (Bakker, 2001; Lach et al., 2005; Davies, 2013). PWCs cannot even make outsized profits from installing meters or encouraging greater consumption – Ofwat uses TOT(al)EX(pense) rather than CAPEX to set PWC prices based on targeted sales volumes. Ofwat does not hesitate to help PWCs cover their debt service, but it has also imposed 'negative price limits' (in 1999) and 'challenged business plans' (2014) when PWC profits grew too fast (Bakker, 2001; NAO, 2007, 2014; Marshall, 2013; Ofwat, 2014b).

Ofwat's focus on total expenses can make metering more attractive to PWCs by reducing demand, and thus their need to invest in capital infrastructure and new sources of supply. The value of avoided capital investments, according to Walker (2009) is £0.14-0.66 per m^3 *not demanded*. Add the nonmonetary costs of controversy over expanding supply or straining ecosystems, and metering is more appealing.

PWCs face ongoing criticism over their costs and prices. On the one hand, they have an obvious incentive to skimp on costs to increase profits (Coles, 2015). On the other, it must be acknowledged that PWCs have invested over £100 billion in their systems since 1989 (Ofwat, ndb). Prices were bound to rise to repay those costs, as well as reward risk – even if that risk sometimes comes from Ofwat (e.g. Bakker 2001).

Putting this discussion (worthy of another paper) aside, it is worth comparing the English PWCs with their less capitalist neighbours, even while acknowledging their widely diverging initial conditions and actions since 1989. DCWW has below-average metering penetration and water stress. Its consumers see meters as a means of helping poor families (via subsidies collected from heavy users); they do not worry about financial exploitation, as DCWW uses excess revenues for *consumer* dividends, price reductions and environmental improvements (Owen, 2015). Indeed, Dalziel et al. (2014: 10) report that consumers in Wales "were more supportive of the option to use profits gained from water companies doing better than expected to provide financial help to those on low incomes than consumers in England", at 47 and 41%, respectively. These attitudes extend to other measures of satisfaction, i.e. value for money (69 vs. 78% in England and Wales, respectively), fair charges (54 vs. 59%), and trust (7.3 vs. 7.7 out of 10). This pattern also appears to apply to Scottish Water, which had lagged behind English companies in performance, cost and customer satisfaction but now supplies services at the top of the range at prices that are some of the lowest in the UK (WIC, 2006; Ofwat, 2007; Scottish Water, 2013). Scottish water, it is worth noting, has not encouraged residential consumers to switch to water meters (current service charges are based on a Scottish version of RV). Consumers who want meters must pay the £300 survey and installation cost themselves. These comparisons suggest that PWCs must be careful to avoid the impression they are pushing meters to increase profits.

ENVIRONMENTAL IMPACTS

The EA faces no such qualms as it tries to reduce the impact of PWC demand (a private good representing the majority of consumptive use) on common pool environmental waters (Defra, 2008; Defra et al., 2015). Among EA's many initiatives, its reforms of abstractions licenses (retiring licenses, higher fees in stressed areas) are pressuring PWCs to reduce abstractions and leaks in basins where demand exceeds minimum variable flows (Young, 2012; Defra, 2013; EA, 2015).[7] The following subsections expand on those points.

Reducing abstractions

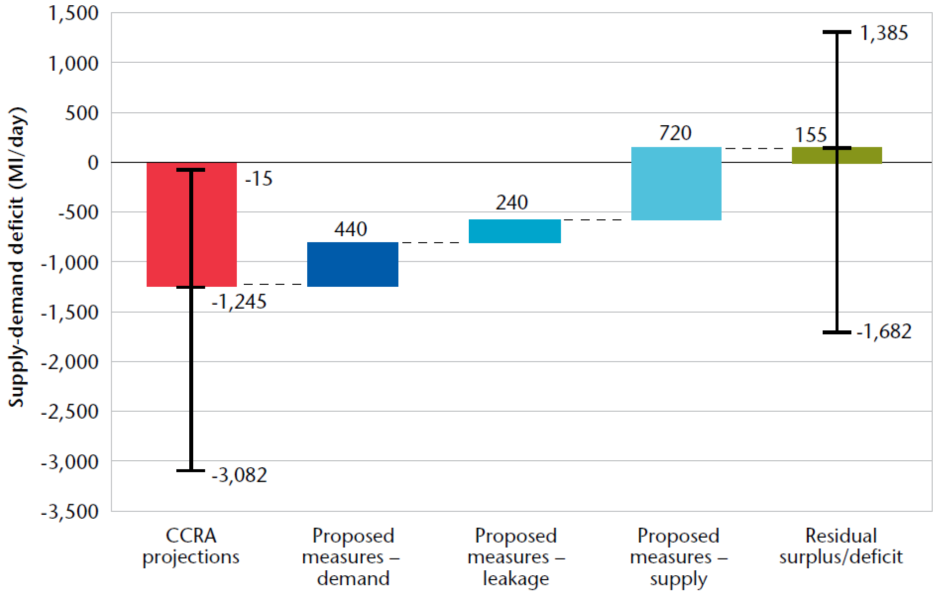
Water supplies in England and Wales tend to be higher in northern and western regions due to favourable precipitation patterns, surface flows and groundwater resources. Demand tends to be higher in the richer, more densely populated southeast. Leakage – call it either an increase in demand or decrease in supply – is worse where the networks are old and street repairs expensive, but it has dropped by one-third since 1990, to an average of just over 20% of PWC's distributed water (Kavanagh, 2013). These supply, demand and leakage factors help explain why the southeastern region around London has water-stress levels (water per person) similar to those of Spain and Italy (EA, 2009). The Environment Agency sees meters as a key instrument for reducing demand in water-stressed areas: Figure 1 shows how reductions in demand and leakage might close the supply-demand gap ('CCRA projections') contributing to water stress.

Water stress may justify metering in the southeast, but the impetus is weaker in the rest of the country. Figure 2 shows national water stress is falling. Figure 3 shows that this progress is uneven.[8]

[7] If abstractions are 30% of spring flows but 60% of fall flows, then a 10% reduction in abstractions means 3% more water in spring but 6% more in the fall. Flows on the Thames vary from 7 to 160 m^3/s, so reduced diversions can have a big impact (NRFA, 2013).

[8] Gogol et al. (2014) criticised the right figure as understating stress. Several PWCs had their water stress switched from 'serious' in the 2012 draft to 'not serious' (formerly 'moderate stress') in EA and NRW (2013).

Figure 1. Proposed measures for reducing the projected 2035 water deficit ('CCRA projections') in England and Wales.



Error bars on 'CCRA projections' indicate the largest (bottom) and smallest (top) estimates of deficits; these explain the same error bars (net of proposed measures) on the 'residual surplus/deficit' estimate.

Source: Catovsky et al. (2012, Figure 3.2).

Figure 2. The Water Exploitation Index (WEI) compares abstractions to long-term freshwater resources for the 1990-2007 base period. Source: EEA (2010).

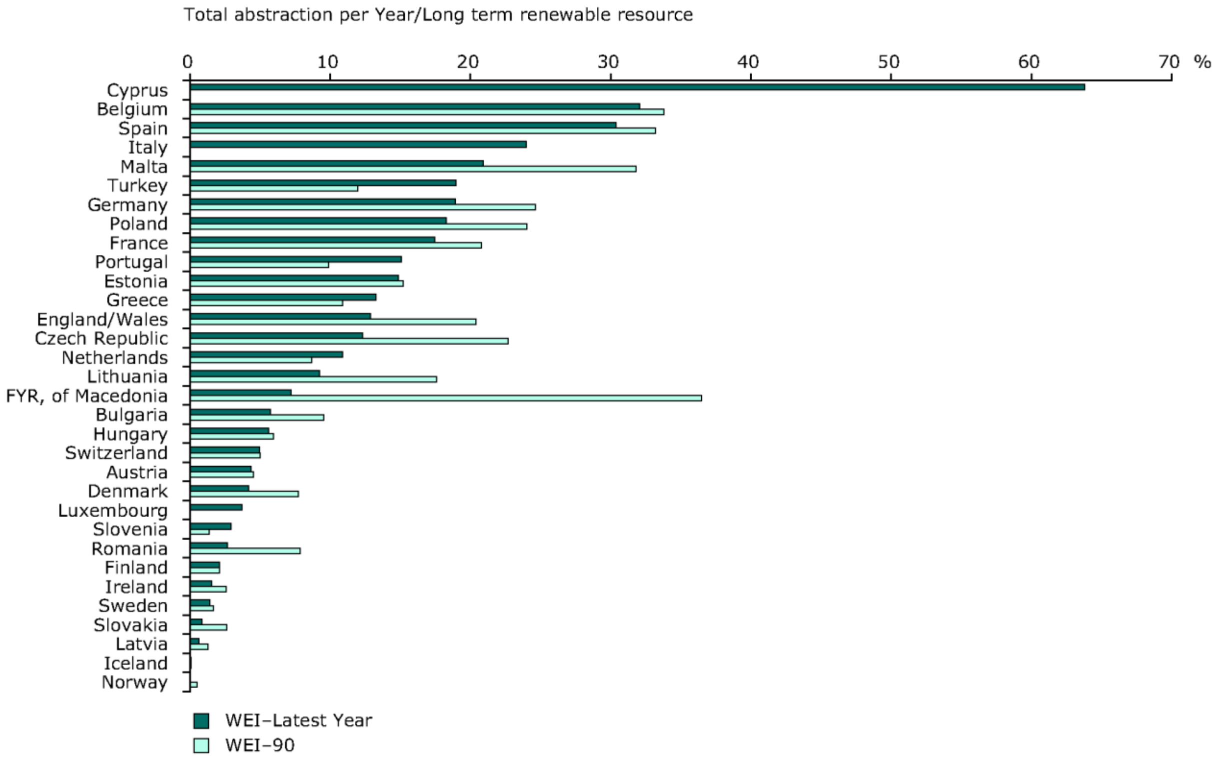
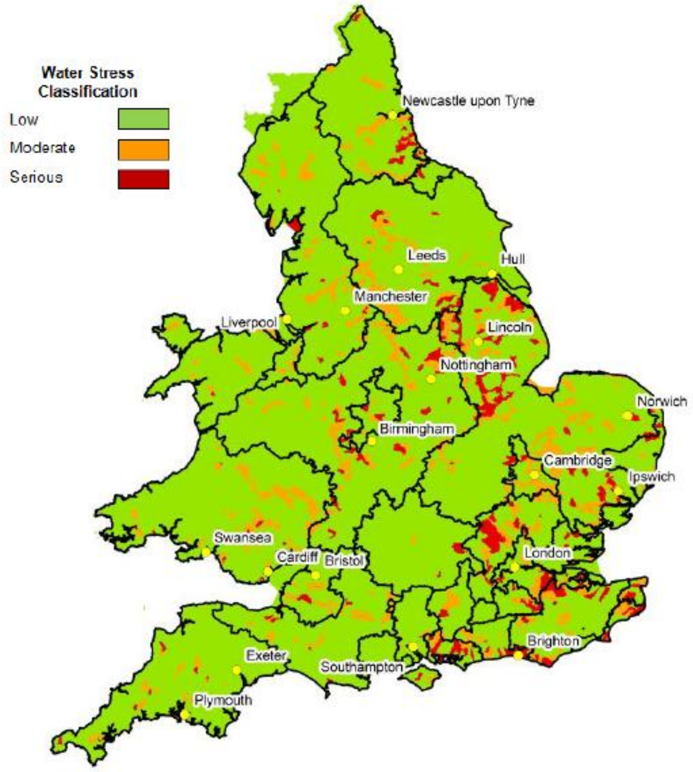


Figure 3. Water stress in England and Wales.



Source: EA and NRW (2013).

These figures explain why some PWCs shown in Table 2 have more meters than others, but the general trend is for more meters. Metering is expected to increase by 18% in both 'serious' (64 to 76%) and 'nonserious' (50 to 59%) service areas by 2020 (Catovsky et al., 2012).

Although perhaps outdated, Table 3 presents meters as the least-cost means of 'improving supply', according to EA (2009). Those examples are limited in their scope (it may be cheaper to reduce demand via education, regulation or reforming the abstraction regime), but they put context on the comparison in Walker (2009) between the £1.50/m^3 cost of installing meters and estimated benefits of £0.50/m^3 from carbon savings and lower operating costs and £0.50/m^3 representing a 'placeholder value' for environmental flows, a net loss discussed below.

Table 3. EA estimates comparing the cost of meters to other sources of supply.

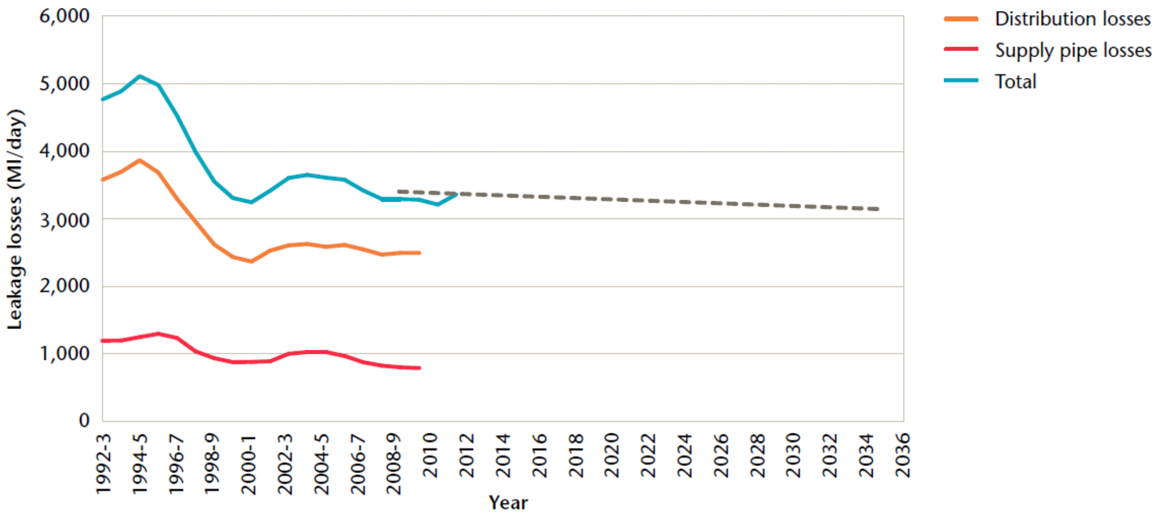
Option	Range of costs (£/m^3)
Near-universal (90%) metering	1.40-1.60
Groundwater development	1.00-5.00
Surface water development	1.00-5.00
New reservoir	3.00-10.00
Desalination plant	4.00-8.00

Source: EA (2009, Table 4.1). NB: Walker (2009) estimates desalination would cost £2/m^3

Reducing leaks

Meters make it easier to identify and repair leaks. EA (2008) reports half the level of leakage in metered supply pipes, i.e. where a meter at the edge of the property means that the consumers pays for water losses between the street and their residence. Would it be cheaper (more efficient) to repair distribution leaks instead of installing household meters? Although Figure 4 supports that claim, Figure 1 – showing double the reduction from reducing demand as the reduction from reducing leaks seems to contradict it. It is probably best to pursue both options in a 'portfolio' attack on leakage (NAO, 2007).

Figure 4. Distribution vs. supply pipe (consumer line) leakages.



Source: Catovsky et al. (2012, Figure 3.9).

Ofwat compares distribution leaks to its targets for the 'economic level of leakage' (ELL) – the level at which the cost of leak repairs equals the value of lost water. EA builds on ELL in targeting a 'sustainable economic level of leakage' (SELL) that "takes account of the social and environmental costs and benefits of leakage management" (EA, 2009: 55-56). SELL will always be lower than ELL because it includes seasonal variations, minimum flows, and other environmentally important conditions ignored in discussions of *average* flows (see Footnote 8). In theory, SELL should include other nonmonetary costs such as the cost of contamination that may result from leaks of sewage into drinking-water or stormwater pipes, the cost of greater risk from system failures, and so on. Such an accounting would usually result in a 'minimise all leaks' policy such as those of Singapore and the Netherlands, but such a policy is considered too expensive in the UK (Tortajada, 2006; Kavanagh, 2013; Jonker, 2016).

Reducing carbon emissions

Ofwat (2011b) includes reduced carbon emissions from using less energy to treat, move and heat water in its cost-benefit study of metering adaption rates. These calculations show a net *loss* of £1.2 billion under a business-as-usual scenario that achieves 90% metering penetration by 2050.[9] That loss grows if metering goes faster (2020) but falls slightly (– £1.0 billion) with a 2030 target. These negative values might suggest a conclusion against metering, but both Ofwat (2011b) and Walker (2009) – who also

[9] The loss would be greater if we used an early-2016 carbon price of £5 per ton of CO_{2e} rather than Ofwat’s prices of £20 (£50) per ton of CO_{2e} traded (nontraded) — values that implied carbon-related benefits of £900 million from metering.

calculates a net cost – recommend metering. As an explanation, Duff (2015) clarified that Ofwat recommended the 2030 universal metering target because stopping at the 2011 level of 38% metering (at zero net cost) was not an option. These results suggest that the government has decided to pursue metering despite weak economic and environmental benefits. The next section explores whether social benefits might fill the gap.

SOCIAL IMPACTS

Earlier sections explained how it might make sense to move water services out of a social equity (water as a right) management paradigm in which water and costs were shared among citizens and into an economic equity (pay for use) paradigm that would make it easier to assign costs, reduce use and reduce free riding that strained PWCs, the environment and taxpayer patience. These transitions, although sensible from an economic efficiency perspective, might create problems if the water charges system is also being used to alleviate poverty. The following sections will describe how meters unwound cross-subsidies between home owners and water users as well as the impact of metered prices on the poor. They will also explain how 'water poverty', which predates privatisation and metering, should be addressed by national policies rather than by the water sector, a topic discussed in the conclusion.

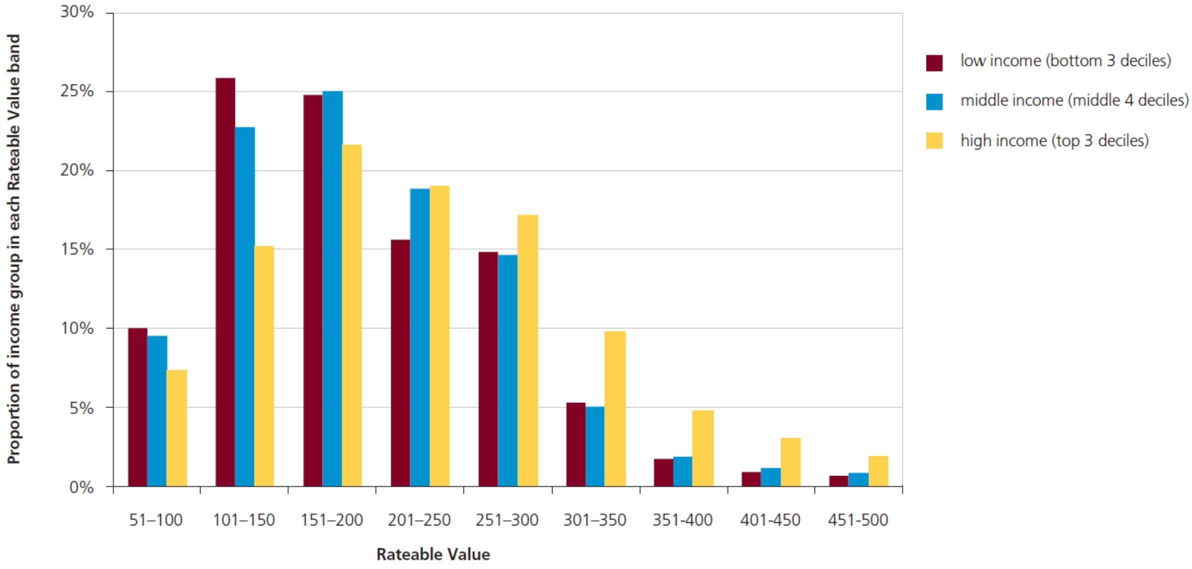
Unwinding cross-subsidies

A shift from RV-charges to metered charges better allocates costs in proportion to use. Although some feel this is fairer (Matthews, 1992; Heino and Takala, 2015), others disagree due to their opinion that RV-charges subsidise the poor (Staddon, 2008). This perception requires that rich people in high RV-houses use less water than poorer people in low-RV houses, but these are not the facts. Rich people tend to use more water (so they would pay more with meters), and they do not always live in the higher-RV houses, as the correlation between RV and wealth (whatever its initial level) has attenuated since 1990. Ofwat (2011a: 15-16) "estimates that the rateable value system currently means a cross-subsidy of about £560 million per year from small households living in properties with high rateable values to large households living in properties with low rateable values". In terms of income, larger households are not necessarily poorer, i.e. "for each low-income household that benefits from being in the lowest rateable value band, almost twice as many middle- and higher-income households get that same benefit – so only about 30% of the help accorded to the lowest rateable value band (£180m) is going to the poorest households" (Walker, 2009: 61). Figure 5 shows the weak correlation between RV and income.

Although these data cast doubt on claims that unwinding subsidies among consumers in a PWC's service area would disproportionately burden poorer households, the government implemented four measures to help optants switch. It introduced WaterSure, which limited monthly charges to consumers with medical conditions or three or more minor children. Second, Ofwat implemented a 'differential test' to divide fixed system charges fairly between metered and unmetered households, i.e. those with water meters paid a 'differential surcharge' because their service had higher costs. Third, optants could cancel their meter (returning to RV-charges) within 12 months of installation. Finally, Ofwat required PWCs to set volumetric charges based on average unmetered use, thereby ensuring that optants *who used less than this average* would save by switching.

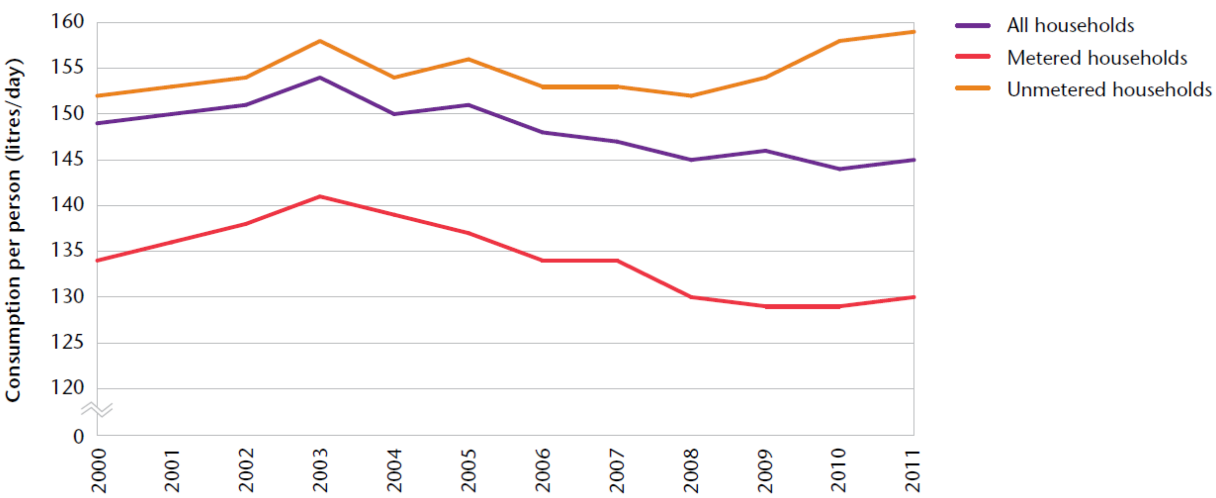
In practice, Ofwat's rules meant optants would save if their water charges fell by more than the differential surcharge of £35 (average water and sewerage charges are £385) per year (Ofwat, 2009; Collinson, 2015). Given average household consumption of 126.5 m^3 per year (2.3 people using 55 m^3/capita (Ofwat, 2009)), a household could cover the differential with a 12 m^3 reduction in use (assuming water/sewer cost of £3/m^3). A household could also save if they replaced higher RV-based charges with lowered metered charges. These complex 'what ifs' explain the popularity of CCW's 'Should you switch?' calculator (CCW, 2016).

Figure 5. The correlation between rateable value and household income is weak.



Source: Walker (2009, Figure 11).

Figure 6. Average use per unmetered consumers rises as users with lower (potential) consumption opt for meters, leaving remaining unmetered consumers to share responsibility for unmetered water on the network.



Source: Catovsky et al. (2012, Figure 3.3).

Ofwat also created a dynamic incentive to switch by increasing the 'average imputed use' for unmetered consumers as low-use optants departed (Walker, 2009). Figure 6 shows the trend, which translates, assuming system costs are allocated by use, into higher charges per remaining unmetered consumer. Rising RV charges encourage the next group of lower-than-average-use consumers to opt for meters in a 'snowball process' that leaves unmetered only the people with the heaviest use, lowest RVs and/or anti-meter attitudes paying RV-charges (Oliver et al., 1985). Those users face the worst of both worlds: rising charges for doing nothing and uncertainty over charges if they do something (Kahneman and Tversky, 1979). In a Kaldor-Hicks world, it would make sense to reduce their risk so they switch to meters, but assistance is very limited.

Impacts on the poor

The switch from RV to metering did not affect consumers whose use and RV were correlated, but it created winners and losers where the correlation was reversed. Most consumers who switched to meters changed their water consuming habits, fixed leaks, or installed efficient appliances. Some who faced higher bills switched back to RV-charges, but the rest may be worse off. Doward and Ledwith (2011), for example, report that 15% of Wessex Water's metered consumers saw annual water bills increase by £100 or more (the percentage with lower bills is not mentioned).

Bradshaw and Huby (2013) report that about 24% of households experience 'water poverty', i.e. spending more than 3% of household income on water. (The poorest 20% of households spend about 12% of their income, in roughly equal shares, on water, gas and electrical bills.) A further breakdown of characteristics reveals that single-headed households and those on benefits (income support) are roughly twice as likely to be 'water poor'. The share of water poor is lower among households with meters (18%) than those without (25%). Metering, in other words, does not cause water poverty and may be able to alleviate it, but the problem is more the result of low income than meters or expensive water (recall the equal shares spent on gas and electricity).

The government's WaterSure programme is supposed to help the poor, but it is available only to households with three minor children or an occupant with a medical condition that requires copious quantities of water. According to Ofwat (2015), 95,000 English and 36,000 Welsh households receive assistance from WaterSure or its Welsh equivalent – far below the 700,000 households (roughly 3% of the population) with three or more children that Walker (2009) suggested for enrolment – and only a fraction of the 22 million households served.[10]

These facts may explain why Defra (2012) 'clarified' that PWCs could use surcharges on some consumers to subsidise a 'social tariff' for consumers identified as poor. According to Ofwat (2015), 14 of 18 major PWCs have introduced social tariffs (the rest are exploring their options), but total enrolment is only 100,000 households. The government's recommended surcharge to fund subsidies – 1.5% of the average, full-tariff bill (£5 per year) – would probably not provide enough funding to subsidise the roughly 25% of consumers with 'unaffordable' bills, but even that surcharge may be too much (Dalziel et al., 2014). Creative Research (2010) reports that only 39% of UK water consumers are willing to pay an additional £2 per year to help others.

Service cutoffs for nonpayment had increased prior to privatisation in 1989, but they attracted plenty of political attention after that date (Bakker, 2001). PWC and Ofwat attempts to adjust were ended by a ban on cutoffs (via Parliament, 1999) that merely treated the symptoms of poverty. Some households have been able to escape debt by installing meters. Others – metered or not – have rising debts but little or no help from WaterSure or social tariffs. Protected from disconnection, these households may stop paying their bills. PWCs are allowed to seize household assets, but most probably want to avoid confrontations and bad publicity (Citizens advice, 2015). At the end of 2015, households owed over £2.1 billion, an amount that – if paid by others – adds £21 (about 5%) to the average household's annual charges. The current situation is bad for those struggling with debt, bad for those

[10] Another 'assistance scheme' discussed in Ofwat (2015), Water Direct, has nearly 280,000 households enrolled, but the programme's only function is to facilitate direct deductions from benefits support against water bills in arrears.

paying more to cover the costs of that debt, and bad for the reputation of a metering programme that could have been represented as an efficient and fair way to help the poor.

DISCUSSION AND CONCLUSION

Meters help consumers understand their water use, find leaks and reduce their demand in response to conservation awareness or financial incentives. Meters increase consumer-utility engagement by replacing fixed, unavoidable charges with payment for service volumes. Meters make it easier for utilities to manage demand and track waterflows, which can help with reducing distribution leaks and environmental abstractions. Meters also shift water services from a social sphere in which water and costs are shared among consumers in a common pool to an economic sphere in which payments reflect private use. This system can be efficient and fair if 'losers' in the shift are temporarily protected from the loss of subsidies they had received from common-pool allocations, but the shift can be financially, socially and politically stressful if losers abruptly face higher costs for the same benefits.

The UK government's programme for metering has been stymied and sidetracked by perceptions that metering is increasing water poverty, even though water-related household debt predates metering and service charges are even more burdensome on households without meters. Although the government insists that financial responsibility rests with households (pay for what you use) or PWCs (pay for your neighbour's use), there are reasons for the central government to provide debt relief and financial support to poorer families.

From a regulatory perspective, it may make sense for the government to reduce the financial burden placed on water users as PWCs improve infrastructure to meet stricter regulations and reduce environmental extractions. Current government payments to South West Water consumers in compensation for undue infrastructural cost burdens (compare Defra, 2011a and Defra, 2011b) provide a template for additional transfers related to common pool or public goods. Approaching the challenge from a different perspective, it is clear that the government could increase subsidies to households too poor to pay for basic water service – as is done in Chile (Chávez and Quiroga, 2002) – in the mirror image of policies collecting additional taxes from wealthy citizens.

The UK government needs to do a better job in explaining why it wants universal metering in England and Wales when its own figures indicate a net loss (in economic and environmental terms) from metering, Scottish Water is 'doing fine' without meters, and metered charges add – rather than reduce – financial strains to the poorest households. After carrying out that step, it can implement a judicious programme of transfers and taxes, as a complement to tariffs on metered water use, to help citizens buy the water they need while protecting the operational and fiscal integrity of English and Welsh PWCs. Metering makes it easy to supply water as a private good, but metering will not work if it threatens common pool goods – such as the environment or social protection – that citizens also value.

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