DEVELOPING MARKET-BASED INCENTIVES FOR GREEN BUILDING ALTERNATIVES

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ABSTRACT

As the 4th most populous and 2nd fastest growing region of the U.S., 70% of Florida's 16-million citizens reside along the coastline in areas served by shallow, fragile aquifers that have largely been destroyed by over-pumping and saltwater intrusion. Resulting wastewater discharge and runoff have contaminated natural waterways and aquifer recharge basins. A case study from the Tampa Bay, Florida (U.S.) region reveals that water suppliers are providing conservation incentives to consumers as a cost-effective alternative to expanding infrastructure capacity to meet the demands of population and economic growth. Research at the University of Florida shows the benefit-cost of several water saving alternatives and the corresponding "willingness-to-pay" for several consumer markets. Together, a methodology is introduced wherein the water supplier can create "optimal" market-based incentives for consumer investment in water saving measures that maximize water use reductions and minimize conservation program costs. The indirect costs of water use such as energy emissions and watershed destruction (externalities) is also addressed.

KEY WORDS

Best management practices (BMPs), demand-side management, externalities, rebates, reclaimed water, water conservation, water resources, willingness-to-pay

INTRODUCTION

Given the similarities of water resource issues in Florida and many other regions of the world, and the common failure of government regulation to stem excessive water use and wastewater discharge, a methodology is proposed for developing market-based initiatives to stimulate demand-side conservation. This approach is founded on the principal that reducing water use and subsequent wastewater discharge through demand-side or "user" intervention is a more desirable means of sustaining water resources than supply-side efforts to gain access to new watersheds and expand infrastructure capacity. Further, market-based approaches have proven to be a more efficient and effective means to affect positive change in consumer behavior than regulatory practices alone.

In theory, inefficient use of resources should result in higher operational costs and reduced productivity, creating a less than competitive environment for the user. However, the commodity cost for water in Florida and throughout much of the world fails to internalize the "true" cost of water resources beyond the capital and operational cost of the supplier. As a result, the benefits from water savings rarely justify the added investment into best management practices (BMPs), or those water policies, systems and structures that reduce water consumption and wastewater discharge beyond minimum standards required by law. However, opportunities exist for the water supplier to incentivize demand-side flow reductions as an alternative to expanding infrastructure. Suppliers can factor the savings of a BMP, such as a low-flow fixture, by forecast quantities of BMP units implemented to estimate net flow reductions and avoided supply costs. Part of this avoided supply cost can be returned to the user in the form of a monetary incentive, rebate or subsidy to stimulate further adoption of the BMP.

APPROACH

Research at the University of Florida's Center for Construction and Environment shows that con-

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sumer willingness-to-pay for green building alternatives varies widely between market sectors. As a result, a water BMP may be adopted without the need for an incentive in one market while requiring a significant rebate or other form of subsidy in another. Depending on the size of respective markets and expected growth trends, suppliers could place an optimal level of incentive where the most significant demand-side flow reductions can be achieved. The resulting "payback" could be used to define the size and scope of the conservation program, meaning at some point, return-on-investment for the supplier would be maximized, and no further incentive justified. Key components in the development of market-based incentives include 1) characterizing water consumption by market segment, 2) assessing the benefit-cost of best management practices, and 3) determining consumer willingness-to-pay for water conservation measures. With this information, the water supplier can create "optimal" market-based incentives for consumer investment in water saving measures that maximize water use reductions and minimize conservation program costs. Water suppliers, especially public utilities and water management districts, may also credit the benefits of water-related externalities, such as reduced energy emissions and watershed sustainability, to the benefit-cost model.

WATER CONSUMPTION BY MARKET SEGMENT

Construction put in place in the U.S. during the late 1990's exceeded $U.S. 600 billion per year. Of all *contracted* construction, more than a third was residential development (Figure 1). Eighty-percent or more of all residential construction was single-family detached housing (Figure 2).[1] In the State of Florida, the residential dwelling stock comprises roughly 4.8 million structures and 0.7 billion m^2 of inhabitable space. Single-family detached units provide the largest contribution, both in terms of number of units (3.1 million, 64.6%) and total gross area (0.44 billion m^2, 64.4%).[2]

FIGURE 1. U.S. contracted construction markets ($U.S. billions).[1]

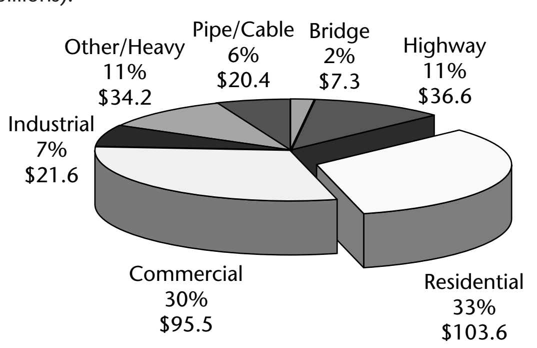
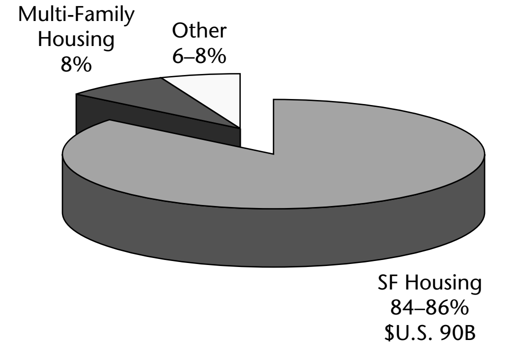


FIGURE 2. U.S. residential market distribution.[1]

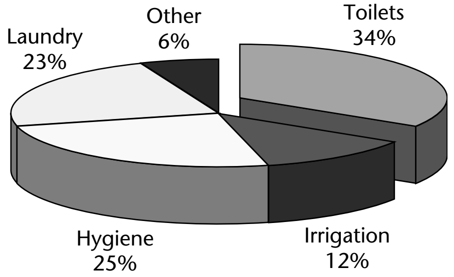


Potable water is defined as all water consumed for drinking, cooking, and personal hygiene. Potable water generally originates from the highest purity source and is the most rigorously treated. A typical single-family dwelling in the U.S. can expect to use between 1135-1890 liters per day (L/d). Typical single-family units use as much as 60% of available potable water for non-potable use, such as irrigation. Based on an average single-family household of 2.65-3.00 persons, between 50,000L and 150,000L of potable water are used for irrigation per person per year.[3]

BENEFIT-COST OF BEST MANAGEMENT PRACTICES (BMPS)

Best management practices are defined as those "green building" fixtures, systems and designs that use less water and discharge less wastewater when compared to minimally acceptable building standards. Since toilet flush water, irrigation and clothes washing comprise more than two-thirds of potable water consumed in single-family dwelling units in the U.S. (Figure 3), BMPs that address one or more of these areas would be expected to have the greatest economic and environmental impact. A brief description of BMPs having the greatest water use reductions in the single-family residential market are

FIGURE 3. U.S. potable water use in single-family dwelling units.[3]



provided below (values based on Tampa, Florida case study; irrigation may vary in other U.S. regions).

Non-potable irrigation: Irrigation source water using a non-potable source. Measures may include utility provided reclaimed wastewater, on-site well or groundwater, rainwater cisterns, on-site gray water reuse systems, drip irrigation, septic tank effluent, and surface water pumping. Average savings per single-family dwelling unit: 1135L/d).[4]

Water efficient landscape: Water efficient landscape to save potable water used for irrigation through efficient irrigation practices and the use of water-efficient landscape designs. May include consultations and rebates as incentives to implement recommended irrigation practices and landscape designs. Average savings per single-family dwelling unit: 530L/d.[4]

Low-flow clothes washer: High-efficiency clothes washers that use 80L per cycle and reduce the volume of clothes-washing water approximately 50% when compared to standard models that use 155L per cycle. U.S. Environmental Protection Agency (EPA) ENERGY STAR™ qualifying washers generally use 35-50% less water and 50% less energy per load than new non-qualifying models. Average savings per single-family dwelling unit: 62L/d.[4]

Low-flow toilets: Low-volume toilets that reduce toilet flush water to 6L per flush (L/f), a significant savings over older, less efficient toilets, which use from 13 to 26L/f. Since the U.S. Energy Policy Act of 1992 (EPACT) now requires U.S. manufacturers to produce toilets that comply with this standard, this BMP is considered solely a retrofit measure for dwelling units constructed prior to the 1994 effective date of EPACT. Average savings per single-family dwelling unit: 102L/d.[4]

Supply-Side (Utility) Perspective Traditionally, water suppliers have turned to new supply sources and infrastructure expansion to meet anticipated increases in demand. For a growing number of regions however, new water sources and wastewater disposal options have become increasingly costly, both economically and environmentally. In response, a renewed interest in demand-side management or conservation has emerged as a cost-effective alternative to expanding capacity. Perhaps one of the most comprehensive demand-side management programs in the U.S. is that of Tampa Bay Water, an association of six public water utilities in central Florida that have unveiled a 5-year program to invest discretionary funds into water reuse infrastructure, monetary incentives (rebates), conservation services, and public education in an effort to defer capital expansion and operations costs. To justify the program, the present value of BMP program costs were compared to the present value of benefits derived from water savings. The value of water savings were defined as the avoided cost associated with increasing water and wastewater infrastructure capacity. Program costs consisted of the capital infrastructure, rebates, staff time and administrative and educational materials needed for program implementation. For the 5-year Tampa Bay Water program, the present value of costs beginning in year 2004 was calculated as follows:

$$
\begin{aligned}
P_{2004} = {} & (BMP_{2004} \times C_{2004}) && \text{(YR1)} \\
& + (BMP_{2005} \times C_{2004}) \times (1 + i)^{-1} && \text{(YR2)} \\
& + (BMP_{2006} \times C_{2004}) \times (1 + i)^{-2} && \text{(YR3)} \\
& + (BMP_{2007} \times C_{2004}) \times (1 + i)^{-3} && \text{(YR4)} \\
& + (BMP_{2008} \times C_{2004}) \times (1 + i)^{-4} && \text{(YR5)}
\end{aligned}
$$

Where: P_{2004} = Total present worth of program costs in 2004

BMP_n = Number of BMPs adopted each year

C_{2004} = Cost per BMP in 2004

i = Discount rate

The supplier could use either a weighted average cost of capital (WACC) or minimal attractive rate of return (MARR) for the discount rate. MARR would approximate what the supplier could earn by investing discretionary program funds elsewhere and would likely be used by investor owned utilities (IOUs) or private suppliers. For public and non-profit utilities, the vast majority of water utilities in the U.S. (84%), cost of capital in terms of bond rates and public debt service would likely be used. For this case study, a 7% discount rate was factored. A lower discount rate would yield a higher present worth of program costs. A higher discount rate would yield a lower present worth of program costs. To determine total water savings over twenty years (the expected life of BMPs), it is assumed that the cumulative number of measures in the final year of the 5-year program would continue to save water for an additional 15 years. Therefore, the program savings in the fifth year were multiplied by 16 years. The water saved over a 20-year period was calculated as follows:

$$S_{20\text{-yr}} = [S_{2004} + S_{2005} + S_{2006} + S_{2007} + (S_{2008} \times 16 \text{ years})] \times 365$$

Where: $S_{20\text{-yr}}$ = Total 20-year water savings in million liters (ML)

S_n = Cumulative water savings in million liter per day (MLD)

Program cost for implementing a BMP was then expressed in \$U.S. per 1,000L saved.

$$C/E = (P2004 \div S20\text{-yr}) \times 1{,}000$$

Where: C/E = Program cost per 1,000L saved

P_{2004} = Total present value of program costs in 2004

$S_{20\text{-yr}}$ = Total 20-year water savings in ML

Table 1 shows the weighted average program cost for each BMP among six participating utilities in the Tampa Bay Water association as well as total aggregate water savings and program costs for all BMPs implemented. These values represent forecast rates of implementation for a five-year program from 2004-2008 and corresponding 20-year water use reductions from 2004-2023.

Demand-Side (User) Perspective As illustrated by the Tampa Bay Water case study, desired water savings must be factored by realistic expectations for user implementation. User implementation is largely determined by life-cycle return on investment as well as non-cost factors such as ease of implementation. Reclaimed water for example, has the highest program cost of the BMPs listed in Table 1 (\$U.S. 0.53/1,000L). However, Table 3 shows that the reclaimed water BMP has the highest rate of return (69%) and the shortest time until capital cost recovery, CCR (1.4 years). Furthermore, implementation of this BMP is accomplished entirely by the utility, requiring little or no effort on the part of the user. For other BMPs with comparatively low program costs, a significant rebate is required to stimulate user implementation. Yet for still other BMPs such as the low-flow clothes washer measure, a rebate sufficient to stimulate meaningful user implementation cannot be justified based on water savings alone, unless coupled with a rebate from an electric utility provider.

CONSUMER WILLINGNESS-TO-PAY

Research conducted by the University of Florida, Powell Center for Construction and Environment found that of 400 homeowners in Florida, consumer

TABLE 1. Average rebate incentives and program cost for water BMPs in the Tampa Bay Water association.[5]

BMP	Incentive (\$U.S.)	P_{2004}: Total 5-year program cost (\$U.S.)	$S_{20\text{-yr}}$: Total 20-year water savings (ML)	E/C: Program cost per 1,000L (\$U.S.)
Non-potable irrigation	350	46,467	730	0.06
Landscape evaluations[a]	200	219,934	5,848	0.04
Landscape evaluations[b]	960	258,586	1,914	0.14
Low-flow toilets	150	7,993,464	31,109	0.26
Reclaimed irrigation	0	149,885,581	285,268	0.53
Low-flow clothes washer	0	0	0	0.00
Totals		158,404,032	324,869	0.49

a. without implementation rebates
b. with implementation rebates

TABLE 2. Annual single-family water and energy savings compared to equivalent use of potable water ($U.S. 0.80 per 1,000L combined water and wastewater charge; $U.S. 0.08/kWh electric energy charge).

BMP	Water Savings L/unit/yr	Water Savings ($U.S.)	Energy Savings kWh/unit/yr	Energy Savings ($U.S.)
Non-potable irrigation[a]	414,458	328	–275	–22
Landscape evaluations	193,414	153	0	0
Low-flow toilets	30,301	30	0	0
Reclaimed irrigation[b]	414,458	209	0	0
Low-flow clothes washer	22,104	18	860	69

a. 0.75kW (1.0hp) groundwater irrigation well or equivalent
b. $U.S. 10 per month surcharge, unlimited use

willingness to pay was strongly correlated to capital cost recovery (CCR) and to a lesser extent, savings-to-investment ratio (SIR). CCR was determined by dividing the investment cost by the annual savings. SIR was determined by multiplying the annual savings by the BMP service life (20 years) and dividing the quantity by the investment cost. Specifically, a random cross-section of homebuyers in Miami, Orlando and Jacksonville, Florida were asked whether or not they would be willing to pay for several water and energy conservation measures. Respondents were given a brief description of each conservation measure as well as information on the investment cost and estimated annual savings of each measure. As expected, results of the survey indicated that consumer willingness to pay declined as time necessary for capital cost recovery (payback) increased and savings-to-investment ratio decreased (Table 4).

Willingness-to-pay was also correlated to increase in capital cost recovery, meaning willingness-to-pay decreased as the time necessary to recover the capital cost investment increased. Results from all conservation measures surveyed showed for each two-year increase in CCR, an average 25% decline in consumer willingness to pay could be expected (Figure 4). The relationship between increased time until CCR and decreased consumer willingness to pay was supported by a correlation coefficient (Pearson's r) score of 0.95 on a scale of 0.00 to 1.00. A 1.00 score would indicate a perfect correlation.

Crosstabulations were used to determine if significant differences existed among different demographic groups of consumers. An analysis of consumer age for example, revealed that willingness-to-pay for BMPs increased to as high as 52% as consumers approached middle age (35–45) but then steadily decreased thereafter to 37% by age 65. Respondents in professional occupations with annual incomes greater than $U.S. 65,000 were nearly twice as likely to invest in BMPs than respondents less than 35 years of age having incomes of $U.S. 34,000 or less. Willingness-to-pay for consumers age 25–34 de-

TABLE 3 Single-family first cost with and without rebate, capital cost recovery (CCR) and 20-year return on investment.

BMP	Unit Cost w/o Rebate ($U.S.)	CCR w/o Rebate (years)	Unit Cost with Rebate ($U.S.)	CCR with Rebate (years)	IRR
Non-potable irrigation[a]	1,500	4.9	1,150	3.8	26%
Landscape evaluations[b]	1,500	9.8	540	3.5	28%
Low-flow toilet	250	8.4	100	3.4	29%
Reclaimed irrigation[c]	300	1.4	300	1.4	69%
Low-flow clothes washer[d]	450	5.2	450	5.2	19%

a. installed cost of 0.75kW groundwater irrigation well or equivalent
b. cost of consultation and implementation
c. reclaimed water connection fee
d. assumes replacement of existing appliance

TABLE 4 Consumer willingness-to-pay for green building alternatives.[6]

BMP	CCR (Years)	Change	SIR	Change	Willingness to Pay	Change
Window, insulated	1.4		10.9		48.4%	
Window, insulated LoE	2.7	48%	6.6	–40%	34.1%	–30%
Low-flow appliances	4.5	40%	5.6	15%	29.3%	–14%
14 SEER heat pump	6.8	34%	4.3	–23%	21.1%	–27%

clined to near zero as CCR approached 7 years and SIR fell below 4.0.

Knowing the composition of various consumer markets and their corresponding willingness to pay, the water supplier can develop rebates that maximize user implementation while minimizing program costs. For example, a $U.S. 150 rebate on a low-flow toilet saving 102L/d in potable water consumption and wastewater discharge is able to reduce time necessary for CCR from 8.4 years to 3.4 years. The same rebate for a for a low-flow clothes washer saving 62L/d is able to reduce CCR from 5.2 to 3.4 years. Considering only CCR, consumer adoption of low-flow toilets and low-flow clothes washers would be approximately equal. The low-flow toilet however, saves 40L/d more water per unit than the low-flow clothes washer, meaning the utility is able to avoid nearly 40% more system capacity for the same $150 rebate. It should be noted however, that the use of low-flow toilets (and other water use fixtures and appliances) has been required of new construction from 1994 to present (1992 Energy Policy Act). As a result, utilities should consider the net natural replacement of remaining pre-1994 fixtures as well as those who would replace these fixtures regardless of a rebate ("free riders") when formulating their incentive strategies.

WATER USE EXTERNALITIES

In addition to the economic benefits "shared" between water suppliers and consumers, indirect benefits also accrue to society and the environment through demand-side conservation. The environmental impacts caused by water use such as energy emissions and watershed destruction are known as "externalities" since the cost of these acts are rarely internalized by the parties responsible for the consequences of their existence. Energy constitutes a critical input in maintaining Florida's domestic water supply. The average energy usage for water treatment and distribution ranges from 0.4 to 0.7kWh per 1000L delivered. Wastewater treatment adds another 0.3-0.7kWh per 1000L of secondary effluent discharged.7 Energy utilization however, has an undesirable effect on the environment. Effects may include the uncontrolled release of nitrogen oxides, sulfur dioxide, carbon oxides, heavy metals, particulates and organic pyrolysis compounds. NO_x and CO_2 emissions in particular, absorb radiant solar energy, contributing to the global greenhouse effect. Aggregating emissions proportionately across Florida's coal, petroleum, gas and nuclear generation capacity, it is estimated that 3.7g of SO_2, 2.3g of NO_x and 0.6kg of CO_2

FIGURE 4 Change in willingness-to-pay relative to capital cost recovery.[6]

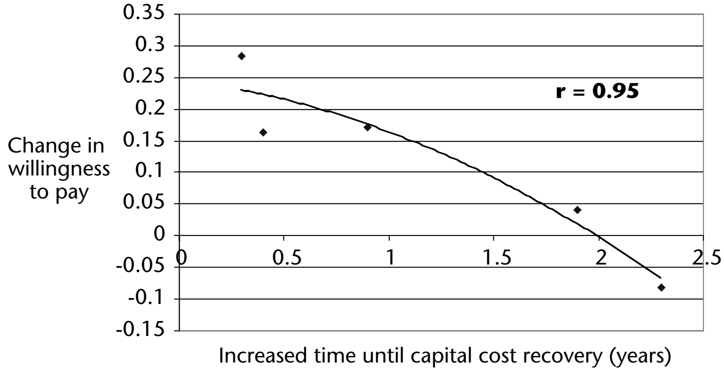


TABLE 5. Estimated emissions from steam electric generating units at Florida electric utilities, in thousand U.S. tons (907.2kg).[8]

	Coal	Petroleum	Gas	Nuclear	Totals
Energy (MWh)[a]	4,551 (38%)	2,614 (22%)	1,912 (16%)	2,869 (24%)	11,963 (100%)
Sulfur Dioxide	445	185	<0.5	<0.5	630
Nitrogen Oxides	255	40	42	<0.5	337
Carbon Dioxide	66,983	19,307	10,997	45	97,332

a. Estimated based on documented 1998 generation rates.

are released for every kilowatt-hour (kWh) of energy used by the supplier to maintain its potable water and wastewater treatment system (Table 5).[8] In addition to direct payback to the consumer and the deferred cost of service to the supplier, participants in the Tampa Bay Water project can expect to eliminate the release of 662,260kg of SO_2, 412,780kg of NO_x and 108×10^6 kg of CO_2 to the atmosphere as a result of reducing potable demand nearly 325 billion L over the next 20 years.

CONCLUSIONS

The following research has provided case study evidence that demand-side water management through market-based conservation programs and incentives can be a cost-effective alternative to expanding water treatment and distribution system capacity. To determine the cost-effectiveness of demand-side management and to optimize program efficiency, a three-step methodology has been outlined to include 1) characterizing water consumption by market segment, 2) assessing the benefit-cost of best management practices, and 3) determining consumer willingness-to-pay for water conservation measures. With this information, the water supplier can create "optimal" market-based incentives for consumer investment in water saving measures that maximize water use reductions and minimize conservation program costs. Fundamentally, the concept model attempts to identify and reconcile the cost-benefit motivations of supplier and consumer in an effort to optimize economic opportunities through sustainable water use.

Although the initial outcome of the model is a market-based program where both supply-side and demand-side interests partner for cost savings through resource conservation, the methodology could further be developed to include those "soft costs" that are not usually internalized into the cash flow consequence of either supplier or user. These "externalities" may include watershed sustainability, energy and emissions, economic development, equitable distribution, national security and human health and safety related to water resources for which definitive costs are difficult to determine, but are nevertheless a very real part of the "true cost" of water.

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