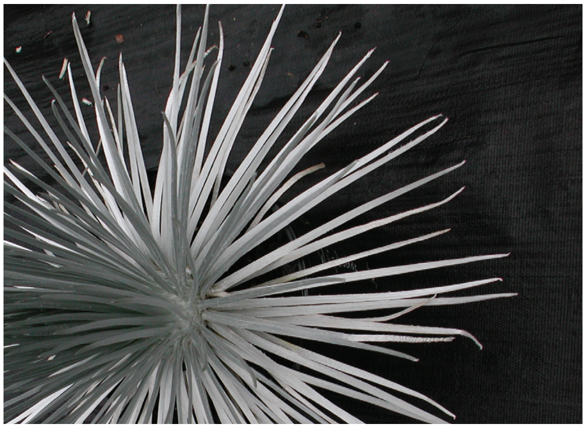
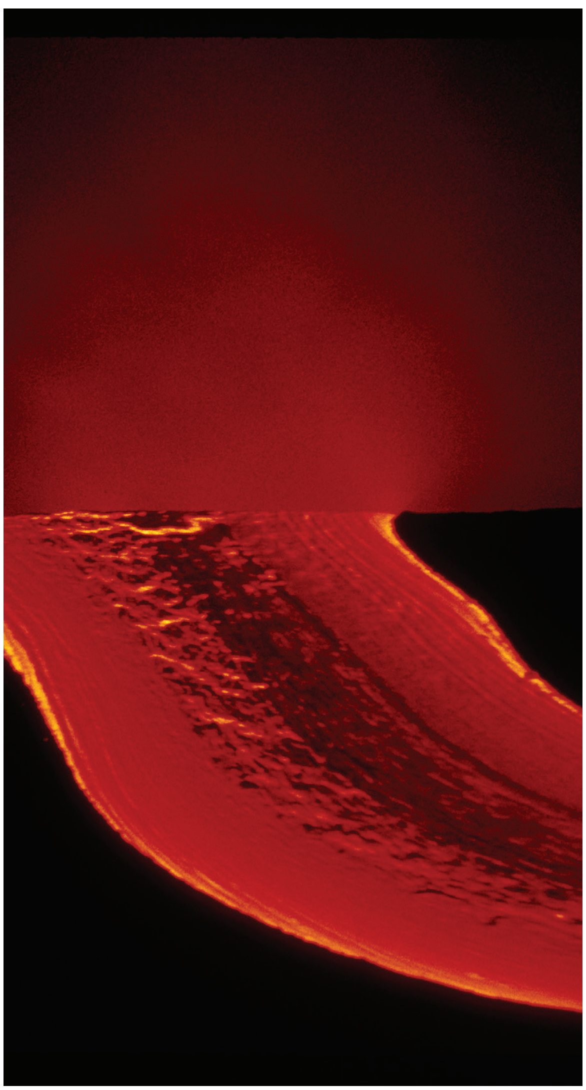


UHERO
THE ECONOMIC RESEARCH ORGANIZATION
AT THE UNIVERSITY OF HAWAI‘I

PROJECT ENVIRONMENT

Benefits and Costs of Implementing the IAPMO Green Plumbing and Mechanical Code Supplement in Hawaii

DECEMBER 18, 2014



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BENEFITS AND COSTS OF IMPLEMENTING THE IAPMO GREEN PLUMBING AND MECHANICAL CODE SUPPLEMENT IN HAWAII

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EXECUTIVE SUMMARY

We calculate the benefits and costs of implementing the International Association of Plumbing and Mechanical Officials (IAPMO) 2012 Green Plumbing and Mechanical Code Supplement (GPMC) for various building types in Hawaii, with particular emphasis on water-use efficiency provisions in the code. Benefits of the GPMC are measured as water savings, where baseline usage is estimated in accordance with the 2012 Uniform Plumbing Code (UPC), which has been recently adopted by the state and will soon be adopted by the counties. We also monetize those benefits at the household level (water bill savings) and at the state level (cost savings to the water supply boards and departments throughout the state). Based on discussions with plumbers, building contractors, developers, architects, mechanical engineers, planners, and other water specialists, as well as an assessment of prices at major home improvement stores and other online retailers, we estimate the costs of GPMC compliance for new structures planned for Hawaii over the next decade. If the GPMC is implemented, the payback period is two years and the net present value assuming a discount rate of zero is $15.13 million. For a discount rate of 5%, the NPV is $11.29 million.

THE 2012 GREEN PLUMBING AND MECHANICAL CODE SUPPLEMENT

The IAPMO GPMC was first published in 2010 and has since been updated once in 2012. The GPMC is unique in that it overlays existing published plumbing codes such as the 2012 UPC and there are no tiers of compliance or rating systems. The GPMC is touted as being 20% more efficient than current plumbing codes and covers several major areas: high efficiency plumbing fittings, fixtures and appliances; submetering for all commercial applications; water heating design, equipment, and installation; occupancy specific provisions; and alternate water sources.

HIGH EFFICIENCY PLUMBING FITTINGS, FIXTURES AND APPLIANCES

The 2012 GPMC sets maximum flow-rate standards for indoor fixtures in both residential and commercial buildings as described in Table 1.

TABLE 1. GPMC FIXTURE EFFICIENCY STANDARDS

Residential toilets	1.28	gallons/flush (gpf)
Residential bathroom faucets	1.5	gallons/minute (gpm)
Residential kitchen faucets	1.8	gpm
Residential showerheads	2.0	gpm
Commercial toilets	1.28	gpf
Urinals	0.5	gpf
Commercial faucets	0.5	gpm
Commercial metering faucets	0.25	gallons/cycle
Commercial pre-rinse spray valves	1.3	gpm
Flushometer valve toilets	1.6	gpf

Also, water pressure should not exceed 60 psi, with the exception of showerheads (max flow-rate of 80 psi). Capping pressure reduces water lost due to leakage and lessens wear and tear on mechanical components.

The GPMC requires that residential clothes washers and residential and commercial dishwashers be in accordance with the Energy Star program requirements. Given that new residential units are already typically being equipped with Energy Star appliances, there is likely to be little additional water savings attributable to GPMC appliance standards. We therefore do not include the costs and benefits of water-using appliances in our analysis.

OCCUPANCY SPECIFIC PROVISIONS

Potential water savings may be large for restaurants. Typical (older) pre-rinse spray valves consume two-thirds of water used in a restaurant, exceed 3.0 gpm, and may be operated for 5 or more hours per day. The 2012 GPMC requires that pre-rinse spray valves have an automatic shut-off feature and have a maximum flow rate of 1.3 gpm. Other occupancy specific water efficiency requirements include those related to ice makers, food steamers and dipper well faucets. In this study we focus on retail space and do not include restaurant-specific provisions in water savings calculations for the commercial sector but recognize that this would be an important potential benefit that could be realized at low cost if restaurants turn out to make up a sizeable share of future commercial development in Hawaii.

SUBMETERING

The 2012 GPMC requires that submeters be installed for all commercial applications including tenant spaces; landscape irrigation systems; high water-using processes; and makeup water to cooling towers, evaporative condensers, and large boilers. In particular, a submeter would be required for all individual tenant spaces on a property where water consumption exceeds 500 gallons per day for that tenant; the space is occupied by a commercial laundry, cleaning operation, restaurant, food service, medical office, dental office, laboratory, beauty salon or barber shop; or the total building area exceeds 50,000 square feet. Individual metering of tenants creates accountability and is a proven water efficiency tool.

WATER HEATING DESIGN, EQUIPMENT AND INSTALLATION

The 2012 GPMC includes provisions for conserving potable and non-potable water and energy associated with the generation and use of hot water in buildings. This includes provisions for the portion of the potable water distribution system between a water-heating device and the plumbing fixtures, including all dedicated return piping and appurtenances to the water-heating device in a recirculation system. Potential water savings from a recirculation or other non-traditional distribution system depends largely on the design of the building under consideration, so estimating the benefits related to water heating efficiency would require a plumber to examine floor plans for all of the planned units included in our analysis (i.e. not just room counts), which is not feasible for this study. Moreover, installation of recirculation systems would not be mandated under the GPMC; rather, the GPMC ensures that if such systems are voluntarily installed, they meet certain efficiency standards. If the code were amended to require recirculation pumps in new residences, however, the rough-in plumbing cost for labor and materials (pump, timer, by-pass valves and connectors) would likely cost somewhere in the ballpark of $750. As already noted, the potential benefits will vary, but pumps currently on the market claim savings of up to 15,000 gallons per year.[1] Together, those estimates could be used to calculate the costs and benefits of requiring recirculation systems in new homes, but we do not consider them in the current analysis, given that they are not mandated under the GPMC. Other provisions for water heating (e.g. those related to water softening) are aimed at reducing energy use, and we do not monetize those potential benefits in the analysis.

ALTERNATE WATER SOURCES

Alternate water sources are non-potable sources of water that include but are not limited to gray water, on-site treated non-potable water, rainwater, and reclaimed (recycled) water. The 2012 GPMC includes provisions for alternate water source systems in the following areas: minimum water quality, backflow prevention, cross-connection testing, system design, permitting, maintenance and inspection, and system marking and coloring. Although these requirements ensure safe installation and operation of non-potable water systems that would ultimately reduce potable water use, the code does not mandate installation of non-potable water systems (or piping) in new buildings.[2] Thus, it would be difficult to estimate the effect of such provisions on water use statewide without a better idea of how those provisions affect the likelihood of alternate water source adoption in various sectors. Furthermore, mandating the installation of alternate water systems in new buildings would be challenging from an implementation standpoint because the benefits of such systems could vary greatly across locations. For example, rainwater catchment systems would not be particularly beneficial in very wet areas where outdoor water use is already low or in very dry areas where the potential to capture rain is small. Residents in such areas would face higher home prices with minimal benefits. If an alternate water system (e.g. graywater irrigation system) were mandated for new construction, the cost would vary according to the completeness of the system. At minimum, a separate main line would be required to separate the gray water from black water, allowing a resident to later hook up an irrigation system without having to make any changes to plumbing inside the house. If the rough-in process included installation of a holding tank and/or the irrigation system as well, then the cost would be much higher.

BUILDING TYPES

In 2013, the value of building permits totaled $2.7 billion statewide, with $1.02 billion attributed to residential permits, $75 million attributed to hotel permits, and $221 million attributed to non-residential permits (DBEDT, 2013). Permits for additions and alterations accounted for the remaining $1.4 billion. Information gathered on planned projects over the next decade suggests that the trend is continuing: residential development largely outweighs hotel and commercial development. In our analysis, we further divide residential development into condominiums and single-family homes (SFHs). Water users therefore fall into one of four general categories: condominiums, SFHs, hotels, or commercial. Although the commercial category could be broken down further into subcategories to account for the potentially large difference in water use between, for example, a restau-

1 http://www.amazon.com/Watts-500800-Premier-Water-Recirculation/dp/B000E78XHG/ref=zg_bs_601479011_9. It should be noted, however, that the purported water savings may be calculated with respect to baseline usage that does not correspond to the standards outlined in the 2012 UPC.
2 Mandating this type of installation may not generate the desired results; people need to elect to "do the right thing" for such a measure to work the way it is intended (personal communication, T. Hiu). One possible way to encourage participation is an incentive or rebate program for the installation of alternative water systems by individual water users.

rant and a clothing store, information about planned commercial development is often not specific enough to do so.[3] Therefore as detailed below, we focus on retail space in the commercial category and estimate savings based on a water use intensity index. Since we do not have detailed information about planned permits for additions and alterations, we project water savings for that category based on its relative historical contribution to total permit value. The average value of permits for additions and alterations accounted for roughly 53% of the value of all building permits over the period 2011-2013. The final calculation for water savings in each building category is therefore based on the total number of new/planned permits, adjusted upward by 53% to account for expected additions and alterations.

Recently completed projects are not included in the analysis because per the 2012 GPMC, no provisions shall be deemed to require a change in any portion of a plumbing system in an existing building when such work was installed and is maintained in accordance with law in effect prior to the effective date of the GPMC.

SINGLE-FAMILY HOMES

We identified 15 SFH developments planned, permitted, or under construction (Table 2).

TABLE 2. PLANNED SFH CONSTRUCTION

Project Name	County	General Location	Units
Kamakana Villages at Keahoulu	Hawaii	Kailua-Kona	2,330
Kamakoa Nui	Hawaii	Waikoloa	49
Kohanaiki	Hawaii	Kona Coast	500
Hoala Kalaeloa (Barbers Point Redevelopment)	Honolulu	Kalaeloa	4,000
Hoopili	Honolulu	Kapolei	11,750
Kapiwai Subdivision	Honolulu	Pauoa Valley	24
Koa Ridge	Honolulu	Waipio	3,500
Hanalei Plantation Resort	Kauai	Hanalei	34
Kukuiula	Kauai	Poipu	1,500
Lima Ola	Kauai	Eleele	400
Makahuena Point Development	Kauai	Poipu	10
Kahoma Village	Maui	Lahaina	203
Kapalua Project District 1	Maui	Kapalua	1,050
Puunani	Maui	Wailuku	597
Waikapu Gardens Phase II	Maui	Waikapu	56
		Total Units:	26,003

In 2013, the average number of bathrooms in new SFHs was 2.47 in the United States and 2.52 in the western region of the country (U.S. Census Bureau, 2013). Assuming Hawaii units have 2.52 bathrooms on average, we estimate that the total number of projected SFH bathrooms is 65,612.

3 As mentioned previously, the water savings on a per-restaurant basis could be significant. Assuming a savings of 0.3 gpm for pre-rinse spray valves (1.3 gpm under GPMC versus 1.6 gpm under UPC) and average usage of 5 hours per day, monthly savings would be in the ballpark of 2,700 gallons.

The average household size in Hawaii was 3.09 for owner-occupied housing units and 2.75 for renter-occupied units over the period 2008-2012 (DBEDT, 2013). Across all housing units, the average number of persons per household was 2.95 over that period (U.S. Census Bureau, 2014). For the purpose of calculating daily water use, we assume that the average household size in the SFH category is 3 people.

CONDOMINIUMS

We identified 35 condominium projects planned, permitted, or under construction. Of those 35 projects, 12 include plans for efficient water fixtures, fittings, and landscaping (DBEDT-HCDA, 2014). Table 3 lists the projects with provisions for water efficient measures. These projects will not be included in our analysis. Table 4 includes the remaining 23 projects for which information on water efficiency was unavailable. Timeshares and resort condos are classified as condominiums because we believe water consumption for these types of users is more likely to resemble permanent residents than visitors at hotels.

TABLE 3. PLANNED CONDO CONSTRUCTION WITH WATER EFFICIENT MEASURES

Project Name	County	General Location	Units
400 Keawe (Block B-1)	Honolulu	Kakaako	95
400 Keawe (Block B-2)	Honolulu	Kakaako	88
690 Pohukaina	Honolulu	Kakaako	804
801 South Street Building A	Honolulu	Kakaako	635
801 South Street Building B	Honolulu	Kakaako	410
803 Waimanu	Honolulu	Kakaako	153
Keauhou Lane (Block A-1)	Honolulu	Kakaako	423
Keauhou Lane (Block A-2)	Honolulu	Kakaako	209
The Collection	Honolulu	Kakaako	467
Ward Village, Land Block 2, Project 1 (Waiea)	Honolulu	Kakaako	177
Ward Village, Land Block 3, Project 1 (Anaha)	Honolulu	Kakaako	318
Ward Village, Land Block 5, Project 1	Honolulu	Kakaako	424
		Total Units:	4,203

TABLE 4. PLANNED CONDO CONSTRUCTION WITHOUT WATER EFFICIENT MEASURES

Project Name	County	General Location	Units
Hilton Waikoloa Resort: Kings' Land	Hawaii	Waikoloa	507
ONE Ala Moana	Honolulu	Ala Moana	206
Park Lane Ala Moana	Honolulu	Ala Moana	215
Symphony	Honolulu	Kakaako	388
Waihonua at Kewalo	Honolulu	Kakaako	341
Building 77	Honolulu	Kalaeloa	100
Cloudbreak Hale Uhiwai Nalu	Honolulu	Kalaeloa	50
East Kapolei II Rental Community	Honolulu	Kapolei	300
Forest City Kapolei (Kapolei Lofts)	Honolulu	Kapolei	499
Ohana Hale	Honolulu	McCully	180

Hilton Time Share Tower	Honolulu	Waikiki	418
Live Work Play Aiea	Honolulu	Waimalu	1,500
Kiahuna Fairways, Pili Mai at Poipu	Kauai	Poipu	191
Kiahuna Poipu Golf Resort	Kauai	Poipu	282
Palms at Poipu Beach	Kauai	Poipu	164
Poipu Sheraton	Kauai	Poipu	382
Kolopua at Princeville	Kauai	Princeville	44
Waipouli Niu/Coconut Beach	Kauai	Kapaa	343
Hyatt Regency Maui	Maui	Kaanapali	131
Villas at Royal Lahaina	Maui	Lahaina	126
Kulamalu Affordable Housing Project	Maui	Pukalani	64
Wailea Residence	Maui	Wailea	328
Maui Lu Timeshare	Maui	Kihei	400
		Total Units:	7,159

Among the 23 projects listed in Table 4, seven projects included specific information on the types of units in the building: 419 1-bathroom units, 598 2-bathroom units, 48 2.5-bathroom units, 70 3.5-bathroom units, and 8 4.5-bathroom units, leaving 6,016 unidentified units. In the western region of the United States in 2013, the distribution of bathrooms in multifamily units was as follows: 52% 1-bathroom, 5% 1.5-bathrooms, and 43% 2-bathrooms or more (U.S. Census Bureau, 2013). Applying that distribution to the 6,016 unidentified units in Table 3 generates the following: 3,128 1-bathroom units, 301 1.5-bathroom units, and 2,587 2-bathroom units. We estimate that the total number of projected condo bathrooms is 10,769.

The average household size in Hawaii was 3.09 for owner-occupied housing units and 2.75 for renter-occupied units over the period 2008-2012 (DBEDT, 2013). Across all housing units, the average number of persons per household was 2.95 over that period (U.S. Census Bureau, 2014). For the purpose of calculating daily water use, we assume that the average household size in the condo category is 3 people.

HOTELS

We identified 22 hotel projects planned, permitted, or under construction (Table 5). As indicated in the previous section, resort condos and timeshares are classified as condominiums for the purpose of estimating water use.

TABLE 5. PLANNED HOTEL CONSTRUCTION

Project Name	County	General Location	Rooms
Holiday Inn Express	Hawaii	Kona	75
Naniloa Hotel	Hawaii	Hilo	383
Hyatt Regency Waikiki	Honolulu	Waikiki	1,230
King's Village Condo-Hotel	Honolulu	Waikiki	256
Laie Courtyard by Marriott	Honolulu	Laie	144
Ohana West Waikiki	Honolulu	Waikiki	659
Outrigger Reef on the Beach	Honolulu	Waikiki	200
Ritz-Carlton Residences Condo-Hotel	Honolulu	Waikiki	309
Ritz-Carlton Condo-Hotel (2nd Tower)	Honolulu	Waikiki	280
Sheraton Princess Kaiulani	Honolulu	Waikiki	1,100
Coco Palms	Kauai	Kapaa	363

Hanalei Plantation Resort	Kauai	Hanalei	86
Kapalawai-Robinson Resort Project	Kauai	Makaweli	250
Kauai Lagoons	Kauai	Lihue	772
Poipu Sheraton	Kauai	Poipu	102
Waimea Kikiaola Land Co	Kauai	Waimea	250
Waipouli Niu/Coconut Beach	Kauai	Kapaa	6
Downtown Kihei Project	Maui	Kihei	150
Grand Wailea Resort	Maui	Wailea	310
Kula Lodge	Maui	Kula	15
Maui Palms	Maui	Kahului	101
Piilani Suites by Marriott	Maui	Wailea	200
		Total rooms:	7,241

Assuming a single bathroom per hotel room, the total number of hotel bathrooms for the purpose of estimating GPMC compliance costs is 7,241. The typical number of persons per hotel room in the United States in 2013 was two (AHLA, 2014), and the median daily water use per hotel room over the period 2006-2012 was 102 gallons (EPA, 2012).

COMMERCIAL

TABLE 6. PLANNED COMMERCIAL DEVELOPMENT

Project Name	County	General Location	Sq Ft
Kamakana Villages at Keahoulu	Hawaii	Kailua-Kona	197,000
Pahoa Shopping Center	Hawaii	Pahoa	104,000
Hoala Kalaeloa (Barbers Point Redevelopment)	Honolulu	Kalaeloa	3,500,000
International Marketplace Redevelopment	Honolulu	Waikiki	357,000
Ka Makana Alii Shopping Center	Honolulu	Kapolei	2,918,520
Target Kailua	Honolulu	Kailua	134,000
Hokulei Village	Kauai	Lihue	620,730
Kilauea Lighthouse Village	Kauai	Kilauea	50,000
Maui Mall Expansion	Maui	Kahului	31,940
Puunene Shopping Center	Maui	Puunene	275,000
The Outlets of Maui Renovation	Maui	Lahaina	146,000
		Total sq footage:	8,334,190

We identified 11 retail commercial development projects planned, permitted, or under construction (Table 6) for which information about square footage was available. In nearly all cases, specific information about the number or size of individual retail units was not available, however. Without more information about the types of units, estimating water consumption based on projected fixture use is difficult. Instead, we calculate total commercial water usage assuming a water use intensity factor of 5 gallons per square foot for retail space (EPA, 2012).

BENEFITS (WATER SAVINGS)

We first calculate water savings in volume for each building type. That savings is then multiplied by the appropriate factor to estimate individual savings and social savings in dollar terms.

SINGLE-FAMILY HOMES

Water savings for a typical SFH is calculated as the difference between the water use baseline under the 2012 UPC (Table 7) and water use under the 2012 GPMC (Table 8), except where noted otherwise. We focus on the benefits of reducing the allowable maximum flow-rate for plumbing fixtures. Total use per housing unit is based on an average household size of 3 people (DBEDT, 2013; U.S. Census Bureau, 2014). Estimated daily use per person is based on Water Use Reduction Guidelines produced by the U.S. Green Building Council for their LEED program (USGBC, 2012) and a water conservation residential telephone survey of Oahu residents (OmniTrak Group Inc. 2009).

TABLE 7. WATER USE BASELINE FOR SFHS (2012 UPC)

Fixture type	Max flow-rate	Unit	Duration	Estimated daily use per person	Number of occupants	Daily water use (gallons)
Residential toilets	1.6	gpf	1	5	3	24
Residential bathroom faucets[a]	1.5	gpm	1	5	3	22.5
Residential kitchen faucets	2.2	gpm	1	4	3	26.4
Residential showerheads	2.5	gpm	8	1.27[b]	3	83.9
					Total use:	156.8

[a] Based on discussions with developers, 1.5 gpm bathroom faucets are already typically being installed in new SFH developments, even though 2012 UPC only requires 2.2 gpm.
[b] Results from the survey suggest that Oahu single family households average 3.8 showers or baths per day. Given our assumption of 3 household members, this is equivalent to 1.27 showers per person per day.

TABLE 8. WATER USE FOR SFHS UNDER 2012 GPMC

Fixture type	Max flow-rate	Unit	Duration	Estimated daily use per person	Number of occupants	Daily water use (gallons)
Residential toilets	1.28	gpf	1	5	3	19.2
Residential bathroom faucets	1.5	gpm	1	5	3	22.5
Residential kitchen faucets	1.8	gpm	1	4	3	21.6
Residential showerheads	2	gpm	8	1.27	3	67.1
					Total use:	130.4

Total daily water savings for a household of 3 people is 26.4 gallons, a 17% reduction from the baseline. Recalling that the total number of planned SFH units is 26,003, total expected daily water savings for new units is 686,038 gallons. Further assuming that additions and alterations contribute additional savings equal to 53% of water savings for planned new units, total daily water savings for the SFH category is 1.05 million gallons.

CONDOMINIUMS

Water savings for a typical condo unit is calculated as the difference between the water use baseline under the 2012 UPC (Table 9) and water use under the 2012 GPMC (Table 10). We focus on the benefits of reducing the allowable maximum flow-rate for plumbing fixtures. Total use per housing unit is based on an average household size of 3 people (DBEDT, 2013; U.S. Census Bureau, 2014). Estimated daily use per person is based on Water Use Reduction Guidelines produced by the U.S. Green Building Council for their LEED program (USGBC, 2012).

TABLE 9. WATER USE BASELINE FOR CONDOS (2012 UPC)

Fixture type	Max flow-rate	Unit	Duration	Estimated daily use per person	Number of occupants	Daily water use (gallons)
Residential toilets	1.6	gpf	1	5	3	24
Residential bathroom faucets	2.2	gpm	1	5	3	33
Residential kitchen faucets	2.2	gpm	1	4	3	26.4
Residential showerheads	2.5	gpm	8	1	3	60
					Total use:	143.4

TABLE 10. WATER USE FOR CONDOS UNDER 2012 GPMC

Fixture type	Max flow-rate	Unit	Duration	Estimated daily use per person	Number of occupants	Daily water use (gallons)
Residential toilets	1.28	gpf	1	5	3	19.2
Residential bathroom faucets	1.5	gpm	1	5	3	22.5
Residential kitchen faucets	1.8	gpm	1	4	3	21.6
Residential showerheads	2	gpm	8	1	3	48
					Total use:	111.3

Total daily water savings for a household of 3 people is 32.1 gallons, a 22% reduction from the baseline. Recalling that the total number of planned condo units is 7,159, total expected daily water savings for new units is 229,804 gallons. Further assuming that additions and alterations contribute additional savings equal to 53% of water savings for planned new units, total daily water savings for the condo category is 351,600 gallons.

HOTELS

Water savings for a typical hotel room is calculated as the difference between the water use baseline under the 2012 UPC (Table 11) and water use under the 2012 GPMC (Table 12). We focus on the benefits of reducing the allowable maximum flow-rate for plumbing fixtures. Total use per hotel room is based on an average occupancy of 2 people (AHLA, 2014). Estimated daily use per person is based on Water Use Reduction Guidelines produced by the U.S. Green Building Council for their LEED program (USGBC, 2012), adjusted for the fact that visitors and permanent residents use water differently. Estimated daily use of toilets and bathrooms is adjusted downward and the duration of showers is adjusted upward until total baseline daily water use is 102 gallons per room, which is the median water use per hotel room estimated by the EPA Energy Star Water Use Tracking

Program (EPA, 2012).

TABLE 11. WATER USE BASELINE FOR HOTELS (2012 UPC)

Fixture type	Max flow-rate	Unit	Duration	Estimated daily use per person	Number of occupants	Daily water use (gallons)
Residential toilets	1.6	gpf	1	3	2	9.6
Residential bathroom faucets	2.2	gpm	1	4	2	17.6
Residential kitchen faucets	2.2	gpm	1	0	2	0
Residential showerheads	2.5	gpm	15	1	2	75
					Total use:	102.2

TABLE 12. WATER USE FOR HOTELS UNDER 2012 GPMC

Fixture type	Max flow-rate		Duration	Estimated daily use per person	Number of occupants	Daily water use (gallons)
Residential toilets	1.28	gpf	1	3	2	7.68
Residential bathroom faucets	1.5	gpm	1	4	2	12
Residential kitchen faucets	1.8	gpm	1	0	2	0
Residential showerheads	2	gpm	15	1	2	60
					Total use:	79.68

Total daily water savings for a typical hotel room occupied by two visitors is 22.52 gallons, a 22% reduction from the baseline. Recalling that the total number of planned hotel rooms is 7,241, total expected water savings for new units is 163,067 gallons per day. Further assuming that additions and alterations contribute additional savings equal to 53% of water savings for planned new units, total daily water savings for the hotel category is 249,493 gallons.

COMMERCIAL

Because specific information about the number or size of individual retail units was typically not available for planned commercial development, it is difficult to estimate fixture use. Instead, we calculate baseline use assuming a water use intensity factor of 5 gallons/sf (EPA, 2012). For a total area of 8,334,190 square feet, this translates to 41,670,950 gallons per year. If the GPMC is roughly 20% more efficient than the UPC along the lines of the percentages realized for residential units, total annual water savings attributed to efficient fixtures is 8,334,190 gallons.

An analysis conducted by the National Science and Technology Council (NSTC, 2011) included three case studies which illustrated that submetering electricity saved an estimated 18-30%. Though we cannot be sure that such savings would translate directly to water submetering, we conservatively estimate a 15% reduction in water use, calculated after the savings generated from efficient fixtures. Total water savings per year in the commercial sector for new units is 13,334,704 gallons. Further assuming that additions and alterations contribute additional savings equal to 53% of water savings for planned new units, total annual water savings for the commercial category is 20.4 million gallons.

MONETIZED TOTAL BENEFITS

Individual water bill savings are calculated by multiplying water saved by a typical residential unit with the first residential block price ($4.03/thousand gallons) in the Honolulu Board of Water Supply (BWS) Rate Structure (http://www.hbws.org/cssweb/display.cfm?sid=1175).[4] Statewide water bill savings include commercial and hotel savings, which are monetized using the non-residential uniform rate of $4.53 per thousand gallons.

Avoided costs to the Board of Water Supply are calculated using information about energy expenditures (the amount billed by HECO) and total water consumption over the period 2010-2013. Expenditures per million gallons delivered daily (MGD) ranged from $150,000 to $210,000 and averaged $188,000. Total expenses include the energy required to pump, treat, distribute, and maintain groundwater.[5] Dividing by 365 days gives the cost saved per unit of water: $515/million gallons. To get savings for water managers, we multiply the $515/MG by the daily, monthly, and annual statewide water savings.

TABLE 13. BENEFITS ACROSS CONSUMPTION CATEGORIES

Type	Daily	Monthly	Annual
Quantity (gallons)			
New Condos	229,804	6,894,117	82,729,404
Condo Additions/Alterations	121,796	3,653,882	43,846,584
New Single-Family Homes	686,038	20,581,153	246,973,842
Single-Family Home Additions/Alterations	363,600	10,908,011	130,896,136
New Hotels	163,067	4,892,020	58,704,235
Hotel Additions/Alterations	86,426	2,592,770	31,113,245
New Commercial	37,041	1,111,225	13,334,704
Commercial Additions/Alterations	19,632	588,949	7,067,393
Statewide Water Savings	1,707,404	51,222,129	614,655,543

Type	Daily	Monthly	Annual
Dollars			

4 The average Oahu household in a single-family home uses approximately 11,000 gallons per month, which falls within the first residential price block. Although statewide calculations are based on data obtained from the Honolulu Board of Water Supply, water management costs and pricing structures vary by island.
5 Labor costs will not vary for changes in water efficiency at the scale we are considering.

Condo Water Bill Savings per Household		$3.88	$46.57
SFH Water Bill Savings per Household		$3.19	$38.28
Statewide Water Bill Savings	$7,034	$211,018	$2,532,212
Savings to Water Managers	$880	$26,390	$316,674
Total Savings	$7,914	$237,407	$2,848,886

COSTS

The cost of upgrading fixtures is minimal. At Home Depot (www.homedepot.com), we found 70 toilets and 24 showerheads that come in standard and low-flow versions of the model with no difference in price. Faucets tended not to have standard and low-flow versions of each model listed on the website. However, the average price of the first 50 results of 2.2 gpm faucets (sorted by price from low to high) was $142, while the average price for 1.5 gpm faucets was $61. Based on discussions with plumbers and subcontractors, we expect that there is likely to be little or no price difference between faucet accessories (or any other plumbing fixtures for that matter) due to different flow rates. Rather, price differences arise from external factors, such as size, style and finish.

A pressure reducing valve would be required for each residential unit to ensure that water pressure does not exceed 60 psi for all fixtures except showerheads, which have a maximum allowable pressure of 80 psi. Installation of a new PRV would cost approximately $100 for the regulator itself, plus $150-200 for the labor. However, new homes are already equipped with PRVs, so meeting the 60-psi standard would only require that plumbers set the pressure accordingly at the time of installation, i.e. there would be no additional cost.

A search of online retailers revealed that 1/2-inch to 3/4-inch water submeters range in cost from $100-200 depending on the brand, material and features.[6] The National Science and Technology Council Subcommittee on Buildings Technology Research and Development (NSTC, 2011) similarly note that nutating disk water meters range in cost from $50-400 (up to 3" connections). To calculate the cost of submetering individual commercial tenants, we assume that each submeter costs $200 and that labor for installation would be roughly 10%, for a total of $220 per submeter.

We use information about Ala Moana Shopping Center to calculate the total number of submeters required for the 8.3 million square feet of projected commercial space statewide. The 2.1 million square feet of gross leasable area in Ala Moana Shopping Center together with the 310 tenants imply an average tenant space of 6,774 square feet. Assuming that this is representative of retail space statewide, we divide 8.3 million by 6,774 square feet to arrive at an estimated 1,230 projected tenant spaces.

Under the GPMC, contractors, installers, or service technicians could be required to demonstrate competency, e.g. through training and certification. Plumbing professionals would incur the cost if the state were to require certification (beyond a standard plumbing license). In 2013, there were 2,050 plumbers, pipefitters, and steamfitters employed in Hawaii (BLS, 2013). Assuming that the IAPMO/GreenPlumbers Training and Certification Program[7] is representative of the type of certification that would be required, the per-applicant cost of $130 implies a total cost of $266,500.

6 EKM Metering (http://www.ekmmetering.com/), Submeter Solutions (http://esubmeter.com/), and Assured Automation (http://assured-automation.com/).
7 http://www.nationalitc.com/NITCService.cfm?GO=CERT&CERTID=50

TABLE 14. COSTS OF GPMC COMPLIANCE

Item	Number of units	Cost per unit	Total cost
Fixtures	N/A	N/A	N/A
Commercial submeters	1,230	$220	$270,663
Training/Licensing	2,050	$130	$266,500

BENEFITS VERSUS COSTS

Total benefits are calculated as the sum of water bill savings and savings to water managers. Total costs include the costs to install commercial submeters in individual tenant spaces and to certify plumbing professionals in Hawaii.

Technically, benefits would only start accruing upon completion of each project (i.e. when water consumption begins), and costs would be accrued at the time of purchase and installation of submeters and at the time of enrollment in certification programs. Given that the calculations are based on planned rather than completed construction, many of the projects do not have a set or even projected completion date. In Figures 1 and 2, we assume that benefits are distributed evenly over a 10 year period, i.e. every year a fraction of total projects are completed that account for one-tenth of the total projected water savings. Thus in year 1, one-tenth of the $2.85 million in annual savings from Table 13 ($285,000) is obtained, and that number continues to increase by $285,000 every year up until year 10. Submetering costs are also distributed evenly over the 10 year period. Unlike for water savings, however, the cost of installing a submeter is only paid once, i.e. one-tenth of $270,663 from Table 14 is included in the total cost every year and the costs from previous years are not incurred again. Training/licensing costs are only included for the initial year.

FIGURE 1. CONTEMPORANEOUS BENEFITS AND COSTS OF GPMC COMPLIANCE

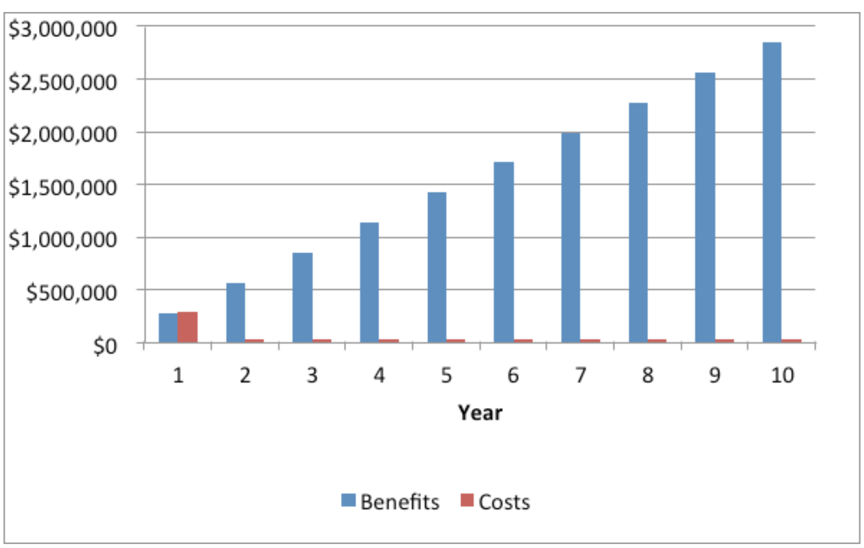
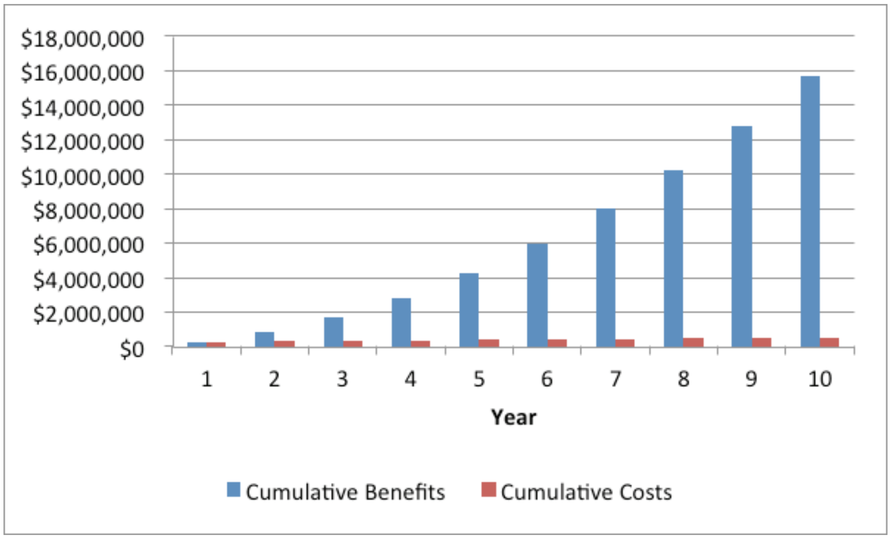


FIGURE 2. CUMULATIVE BENEFITS AND COSTS OF GPMC COMPLIANCE



If the GPMC is implemented, the costs will exceed the benefits in the initial year by roughly $9,000. Thereafter, annual benefits will always exceed costs, with the net benefit reaching a peak of $2.82 million in year 10. Figure 2 shows that the payback period is two years; the value of cumulative water saved in year 2 exceeds the total costs accrued over the entire time horizon. For a discount rate of zero, the net present value (NPV) of the project is $15.13 million. For a discount rate of 5%, the NPV falls to $11.29 million.

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