Cost-Benefit Analysis of Onsite Residential Graywater Recycling – A Case Study: the City of Los Angeles

Zita L.T. Yu*, J.R. DeShazo, PhD, Michael K. Stenstrom*** and Yoram Cohen, PhD***

* Chemical and Biomolecular Engineering Department, University of California, Los Angeles, CA 90095, USA
** Public Policy and Urban Planning Department, University of California, Los Angeles, CA 90095, USA
*** Civil and Environmental Engineering Department, University of California, Los Angeles, CA 90095, USA

Abstract: A cost-benefit analysis of onsite graywater recycling in single-family and multifamily homes was conducted to evaluate the merits of graywater recycling in arid urban regions using the City of Los Angeles as a case study. Onsite graywater recycling reduces potable water demand by 27% and 38% in single family and multifamily homes, respectively. At participation of 10%, the City will be able to reduce water supply and treatment related energy by 43,000 MWh/year, potable water demand by 2% and wastewater treatment load by 3%. Amending local building codes to require new constructions to include plumbing to divert graywater for reuse will be important for lowering the cost and encouraging adoption of graywater recycling. Given the economic benefits to the City, establishing a rebate program for residential graywater recycling could provide a needed incentive for developing an effective residential graywater recycling program. A third-party ownership model could be a viable model for residential graywater recycling program that reduces the upfront system and installation cost barrier as well as relieves residential property owners the responsibility for system operation and maintenance. A City-wide graywater reuse program could also be developed to satisfy regulatory requirements by monitoring system operation and maintenance by certified contractors.

Key words: graywater recycling, cost-benefit analysis, single-family, multifamily, energy saving

Introduction

Onsite graywater reuse has emerged as an important sector in water reuse, especially in arid regions and where water reuse capability is limited. In order to minimize human exposure to pathogens, graywater reuse without treatment is generally encouraged for subsurface irrigation (Yu et al., 2013a). Aboveground water reuse is often only allowed when treatment is provided. The cost of treatment encompasses the system cost, operations and maintenance (O&M) costs and building retrofitting cost. Graywater treatment systems (provide organic, total suspended solids and turbidity removal) marketed for single-family homes can vary between $6,000 and ~$13,000 for treatment capacity of 1.2 – 1.6 m^3 /day (EMRC, 2011). Additionally, maintenance is usually required and can ranges between $200 to $900 per year (GHD Australia Pty Ltd., 2012). It has been suggested that high treatment cost favors onsite graywater treatment in high density multifamily homes (Friedler et al., 2005), but impedes the adoption of onsite graywater treatment in low-density residential housing such as single-family homes. Based on more recent work by Yu et al. (2013b) showed that relatively short breakeven periods were achievable using a wetland treatment system in a single-family home. Even shorter payback periods and broader economic implications of onsite graywater reuse may be possible in cities in arid regions that are facing water scarcity and have limited capability for reusing centralized recycled water due to the lack of distribution system.

The City of Los Angeles, located in an arid region in Southern California is one of those Cities facing the above contracts. The City has population of ~4.1 million and has limited local water resources, relying mainly on imported water. The City purchases 48% of its water supply from the California's state water wholesale agency, the Metropolitan Water District (MWD), which obtains its water from the Colorado River and from the California Bay Delta region (LADWP, 2011). The City also imports another 38% of its water via the Los Angeles (L.A.) Aqueduct. Local groundwater accounts for only 14% of LA's water supply. A small fraction of the City's water supply (~1%) is from centralized water recycling and from water conservation, respectively. The low utilization of recycled water is mainly due to the lack of distribution infrastructure throughout the City. As a result,

~76% of the City's effluent is disposed in the Pacific Ocean while the reclaimed water is used mainly for irrigation in recreational areas (LADWP, 2011). Given that the residential water use accounts for 65% of the City's water demand, the City has encouraged rainwater capture projects in residential homes as an alternative onsite water source for irrigation. However, the City's low annual precipitation of 37 cm/year 33-year-average usually occurs over a short period of 10 days (33-year average). Therefore, the captured rainwater is unlikely to meet the non-potable water demand in the residential sector (LADWP, 2011). In contrast, onsite graywater recycling in residential homes could serve as an important water source for the City but has not been fully evaluated. Furthermore, the broader economic and environmental implications and the economic drivers to help the growth of this sector have not been fully assessed.

The present study focuses on evaluation of the economic drivers for fostering onsite graywater recycling in metropolitan cities in arid regions using the City of Los Angeles as a case study. The objectives of the study are to: 1) evaluate the relationship between housing types and reuse opportunities; 2) conduct cost-benefit analysis of onsite graywater recycling for property owners, 3) assess the cost-benefit of graywater recycling for water and wastewater agencies, and 4) identify the key economic drivers needed for encouraging graywater recycling.

Water Uses in Los Angeles Households

The City of Los Angeles consumes 685 million m^3 /year of potable water with ~68% used for residential purposes. In order to evaluate onsite production and utilization of graywater in single and multifamily residential homes, water consumption for indoor and outdoor water use was estimated using published indoor water use surveys (DeOreo, 2011, DeOreo and Hayden, 2008) and land and water consumption data from Los Angeles Department of Power and Water (LADWP) (LADWP, 2011). Indoor water use was assumed to be for toilet flushing, kitchen uses (dishwashing, food preparation and drinking), clothes washing, showers, baths and hand washing and other personal hygiene activities. Outdoor water use was assumed primarily for landscape irrigation and was estimated as:

$$Ir_{total} = \frac{f \times LA \times ET_o \times PF}{Ir_{ef}} \quad (1)$$

where Ir_{total} is outdoor irrigation water use, L/year, ET_o is Reference evapotranspiration rate of plants for the City of Los Angeles, inch/year, Ir_{eff} = Irrigation efficiency, LA is the landscaped area, ft^2, f is a unit conversion factor equal to 2.35, and PF is the plant factor (0-1) which represents the irrigation demand of vegetation planted with lower number require less water(Hanak and Davis, 2006). The values of the parameters for calculating the indoor and outdoor water use are presented in **Table 1**.

Of the ~4.1 million population, based on the assumption of 3 people per household in the City of L.A. (U.S. Census Bureau, 2011), there are ~1.85 million residents living in 627,400 single-family units while the remaining 2.25 million residents are living in 764,400 multifamily units (LADWP, 2011). Single-family home residents consume ~301million m^3/year as compared to ~227 million m^3/year by multifamily home residents (LADWP, 2011). **Fig. 1** shows that on average a single-family home (with three residents) water use is about 1,320 L/day; while a single multifamily residence uses ~810 L/day. The most striking water use pattern difference between these two residential classes is irrigation. A single-family home uses ~52% of its water for irrigation, which is significantly more than the 18% used in a multifamily home. Such estimates are consistent with the data reported by LADWP (LADWP, 2011). **Fig. 1** also shows that about half of the water consumed indoor becomes graywater, which in principle can be collected, treated and reused for non-potable water applications onsite.

Table 1 Parameters used for calculating indoor and outdoor water consumption activities in single and multifamily homes.

Parameters		**Reference**
Toilet flushing, L/day-capita	59	(DeOreo, 2011, DeOreo and Hayden, 2008)
Kitchen sinks, L/day-capita	17	
Laundry machine, L/day-capita	52	
Showers, L/day-capita	41	
Bathtubs, L/day-capita	4	
Handwashing basins, L/day-capita	17	
Average household size, person/household	3	(U.S. Census Bureau, 2011)
Total number of households residing in single family houses	627,395	(LADWP, 2011)
Total number of household residing in multifamily buildings	764,402	(LADWP, 2011)
Single family home land area, km^2	499	(LADWP, 2011)
Multifamily home land area, km^2	128	(LADWP, 2011)
Percent of irrigated land, %	30	(Li and Saphores, 2012)
Evapotranspiration rate, inch/year	50.1	(Hanak and Davis, 2006)
Irrigation efficiency, %	70	(Hanak and Davis, 2006)
Plant factor for single family home (assuming 20%, 40% and 40% of low, medium and high water use plants, respectively, were used)	0.58	(Hanak and Davis, 2006)
Plant factor for single family home (assuming 15%, 15% and 70% of low, medium and high water use plants, respectively, were used)	0.67	(Hanak and Davis, 2006)

There are three main non-potable water applications in residential homes that can benefit from graywater recycling, namely irrigation, toilet flushing and laundry (Yu et al., 2013a). **Fig. 2** shows the extent of potable water reduction that can result from onsite graywater recycling. Onsite graywater recycling could displace ~50% of the irrigation water and reduce daily potable water use by 27% to 970 L/day in a single-family home. On the other hand, onsite graywater recycling would satisfy the water demand for both irrigation and toilet flushing and reduce potable water consumption by 38% to 500 L/day in a household living in a multifamily dwelling. The estimated available graywater in the City of Los Angeles is equivalent to be ~25% of its 2013 water supply.

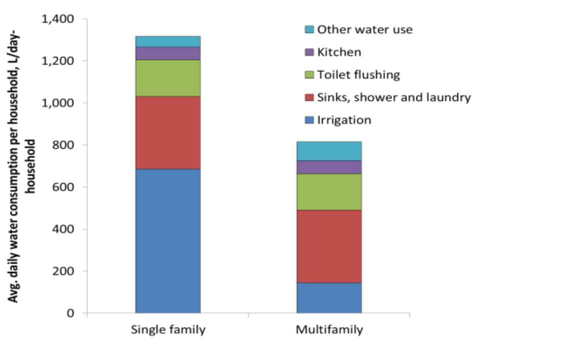

Figure 1 Drinking water demand in a typical 3-person single family household and in a multifamily dwelling.

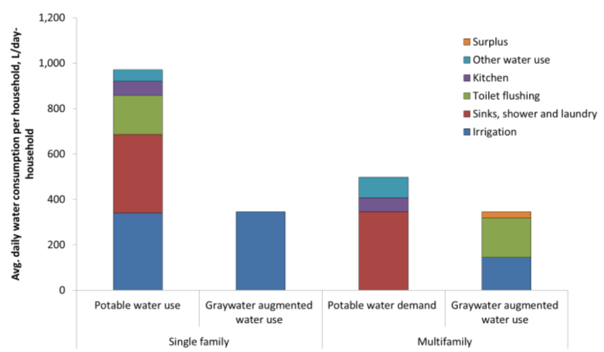

Figure 2 Potential reduction in potable water demand achievable b onsite graywater recycling in single and multifamily homes in Los Angeles.

Cost-benefit analysis of onsite recycling for residential homes

Graywater treatment cost is a combination of system capital and recurring O&M costs, as well as the cost of financing if required. Low-cost treatment systems would be preferred for residential deployment. Small treatment systems that are commercially available for single-family can vary in cost between $6,000 and >$13,000 for treatment capacity range of 1.2 – 1.6 m^3/day (EMRC, 2011). Operational cost includes mainly electricity, and possibly chemicals depending on the treatment technology. In addition, periodic maintenance visits may be required and can be in the range of $200-$900 per year (GHD Australia Pty Ltd., 2012). It is expected that vertical wetland (Yu et al., 2013b) for graywater recycling would be lower cost in the range of $1,500-$2,500 for treatment capacity of up to 2.1 m^3/day. It is estimated that such wetlands would require only low-cost biannual maintenance visits (cost $150/year).

In order to evaluate the achievable cost-saving provided by residential graywater treatment systems, the low-cost vertical wetland treatment (Yu et al., 2013b) and a typical commercial treatment system of \$7,000 are used for comparison. The commercial system is a submerged attached growth biological treatment system with sand filtration as post-treatment (NSW Health Dept, 2011). The annual maintenance cost is ~\$430/year (Nubian Water System, 2014). The annualized cost-saving from graywater recycling using these two treatment systems with an average service lifetime of 15 years without financing was assumed and is calculated using **Eq. 2**.

$$Cost - saving = \alpha W \cdot V_d - \frac{P}{Y} - \alpha E \cdot R \cdot V_d - M \qquad (2)$$

in which P is the system capital costs (\$), Y is the service lifetime (year), W is the water rate (\$/m^3), V_d is the daily volume to be treated and reused (m^3/day), E is the daily power consumption (kWh/m^3), R is the electricity rate (\$/kWh), α is the conversion factor (356 days / year), and M is the annual maintenance cost (\$/year).

The wetland treatment system provides greater cost-saving than the higher cost commercial treatment system (**Fig. 3**). The annual cost of the wetland system with maximum treatment capacity of 2.1 m^3/day is ~\$420 with \$170 attributed to depreciation of the treatment system over a service lifetime of 15 years. In contrast, the annual cost for a commercial system with maximum treatment capacity of 1.2 m^3/day, without financing, is ~\$1,000 with \$470 attributed to depreciation of the treatment system over a service lifetime of 15 years. The annual cost of treatment would be less than paying water and sewer charges if recycling is >60 m^3/year or 165 L/day when using the lower cost wetland treatment system. Clearly, the economy of scale is important (**Fig. 3**). Given that a typical 3-resident home generates ~130 m^3/year, the cost from water savings would be sufficient to offset the cost of treatment and would be lower than not having graywater recycling. Net savings can be achieved in low-density multifamily homes because their treatment volumes likely exceed 130 m^3/year. In contrast, graywater treatment cost using the more expensive commercial system for a 3-person residential home (treating ~130 m^3/year) is expected to be higher than paying the current City water and sewer charges. For the commercial system, recycling 310 m^3/year of gray water is required to recover the operating and capital cost. The analysis suggests that treatment systems that have higher capital and annual maintenance costs may only be economically feasible for dwellings large than single family.

Local building codes are likely to affect home plumbing retrofitting costs associated with diversion of graywater to the treatment systems. Costs for graywater plumbing retrofit will increase when one needs to intercept graywater before it mixes with black water and divert it to a single location for connecting to a treatment system. When treated graywater is reused indoors, (e.g. toilet flushing or laundry machines), a separate plumbing system for non-potable water distribution must be installed, thereby to the cost of retrofitting. Another retrofitting cost may involve distribution system for irrigation with treated graywater.

The cost for residential retrofitting will depend on various factors. Analysis of retrofitting costs was based on the cost factors presented in **Table 2**; these cost factors are expected to have some degree of site-specific variability. **Fig. 4** shows that the costs of different types of retrofitting of existing buildings. Six building types are evaluated: 1) a one-story single-family houses with two bathrooms built on raised foundations, 2) the same house but built on a concrete slab, 3) the same house but is under construction, 4) a two-story multifamily building with 9 bathrooms and 6 units built on raised foundations, 5) the same building but built on a concrete slab, 6) the same building but is under construction. The cost of installing graywater collection and distribution systems in new construction is assumed to be negligible, thus only material cost is considered.

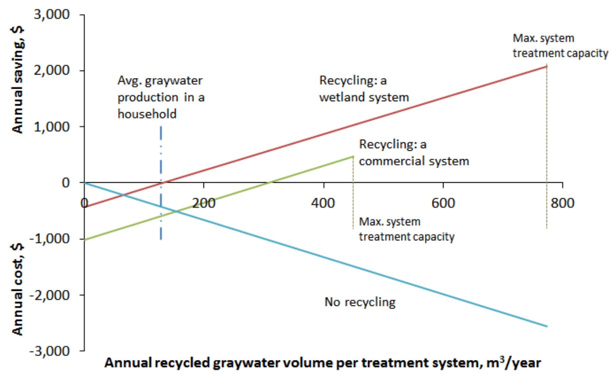

Figure 3 The relationship between annual cost-saving of total graywater recycled annually using of two treatment systems acquired without financing.

Table 2 Parameters used for estimating the cost of installing collection and distribution systems for graywater recycling.

Collection system			
Material cost	**Material Cost**		
ABS pipes, fittings, valves, $/ bathroom +laundry machine	120		
Labor costs	**Plumber**		**site worker**
hourly rate, $/hour	65		25
Retrofitting labor hours	**1st 2 bathroom**	**Each additional bathroom**	**Laundry**
With crawl space, hr	4	1.5	2
On concrete slab, hr	16	8	8
Outdoor distribution system for Irrigation (yard size: 19 m^2)			
Labor hours	**Plumber**	**Site workers**	
Subsurface irrigation, hr	16	25	
Connecting to existing irrigation system, hr	8	0	
Indoor distribution system for toilet flushing			
Materials	**1st 2 toilets**	**Each additional toilet**	
PVC pipes, fittings and pump, $	920	80	
Total labor hours	**1st 2 toilets**	**Each additional toilet**	
With crawl space	8	4	
On concrete slab	16	8	

It should be recognized that indoor recycling increases the overall cost of graywater recycling, and new construction are less expensive than retrofitting. Therefore, the most favorable conditions for graywater recycling will be for new construction with recycling only for irrigation. The above findings demonstrate the importance of anticipating the plumbing requirements in new buildings in order to reduce retrofitting costs. The City of Tucson Arizona requires residential construction to provide plumbing for facilitating onsite graywater reuse (City of Tucson, 2008). At present, California only requires multifamily dwellings and commercial buildings to install dual plumbing for the supply of portable and recycled water (California Building Standards Commission, 2010). However, it does not require plumbing installation for graywater diversion for onsite recycling in all buildings. The absence of such building requirement means that retrofitting cost for graywater recycling will remain high.

In addition to the need for including graywater recycling plumbing in new construction, selecting plumbing materials to facilitate retrofitting will also reduce cost. The results presented in **Fig. 4** are based on the use of plastic pipes and fittings. Retrofitting costs are expected to increase if metal pipes and fittings are required for the collection and distribution of graywater. California only allows plastic pipes and fittings to be used in single-family or residential buildings that are two-stories or less for fire safety reasons (California Building Standards Commission, 2010). The cost for retrofitting larger residential buildings will be even more expensive due to higher labor and material costs.

Cost benefits of graywater recycling for water and wastewater agencies

Graywater recycling can provide the City with greater water supply reliability and reduce the energy demand for water supply and wastewater treatment (WWT). As shown in **Fig. 5** water supply from MWD has the highest energy density of 2.3 kWh/m^3 as compared to other existing water sources. The energy density for water imported via the LA Aqueduct is unusually low because the water source is located at high elevation and flows to the City by gravity. Onsite graywater treatment using a vertical flow wetland is estimated at 1.2 kWh/m^3. The energy required for graywater recycling is much lower than energy of water purchased from MWD and relative to centralized wastewater treatment. Onsite graywater recycling offers an opportunity to lower energy footprint related to water supply and treatment.

Considerations of the energy that could be conserved by graywater recycling (**Fig. 6**) suggest that even at a low population participation rate of 1% (i.e. equivalent to 2% of the 3-resident single-family home units), the City could reduce water supply and treatment related energy use by 4,300

MWh/year, while reducing potable drinking demand by 0.2% and wastewater loading to centralized WWT plants by 0.3%. Higher participation rate, e.g. 10%, would translate to ~43,000 MWh/year of energy saving. Such graywater recycling volume could reduce drinking water demand by 2.3% and wastewater treatment load by 3.5%. Although there are concerns that reduction of wastewater flow to centralized treatment plant could impair sewer conveyance system and wastewater treatment performance, there is very little evidence that supports or validates such concern. Given the projected annual population growth rate of 0.4% for the City for the next 20 years (LADWP, 2011), the City's centralized treatment plants may benefit from graywater diversion by reducing its daily peak loads, maintaining a relatively stable wastewater treatment loading and hence avoiding the cost of expansion.

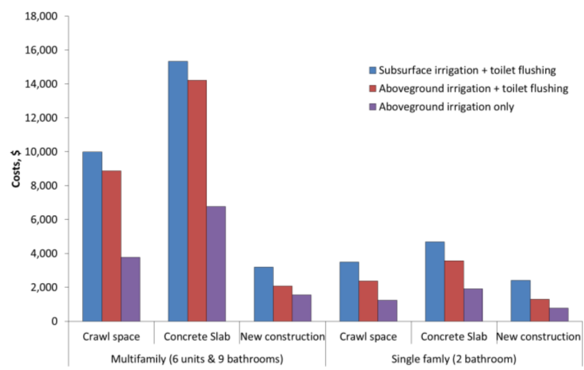

Figure 4 Construction costs for providing plumbing for raw graywater collection and recycling for indoor and outdoor reuse or outdoor only water reuse.

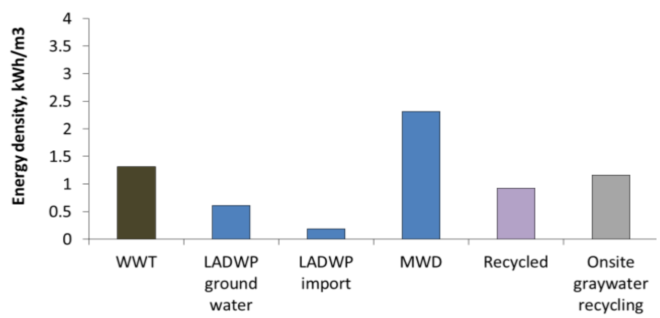

Figure 5 Energy density of wastewater treatment (WWT) and other potable and non-potable water sources. Sources for energy density data WWT including conveyance were from (GEI Consultants and Navigant Consulting, 2010a); for LADWP groundwater, LADWP import, MWD and recycled water after secondary treatment were from (LADWP, 2011); for onsite graywater recycling using vertical flow wetland were from(Yu et al., 2013b).

It is instructive to compare the cost of potable and non-potable water supply (LADWP, 2011) relatively to the cost of onsite graywater treatment using a low-cost vertical flow wetland system (Yu et al., 2013b). The costs of potable water sources are lower than non-potable water sources. Rainwater and storm water can be an important source to supplement non-potable water supply during the short rainy period, but it is an expensive and not a sustainable water source throughout the year. In this regard, the cost of graywater recycling of \$0.5/m^3 (**Fig. 7**) using a low cost treatment system would make graywater recycling competitive against other non-potable options, including centralized water recycling. The current cost of water from MWD (with a median cost of ~\$0.6/m^3) is higher than all other potable water sources including onsite graywater recycling, and its cost is expected to rise further in the future.

In order to estimate the potential water cost increase for MWD water supply in the future, and a cost project analysis was conducted. MWD sells two tiers of water, Tier 1 and Tier 2, which can be purchased as treated or untreated. Between 1995 and 2014, the prices for these four types of water have increased at an average annual rate of 3-5% (MWD, 2014). Based on such annual rate increase, the projected treated water supply cost could exceed \$2/m^3 by 2035. Between 2003 and 2010, LADWP annual purchased water averaged ~29% from Tier 1 untreated water, 61% from Tier 1 treated water, 8% from Tier 2 untreated water and 2% from Tier 2 treated water (KPMG, 2004-2011). Assuming that LADWP will continue purchasing the same percentage for each water type from MWD, the average water cost for LADWP could be as much as \$1.2/m^3. Such high price makes graywater a more competitive alternative water source for non-potable use. As technology improves and building regulations change, the cost of graywater recycling could even be lower, and reliance on

MWD purchases could be reduced. Reduced dependence on MWD may be important because diminishing water resources in the Bay Delta region and Colorado River, as well as environmental concerns may all impact MWD's ability to provide a reliable water supply to its member agencies.

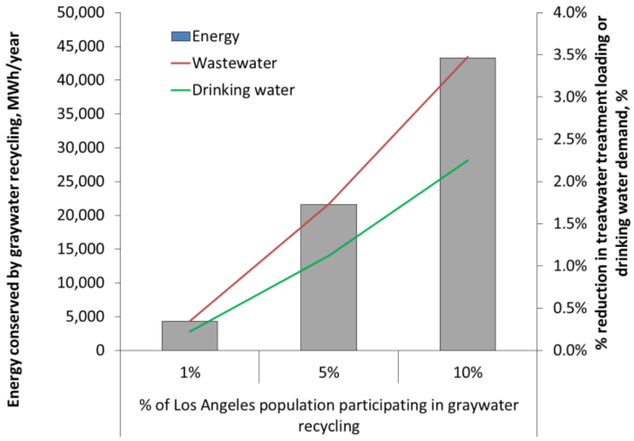

Figure 6 Energy saving, and potable water demand from MWD and wastewater loading to wastewater treatment plant reduction resulting from onsite graywater recycling.

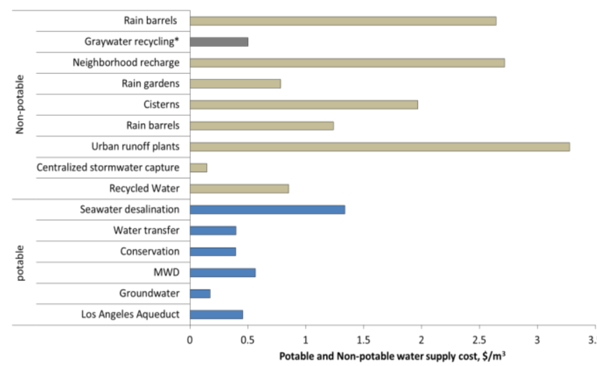

Figure 7 Median potable and non-potable water supply option cost to LADWP (LADWP, 2011). The cost of graywater recycling was calculated based on gross treatment cost before factoring in water savings and the cost of retrofitting (Yu et al., 2013b).

Economic drivers for fostering onsite graywater recycling

The information presented above suggests that onsite graywater recycling can provide both economic and environmental benefits to the City. However, in order to encourage adoption of onsite graywater recycling, financial barriers of graywater recycling that include system capital cost, and maintenance and retrofitting costs must be lowered. High upfront costs of retrofitting and system capital costs are the greatest barrier for property owners. Rebates for onsite graywater recycling are not available for residential homes (LADWP, 2012). If rebates for residential homes existed, the size of the rebates must be significantly large to make an impact on the overall cost. In this regard, it is noted that in Australia, rebates were provided rebates of up to $500 or half the project cost for graywater recycling (DoE Australia, 2014) when the least cost treatment option was ~$6,000 (EMRC, 2011). Unless rebates are relatively large, alternative financing may be needed.

An alternative way to overcome the upfront costs for purchase and installation of graywater treatment system is to use the third-party ownership model that is widely used for financing the onsite solar power generation in the residential sector (Coughlin and Cory, 2009). This model could allow commercial project developers to finance the capital and retrofitting costs of the treatment system and assume maintenance responsibilities. Homeowners will assume no upfront cost or responsibility of maintaining the treatment system but will agree either to pay a monthly leasing fee or to use the resulting water cost savings from graywater recycling as the lease payment. A second reason for adopting the third-party ownership model is that, as in the solar sector, large developers may be in better position to leverage financial subsidy programs offered by the Federal, State and local governments, which otherwise would be unavailable to individual property owners.

In addition to lowering the upfront system capital and installation costs, a third-party ownership program could provide a solution for the management of onsite treatment systems, which is a major implementation barrier for onsite graywater recycling. If a project developer assumes the responsibility of operational and maintenance cost for the treatment system (during the service agreement period), government agencies will be in position to require maintenance records and water quality data to ensure treatment performance that meets required standards for aboveground non-potable reuse. It is interesting to note that the Australian government requires homeowners to retain approved contractors for the services and maintenance of their onsite graywater recycling systems (EMRC, 2011). Such a program can also be implemented for those homeowners who choose to own their treatment systems instead of leasing from a developer.

Conclusions

The cost and environment benefits of onsite graywater recycling in single-family and low-density residential dwellings have been evaluated using the City of Los Angeles as an example. Graywater recycling can increases the City's ability to reduce potable water consumption, in addition to lowering water supply and treatment-related energy demand. Graywater recycling can reduce the City's potable water consumption by 27% for single-family homes, and by 38% for a multifamily dwelling. At even 1% population participation, the City will be able to reduce water supply and treatment related energy by 4,300 MWh/year. Graywater recycling will reduce potable water demand by 0.2% and wastewater treatment load by 0.3% at such a participation rate.

Amending local building codes to require new constructions to include plumbing to divert graywater for reuse will be important for adoption of residential graywater recycling by homeowners. There are multiple ways that the City can lower financial barriers to adoption of graywater recycling to its residents including: 1) providing rebates to lower the upfront system and retrofit costs, 2) providing low or zero interest financing for system purchase and installation to property owners and allow them to repay through their utility bills, and 3) providing financing incentives to attract investors or developers to provide onsite graywater recycling services through a third-party ownership model. The added benefits for a third-party ownership model are that developers will assume responsibility for regular service and maintenance of the treatment systems to ensure treatment performance and regulatory compliance. In cases where homeowners own their treatment systems, a regulatory requirement for certified service contractors can be implemented.

References

California Building Standards Commission (2010) 2010 California Plumbing Code. Commission, C.B.S. (ed), International Association of Plumbing and Mechanical Officials, CA, USA.

City of Tucson (2008) Residential Gray Water Ordinance. City of Tucson, A. (ed), The City of Tucson, Arizona Tucson, Arizona.

Coughlin, J. and Cory, K. (2009) Solar Photovoltaic Financing: Residential Sector Deployment, National Renewable Energy Laboratory Golden, CO.

DeOreo, W.B. (2011) Analysis of Water Use in New Single Family Homes, Aquacraft Water Engineering & Management.

DeOreo, W.B. and Hayden, M. (2008) Analysis of Water Use Patterns in Multifamily Residence, Aquacraft, Inc Water Engineering and Management.

DoE Australia (2014) National Rainwater and Greywater Initiative, Department of the Environment, Australia Government Parkes.

EMRC (2011) Reuse of Greywater in Western Australia, Eastern Metropolitan Regional Council Belmont, , Western Australia.

Friedler, E., Kovalio, R., Galil, N., Mathew, K. and Ho, G. (2005) On-site greywater treatment and reuse in multi-storey buildings. 51(10), 187-194.

GHD Australia Pty Ltd. (2012) Yarra Valley Water Report for North Warrandyte Sewerage Backlog: Alternative Options Assessment.

Hanak, E. and Davis, M. (2006) California Economic Policy: Lawns and Water Demand in California. Hanak, E. and Neumark, D. (eds), Public Policy Institute of California San Francisco

KPMG (2004-2011) Los Angeles Department of Water and Power: Water System Financial Statements. LLP, K. (ed), KPMG LLP, Los Angeles

LADWP (2011) Urban Water Management Plan 2010, Los Angeles Department of Water and Power, Los Angeles.

LADWP (2012) Go Green - Graywater Los Angeles Department of Water and Power, Los Angeles.

MWD (2014) Water Rates, Metropolitan Water District of Southern California, Los Angeles

NSW Health Dept (2011) Certificate of Accreditation of Nubian GT600 DGTS.

Nubian Water System (2014) Greywater Treatment and Recycling Nubian Water Sydney.

U.S. Census Bureau (2011) American Community Survey

Yu, Z.L.T., Rahardianto, A., DeShazo, J.R., Stenstrom, M.K. and Cohen, Y. (2013a) Critical Review: Regulatory Incentives and Impediments for Onsite Graywater Reuse in the United States. Journal of Water and Environment Research 85(7), 650-662.

Yu, Z.L.T., Stenstrom, M.K. and Cohen, Y. (2013b) Pilot Evaluation of Compact and Modular System for Point-of-Use Graywater Treatment, Metropolitan Water District of Southern California, Los Angeles.