A route to a resourceful water efficiency exploration: Residential Water usage of Water Efficiency section of USGBC, LEED Program

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A project of water usage was assigned to the freshman students of Architectural and Construction management of the State College in fall 2009. In this project all students recorded their water usage for seven days and were able to calculate their average consumption of water per day. The results of this assignment were analyzed by students using Excel software statistical package. The goal of this project was to alert the students to water efficiency which is one of the categories of (LEED) Leadership in Energy and Environmental Design. Residential buildings are major users of potable water supply and the bathrooms are usually the smallest room in the household but using the most water so the focus of project was on the fixtures in bathroom. Therefore awaking the students to usage of water is a big step toward water conservation. "According to the United States Environmental Protection Agency (EPA) upgrading toilets can save up to 11,000 gallons of water per household per year and, up to two billion gallons of water per day national wide”![5]

Introduction:

Water is a limited resource that is essential to all life. There is a demand for expanding freshwater resources to provide drinking water for increasing population, in the mean time preventing pollution and leaving enough water for natural ecosystem functions. These combined describe the need for sustainable water resources. A recent government survey showed at least 36 states are anticipating local, regional, or statewide water shortages by 2013. This is the reason that water becomes a national priority. Water efficiency will be 21st century growth industry. Water Efficiency programs have an established track record as cost effective long term public resource investments. The water and energy sectors are highly interdependent. Water utilities and water customers use enormous amounts of energy to withdraw, treat, and distribute water. Thus, saving energy becomes one of the most compelling reasons to save water. Both water and energy efficiency reduces other negative externalities as well[9]. LEED Leadership in Energy and Environmental Design is a rating system developed by United State Green Building Institute. LEED v3 is subdivided into seven groups for which there are prerequisites, subcategories, and credits in place of possible points. The seven categories are: Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Material and Resources (MR), Indoor Environmental Quality (EQ), Innovation in Design Processes (ID) and Regional Priority (RP). Water efficiency is one of these categories. Buildings are major users of our potable water supply. The goal of the Water Efficiency credit category is to encourage smarter use of water,

inside and out[12]. Water reduction is typically achieved through more efficient appliances, fixtures and fittings inside and water-wise landscaping outside.
The concept of sustainability is defined by John Ehrenfeld as “the possibility that human and other forms of life will flourish on the planet forever.” Sustainable engineering makes resources useful for future and current generation in useful ways. Green engineering is the design and implementation of engineering solution that takes environmental issues into account throughout the life cycle of the design[7]. Based on Anastas and Zimmerman, 2003 there are twelve principals for green engineering[11]. In general the terms that would be related to our topic are as follow:

- It is better to prevent waste formation than to treat it after it is formed.
- Separation and purification operations should be designed to minimize energy consumption and material use
- Embedded entropy and complexity must be viewed as an investment when making design choices on recycle, reuse.

In common, buildings and infrastructures have different points that are one of the most important aspects in sustainable engineering[9]. There are couples of reasons such as their long lives, and designed in place which usually are one time design and etc. As a result each project is an opportunity for a unique contribution to responsible technology and sustainability. Water infrastructure use large amount of energy and large quantity materials[8]. Such characteristics provide strong motivations for water use and for dedicated maintenance in order to limit the amount of water needed and the amount of water lost[10].

Green Buildings:

As with all products buildings are repositories of materials and represent the energy consumed to prepare those materials for use. On the ongoing basis buildings are responsible for 30-40 % of energy use and 15-20 % of water use worldwide[8]. Environmental Protection Agency EPA defined green buildings as “ the practice of creating structures and using processes that are environmentally responsible and resources efficient throughout a buildings’ life cycle from sitting to design, construction , operation, maintenance , renovation and deconstruction.” The emphasis is on the careful choice and efficient use of materials, energy and water and the minimization of environmental outcomes of all types. Green Buildings design avoids the traditional architecture approach of setting up firm barriers with the outside world. The Green goal is to take advantage of local resources when is possible such as using natural light instead of artificial light, outside air circulation rather than heating or air conditioning , solar power and so on. As a result energy usage is less; water is recycled and reused in different ways[1].
All of these details of green buildings design are gathered at least in the principal set by the Leadership in Energy and Environmental Design (LEED) of the Green Building Rating System, developed by the U.S. Green Building Council (USGBC). There are several other green rating systems but the LEED system, Australia’s green star system and the alternative Green Globes system are the most well-known. Green Globe Initiative (GBI) is based on the system developed in Europe and later also used in Canada. LEED was formed to define green building by creating a common standard of measurement, promote integrated, whole-building design practices, and recognize environmental leadership in the building industry, stimulate green competition, raise consumer awareness of green building benefits and transform the building market. The LEED 2009 Green Building Rating System for New Construction and Major Renovations is a set of performance standards for certifying the design and construction of commercial or institutional

buildings and high-rise residential buildings of all sizes, both public and private. The intent is to promote healthful, durable, affordable, and environmentally sound practices in building design and construction. The rating system is subdivided to seven categories: Sustainable sites (SS), Water efficiency (WE), Energy and atmosphere (EA), Materials and resources (MR), Indoor environmental quality (EQ), Innovation in design (ID) and Regional Priority (RP). Different LEED versions have varied scoring systems based on a set of required "prerequisites" and a range of "credits" in the seven major categories. Based on USGBC LEED 2009 (v3) there are 100 possible points plus an additional 6 points for Innovation in Design and 4 points for Regional Priority[12]. Buildings can qualify for four levels of certification:

- Certified - 40-49 points
- Silver - 50-59 points
- Gold - 60-79 points
- Platinum - 80 points and above

Water Efficiency:

Clean water is a natural resource which is critical to humans, plants and animals that is being rapidly depleted due to pollution and human population growth. Water efficiency means the reducing usage of water and reducing waste. Efficiency is reducing not restricting. Well designed buildings use water efficiency to decrease waste. Efficient water delivery systems incorporate strategies to reduce the amount of water used while maintaining a high standard of performance[4]. Water efficient steps are including fixing leaking taps, taking showers rather than baths, installing displacements devices inside toilet, using low-flow faucet and using dishwashers and washing machines with full loads. The Water Efficiency (WE) portion of the LEED deals with issues that reduce the use of potable water at the site and discharge of wastewater from the site. This will help limit the amounts of freshwater drawn from our water bodies and treated for distribution and use which damage our freshwater resources. Another purpose is to reduce the wastewater volumes discharged to these receiving bodies. The objective of water use reduction is maximizing water efficiency within buildings to reduce the burden on municipal water supply and wastewater systems. Based on prerequisite 1 Water Use Reduction, 20% Reduction is required. Credit 1.1 Water Efficient Landscaping, Reduce by 50% ,Credit 1.2 Water Efficient Landscaping, No Potable Use or No Irrigation, Credit 2 Innovative Wastewater Technologies Credit 3 .1 Water Use Reduction, 30% ,Credit 3 .2 Water Use Reduction, 35% and Credit 3 .3 Water Use Reduction, 40% at least Credit 4 Process Water Use Reduction, 20% . The definition of these prerequisites are as follows: Potable Water is meets or exceeds EPA’s drinking water quality standards, Process Water is used industrial processes and building systems such as cooling towers, boilers, and chillers. Blackwater is wastewater from toilets and urinals. Some state and local codes consider wastewater from kitchen sinks, showers, and bathtubs as blackwater. Greywater must be processed before reuse to meet standards of the federal Department of Health and Human Services[12]. Once the water has reached an acceptable level of quality, it can be reused for site irrigation and potentially for building use. In general we can obtain this aim by using high efficiency fixtures, dry fixture such as composting toilet systems and non water using urinals, and occupant sensors to reduce the potable water demand.

Methodology:

A project of water consumption was assigned to the freshman students of Architectural and Construction management of the State College in fall 2009. At the beginning of the project the attention of students were gathered toward the significance of water efficiency. To have better perspective of the water efficiency the usage of water in their houses especially in the bathroom was the target. There are three main fixtures in the bathroom including toilet, showerhead and faucet. The following questions were asked from students:

- A typical toilet built before 1994 uses about 4.5 to 6 gallons of water per flush; the number of person flushes in the home is about 4 to 5. How many gallons of water are per month for a family of 4? Now if we install a low-flow toilet that uses 1.6 gallons of water per flush, how much water can be saved in a month? What about in a year? How much energy, money will be saved for Long Island that has almost 7.5 million people population.
- Faucet water flows at about 2 gallons per minute, how much water can be saved by turning off the water for example when we are brushing our teeth? Or comparison of the high efficiency faucet versus non high efficiency faucet.
- Knowing the shower head has a water flow of 4 gallons per minute and using water saving faucet will save 45% over the older ones. In addition taking shower even one minute shorter, or taking shower versus bath, comparing all of these conditions how much water could be saved for the Long Island population?

After critical thinking about the water efficiency by using practical examples of the daily life, students suppose to monitor their water usage in a week and showing the data in excel programming. The following tables which are based on the usage of water in bathroom handed to students for data collection. The table is used as following:
<u>Faucet column</u>: record number of minutes per faucet per day. For calculating the total number of gallon per person per day two things should be considered, if the faucet is not high efficient, multiply each number of minutes by 2.2 which equals the maximum number of gallon per minutes for an average faucet. On the other hand, if a high efficiency or Water Sense labeled faucet was used then multiply the total number of minuets by 1.5 (maximum number of gallon per minutes used by most high efficiency faucets).
<u>Shower column</u>: record number of minute of the shower per day. For the regular shower head multiply total minutes by 2.5 and for a high efficiency shower head total number of minutes of use for the shower multiply by 1.5.
<u>Toilet column</u>: record the number of times that you are the first thing is to determine the age of the toilet, there are 4 different categories based on the water usage per flush:

- If the toilet was made before 1982, number of times the toilet is flushed each day, should by multiplied by 6.
- If the toilet was made between 1983 and 1993 multiply the number of flushes per day by 3.5.
- If the toilet made after 1994 multiply the number by 1.6.
- For a Water Sense-labeled toilet multiply the number of flushes by 1.28.

Results and Discussion: Seventeen freshman students of Construction Management and Architectural Department recorded their water consumption for one week. Tables 1 to 3 show the total number of minutes per fixture per week and the average number of gallons of water used per person per day. Table 1 reports water usage of faucets indicating a range of 4 – 30 gallons per person per day. Table 2 lists water usage for showers ranging from 16 – 116, and Table 3 shows toilets water usage ranging from 1.5 to 20 gallons per day per person. As it shows in Table 3 the last 3 students had a water sense labeled toilet which shows significant difference with the others.

7 Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Faucet																	
1st	25	35	30	12	7	3	11	22	12	14	22	12	7	20	26	25	14
2nd	7	42	39	4	8	5	10	18	16	20	21	6	4	20	22	19	18
3rd	7	20	24	11	9	12	13	20	18	18	23	6	13	24	23	20	15
4th	21		17				12	6		10		5		12	9	9	
5th			20														
Total # of minutes per week	**60**	**97**	**130**	**27**	**24**	**20**	**46**	**66**	**46**	**62**	**66**	**29**	**24**	**76**	**80**	**73**	**47**
Total # of gallons per week	**132**	**213**	**286**	**40**	**36**	**30**	**101**	**145**	**101**	**136**	**145**	**64**	**53**	**167**	**176**	**161**	**102**
Average # of gallons per person, per day	**19**	**30**	**41**	**6**	**5**	**4**	**14**	**21**	**14**	**19**	**21**	**9**	**8**	**24**	**25**	**23**	**15**

Table 1- Water usage per person per day for faucets examined by students.

The average US household uses about 60-70 gallons per person per day based on Department of Environmental Protection data[6]. Based on our students observation per one week the total amount of water used for all the fixtures was 1344 gallons divided by 17 students will give us 79 gallons per person per day which is not that far from the reported DEP data. This is 7 times the average of water consumption per person per day by the rest of the world[3]. According to the World Health Organization, a good health and cleanliness require a total daily supply of about 8 gallon of water per person per day[2]. While some of the numbers seemed out of range and non-realistic, the whole experience generated a positive discussion on water usage in residential buildings. Students who were by this time familiar with the importance of water scarcity in the near future, appreciated the experience and discussed ways and means of better use of water and avoid wasting it.

7 Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Shower																	
1st	25	29	25	35	25	25	8	10	10	40	17	20	10	35	41	15	15
2nd	15	18	25	42	27	25	7	10	10	40	20	30	15	29	55	12	14
3rd	24	16	25	35	35	17	6	12	10	20	30	20	5	27	45	27	18
4th	23	15				25	8	17	10	40	15	23	15	25	50	20	15
5th	27	18					7		10	25	22	25	10	27	49	25	15
6th	28	18					8		10	30	16	32		25	55	20	18
7th										20	31	45		24	29		
Total # of minutes per week	**142**	**114**	**75**	**112**	**87**	**92**	**44**	**49**	**60**	**215**	**151**	**195**	**55**	**192**	**324**	**119**	**95**
Total # of gallons per week	**355**	**285**	**188**	**168**	**131**	**138**	**110**	**123**	**150**	**538**	**378**	**488**	**138**	**480**	**810**	**298**	**238**
Average # of gallons per person, per day	**51**	**41**	**27**	**24**	**19**	**20**	**16**	**18**	**21**	**77**	**54**	**70**	**20**	**69**	**116**	**43**	**34**

Table 2- Water usage per person per day for showers examined by students.

7 Days	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Toilet																	
1st	7	6	9	9	7	8	4	4	4	4	6	6	4	5	2	2	2
2nd	7	6	6	8	8	9	4	7	5	3	6	6	9	10	2	2	2
3rd	8	7	9	8	4	4	3	12	7	5	8	5	3	10	2	2	2
4th	5	4		10	4	6	7	1	4	8	4	3	6	5	2	2	2
5th					5	4	4	4	4	5		3		5			
6th								5		4							
7th	7	6	9	9	7	8	4	4	4	4	6	6	4	5	2	2	2
Total # of minutes per week	**27**	**23**	**24**	**35**	**28**	**31**	**22**	**33**	**24**	**29**	**24**	**23**	**22**	**35**	**8**	**8**	**8**
Total # of gallons per week	**162**	**138**	**144**	**210**	**168**	**186**	**132**	**198**	**144**	**174**	**144**	**138**	**132**	**210**	**10**	**10**	**10**
Average # of gallons per person, per day	**23**	**20**	**21**	**30**	**24**	**27**	**19**	**28**	**21**	**25**	**21**	**20**	**19**	**30**	**1.5**	**1.5**	**1.5**

Table 3- Water usage per person per day for toilets examined by students.

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