Estimating Energy Savings and Greenhouse Gas Emissions Reduction through Substitution of Penn State Harrisburg's Water Source

Natalie Neptune
Penn State Harrisburg
Department of Civil Engineering

Abstract

- Project Drawdown highlighted the energy required to distribute drinking water to customers and noted that system operational improvements.
- Locally harvested rainwater and air-conditioning condensate, by replacing non-potable use water from a distant treatment plant, may reduce the energy required for treating and pumping water.
- This feasibility study assesses the potential of water capture and reuse at Penn State Harrisburg, based on potential end uses of the harvested water and needed levels of treatment.
- The feasibility analysis addressed the question of whether water capture and reuse can reduce the embedded carbon emissions of drinking water used on campus when compared to pumping potable water several miles for non-potable and potable uses.
  - Economically, this may not currently be feasible.
- On a positive note, it is estimated that 9,250 lbs. of carbon dioxide emissions can saved through harvesting rainwater and using it where treatment is not needed. Condensate harvesting, in contrast, may have a negative carbon cost of an estimated 9,400 lbs. of carbon dioxide emissions from the harvesting equipment.
- Penn State Harrisburg's lack of need of the water for irrigation and having the existing piping system in place reduces the benefits of rainwater harvesting on campus. Rainwater harvesting, however, should be explored in areas with less rainfall or longer inter-event periods, especially in conjunction with new development.

Objective

- This study will analyze the feasibility of rainwater and condensate harvesting on campus by addressing whether water capture and reuse using a conventional harvesting system (Figure 1) can reduce carbon emissions on campus when compared to pumping potable water several miles for non-potable & potable campus uses (Figure 2).

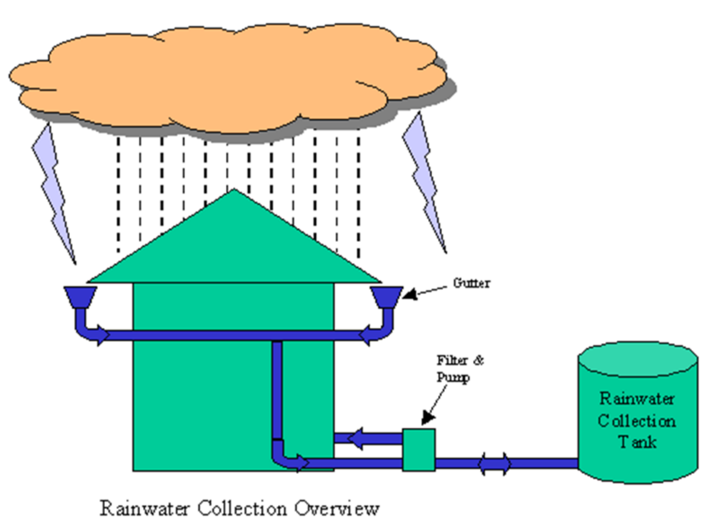

Figure 1. Rainwater harvesting system. www.kadvacorp.com/wp-content/uploads/2016/06/AnimatedRainwater.gif

Figure 2. Distance from Highspire Drinking Water Treatment Plant to Penn State Harrisburg. This is a distance of less than 12 miles. (Google Earth®)

Significance

- To reduce the environmental footprint of the campus through the practice of capture and reuse of water
- To spread the awareness of potential of water reuse regionally, using the campus as a case study

Conclusions

- The campus' established water-distribution infrastructure and currently-sufficient rainfall to preclude a need for a water source for irrigation reduces the potential benefit of modifying the campus to capture rainwater.
- The benefit analysis may improve for new construction.
- Future research could address the feasibility of targeting a limited harvesting system on campus where non-potable water is needed and currently being supplied by city water.

Acknowledgements

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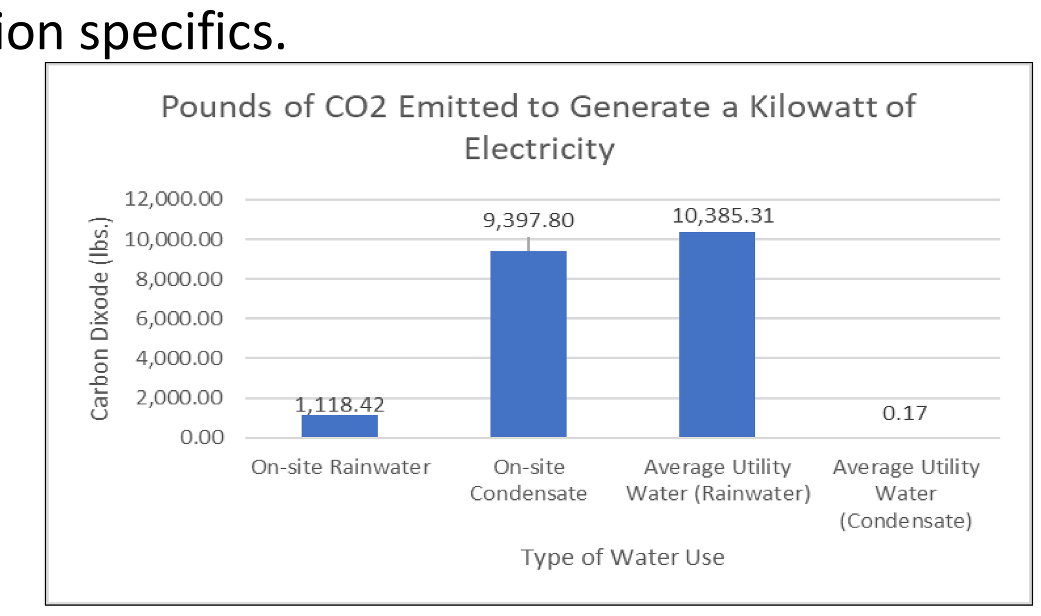
Method

- This study calculated (1) the water usage on campus, using student population numbers, (2) the amount of stormwater available to be captured, and (3) the amount of condensate to be captured.
- This study then compared the energy cost in terms of fueling these systems using natural gas.
- A HVAC condensate calculator was used along with approximal data on the values. Carbon values were averaged as emissions vary based on region's power-generation specifics.



- Figure 3: Energy Produced Using Rainwater or Condensate Harvesting. (Lancaster, 2011)

Total Gallons of Non-Potable Water for Residental Students					
Type of Water Use	How Many Times Per Day	Duration (min)	Amount of Water (per use)	People (per person)	Total
Hand Washing	3	0.25	1 gal	433	324.75
Shaving	1	4	5 gal	433	8,660
Dishes	3	0.75	4 gal per min	433	3,897
Brushing Teeth	2	1	2.5 gal	433	2,165
Shower	1	5	4 gal of hot water per minute	433	8,660
Washing Machine	0.29 (2 loads per week)	7 (49 min - regular) 5.71 (40 min- delicate)	5.71 (40 per load)	433	Average at 9,113.13
Drying Machine	2 loads per week	-	-	433	-
Toilet	3	-	24 gal per day	433	2,078.40
Drinking	-	-	3 gal	433	1,299
Total					32,819.88 gallons per day (with washing machine)

Total Gallons of Non-Potable Water for Non-Resdiental Students					
Fixture Type	Duration (sec)	Amount of Water	Amount of Times (per person	People	Total
Toliet (Female)	-	1.6	3	4309	20,683.20
Toilet (Male)	-	1.6	3	2713	13,022.40
Urinal (Male)		2.5	3	2713	20,347.50
Lavatory Faucet	30	1.5	4	9735	58,410
Showers	160	8 gal per 2 min	1	507.7	4,061.60
Total					116,524.7 gallons per day

- Tables 1 & 2: Water on Campus (Reference: https://nature.berkeley.edu/classes/es196/projects/2004final/buckley.pdf)

Results

- Since irrigation was not needed, the analysis including the potable uses resulted in an estimate of approximately 250,000 gallons needed per day.
- The amount of runoff was estimated as 21,000,000 gallons per day (1-year storm). Storms occur on average every 3 days, resulting in 7,000,000 gallons available per day to empty the tank between storms, well more than needed for both non-potable and potable uses.

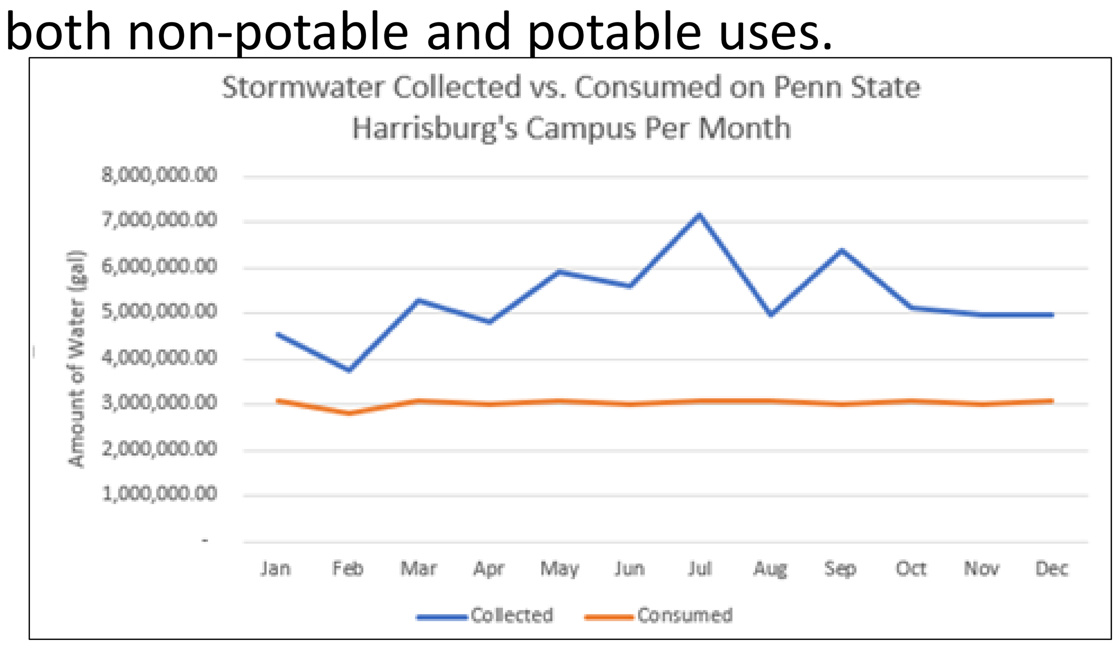


Figure 4: Total Stormwater on Penn State Harrisburg's Campus (Reference: http://www.thecenterforrainwaterharvesting.org/)

- For condensate harvesting, 23 gallons per day were calculated based on the summer months in which condensate is produced.
- Condensate harvesting was not energy beneficial: The pounds of CO_2 emitted from condensate harvesting was 9,400 lbs. Rainwater harvesting saved 9,300 pounds of CO_2, assuming that no treatment of the rainwater is needed prior to use.
- Rainwater treatment to meet drinking water standards will result in CO_2 emissions that are slightly less than getting treated water from a regional utility (pumping costs saved, but not treatment costs).

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