UNIVERSITY OF MARYLAND

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2017

reACT
TEAM MARYLAND

U.S. DEPARTMENT OF ENERGY SOLAR DECATHLON 2017

Contest 6: Water Narrative

August 10, 2017

THE VITAL NEED FOR *REACT*

The United States uses more water per person than any other country[1]. The average person in the United States consumes about 70 gallons of potable water per day for indoor uses (265 L/day) [2], and around 30 gallons per day outside (114 L/day) [3]. Generally, that water is used only once before being dumped down the drain. This level of consumption and waste is unsustainable. Aquifers throughout the U.S., and especially in the western states, are being depleted rapidly. Water quality is also suffering as a result of this excessive use. Municipal sewer systems are being overwhelmed as the population grows as well. A new model for water purification, use, reuse and disposal is needed. reACT is intended to demonstrate one solution to this important issue, a decentralized infrastructure in which dwellings, building and small communities harvest and recycle their own water.

REDUCING OUR LOAD

The first priority in any model of sustainable water use is to reduce consumption. This greatly facilitates achieving net-zero water balance through means such as rainwater harvesting and wastewater recycling.

reACT will implement commercially available low-flow fixtures: lavatory faucet, showerhead and kitchen faucet. The kitchen faucet will also be equipped with a touch on/off control to reduce the amount of waste associated with washing dishes, fruits, vegetables and other food.
(give specs on fixtures)

reACT's appliances, including the dishwasher and clotheswasher, will also be water and energy efficient. All appliances are commercially available, though some have been imported from Europe because of their higher performance standards. It is the Team's hope that exhibiting these appliances at the Solar Decathlon will create greater demand for these appliances and their domestic counterparts in the U.S. market.

Toilet flushing also represents a significant use of water. Low-flush toilets do save on water, but treat the organic matter in question as a waste product to be removed instead of as a valuable resource in the carbon cycle of the Earth. *reACT* incorporates a composting toilet with urine separation to convert this material into fertilizer for the landscape (used only on non-food plants and crops for livestock). All water normally associated with toilet flushing is also conserved.

In the landscape, water is conserved through the integration of high efficiency drip emitters which can be used to deliver precious water directly to the plants' root systems. The SmartHouse control system is designed to control irrigation based on soil moisture level and predicted weather (i.e. don't water if it is going to rain this morning). By monitoring and displaying water use vs. available resources, the SmartHouse system will also make it easier for residents to be mindful of their water use.

---

[1] Environmental Protection Agency, "Managing Wet Weather with Green Infrastructure Municipal Handbook: Rainwater Harvesting Policies," December 2008, https://www.epa.gov/sites/production/files/2015-10/documents/gi_munichandbook_harvesting.pdf.

[2] Ibid.

[3] Environmental Protection Agency, "How We Use Water," Data and Tools, (January 16, 2017), https://www.epa.gov/watersense/how-we-use-water.

Through the implementation of low-flow devices and a composting toilet as described above, *reACT* will reduce its indoor water use to less than 20 gallons (76 L) per capita per day . Total plant irrigation water demand is estimated to be ~26 gallons (99L) per day for a family of three with a small food garden.

HARVESTING AND RECYCLING TECHNOLOGIES

Most buildings not connected to a municipal water supply rely on wells which tap underground aquifers. Unfortunately, our use of fresh potable water far outstrips the recharge rate from infiltration, leading to aquifer depletion. Municipal water infrastructure is expensive to build and maintain, and often causes significant damage to the watershed. In order to avoid this serious environmental and economic impact, *reACT's* goal is to supply 100% of the home's non-potable water needs using rainfall and not well water or municipal water supplies. In some parts of the U.S., the annual rainfall is sufficient to meet that need, but in Denver, for example, the annual precipitation is only 15 inches. A 1000 sq.ft. house roof will be able to harvest 9,345 gallons per year from this level of rain and snowfall, while a family of three will consume 21,900 gallons for indoor use and approximately 5000 gallons in their garden. In the current centralized infrastructure model, all water provided for indoor uses is used only once and then flushed into the sewer or septic system. Potable water is used for irrigation, even though non-potable water would serve this function just as well, wasting energy and money for purification. *reACT* will convert what most people see as waste – water poured down the drain - into a resource (a common theme in *reACT's* design principles).

In order to change the water paradigm in this country, it is necessary to consider not only the quantity of water, but its quality. Not all uses in a household require potable water. It has been estimated that non-potable water can satisfy over three-quarters of daily water demand in the United States, potentially being used for clothes washers, toilets, and outdoor activities, such as irrigation[4]. There are also different levels of 'waste' water quality.

- Rainwater – generally the cleanest form of water (other than potable). Can be used untreated for landscape irrigation.

- Greywater – water from indoor source which does not contain biosolids like food, urine or fecal matter. Sources are lavatories, tubs and showers, and clotheswashers.

- Blackwater – water containing biosolids (see above). Sources are toilets, kitchen sinks with garbage disposals and dishwashers.

reACT will harvest and store rainwater separately from graywater and blackwater. In order to be stored for reuse, *reACT* must first filter and sanitize greywater to a quality similar to rainwater in order to prevent it from becoming 'septic'. Blackwater will be stored in a separate waste tank and will not be filtered for reuse. In a permanent dwelling application, the blackwater would be sent to a septic tank, digester or Living Machine™ for treatment before being allowed to infiltrate into the ground for eventual return to the aquifer. *reACT* includes a composting toilet with urine

[4] Peter W. Mayer et al., *Residential End Uses of Water* (American Water Works Association, 1999), http://www.sdu.dk/en/Om_SDU/Institutter_centre/ITI/Forskning/Forskningsprojekter/NATO_ARW/~/media/484CB39B4E4349AFA01FC8E3EFAF4813.pdf.

separation, which will dramatically reduce the water demand and generation of blackwater; fecal matter will be biodegraded in the composting toilet until it is safe for use as fertilizer on non-food landscape plants.

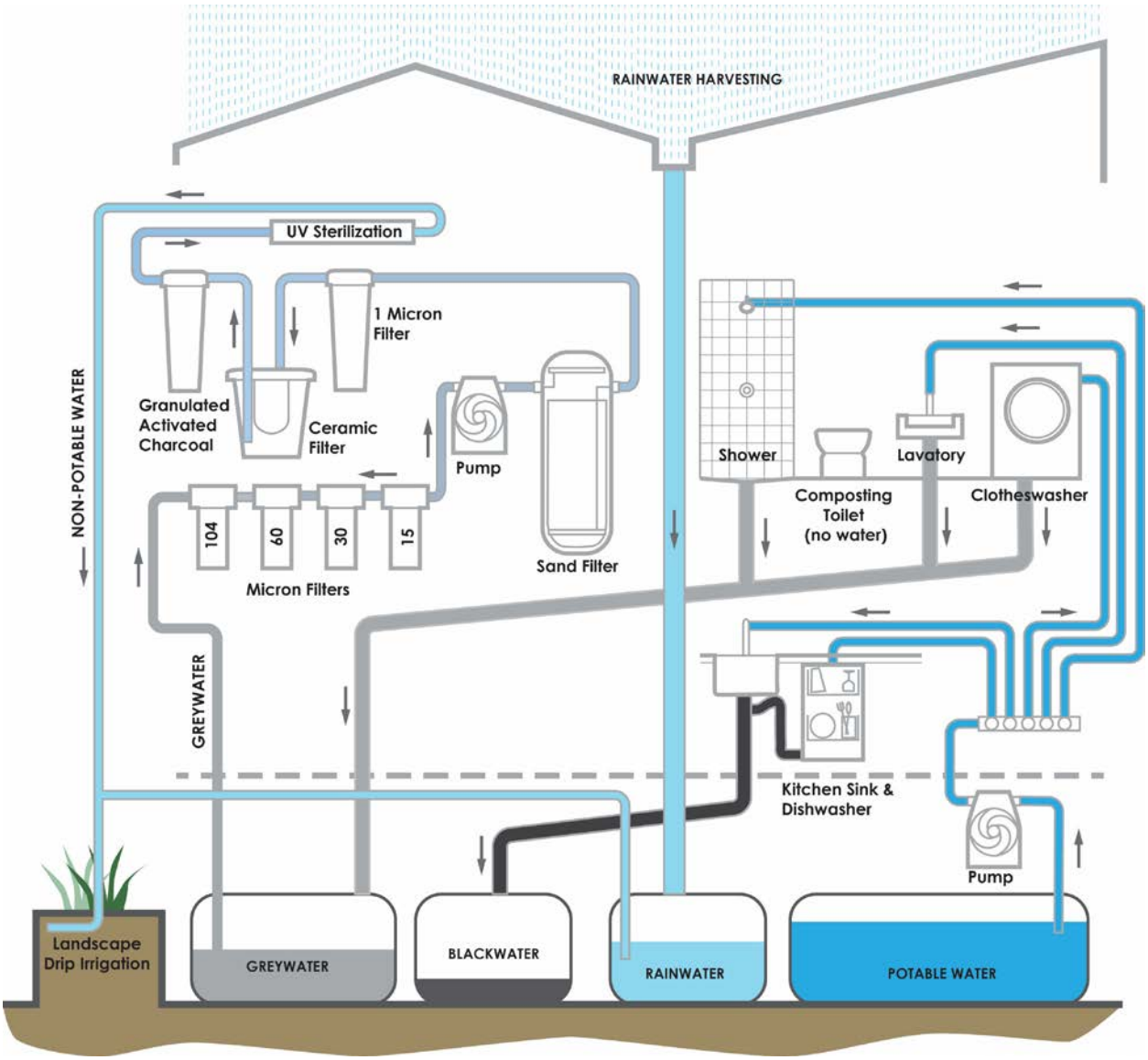
Rainwater and treated greywater will, for the sake of this discussion, be referred to as *non-potable* water, which can be used for irrigation and certain indoor uses like clotheswashing. For the Solar Decathlon competition, non-potable water will be used for landscape irrigation only.

CONVERTING GREYWATER TO NON-POTABLE WATER

In order to be stored for extended periods of time, greywater must be treated to a quality similar to that of rainwater. This is achieved using the process represented in Figure 3. Graywater is collected and allowed to settle for a period of hours. The greywater is then pumped through a sand filter and through a series of successively finer canister filters : 104 microns, 60 microns 30 microns, 15 microns and 1 micron. Finally, it is passed through a ceramic filter, a granulated activated charcoal (GAC) filter and a UV sterilization light. All filters are designed to be cleaned and reused as part of a regular maintenance schedule that can be performed by the homeowners or by a professional service provider. One of the functions of the SmartHouse controller is to monitor the water use for the house and remind the owner when maintenance is required. SmartHouse can also send automated messages to the service provider.

The SmartHouse controller is in charge of the overall filtration process, detecting when sufficient greywater has collected for batch processing, turning on the pumps and opening the valves as required. Manual shut-off valves in the system facilitate removal, servicing and maintenance of components within the system.

After undergoing this treatment, the non-potable water should be safe for release into the landscape, where it can nourish plants, and ultimately recharge the aquifer. This non-potable water is not stored.



CONSTRAINTS FOR THE SOLAR DECATHLON COMPETITION

As noted previously, the Competition Rules restrict the use of treated non-potable water for indoor uses, so non-potable water will not be used in the clotheswasher. Colorado Law only recently began permitting the use of collected rainwater for residential irrigation, and so this has been implemented with a relatively small 150 gallon tank.

In general, due to the Competition prohibition against site disturbance and the limited space available under the house, the Potable Water Tank, Greywater and Blackwater Tanks have all been sized for the needs of the Competition, and not for a permanent application. For a permanent residence, the tanks would have to be considerably larger to allow up to a year of rainfall and as much as 14 days worth of treated greywater to be stored.

To demonstrate the viability of treating greywater water to irrigation standards, The University of Maryland will be collecting water samples during the Competition and throughout an extended

test phase, which will be sent to an EPA certified water quality testing laboratory to verify the water quality of the effluent that goes through the grey water filtration system.

The *reACT* prototype exhibited at the Competition will also meet all other building codes related to potable and non-potable water sources. In particular, the cold water supply lines to the clotheswasher will be purple in color and labeled "Non-Potable – Do Not Drink". All landscaping irrigation spigots will be similarly labeled to warn team members and the public that the water is non-potable.