Help Wanted

The Family Water Box Project



Paul Berg and David Conklin Oregon Freshwater Simulations

Help Wanted for the Family Water Box Project

Paul Berg and Dave Conklin, Oregon Freshwater Simulations, 9/28/20

Our Project

Deploy a human-powered ultraviolet (UV) household water treatment product ("family water box") at scale as an alternative to boiling water in regions where tap water isn't safe to drink.

Why

To achieve:

- a measurable reduction in global greenhouse gas emissions
- a reduction in water-borne disease and mortality, especially among children
- reduced pressure on forests from gathering of fuel wood

- in combination with deployment of clean cookstoves, a reduction in disease and mortality from inhalation of smoke from cooking fires

Potential Global Benefit

Six hundred million people rely on boiling water to make it safe to drink, mostly over wood or charcoal fires.¹ Treating water with UV light is at least 1,500 times more energy efficient than boiling.² The energy for the UV light in the family water box is supplied by manually turning a crank. Elimination of biomass combustion as the energy source for daily water treatment, together with the widespread adoption of clean cookstoves, could reduce greenhouse gas emissions by 15 to 20 gigatons over the 30-year timeframe used for reference in *Drawdown*, Paul Hawken's compilation of the most effective solutions to global warming. The contribution of clean cookstoves alone ranks #21 in the *Drawdown* list of the top 100.³

Water-borne diseases kill 600,000 children a year.⁴ The family water box disinfects water at home whenever it is needed, without electrical power. Hand-cranking for one minute yields one gallon of treated water. Point-of-use, time-of-use UV water treatment will reduce the need to drink unsanitary water.

Help Wanted

Help Wanted: An investor or partner organization with the capital and know-how to create a water box benefit corporation capable of having a global impact.

¹ Rosa G & Clasen T, 2010. Estimating the Scope of Household Water Treatment in Low- and Medium-Income Countries. American Journal of Tropical Medicine and Hygiene, 82:2:289. Page 289, in the Abstract for the article. ² See the section "Energy Required for Disinfection: Boiling vs. UV" later in this document.

³ Drawdown, Paul Hawken, ed. Penguin Books 2017. ISBN 9780143130444. pp. 44-45.

⁴ UN-Water GLAAS (Global Analysis and Assessment of Sanitation and Drinking Water), 2014. Investing in Water and Sanitation: Increasing Access, Reducing Inequalities, Main Findings. World Health Organization, Geneva. http://www.who.int/water_sanitation_health/glaas/en/ (accessed December 4, 2019). Page 2.



The Water Box

The family water box is a hand-cranked water treatment appliance which uses UV light to treat water for microbiological contamination. Turning the crank drives a direct current generator, which supplies electrical power to a germicidal UV lamp inside the water tank. The tank holds 1 gallon of water. Treatment is done one batch at a time, with the treatment container also providing safe storage of treated water. An effective exposure of the germicidal UV light is achieved by turning the crank for one minute.

Current Project Status

We have developed and are beginning to produce water box products for emergency preparedness in the U.S. We see this effort as meeting a real need in our own society and as a stepping stone to a family water box product for parts of the world which do not have reliable, safe tap water.

We built three prototypes in January 2019. One of the prototype units was tested by an independent lab in July. Here is the first paragraph from the lab report.

"EXECUTIVE SUMMARY: One unit of batch process UV based water purifier was tested with very high concentrations of MS2 phage ATCC15597B1 (surrogate Virus) for an UV exposure of 40 sec and 60 seconds separately. The log reduction in various trials was found to be in the range of 4.97 to 5.30. MS2 phage reduction performance by the tested unit exceeds the requirement of 4.0 log reduction (minimum) as per NSF P231 protocol."

In short, our prototype unit passed the commonly used test protocol for microbiological water purifiers.

We carried out a pilot run of 15 units in summer 2019. Ten of the pilot run units were sold almost immediately to local customers for emergency preparedness. We retained the other 5 units for development and marketing.

In late 2019 we added the ability to operate the units from an external 12V DC power source. The DC power can come from either a household electrical outlet using an AC adapter, or from an automobile electrical system using a car cigarette lighter adapter. Both adapters are included with the hand-cranked model.

In early 2020 we purchased 25 sets of parts and carried out a second pilot run, producing quantities of 4 different models: the original design with the black polypropylene tank, and 3 models using a blue, less costly, high density polyethylene tank. Experience gained in the second pilot run led to further design changes: an automatic shut off timer in the external power circuit, an outlet valve, and a switch which disconnects the UV bulb when the tank lid is open. Parts from the second pilot run were salvaged and

re-used for a third pilot run of 12 blue tank units, 6 each of 2 models. During the spring, we bought parts for about 50 more units.

In late June we began our first production run. As of summer's end, we have built 20 of the production units, and they are now for sale on our website, <u>www.uv-h2o-box.com</u>. Half of these first 20 units have already been shipped; we'll build more as necessary to maintain a small inventory of finished goods.

Our challenge now is to increase the sales rate. One of the production units was sold to the leader of a neighborhood emergency team (NET) in our own city. Portland's "NETs" are the local version of FEMA's "CERTs", community emergency response teams. To facilitate quantity purchases by CERTs, we added a "4-pack" bundle to our pricelist. The pricelist is included at the end of this document.

The Back Story

Paul Berg is a water systems engineer who worked many years for an international engineering company. In 2009-2010 he took a year-long sabbatical from his firm to provide volunteer assistance on water projects in East Africa. He began working on the family water box prior to this trip, and used an early prototype version as a means to assure safe water for his own family while they lived in Kampala, Uganda. Paul holds U.S. Patent No. 7,754,090 "Portable ultraviolet water treatment apparatus". He is the author of an article for the Journal of the American Water Works Association, published in their October 2015 edition, titled "The World's Need for Household Water Treatment"⁵.

Dave Conklin is a climate change researcher and computer modeler. He started Oregon Freshwater Simulations ("Freshwater") in 2015 to provide watershed modeling services to climate change research projects. Freshwater is an Oregon Benefit Corporation⁶.

Dave and Paul met in December 2017 at a workshop about how to obtain safe water after an earthquake. In 2019 Paul licensed his patent to Freshwater in exchange for an equity stake. The license requires the formation of a new benefit corporation focused on household water treatment products within two years, once a suitable investor or partner organization has been found.

Energy Required for Disinfection: Boiling vs. UV

Boiling

For disinfecting water, the EPA recommends maintaining a rolling boil for one minute.⁷ Here we use a conservatively low figure for the energy required for boiling disinfection by estimating the energy required to raise the temperature of one gallon of water from room temperature to the boiling point. The specific heat of water, the quantity of heat necessary to increase the temperature of water by one degree Celsius, varies from 4.18 kilojoules per kilogram at 20°C (68°F room temperature) to 4.22 kJ/kg at 100°C, the boiling point.⁸ Here we use a value of 4.2 kJ/kg for the specific heat of water.

⁵ Journal of the American Water Works Association, 107:10, October 2015, pp. 36-44.

⁶ "a corporate status for companies that aim to make a positive impact on society and the environment in addition to earning a profit" (<u>https://sos.oregon.gov/business/Pages/benefit-company-faq.aspx</u>).

⁷ https://www.epa.gov/ground-water-and-drinking-water/emergency-disinfection-drinking-water

⁸ <u>https://www.engineeringtoolbox.com/specific-heat-capacity-water-d_660.html</u>

A gallon of water weighs 8.3 pounds at room temperature and sea level. There are 2.2 pounds in a kilogram. To raise one gallon of water from room temperature to boiling requires

[8.3 lbs / (2.2 lbs/kg)] x 4.2 kJ/kg/°C x (100°C - 20°C) = 1268 kJ

UV

Independent lab testing of the family water box confirmed that it meets the requirements of the NSF International Protocol P231 for Microbiological Water Purifiers. The directions for use of the water box call for exposing each batch of water to the UV light for one minute. Here we use a conservatively high figure for the energy required for UV disinfection of one gallon of water as the energy required to light the germicidal bulb in the water box for one minute.

The G14T5L4 germicidal UV lamp used in the water box draws 14 watts of power. There are 3.6 kilojoules in a watt-hour.⁹ Each batch of water contains 1 to 1¼ gallons. The energy required for a one-minute exposure is

14W x 1 minute x (1 hour/60 minutes) * 3.6 kJ/Wh = 0.84 kJ

UV is more than 1500 times more energy efficient than boiling

Our figure for the energy required to boil a gallon of water, 1268 kilojoules, is a lower bound, since it doesn't account for the inefficiency of transferring heat from the fire to the water itself, nor does it account for the energy required to keep the water at a boil for the recommended time. Even so, 1268 kJ is 1500 times larger than the 0.84 kJ that it takes to operate the germicidal fluorescent tube in the water box for one minute.

How much greenhouse gas is produced by boiling water?

It is feasible to estimate a lower bound for how much greenhouse gas is produced by boiling water:

- 600,000,000 people rely on water which has been treating by boiling¹⁰

- each person requires at least one gallon of treated water per day¹¹

- the heat for boiling the water comes predominantly from combustion of carbon-based fuels, typified by burning wood or charcoal¹²

- as calculated earlier, 1268 kJ of heat energy is required to raise the temperature of a gallon of water from room temperature to boiling

- a cord of green firewood weighs about 4000 lbs¹³; a cord of seasoned firewood weighs about 2500 lbs

- when seasoned, a cord of firewood can be burned to produce about 20,000,000 BTUs of heat energy¹⁴

- each carbon atom (atomic weight 12) which is oxidized by burning a biomass fuel goes into a molecule of carbon dioxide (molecular weight 44 = 12 for the carbon atom + 2 * 16 for the two oxygen atoms)
- when dry, wood is about half carbon by weight¹⁵

⁹ https://www.engineeringtoolbox.com/unit-converter-d 185.html#Energy

¹⁰ Rosa G & Clasen T, 2010. Estimating the Scope of Household Water Treatment in Low- and Medium-Income Countries. American Journal of Tropical Medicine and Hygiene, 82:2:289. Page 289, in the Abstract for the article. ¹¹ <u>https://www.ready.gov/water</u> One gallon of water per day per person is recommended for emergency preparedness kits.

¹² Rosa & Clasen 2010 as before.

¹³ http://www.globalwood.org/tech/tech wood weights.htm

¹⁴ canr.msu.edu/news/how much heat energy is in firewood, a University of Michigan website

¹⁵ Lamlom SH & Savidge RA 2003. A reassessment of carbon content in wood: variation within and between 41 North American species. Biomass and Bioenergy 25(4): 381-388.

How much CO₂ is produced by burning wood to boil a gallon of water? A lower bound for that number is the amount associated with combustion to produce 1268 kJ. Each BTU is equivalent to 1.005 kJ¹⁶. 1268 kJ / (1.005 kJ/1 BTU) = 1262 BTU to heat 1 gallon of water to boiling 20,000,000 BTUs per cord / 2500 lbs per cord = 8000 BTU per pound of seasoned firewood (1262 BTU/gal) / (8000 BTU/lb) = 0.16 lbs of seasoned firewood per gallon 0.16 lbs x 50% carbon = 0.08 lbs carbon 0.08 lbs carbon x (44 MW of CO_2 / 12 AW of C) = 0.29 lbs CO_2 So a lower bound for the amount of CO₂ produced by burning biomass to boil one gallon of water is 0.29 lbs of CO₂.

How many metric tons of CO_2 are produced each year by boiling water for 600,000,000 people? 600,000,000 people x 1 gal/day x 365 days/yr = 219 billion gals/yr 219 billion gals/yr x 0.29 lbs $CO_2 \times (0.45 \text{ kg/1 lb}) = 30 \text{ billion kg of } CO_2$ 30 billion kg $CO_2 \times (1 \text{ metric ton}/1000 \text{ kg}) = 30 \text{ million metric tons of } CO_2$

At least 30 million metric tons of CO₂ are produced each year by burning biomass to boil water. This figure accounts only for the heat required to raise the temperature of the water from room temperature to the boiling point. It does not account for the heat from the fire that doesn't go to warming up the water, nor for the heat required to maintain the water at a boil for the duration of boiling treatment.

What's in a name?

Early in our project, we called the unit a "Berg box", after the inventor. As we began to put together sales literature for the first pilot run, we switched from "Berg box" to "WaterBox". We added the prefix "UV" to get "UV-WaterBox" in the runup to the second pilot run.

Shortly after our uv-h2o-box.com website went live, we discovered that a company in the Netherlands, Aqua-Aero WaterSystems BV, has marketed a solar-powered "UV WaterBox" product in Africa and Asia for nearly 10 years. After consultation with Martijn Nitzsche, the managing director at Aqua-Aero, Freshwater agreed to take up Mr. Nitzsche's suggestion that we use "UV-H₂O-Box" as the print version of our product name, which is consistent with the domain name of our website, "uv-h2o-box.com". This arrangement allows us to continue to say the name of our product verbally as "you-vee-waterbox", while the print version uses the chemical symbol for water, H_2O . An advantage of the chemical symbol in the print version is that it will be recognized in some places where the English word "water" is not.

We in turn offered to put a note on our website about Aqua-Aero's UV WaterBox product, and a link to their website. Mr. Nitzsche provided https://www.aaws.nl/fresh-water-purification/ for the link. The Aqua-Aero link is in the footer of our webpages.

For our water box business in North America, we are doing business as "DayZero Products Co." The "Day Zero" term originally came to our attention in 2018 as shorthand for the day on which the city of Capetown, South Africa, would have to turn off its municipal water system because of a drought. In essence, Day Zero is the first day when you can't drink water from the tap. Day Zero events around the world are the subject of a recent article in Engineering News-Record at

https://www.enr.com/articles/49714-threats-of-day-zero-water-scarcity-multiply.

¹⁶ https://www.engineeringtoolbox.com/heat-units-d 664.html

PRICE LIST

DayZero Products

UV-H₂O-Box models

Our family water box is a water treatment appliance which uses ultraviolet (UV) light to disinfect water for drinking and cooking. It applies technology which is already proven and widely used in municipal water systems, but scales it down for use by single families.



UV-H₂O-Box Model WB-GX

\$299

generator germicidal UV bulb 1 gallon blue high density polyethylene tank Power can be supplied by hand-cranking, or from a 110V AC electrical outlet, or an automobile 12V DC outlet; both adapters are included. When external power is used, an automatic timer turns off the bulb after 1 minute.

UV-H2O-Box Model WB-X\$199germicidal UV bulb11 gallon blue high density polyethylene tank12V DC external power is required,
from a 110V AC electrical outlet,
or from an automobile 12V DC outlet;
both adapters are included.
An automatic timer turns off the bulb
after 1 minute.



4-Pack for Community Emergency Response Teams

UV-H₂O-Box Model WB-CERT4

\$999

4 water boxes without accessories Each water box has: generator germicidal UV bulb 1 gallon blue high density polyethylene tank Power can be supplied by hand-cranking, or from any 12 volt 2 amp direct current power source. When external power is used, an automatic timer turns off the bulb after about 1 minute. Accessories, including adapters for 110V AC outlets and automobile 12V DC outlets, may be ordered separately from *DayZero* or directly from *DayZero*'s suppliers (see reverse side of this price list).



Manufacturer: DayZero Products Co., Portland, OR 503-954-1826 www.uv-h2o-box.com



Accessories

Accessories are included in the WB-GX and WB-X models, but not in the WB-CERT4 multi-unit case for emergency response organizations. Accessories may be purchased from *DayZero* at a small markup from our cost, or directly from our suppliers. Prices given below are for single items from *DayZero*. Supplier information is as of 7/1/20.

AC adapter	\$5.51	Amazon.com <u>12V DC Power Supply 2A Adaptor, SANSUN 12 Volt Power Supply for</u> <u>LED Strip Lights, AC120V to DC12V Transformers (Pack of 5) Sold by</u> <u>SANSUN Direct</u>
canvas bag	\$4.21	totebagfactory.com small canvas laundry bag 18" x 24"
car cigarette lighter adapter	\$3.49	ebay.com <u>Car Cigarette Lighter Male DC Power Supply Charger to 5.5. x 2.1mm</u> <u>Male 12V cable, 10' length</u>
Funnel	\$1.71	Amazon.com <u>8 Pack Multi-Purpose Plastic Funnels with Long Reaching Spout (4.7")</u> for Water Pottle, Easy and Smooth Content Transfer by ZMYPCPACK
outlet valve	\$1.30	Amazon.com <u>Cosweet 12 Pack 3/4" Plastic Garden Hose Shut Off Valve</u>
outlet cap with magnet	\$1.00	magnet: Amazon.com 0732515012598 cap: hose bib cap at Wichita Hardware, Portland, OR
1-minute sandglass timer	\$1.00	Amazon.com Dsmile 1 MINUTE SAND TIMERS SET OF 20

Spare bulb

germicidal UV bulb \$22.44 1000Bulbs.com AU-LG14T5L4

WB-GX and WB-X models include:

germicidal UV bulb generator (WB-GX only) AC adapter canvas bag car cigarette lighter adapter funnel silicone rubber inlet stopper outlet valve outlet cap with magnet 1-minute sandglass timer (WB-GX only)

WB-CERT4 model includes, for each water box, only: generator, bulb, inlet stopper, and outlet cap

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