Achieving Net-Zero Water
Fifth International Emerging Technology Symposium

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Sponsored by: Whirlpool Corporation & CleanBlu Inc.
Water is essential for life. About 60% of our bodies are made of water and we can only survive for 3 days without it.

More than 750M people (1 in 9) do not have access to clean water.

Multi year drought affecting Western and Southwestern US.

In 2015, 25% mandatory residential water cuts were enacted in California.

Aging water infrastructure in developed countries will require extensive investment over the coming years.
Targeting Net-Zero Water | Motivation

Water = Life
Water ≠ ∞

Abandon the term *wastewater*

Alternate Water Source
The Largest Ignored Water Source

Mount Wai’ale’ale
452 inches of rain per year

Atacama Desert
0.6 inches of rain per year

It needs to be as simple, reliable and inexpensive as an appliance – that’s why a leading water innovator and the largest appliance manufacturer got together – to create *THAT* appliance

It needs to be an appliance to make the impact needed
Achieving Net-Zero Water | Definitions

A single family home at Purdue University that is a live in laboratory and sustainable living showcase.

Net-Zero Water
Structure capable of capturing, storing, purifying & reusing enough locally available water (via rain or snowmelt) as needed for all uses

Alternate Water Source
Any water source that can be processed for beneficial use not included in other categories

Rainwater
Water that has fallen as or been obtained from rain
Potable Water
Water suitable for drinking

Non-Potable Water
Water that has not been examined, properly treated, and not approved by authorities as being safe for consumption (on/site/off-site variant)

Greywater (NSF/ANSI 350)
Relatively clean wastewater from baths, sinks, washing machines, and other kitchen appliances

Blackwater
Wastewater containing feces, urine, flushwater toilets and bidet water

Dark Grey Water
As California Bill AB1738 sponsored by Kevin McCarthy
Achieving Net-Zero Water | Avg. US Residential Water Use

Average per person water use is around 91 gallons / day
Achieving Net-Zero Water | Path to Net-Zero / Efficiency First

Water use dropped from 103 to 34 gallons/person/day!
Achieving Net-Zero Water | Path to Net-Zero / Renewables

Satisfy reduced demand with onsite renewables
Achieving Net-Zero Water | Treatment System Photos

- Expansion Tank
- UV Light
- 1 Micron Filter
- Activated Carbon
- Backflow Prevention Devices
- UV Light
- 5 Micron Filter

Designed to meet EPA guidelines for surface water treatment
Achieving Net-Zero Water | Rainwater Not Enough!

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<td>3030</td>
<td>2177</td>
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Assume tanks are full (3000 gal) at start of January
Achieving Net-Zero Water

Modeled total usage: 36,360
- Potable usage: 29,088
- Non-potable usage: 7,272

Non-potable usage can be satisfied with previously used potable water that has been processed.

Modeled total rainwater harvest: 31,912

Treat potable water as the precious resource it is.

Shower drain water being reprocessed for toilet flushing, irrigation, etc.
Achieving Net-Zero Water | AWS Design Philosophy

Design Criteria

• No user interaction should be required
• User should not need to replace any parts
• Full remote monitoring via the internet and CleanBlu app
• There should be no pumps
• The system should be self calibrating
• Power consumption should be less than 50 watts
• The appliance should have ability to fit through a 34” door frame
• System should process more than 250 gallons per day
• The microbial product cycle should be six months
• No user behavior modifications and product substitutions

All design and performance criteria have been met!
Achieving Net-Zero Water | AWS Technology Overview

Residential Alternate Water Source Prototype
• Whirlpool asked CleanBlu to design a wastewater reuse appliance for homes capable of processing up to 450 gallons for reuse

Design
• Two polyurethane tanks, each containing a CleanBlu Bio-Element, are stacked with levels monitored using weight sensors embedded into the mounts
• The system is fully automated and controlled and monitored using the CleanBlu App

Dual Stage Processing
• First is a fully aerobic biological stage utilizing oxygen, delivered by air injection and an aerobic microorganism and bio-nutrient blend to reduce contaminants via aerobic bioremediation
• Second stage provides sterilization using ozone gas to sanitize the water before discharge

Capable of reducing potable water use by ~40%
Achieving Net-Zero Water | FOG-DS Technology

Designed to Reuse Kitchen Water
• In a family home a large part of the water is used in the kitchen
• Problem contaminant is FOG – Fats, Oil and Grease

Patented Technology Adapted from Commercial Application
• CleanBlu is the leader in bioremediation of FOG from commercial Food Service Establishments

In-situ Bioremediation of FOG from FSE’s
Achieving Net-Zero Water | Kitchen Water Reuse

Technology Designed to Reuse Commercial Kitchen Water

- Will process FSE effluent to irrigation water quality
- Potentially reclaiming 20,000 to 40,000 gallons a day

Resorts and Hotels could reuse water for all their laundry, landscape needs
Achieving Net-Zero Water | AWS System Overview

Prototype Design

Shower drain water being reprocessed for toilet flushing, irrigation, etc.
Achieving Net-Zero Water | Lessons Learned

Particulate Filtration
• Graywater exiting the unit was not filtered and had a turbidity of 30 – 35 NTU – cosmetically unappealing – will result in long term build up

A New Type of Self Cleaning Filter is Needed
• The challenge is to design such a filter – reliable and low cost

Valves Need to be Able to Open/Close with Buildup
• We had leaks due to debris in the valves – replaced with different valve type

More Effective Way to Dissolve Ozone into Water
• Current employed method is not efficient enough, although turbidity could be interfering with the ozone’s effectiveness
• Must be achieved without the use of a recirculation pump as typically used in combination with a venturi type injector.

Shower drain water being reprocessed for toilet flushing, irrigation, etc.
Achieving Net-Zero Water | NSF/ANSI 350

NSF/ANSI 350: Onsite Water Reuse is a standard that was developed by the National Sanitation Foundation (NSF) governing water quality parameters for water that is to be reused and test water and a testing methodology to verify that systems meet the specified quality.
Achieving Net-Zero Water | ReNEWWW House Monitoring

Flow sensor
Shower drain water heat recovery
Hot water recirculation return
Flow meter
Thermocouple

Over 100 channels monitored and collected every second
Achieving Net-Zero Water | Water Usage Data & Insights

Top Water Use Fixtures
1. 2\textsuperscript{nd} floor shower hot water
2. 2\textsuperscript{nd} floor toilet
3. 1\textsuperscript{st} floor toilet
4. 2\textsuperscript{nd} floor sink hot water
5. 2\textsuperscript{nd} floor shower cold water

- Hot water usage increases with colder months from 611 gallons in October to 950 gallons in January
- Greywater has offset \(~22\%\) of indoor water use (toilet flushing only), system down for two weeks which lowered this number
# Achieving Net-Zero Water

## Water Usage Data & Insights

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<td>200</td>
<td>562</td>
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- City water use has declined throughout first three months due to commissioning of rainwater system and increased greywater utilization.
- Greywater utilization has increased over the first three months.
- Actual per person use lower than modeled 34 gallons/person/day.

Greywater can offset a significant portion of formally potable water.
<table>
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<tr>
<th>Testing Scope</th>
<th>Tests Performed</th>
<th>Results</th>
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<tbody>
<tr>
<td>Microbiology</td>
<td>Cryptosporidium &amp; Giardia</td>
<td>None Detected</td>
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<tr>
<td></td>
<td>Total Coliform &amp; E.Coli</td>
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<tr>
<td></td>
<td>Heterotrophic Plate Count</td>
<td>2132 [CFU/ml]</td>
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<td></td>
<td>Enteric Viruses</td>
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<td>Physical Factors</td>
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<td></td>
<td>Hardness (as CaCO3)</td>
<td>82 [mg/l] or 5 [grains/gallon]</td>
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<td>Turbidity</td>
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<td>Inorganics</td>
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<td></td>
<td>Mercury</td>
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<tr>
<td></td>
<td>Silver</td>
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Achieving Net-Zero Water | Conclusions

- Domestic water use in the developed world is very large and actions will need to be taken as water demand increases globally coupled with projected scarcity.

- When targeting net zero, always start with efficiency first! There are many simple actions to take that can greatly reduce domestic water use including upgrading appliances, toilets, fixtures and avoiding hand washing of dishes.

- Treated greywater is relatively high quality and offers numerous advantages over public water supply for certain applications.
Achieving Net-Zero Water | Website

www.renewwhouse.com

www.CleanBlu.com

Check into project website from time to time for more information on energy & water retrofits, as well as data on how the house is performing!

Check out our latest innovations and see how our technology is developing
Thank You!

Questions & Answers