VIRTUAL ACLCA 2020 CONFERENCE

September 22, 2020

NEWR: A Planning Tool for Estimating the Environmental Economic Suitability of Onsite Non-potable Water Reuse Systems for Large Buildings

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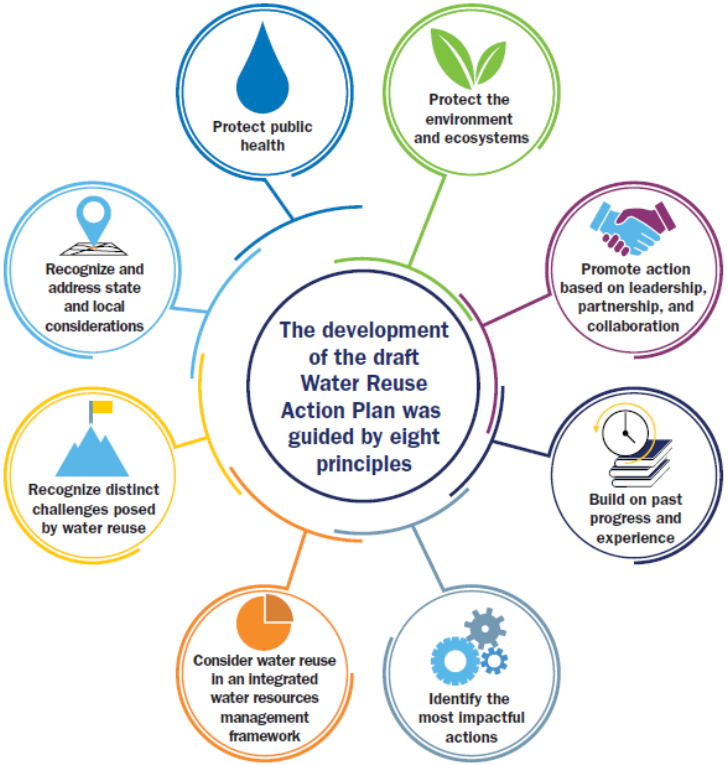
Research Program

Guiding Principles of the Water Reuse Action Plan



Source: www.epa.gov/sites/production/files/2019-09/documents/water-reuse-action-plan-draft-2019.pdf

Focuses on human health, environmental impact and comparative economics of building scale non-potable reuse (NPR)

Project Background

- Project team has completed several life cycle assessment (LCA) and cost studies on decentralized non-potable reuse (NPR) configurations
- Previous study focused on large urban buildings in San Francisco, treating mixed wastewater or source separated graywater with aerobic membrane bioreactor (Arden et al., 2020)
- Work expanded to an EPA web-based calculator (Arden et al., pending submission)

Online Calculator

NEWR - Non-potable Environmental and Economical Water Reuse Calculator (currently in beta testing)

- **Objective**: Build on previous LCA and cost case studies of NPR options for urban buildings and create a simple calculator to develop screening-level assessments for any large building across the US
- **Research Questions**: What is the most environmentally and cost-effective source water(s) to meet large building non-potable water needs?
    - As a function of location
    - As a function of building type/size

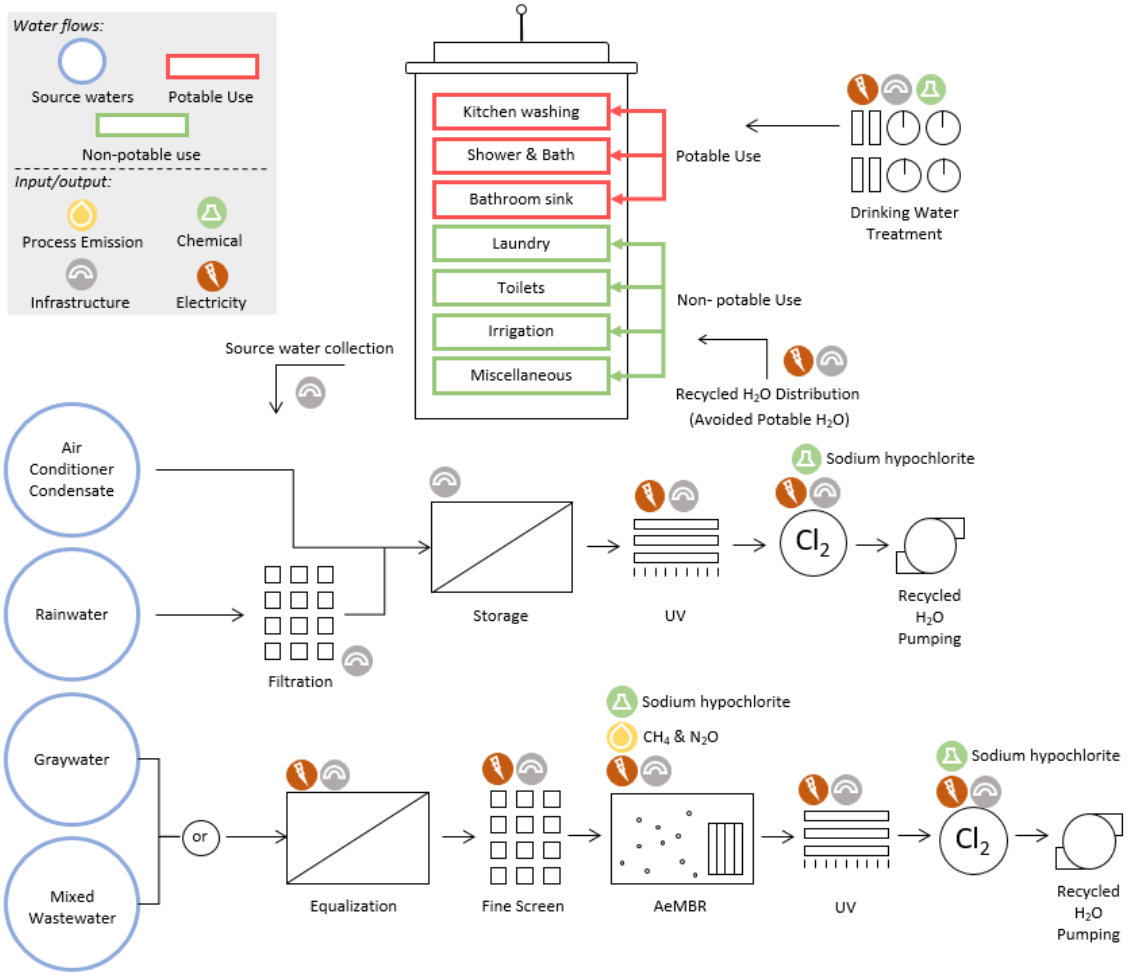
Source Water and Technology Options

- NEWR assesses the following source water options:
  - Rainwater harvesting (RWH)
  - Air conditioning condensate harvesting (ACH)
  - Separated Graywater
  - Mixed Wastewater

- Separated graywater (GW) and mixed wastewater (WW) treatment via aerobic membrane bioreactors (MBRs)
  - Incorporate disinfection steps (UV, chlorination) to meet log reduction targets for NPR
  - Option for recovery of thermal energy for hot water heating

Water Balance Calculations

- **Wastewater supply and non-potable demand** based on per capita flow rates for standard or high efficiency fixtures
- **Outdoor irrigation demand** dependent on irrigation area, types of plants, and evaporative demand
- **Rainwater collection** is a function of building footprint for collection, collection efficiency, and monthly rainfall
- **Air conditioning condensate harvesting** is based on the difference between the moisture level of air entering air handling unit and moisture content leaving air handling unit



Treatment Configurations

- All systems designed to meet NPR log reduction targets
- Option for recovery of thermal energy for hot water heating

NEWR Results

- Water availability and demand per month
- Environmental and cost results using a life cycle approach (per gallon and per year)
  - Global warming potential *(100-yr time horizon IPCC AR5)*
  - Total energy demand *(MJ)*
  - Fossil fuel depletion *(kg oil. eq. per ReCiPe 2016 life cycle impact assessment method)*
  - Water consumption *(liters)*
  - Water scarcity *(liters water deprivation per WULCA's AWARE method)*
  - Cost *(net present value in 2016 $)*

Intended Audience

- Building developers can use the calculator as an initial screening tool prior to a more detailed engineering design analysis
- Urban communities interested in implementing NPR at the building-scale
- Research scientists investigating NPR options

User Interface: Location

Non-Potable Reuse Building-Scale Calculator

Specify ZIP Code

Enter a 5 digit ZIP Code to start: 55403

The Non-Potable Reuse (NPR) Building-Scale Calculator can help identify environmentally and cost effective options for on-site NPR based on user selected geography, building specifications, source water type, and end use. Follow the prompts to explore building-scale NPR opportunities in your region. The Calculator is intended for buildings with 50 or more residential and/or office occupants.

Next

User Interface: Building Characterization

Non-Potable Reuse Building-Scale Calculator

Building Characterization

Select Building Type

- (•) Mixed Use (30% commercial, 70% residential)
- ( ) Residential
- ( ) Commercial

Specify # Building Occupants

- (•) Large Building (1100)
- ( ) Medium Building (550)
- ( ) Small Building (110)
- ( ) Number of Occupants (recommended minimum value is 50)

Specify # Floors in Building

4

Enter Building Footprint

20000

Previous

Next

User Interface: Source Water Characterization

Non-Potable Reuse Building-Scale Calculator

Source Water Characterization

Select Source Water Option ⓘ

- [x] Rainwater

Enter portion of the building footprint that is allocated to rainwater harvesting:

20000

- [x] Air Conditioning Condensate
- [x] Wastewater

Incorporate Thermal Recovery Unit? ⓘ

- (•) Yes, Natural Gas Hot Water Heater
- ( ) Yes, Electric Hot Water Heater
- ( ) No

Select Wastewater Collection Type ⓘ

- ( ) Mixed Wastewater (treated with Aerobic MBR)
- (•) Separated Graywater (treated with Aerobic MBR)

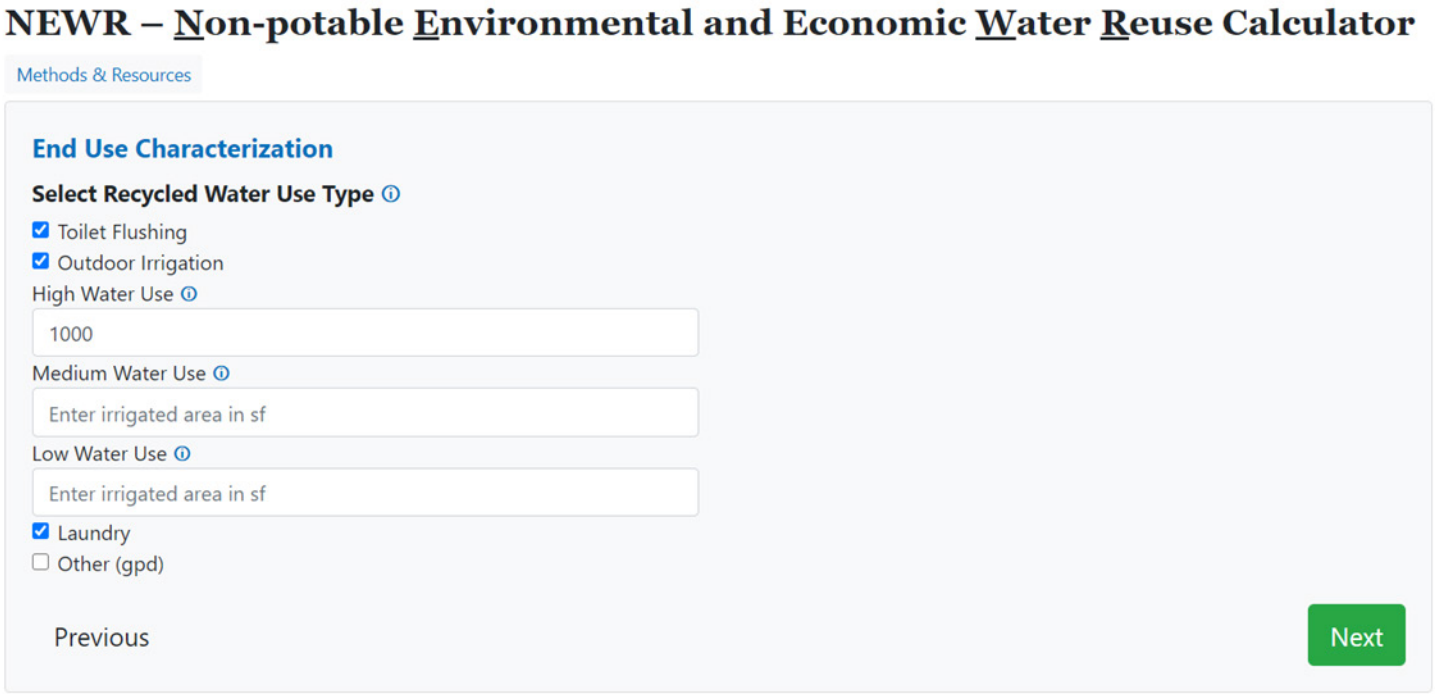
Specify Building Water Use Efficiency ⓘ

- (•) High Efficiency
- ( ) Standard Efficiency

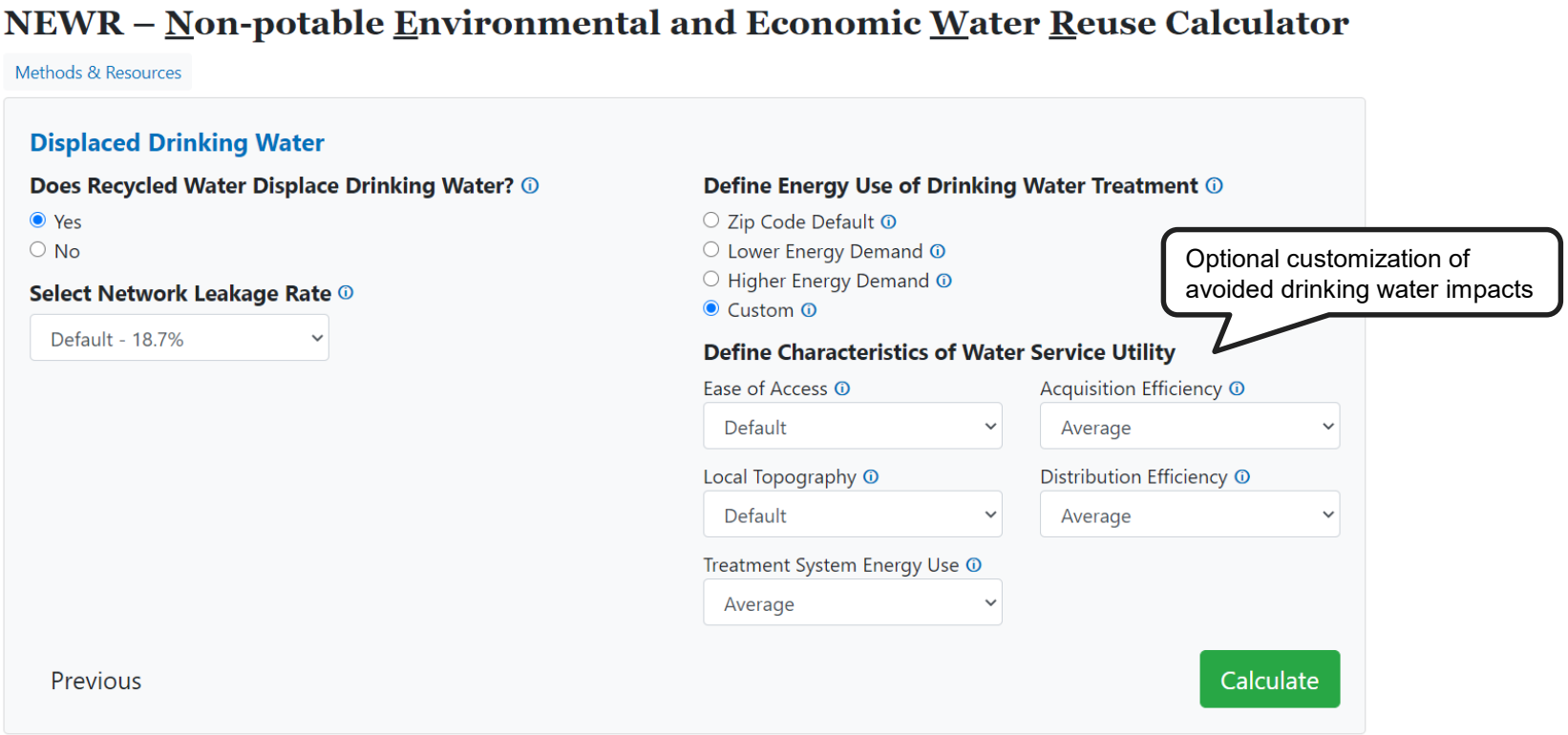
Previous

Next

User Interface: End Use Characterization



User Interface: Displaced Drinking Water



User Interface: Zip Code Data

Review background information and data entered

NEWR – Non-potable Environmental and Economic Water Reuse Calculator: Results

Methods & Resources | Show data entered | New Calculation

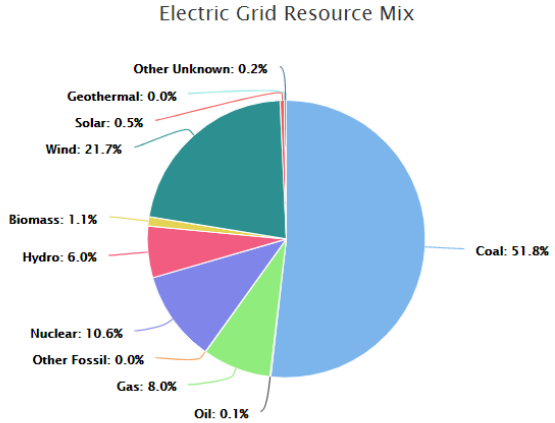
ZIP Code Data | Water Availability & Demand | Global Warming Potential | Total Energy Demand | Fossil Fuel Depletion | Water Consumption | Water Scarcity | Cost (Net Present Value)

ZIP Code Data for 55403

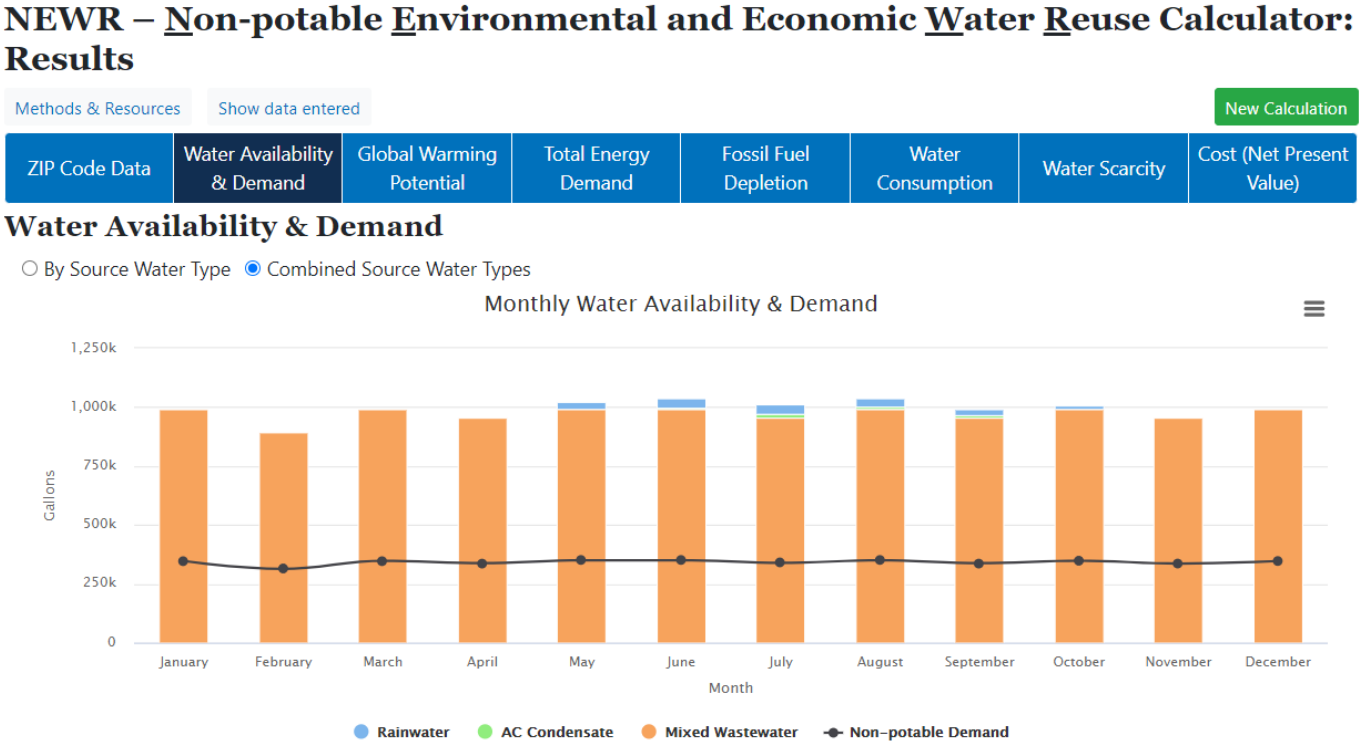
Month	Rainfall (inches)	AC Condensate Harvesting Potential (gal/cfm)	Reference Evapotranspiration (inches)
January	0.00	0.0000	0.67
February	0.00	0.0000	0.93
March	0.00	0.0011	2.19
April	0.00	0.019	3.88
May	3.46	0.13	5.46
June	4.25	0.85	5.96
July	3.98	1.51	6.46
August	3.98	1.22	5.42
September	2.99	0.68	4.06
October	2.09	0.015	2.64
November	0.00	8.00e-4	1.22
December	0.00	0.0000	0.60

Water Scarcity Factor	1.28	
Natural Gas Rate	0.30	$/1000 cf
Electricity Rate	0.12	$/kWh
Water Supply Rate	5.30	$/1000 gallons

eGRID Subregion - MRO West

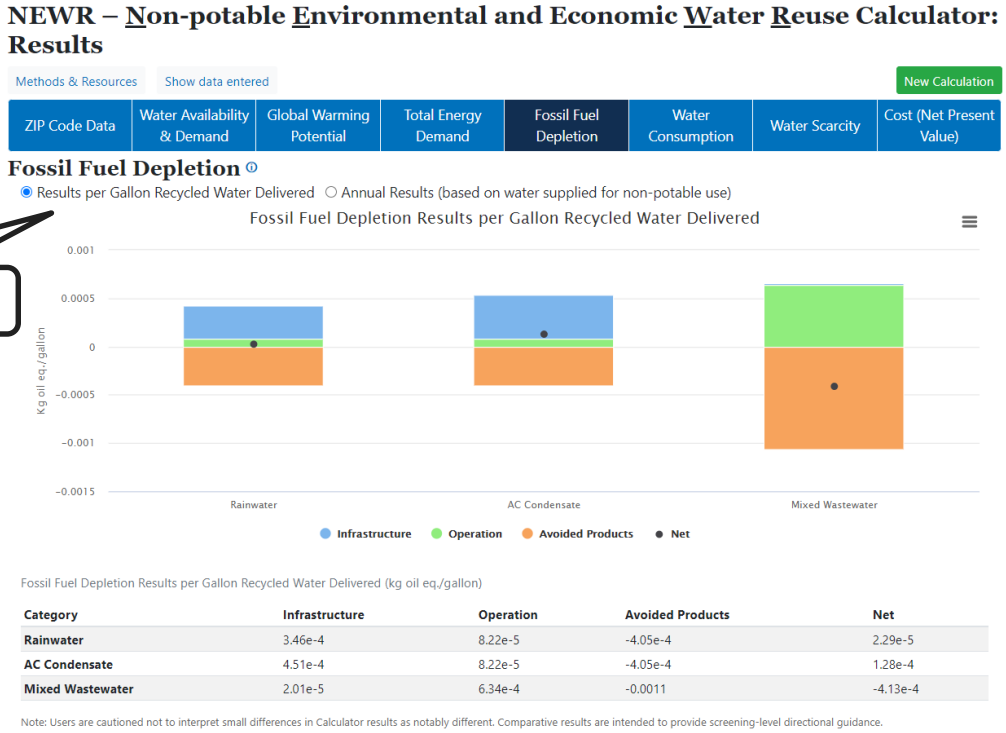


User Interface: Water Availability and Demand



User Interface: Results

Result per gallon and per year



Fossil Fuel Depletion Results per Gallon Recycled Water Delivered (kg oil eq./gallon)

Category	Infrastructure	Operation	Avoided Products	Net
Rainwater	3.46e-4	8.22e-5	-4.05e-4	2.29e-5
AC Condensate	4.51e-4	8.22e-5	-4.05e-4	1.28e-4
Mixed Wastewater	2.01e-5	6.34e-4	-0.0011	-4.13e-4

Note: Users are cautioned not to interpret small differences in Calculator results as notably different. Comparative results are intended to provide screening-level directional guidance.

Infrastructure = all capital equipment for treatment, collection, and distribution
Operation = electricity and chemicals for treatment and disinfection
Avoided products = displaced drinking water requirements and hot water heating requirements (MBR with thermal recovery)

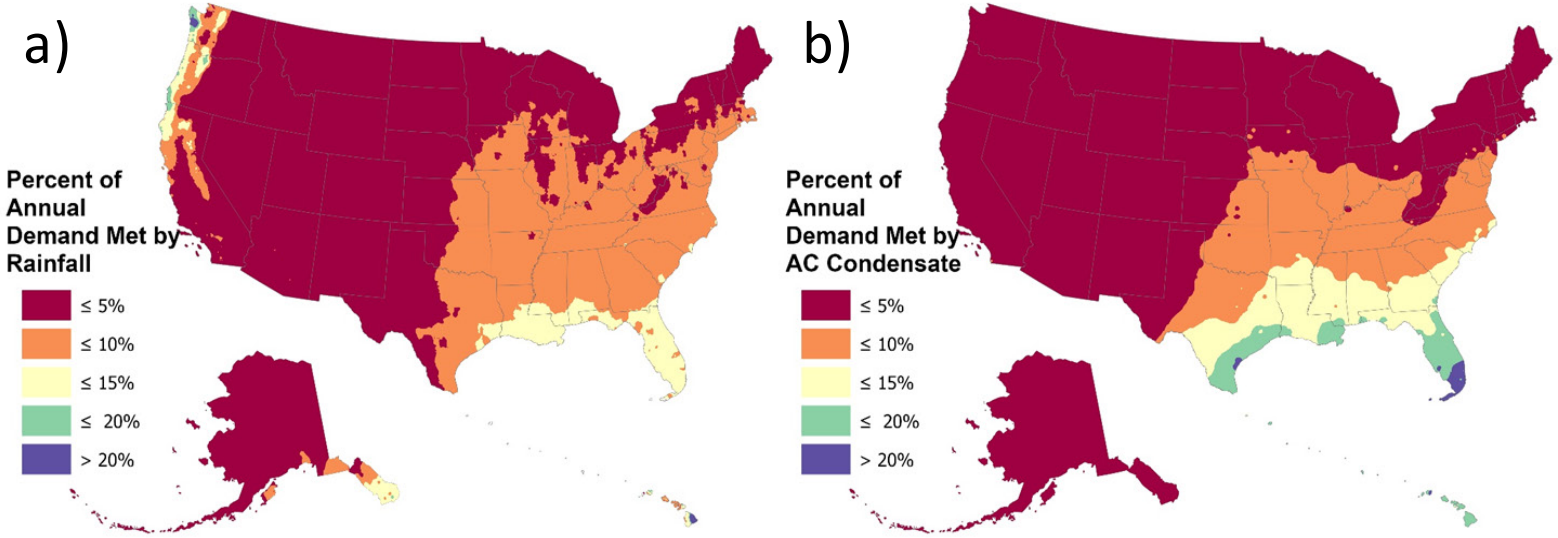
Scenario Generation

Simulation Parameter	Simulation Set 1 – "Large Building"	Simulation Set 2 – "Large Building –AWWA"	Simulation Set 3 – "Random Generator"	Note (Units):
Geographic Coverage				
Geographic Coverage	Entire U.S.	AWWA Cities[a]	Entire U.S.	see Figure S1 for Simulation Set 1, Figure S11 for Simulation Set 3
# of ZIP Codes	40,873	3,382	1,276	
NEWR Inputs				
Building Type	Mixed Use	Mixed Use	Mixed Use	70% residential, 30% commercial
Building Occupants	1,100	1,100	min = 50 max = 1,100	count (persons)
Building Floors	19	19	min = 2 max = 20	count (floors)
Building Footprint/Occ.	18.2	18.2	min = 10 max = 20	Used to constrain area/occupant ratio (ft^2/person)
Building Footprint	20,000	20,000	min = 500 max = 22,000	Calculated as building occupants x area/occupant (ft^2)
Irrigated Area	0	0	min = 0% max = 100%	High water use area as a percentage of total building footprint (ft^2)

a – each of the 234 cities included within AWWA's 2019 rate survey (AWWA, 2019)
b – for Simulation Set 3, water balance results represent simulated ranges, not maximum ranges based on NEWR inputs
c – SWA = Source Water Availability

From Arden et al. 2020
(Submitted for Publication)

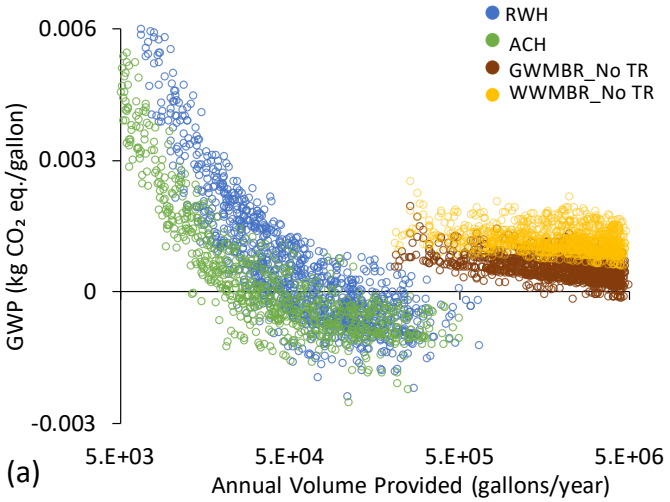
Percent of Annual Non-Potable Demand Met ("Typical" Large Building)

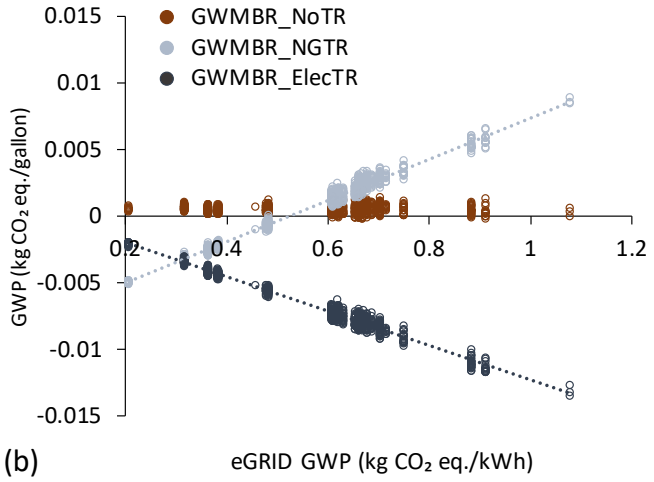


Mixed WW and GW systems always meet non-potable demand under modeled conditions.

From Arden et al. 2020 (Submitted for Publication)

Global Warming Potential Across Source Waters, Variable Location and Building Characteristics

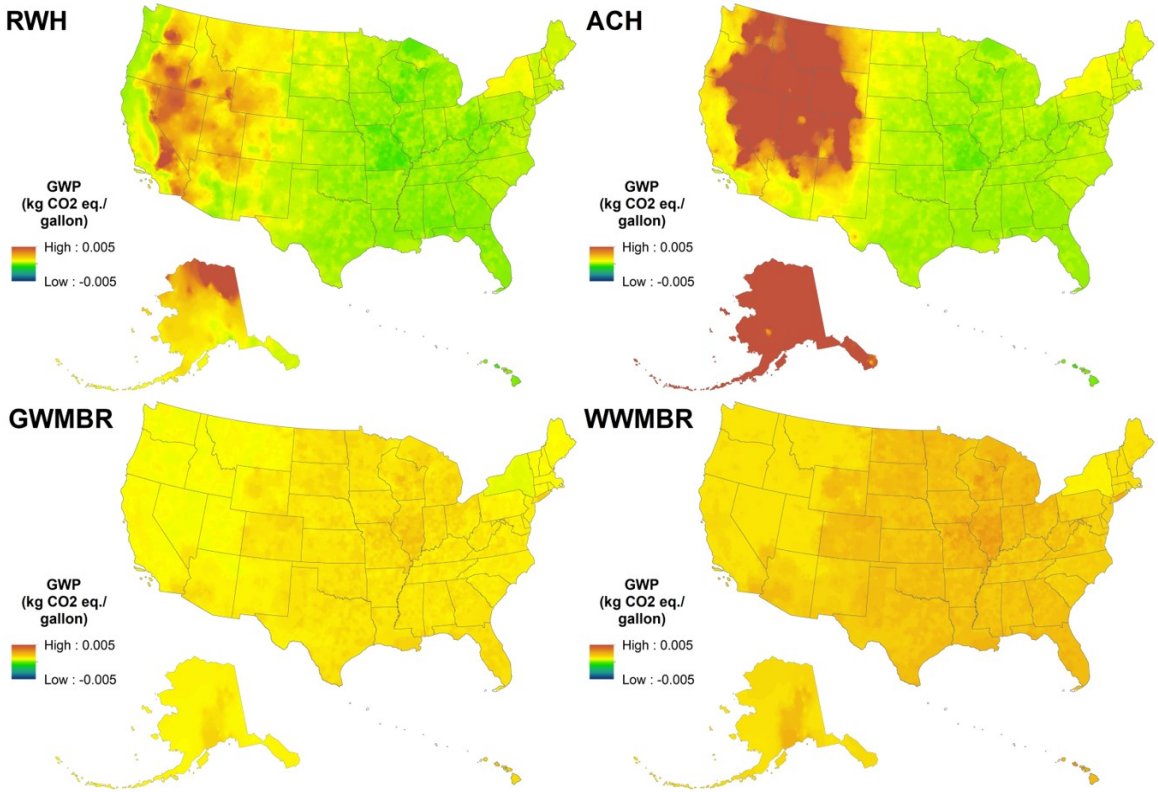




Simulation Set 3 (Random Scenario Generator)

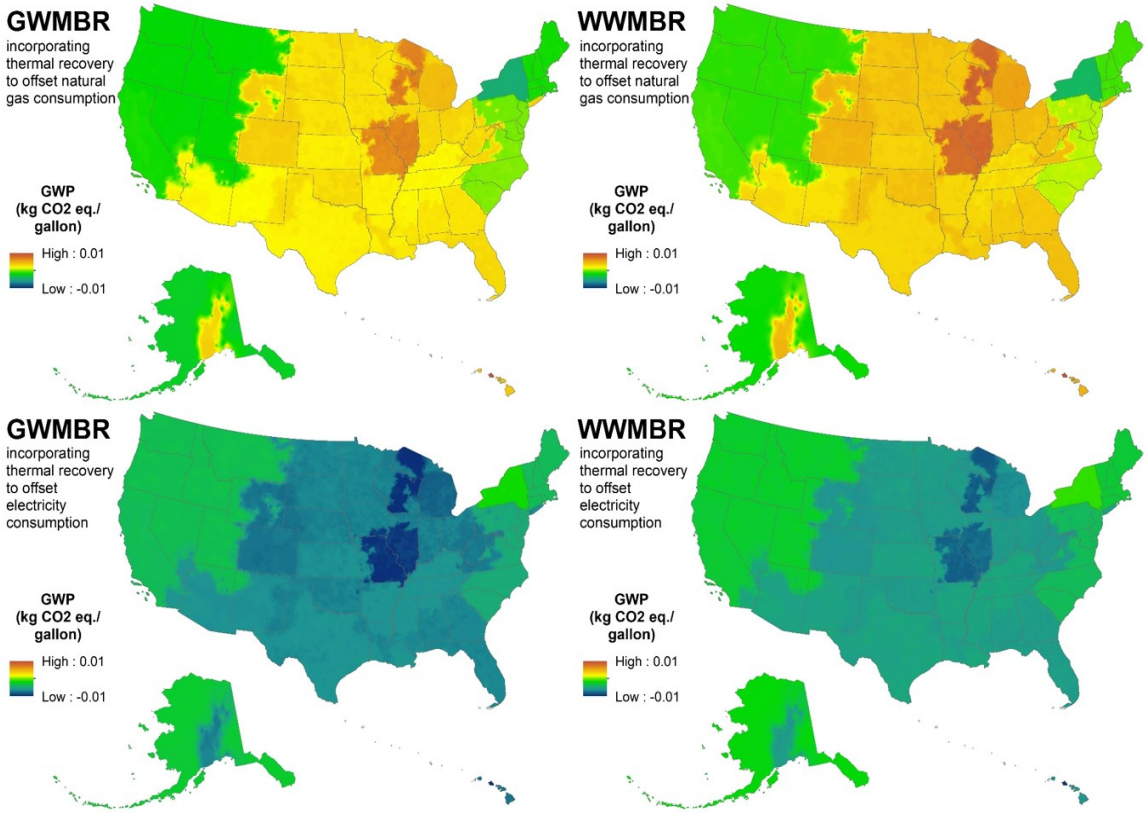
From Arden et al. 2020
(Submitted for Publication)

Fixed Building Global Warming Potential Across Source Waters (no thermal recovery)



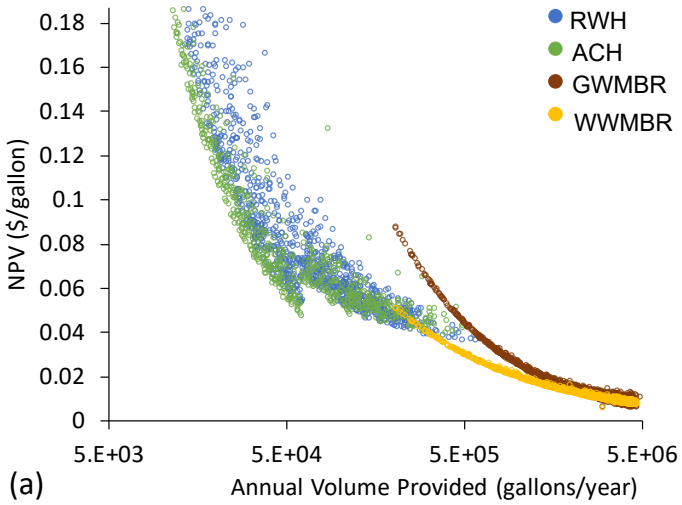
From Arden et al. 2020 (Submitted for Publication)

Fixed Building Global Warming Potential Across Source Waters *(with thermal recovery offsetting NG (top) and electricity (bottom))*

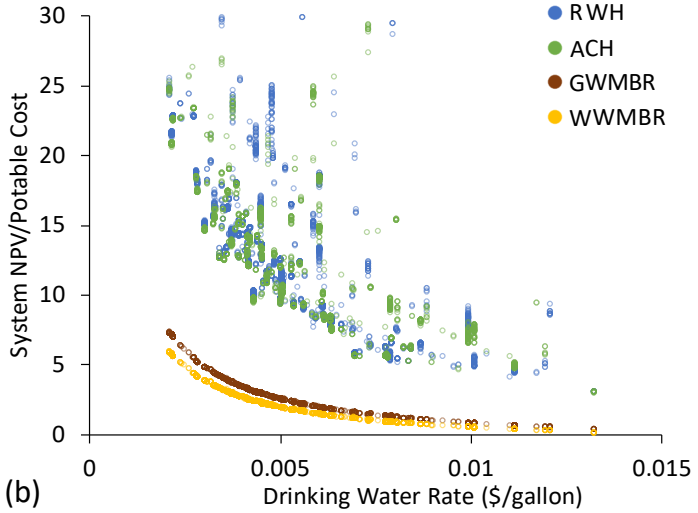


From Arden et al. 2020 (Submitted for Publication)

Net Present Value Across Source Waters, Variable Location and Building Characteristics



Simulation Set 3 (Random Scenario Generator)



Simulation Set 2 (AWWA, Large Building)

From Arden et al. 2020
(Submitted for Publication)

Summary of Geospatial Analysis

- In most areas of the country, rainwater and AC condensate provide less than 10% of non-potable needs for large buildings
  - Where available, these water sources can provide an environmentally beneficial, but costly, option for reuse
- Wastewater and graywater provide 100% of the demand
  - Energy demands for treatment lead to environmental impacts, especially in areas with carbon intensive energy grids
  - Can be a cost-effective source, especially where drinking water costs are high
- Planning and design of non-potable systems needs to be regionally specific and the NEWR tool provides local developers a quantitative, screening level assessment of the relative costs/benefits

Next Steps with NEWR

- Release of existing tool for general use
  - Currently in β-testing with USGBC, CGBC, City of Austin, SFPUC, and NYC
- Model improvements
  - Combined source waters (e.g., linking rainwater and condensate collection, storage)
  - Alternative source waters (stormwater, foundation drainage) & end uses (cooling tower)
  - Expansion to community scale scenarios
  - Improved estimates of impacts on sewer flow, including potential reductions in CSOs/eutrophication
- Targeted, collaborative applications to different metropolitan areas
  - Refined estimates of local inputs
  - Enhanced spatial detail, including different extents of onsite non-potable reuse

Disclaimer

The views expressed in this presentation are those of the author(s) and do not necessarily represent the views or policies of the U.S. Environmental Protection Agency (EPA). The research described in this presentation has been funded in part by EPA under contract EP-C-15-010 to Eastern Research Group. Portions of the research were conducted by EPA and Eastern Research Group under a memorandum of understanding for cooperative research. This presentation has been reviewed in accordance with EPA policy and approved for release. Any mention of trade names, manufacturers or products does not imply an endorsement by the United States Government or the U.S. Environmental Protection Agency.

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