IAPMO's Water Demand Calculator™ Can Help You Save Water, Energy, and Reduce Embodied Carbon

EXECUTIVE SUMMARY

Reacting to needs to address profound water quality and wasted water and energy concerns resulting from oversized water supply pipes in home and buildings, IAPMO led a research project to develop a new statistics based pipe sizing method. This multi-year effort resulted in the development of the Water Demand Calculator™ (WDC).

IAPMO commissioned ARUP to calculate the water, energy, and carbon savings potential of applying the WDC as compared to applying the sizing methods contained in the 2021 baseline plumbing codes, specifically, IAPMO's *Uniform Plumbing Code*®, the International Code Council's (ICC) *International Residential Code*® (IRC) and the ICC's *International Plumbing Code*® (IPC).

The WDC provides sustainability improvements resulting from the use of smaller water pipes, fittings, and related components. This paper illustrates the potential sustainability benefits of applying the WDC over traditional pipe sizing methods.

BACKGROUND

IAPMO's WDC represents 12 years of collaboration with American Society of Plumbing Engineers and the University of Cincinnati to provide the first significant update for water pipe sizing in buildings in over 80 years, since the development of Hunter's Curve. Much has changed in the way Americans use water since 1940. In fact, plumbing fixtures and appliances use only a fraction of the water they have consumed since the mid-1980s. See Table 1.

TABLE 1

Water consumption by water-using plumbing products and appliances – 1980s to 2021[1]

Water-using Fixture or Appliance	1980s Water Use	1990 Requirement	EPAct 1992 Requirement	2021 Baseline Plumbing Code (UPC)	2020 "Green Code" Requirements (EPA WaterSense)	% Reduction in since 1980s
Residential Bathroom Lavatory Faucet	3.5+ gpm	2.5 gpm	2.2 gpm	2.2 gpm	1.5 gpm	57%
Showerhead	3.5+ gpm	3.5 gpm	2.5 gpm	2.5 gpm	2.0 gpm	43%
Toilet – Residential	5.0+ gpf	3.5 gpf	1.6 gpf	1.6 gpf	1.28 gpf	74%
Residential Clothes Washer	51 gallons/load	No requirement	26 gallons/load (2012 standard)	No requirement	13 gallons/load (Energy Star)	75%
Residential Dishwasher	14 gallons/cycle	No requirement	6.5 gallons/cycle (2012 standard)	No requirement	3.5 gallons/cycle (Energy Star)	75%

GPM = US Gallons Per Minute, GPF = US Gallons Per Flush

As a result, the plumbing systems in our single and multi-family homes and buildings are oversized, which results in:

- increased water aging and declining water quality resulting in an increased risk from biofilm development, Legionella and other opportunistic pathogens
- wasted energy and water
- an increase in hot water delivery times
- unnecessary material and labor costs during construction

THE WATER DEMAND CALCULATOR™

The WDC was developed specifically to address the water quality, water efficiency and energy efficiency problems associated with oversized building water pipes. However, use of the WDC also provides significant cost saving efficiencies.

To ensure a fair comparison, the most efficient design options offered in the entirety of the UPC, IRC, and IPC were investigated and applied, including the application of the code appendices. Visit https://www.iapmo.org/water-demand-calculator/ to learn the technical details about how the WDC works and how to download it.

For more information on cost savings, refer to the following link to the Stantec Report on Construction Cost Savings: https://www.iapmo.org/media/25276/water_demand_calculator_report_summary.pdf

[1] *The Drainline Transport of Solid Waste in Buildings*, PERC 1 Report - Chart by J. Koeller, P. DeMarco (updated)

THE BUILDING PROTOTYPES

Four building prototype were used: an average size, 2,379-square-foot single family home, a 6-unit multi-family residence, a 45-unit multi-family residence, and a 48-unit multi-family high-rise building (for energy only). The prototypes were specifically developed to represent typical homes and multi-family residences that are currently being constructed.

RESULTS

A summary of results showing the savings as a difference in hot water wasted, energy consumed, embodied carbon, and carbon emission from applying the WDC as compared to applying the IPC or IRC can be found below. These values represent the sustainability savings that can be expected when applying the Water Demand Calculator™ on one single-family home or multi-family building.

Fig. 1

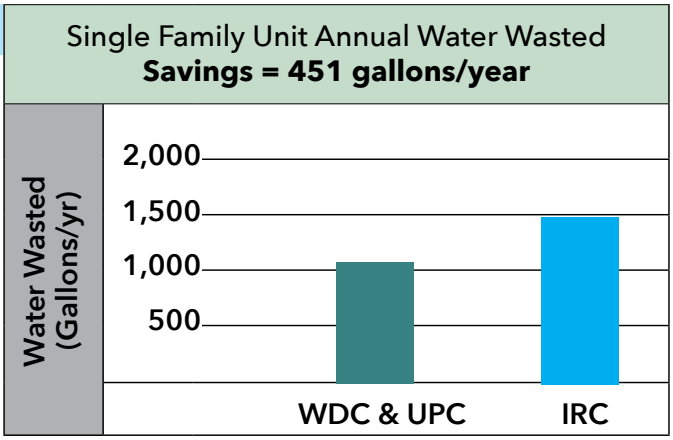


Fig. 2

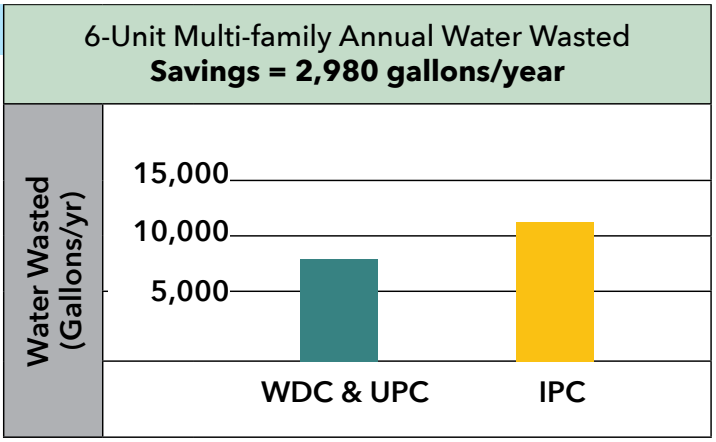


Fig. 3

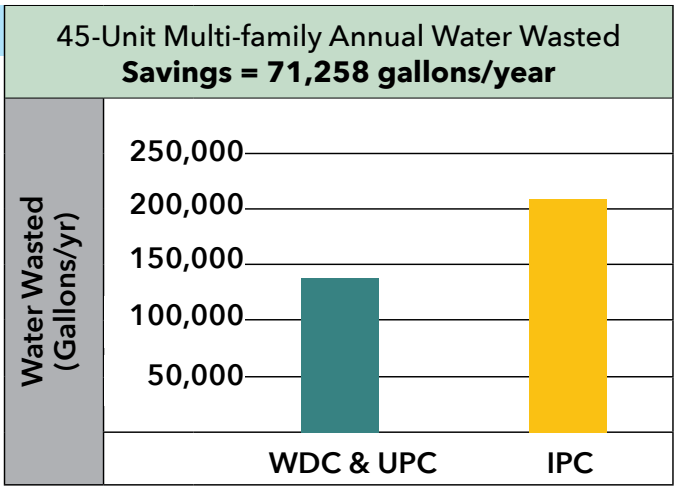


Fig. 4

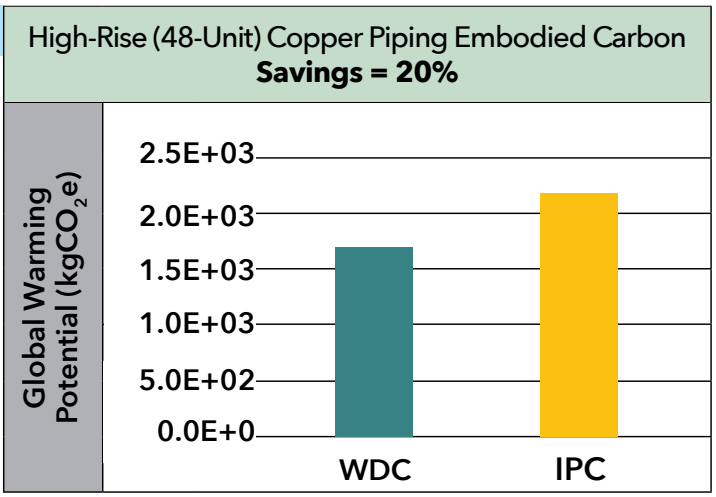


Fig. 5

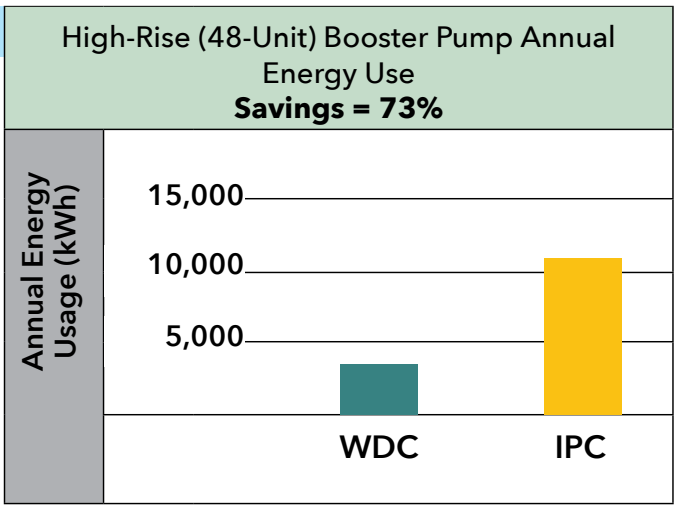
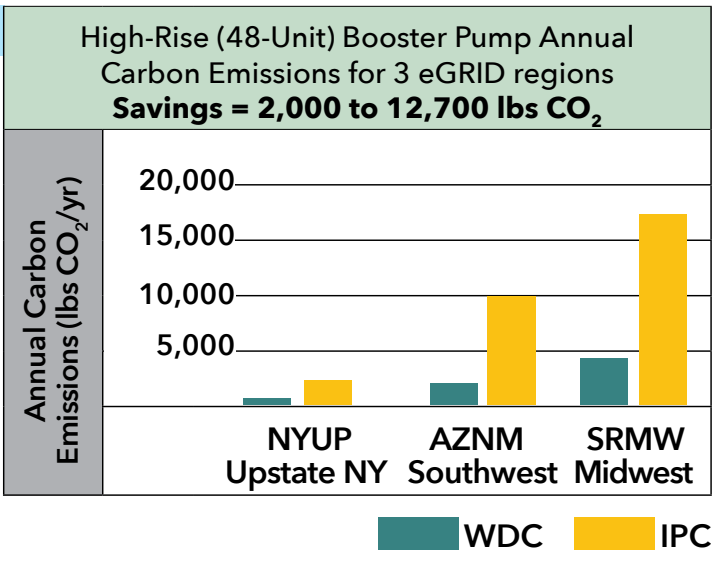


Fig. 6



FINDINGS

Water savings were demonstrated through minimized time-to-tap using the Water Demand Calculator™ sizing. Water savings range from 450 gallons to 71,000 gallons (Figs. 1 – 3) annually depending on the building size. This represents 27% - 34% of water savings in single-family, 6-unit, and 45-unit buildings from oversizing using IPC and IRC. A single-family unit prototype showed annual water savings of 450 gallons. Using U.S. Census Data for single residential permits, this water savings across the 975,584 single-unit residences permitted in 2022 has the potential to save approximately 440 million gallons of water annually when compared to use of IRC for sizing[2].

Using the Water Demand Calculator™ to size domestic water systems in single-family residences can save up to 32.9 kg CO_2e from water service entry appurtenances per single family home alone. For ease of comparison, a savings of 32.9 kgCO_2e is equivalent to CO_2 emissions from charging 4,002 smartphones, consuming 3.7 gallons of gasoline, or using one and a half 16 pounds propane cylinders used for home barbeques. Similarly, 32.9 kgCO_2e savings is equivalent to the savings in greenhouse gas emissions from driving 84.3 miles by an average gasoline-powered passenger vehicle.

High-rise (48-unit) residential building showed savings in operational carbon of 73% for booster pumps (Fig. 5) and embodied carbon savings of 20% (Fig. 4). Using the Water Demand Calculator™ instead of the IPC Hunter's method to size domestic water systems in high-rise residential buildings shows savings of operational carbon ranging from 2,000 lbs CO_2 to 12,700 lbs CO_2 per high-rise residential building, depending on grid emissions at the project site (Fig. 6).

[2] U.S. Census Permits 2022

More Yet to Come...

The use of IAPMO's Water Demand Calculator™ can reduce water age in pipes, enhance water quality in addition to saving you money – so stay tuned for updates!