WaterSense® Labeled Homes Communities Save Energy and Support Decarbonization

In communities across the country, bringing water to homes requires a substantial amount of energy. This means that for every drop of water that comes out of a home's tap, there's energy that helped get it there. Within new residential developments, builders have an opportunity to construct homes that not only reduce the impact on regional water resources, but also minimize the energy use and carbon emissions associated with the water supplied to and used in those homes. As part of its commitment to energy and water efficiency, as well as climate resiliency, KB Home launched two communities—Oak Shade and Durango—comprised of more than 200 all-electric, solar-powered, WaterSense labeled homes in Menifee, California. Designed to be both energy- and water-efficient, the homes use 40 percent less energy and at least 30 percent less water than typical new construction, feature solar panels, and are backed by a microgrid community battery to reduce dependence on the conventional electrical grid. Further energy savings and emissions reductions are realized at each home and across the broader region by reducing the amount of energy needed to supply each of these homes with water and treat their wastewater.

Case Study Highlights

Location: Oak Shade and Durango communities in Menifee, California

Number of WaterSense Labeled Homes in Study: 219

Builder: KB Home

Average Home $HERS_{H2O}$ Score: 59

Estimated Water Savings: 13.5 million gallons per year

Estimated Water-Related Energy Savings: 530,000 kilowatt hours (kWh) per year

Estimated Water-Related Carbon Reduction: 331,000 pounds CO_2 per year

The U.S. Environmental Protection Agency's (EPA's) WaterSense program and KB Home partnered to evaluate the impact that water savings will have on energy use and greenhouse gas emissions from these communities compared to a community comprised of similar-sized, typical new construction homes. The analysis considers the unique energy intensity of the water sources supplying the Oak Shade and Durango communities (i.e., the estimated energy used to extract, treat, and convey each water source); the communities' projected water use patterns; and the design and technology used within the homes to estimate the energy and emissions reductions from reduced water use. EPA and KB Home estimate that when fully built, each year these communities will save 13.5 million gallons of water; save 530,000 kilowatt hours (kWh) of water-related energy; and avoid 331,000 pounds of carbon dioxide (CO_2) emissions when compared to a community of typical new homes. This case study of Oak Shade and Durango can serve as a blueprint for future communities pursuing decarbonization and energy savings and highlights the impact constructing WaterSense labeled homes can have on reducing energy use and carbon emissions.

KB Home's Oak Shade and Durango Communities in Southern California

KB Home—an award-winning builder partner in EPA's WaterSense program—is committed to water and energy efficiency throughout its construction portfolio. In Menifee, California, KB Home took its commitment to sustainability and climate resiliency to the next level by launching two communities comprised of 219 water- and energy-efficient homes served by a community-scale microgrid to reduce dependence on the conventional electrical grid.

These single-family homes—which average 2,300 square feet, four bedrooms, and 6,800-square-foot lots—stretch across two communities referred to as Oak Shade and Durango. The homes are exceptionally energy-efficient, with heat pump water heaters featuring best-in-class efficiency, solar panels, and onsite electric battery storage that combined contribute to each home's lower carbon emissions. The communities are all-electric and rely on solar power to reduce reliance on the regional grid, but can draw on both individual home and community battery storage when solar sources aren't sufficient. Local storage can also be used for load management. These microgrid features, along with the homes' high levels of efficiency, give Oak Shade and Durango homes a lower carbon footprint than houses in typical developments. And they have one more thing in common—they have all earned the WaterSense label, which means they use at least 30 percent less water than typical new homes. Since it takes energy to extract, pump, treat, convey, and heat water, this water savings translates directly into additional, quantifiable energy and CO_2 emissions reductions—not just within each home, but more broadly in the Southern California region and beyond.

WaterSense Labeled Homes Program

EPA's WaterSense labeled homes program is the first national certification for water efficiency. Homes with the WaterSense label are built to use at least 30 percent less water compared to typical new construction and are independently certified to meet the *WaterSense Specification for Homes* and ensure performance. Find out more about the program at www.epa.gov/watersense/homes.

we build WaterSense Meets EPA Criteria

What Features Make These WaterSense Labeled Homes?

As required by the *WaterSense Specification for Homes*, all WaterSense labeled homes are free of leaks at delivery and include WaterSense labeled toilets, showerheads, and lavatory faucets. The homes at Oak Shade and Durango include additional water-efficient features to meet the WaterSense specification, such as ENERGY STAR® certified dishwashers and efficient hot water distribution systems that deliver hot water faster. Outdoors, KB Home used synthetic turf and pavers to create entertainment areas that reduce the amount of landscape area that requires irrigation. Where irrigation is needed, drip irrigation is installed in plant beds, and WaterSense labeled weather-based irrigation controllers manage each home's system, ensuring that the landscapes are only irrigated when necessary. Lastly, an irrigation professional certified by a WaterSense labeled program audited the irrigation systems to ensure proper irrigation system design, installation, and programming. The figures below show just how water- and energy-efficient these homes will be. Figure 1 illustrates projected estimates for major end uses of water in a typical 219-home community in Menifee, California, compared to the Oak Shade and Durango communities. Figure 2 on the next page shows the water efficiency features included in a model home within the communities.

FIGURE 1. WATER USE FROM A COMMUNITY OF TYPICAL HOMES COMPARED TO OAK SHADE AND DURANGO HOMES

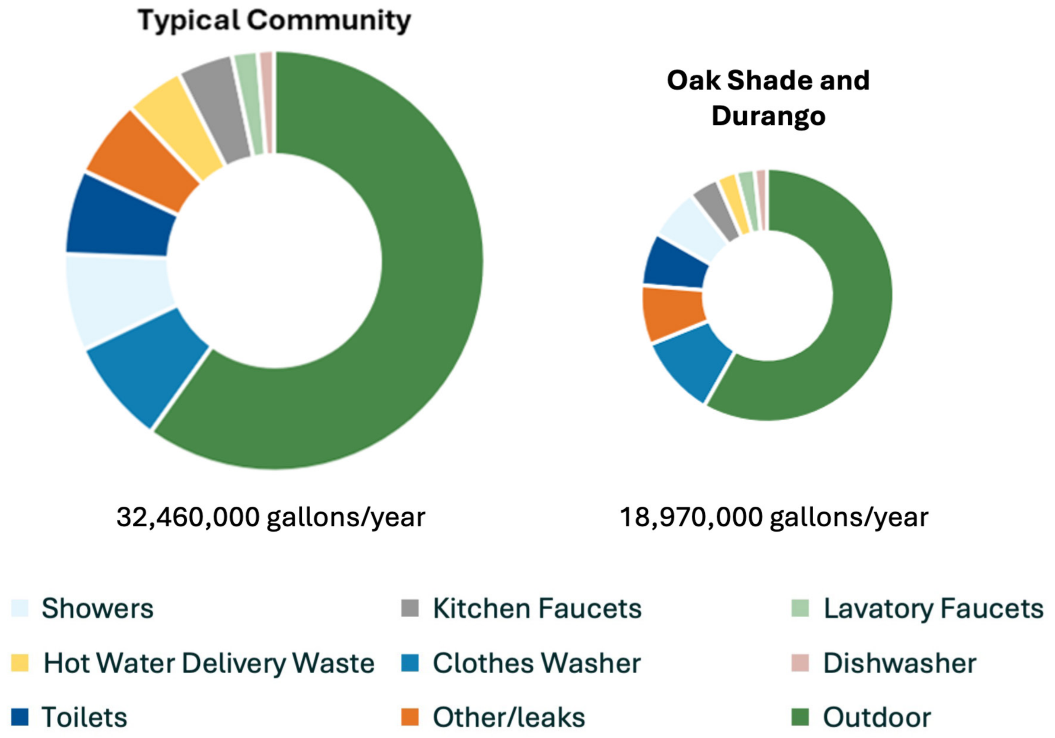
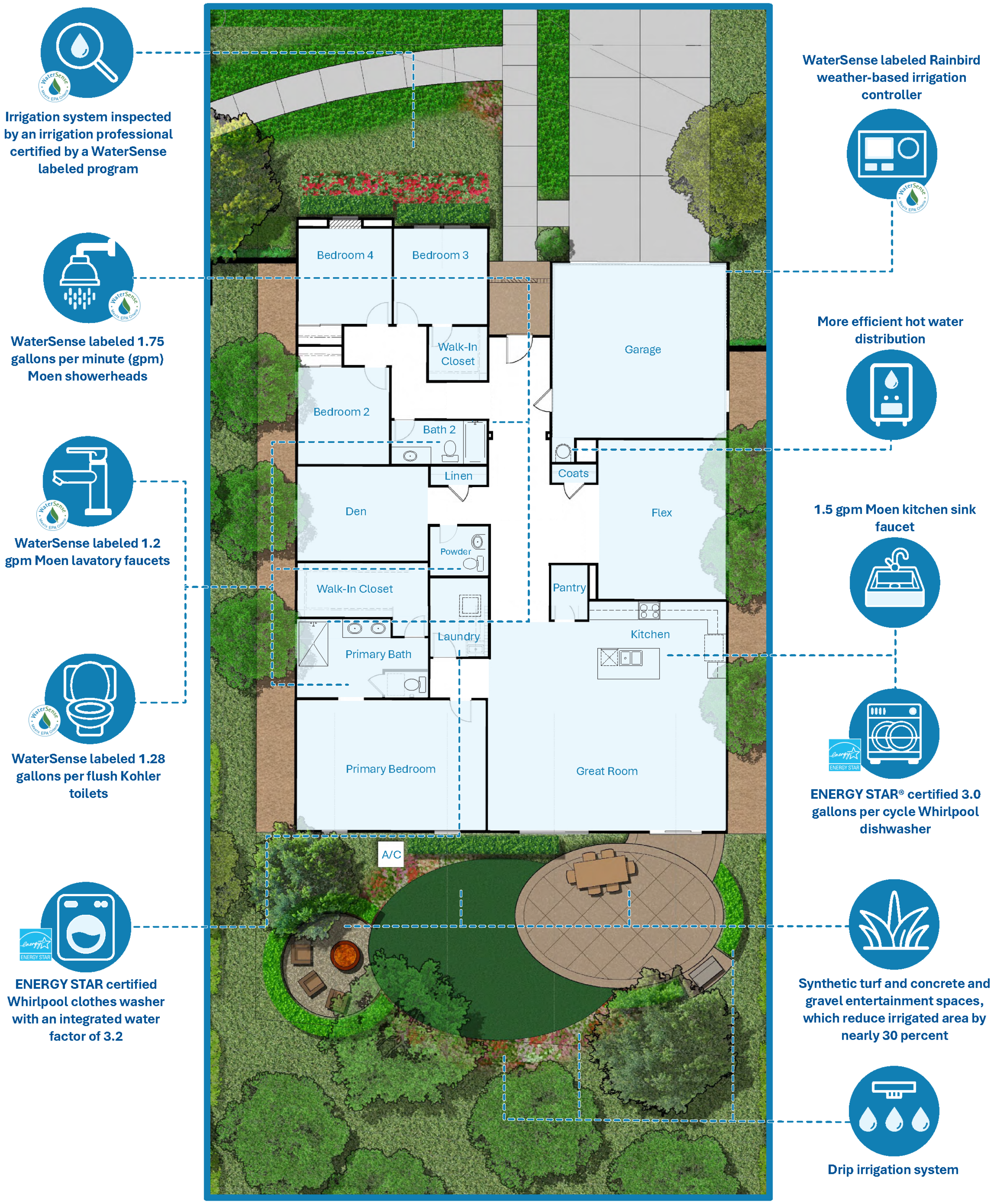


FIGURE 2. WATER EFFICIENCY FEATURES INCLUDED IN MODEL HOME IN DURANGO COMMUNITY



On average, each home in these communities will use an estimated 87,000 gallons of water each year—that's 62,000 fewer gallons of water per home each year compared to typical new construction. KB Home achieved certification that these homes meet the WaterSense specification through RESNET—a WaterSense Home Certification Organization. Their verification company partner was Arcxis—a provider of inspections and engineering services for homebuilders who has partnered with RESNET and supported the EPA's WaterSense program for many years.

RESNET's water efficiency rating system, $HERS_{H2O}$, is a 1-to-100 scale performance rating used to evaluate household water efficiency. Using this scale, lower numbers mean less water use and a more water-efficient home (with a score of 0 representing no net water consumption), while higher numbers mean more water use and a less water-efficient home (with a score of 100 equaling the typical home). The homes in Oak Shade and Durango have an average $HERS_{H2O}$ score of 59, which suggests an expected water savings of 41 percent when compared to typical homes—well below the $HERS_{H2O}$ rating of 70 that is required to earn the WaterSense label.[1]

With help from KB Home, Arcxis, and RESNET, WaterSense was able to estimate the water-related energy savings and CO_2 emissions reductions from the entire Oak Shade and Durango communities, as described below.

[1] Water use and savings estimates for the entire Oak Shade and Durango communities were based on rating files from 98 homes (the number that had been certified at the time of the analysis) and extrapolated to all 219 homes planned. Since all homes in the communities have the same climate and share nearly identical features and design elements, EPA found this to be a reliable projection.

Embedded Energy in Water Supply and Treatment Systems

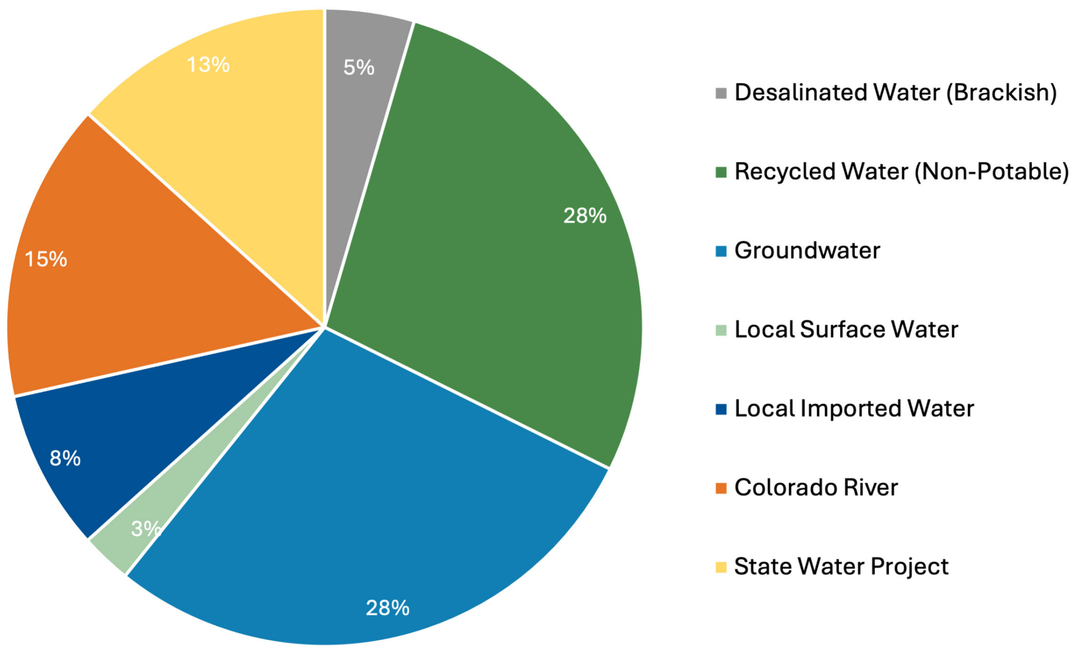
Communities use energy to support water systems and deliver water to homes and businesses in a variety of ways. Table 1 summarizes the various aspects of water distribution in communities, as well as some of the major influences on its energy intensity. In short, the energy embedded in any single gallon of water is the result of where it comes from, where it is going, the level of treatment required, and how it is used.

TABLE 1. INFLUENCES ON ENERGY INTENSITY DURING EACH STEP OF THE DOMESTIC WATER DISTRIBUTION SYSTEM

Step	Energy Use and Expected Influences on Energy Intensity
Extraction	Water is extracted from its source to feed supply systems. The amount of pumping energy needed for extraction is influenced by the source water location. Generally, surface water will have a lower energy intensity than groundwater.
Conveyance	Since water is not always available exactly where it is needed, it often needs to be moved from its source to the community. Water is transported (sometimes over long distances via both gravity-fed and pumped systems) from the point of extraction to the communities that will utilize it. Longer distances and greater elevation gains tend to increase the amount of energy required for this step.
Treatment	Ensuring water supply is safe to use for its intended purpose typically requires treatment, which uses energy. While water is usually treated to drinking water standards, less treatment may be needed if used for non-potable purposes (e.g., irrigation). The treatment technology used will influence the energy intensity value, as will water quality—lower quality water sources that require more treatment will usually require more energy.
Distribution	Treated water is delivered to customers. Energy is needed to pump water from the treatment location to the users. Like conveyance, longer distances and greater elevation gain increase the energy intensity values.
Heating	A significant portion of the water used in homes is heated, and heating water uses energy. The uniform energy factor (UEF) of the water heater; efficiency of the distribution system (how quickly it can deliver heated water to point of use); set point of the water heater; and the temperature of the incoming water will influence the overall energy intensity value. Naturally, lower efficiencies in water heaters and distribution systems result in more energy-intense domestic hot water systems. Colder climates also require more energy due to a higher difference between the incoming water temperature and the set point of the water heater, as well as a tendency for consumers to use a greater ratio of hot water to cold due to lower cold water line temperatures.
Wastewater Collection	For water that goes down the drain and to a wastewater treatment facility, energy is needed to convey it to the treatment plant through a combination of gravity and supplemental pumping.
Wastewater Treatment	Energy is used as part of the wastewater treatment process. The treatment technology, the quality of the incoming wastewater, and the required quality of the wastewater treatment discharge will influence the energy intensity value.

As discussed in Table 1, embedded energy for water supply and treatment will vary based on the water source supplied. Eastern Municipal Water District (EMWD) supplies all of the water to homes in the Oak Shade and Durango communities. EMWD's water sources are documented in their Urban Water Management Plan. However, a significant portion of the water that EMWD supplies is purchased from Metropolitan Water District of Southern California (MWD). For this analysis, any water purchased from MWD was assumed to have a regionally proportional mix of sources, and those values were used along with other sources EMWD obtains directly to estimate a final mix of sources supplied by EMWD, as illustrated in Figure 3.

FIGURE 3. EMWD WATER SOURCES (INCLUDING WATER PURCHASED FROM MWD)



Using this approach, EMWD water includes mostly a mix of recycled water, groundwater, Colorado River water, water from the State Water Project, and other locally imported sources. While water delivered to a given section of a large and diverse service territory (such as EMWD) is not perfectly mixed based on the district's sources as a whole, data limitations do not allow further analysis of water sources used at a given location. Similar to the assumption made for MWD supplied data, EPA assumes that any water delivered to Oak Shade and Durango homes contains a proportional mix of potable water based on the EMWD sources. Non-potable sources are excluded, since non-potable water is not provided to the homes in the communities.

Each water source requires a different amount of energy to extract, convey, treat, and distribute the water. Data from the California Public Utilities Commission (PUC) Water Energy Calculator details this information for each source of water and each geographic region of the state (see Table 2 on the next page).

TABLE 2. PUC EMBEDDED ENERGY INTENSITIES IN KWH/ACRE-FOOT

Source	Extraction and Conveyance	Water Treatment	Distribution	Wastewater Collection and Treatment
Desalinated Water (Brackish)	696.8	1,406.5	163.0	723
Recycle Water (Non-Potable)	107.3	606.8	415.8	723
Recycled Water (Potable)	696.8	1,271.5	163.0	723
Groundwater	696.8	205.3	163.0	723
Local Surface Water	88.9	205.3	163.0	723
Local Imported Water	33.0	205.3	163.0	723
Colorado River	2,110.9	205.3	163.0	723
Central Valley Project	225.0	205.3	163.0	723
State Water Project	3,306.2	205.3	163.0	723

Impact From Hot Water Use and Water Heating Efficiency

Since homes in the Oak Shade and Durango communities include WaterSense labeled showerheads and faucets, as well as ENERGY STAR certified dishwashers and clothes washers, they are reducing hot water demand and energy consumption associated with heating water. Data obtained from the $HERS_{H2O}$ rating files allowed EPA to estimate that the homes in these communities save an average of nearly 6,000 gallons of hot water per home per year compared to typical homes.

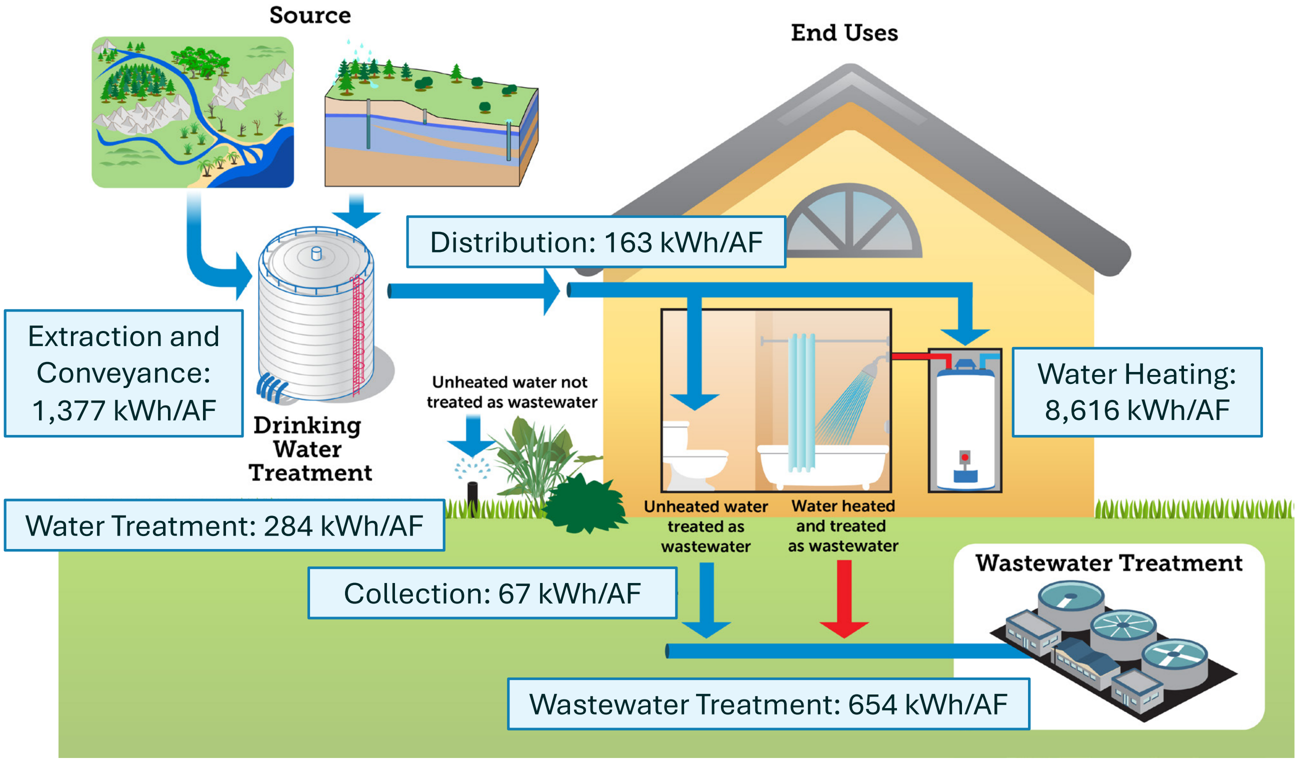
If the homes had standard products, appliances, and water heaters, the energy needed to heat water would be more than 540,000 kWh per year for both communities. However, KB Home installed best-in-class heat pump water heaters that have a uniform energy factor (UEF) rating of 4.07, which are more than four times more energy-efficient than standard water heaters and reduce the energy needed for water heating. When combining the impact of these high-efficiency heat pumps with the lower demand for hot water at Oak Shade and Durango due to the homes' water-efficient design, it is estimated the communities will use only 93,000 kWh per year for water heating—a savings of nearly 450,000 kWh per year.

The energy savings associated with reduced hot water demand and greater water heating efficiency also reduce CO_2 emissions. At Oak Shade and Durango, the presence of solar power and the microgrid technology that are supplying electricity to the water heaters also influence carbon emissions. A typical community without water efficiency improvements and with standard water heaters using energy from the electrical grid would generate 289,000 pounds of CO_2 emissions per year solely from water heating. Since all electricity used for water heating is assumed to be carbon-free in this analysis, the carbon emissions attributed to water heating are zero.[2]

Total Water-Related Energy and Carbon

Based on the analysis above, EPA estimated that each acre-foot of water supplied to the community requires an average of 1,820 kWh of electricity for extraction, conveyance, treatment, and distribution. Heated water consumes an additional 8,616 kWh per acre-foot based on the location, design, and water heaters of the homes. Finally, each acre-foot of wastewater treated requires an average of 720 kWh of electricity for wastewater collection and treatment. Figure 4 illustrates the energy each step requires, from extraction through wastewater treatment.

FIGURE 4. WATER-RELATED ENERGY CONSUMPTION PER ACRE-FOOT OF WATER AT EACH STAGE FOR HOMES IN THE OAK SHADE AND DURANGO COMMUNITIES



[2] For purposes of this analysis, EPA assumed that energy used for water heating in the Oak Shade and Durango communities is completely supplied by onsite/community sources and will therefore be carbon-free. It is possible that homes will need additional energy sourced from the electrical grid at times; however, in this analysis EPA assumed that 100 percent carbon-free electricity is used because exact ratios of power drawn from the microgrid versus the electrical grid depend on many factors and aren't currently known. Assuming the communities are using all carbon-free electricity creates a conservative estimate of the impact of water use reductions on carbon emissions. While the total carbon emissions would go up with any power drawn from the electrical grid, the water-related carbon reductions would also increase compared to communities with typical hot water use.

If homes reduce water use, the energy needed in each of these steps is also reduced. To calculate the water-related energy the Oak Shade and Durango communities save, EPA combined the calculated energy intensity values with the data on how the homes are likely to use water from RESNET's $HERS_{H2O}$ rating files, both discussed above. Since the $HERS_{H2O}$ data allows for estimating individual end uses of water, as well as the ratio of hot to cold water for specific end uses, the average values for energy intensity were applied to the total predicted end uses as appropriate. For example, water used for toilets requires energy for extraction, treatment, delivery, and collection and treatment of wastewater, but not for water heating. On the other hand, water used for irrigation does not require wastewater collection and treatment, since it does not discharge to the sanitary sewer system.

In total, EPA estimates the communities will save 13.5 million gallons of water per year. These water savings, when combined with the efficient water heating and distribution within these homes and solar generation with microgrid storage, result in an estimated savings of 530,000 kWh of electricity per year. Of this savings, 80,200 kWh is the result of embedded energy savings from not having to convey, treat, and distribute the water and collect and treat the wastewater. It is important to note that this embedded energy will be realized beyond the communities—either by the water provider (EMWD) or even hundreds of miles away for imported water sources.

Using the energy savings discussed above, EPA also estimated the resulting CO_2 emissions reductions. Based on EPA's Emissions and Generation Resource Integrated Database (eGRID) for the region, every kWh of electricity generates 0.532 pounds of CO_2. Therefore, the water-related electricity savings results in 331,000 pounds of CO_2 emissions avoided each year. Of that, 42,600 pounds of CO_2 are the result of embedded energy savings from not having to convey, treat, and distribute the water and collect and treat the wastewater.

Water Efficiency as a Cost-Effective Solution for Decarbonization

This analysis clearly shows that using water efficiently can contribute to energy savings and decarbonization efforts, but the scale of the impact and the cost-effectiveness of it as a strategy relative to other technical and policy solutions are also important considerations. To evaluate the relative impact and cost-effectiveness of the various strategies employed at Oak Shade and Durango, EPA developed three scenarios where savings and emissions reduction estimates were calculated individually: incorporation of a microgrid, more efficient water heaters, and water efficiency. These upgrades correspond to those found at Oak Shade and Durango: a carbon-neutral microgrid for

> "We addressed water-related carbon impact in three ways at Oak Shade and Durango: with the microgrid, with the heat pump water heaters, and with water efficiency. We believe that using all three is the best approach, but water efficiency was clearly the least expensive and would certainly be the most cost-effective if we were to evaluate the cost per pound of carbon emissions avoided. This is one of the reasons we're dedicated to water efficiency at KB Home and have committed to build 100 percent WaterSense labeled homes in our Southwest regions."
>
> – Jacob Atalla, KB Home Vice President of Sustainability

electricity, water heaters with a UEF of 4.07, and annual water use reduction of 13.5 million gallons per year.

To isolate the potential impact of each strategy, each scenario was run with the other two strategies left at these reference levels: 531.68 pounds CO_2 per megawatt hour (MWh) of electricity generated as specified for the location by eGRID; water heaters with the federal minimum efficiency of 0.95 UEF; and water consumption of 32.5 million gallons of water per year based on a typical community of a similar size and location from the $HERS_{H2O}$ rating file. Table 3 lists the estimated water-related energy savings and carbon emission reduction potential for Oak Shade and Durango from each of the three decarbonization strategies when assessed on their own.

TABLE 3. ESTIMATED ENERGY SAVINGS AND CARBON EMISSIONS REDUCTIONS FROM WATER-RELATED DECARBONIZATION STRATEGIES AT OAK SHADE AND DURANGO

		Microgrid Scenario	Heat Pump Water Heaters Scenario	Water Efficiency Scenario
Features	Electric Generation	0 lbs CO_2/MWh	531.68 lbs CO_2/MWh	531.68 lbs CO_2/MWh
	Water Heater Efficiency	0.95 UEF	4.07 UEF	0.95 UEF
	Water Consumption	32.5 million gallons/year	32.5 million gallons/year	19 million gallons/year
Savings	kWh/Year Saved	0	416,000	224,000
	Pounds CO_2/Year Avoided	289,000	221,000	119,000

It is important to note that the energy savings and carbon emissions reductions within the table are not additive, since in a real-world setting, all three strategies are occurring simultaneously and influence each other. However, the results are informative about the potential scale of each solution, all of which hold significant carbon reduction potential.

Conclusion

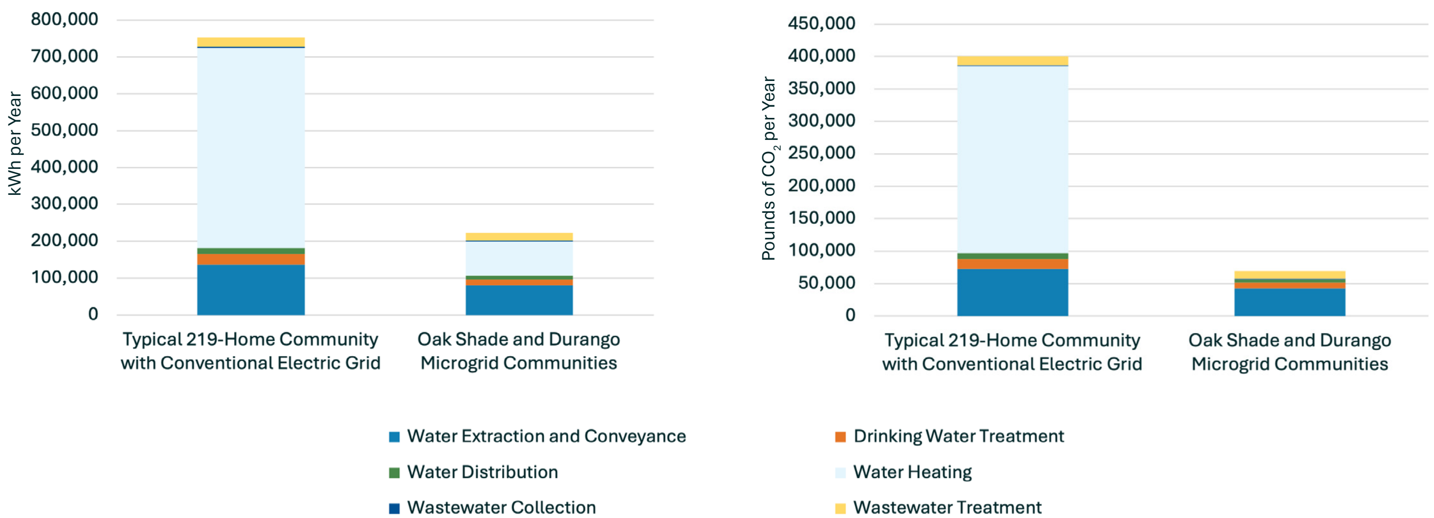
In summary, the 219 homes within the Oak Shade and Durango communities provide significant water and energy savings, resulting in lower carbon emissions. As shown in Figure 5 on the next page, these communities will reduce water-related energy consumption by approximately 530,000 kWh per year, equivalent to the average electricity consumption of 49 homes. Similarly, also shown in Figure 5, the communities will reduce water-related CO_2 emissions by 331,000 pounds per year, which is equivalent to taking 33 gasoline-powered cars off the road each year.

The strategies used to reduce water and energy consumption and carbon emissions associated with KB Home's Oak Shade and Durango communities serve as a blueprint for future communities pursuing decarbonization and climate resilience. By identifying the weighted mix of water sources for the communities; the estimated energy used to extract, treat, and convey each water source; the total water saved by the communities; and the energy and emissions reductions from water use avoidance and water heating, EPA was able to show the total water-related impact on energy and carbon emissions. KB Home is helping families and the broader region realize significant energy savings and emissions reductions through water efficiency from the 219 WaterSense labeled homes in these communities. Builders across the county can adopt these methods to estimate energy savings and emissions reductions from their WaterSense labeled homes projects to illustrate how a whole-house approach to water efficiency can contribute to community decarbonization goals.

WaterSense Partner Savings Calculator Tool

EPA maintains a tool for builders, manufacturers, and retailers to calculate conservative estimates of water and energy savings and associated CO_2 emission reductions from WaterSense labeled homes and products. Contact the WaterSense Helpline for more information at watersense@epa.gov.

FIGURE 5. WATER-RELATED ELECTRICITY (KWH) CONSUMPTION AND CO_2 EMISSIONS (POUNDS) PER YEAR AT OAK SHADE AND DURANGO



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