50L HOME

ARCADIS

A Roadmap to Operationalize the Water-Energy-Carbon Nexus for Homes

Contents

A message from the 50L Home co-chairs....3

Executive summary....4

Context....6

The whole home approach: deeper into the WEC nexus....10

Pillar 1 – Technology innovation....14

Pillar 2 – Behavior change....22

Pillar 3 – Policy....24

Way forward: Call for action....28

A message from the 50L Home co-chairs

The 50L Home Coalition's vision is in its namesake: creating a future where households can meet their needs with only 50 liters of water (13 gallons) per person per day, but with the feeling of 500 liters (132 gallons). The coalition unites companies, organizations, governments, and experts to develop, test and scale innovations for efficient water and energy use in urban homes, in order to transform building systems and communities toward water efficiency and low carbon emissions.

The water-energy-carbon (WEC) nexus is a concept that helps explain the interconnection of water, energy and carbon emissions, highlighting the interdependencies and trade-offs involved in the management of these aspects. Understanding these relationships has in turn helped the 50L Home Coalition work to address complex and pressing problems related to water and energy usage in homes. The energy used to extract and treat water for consumption, deliver it to homes, heat it inside the home, then remove and treat wastewater all contribute to the greenhouse gas (GHG) emissions. The Coalition's 2022 Water-Energy-Carbon Nexus in our Homes: A blind spot for climate crisis? white paper highlights that no individual, industry, utility or municipality can unlock meaningful GHG reductions in the home on their own: impact and scale require all to work together.

This paper provides a roadmap for action by focusing on implementation. Through our pilot project in Los Angeles, we have gathered and analyzed real-world data on how consumers use water and energy needed to heat the water, in their homes. We then retrofitted homes with appliances, fixtures and products that are designed to save water and energy and surveyed consumers to learn about their experiences. We also analyzed relevant policies and regulations to drive scalable improvement. Through the pilot project, we learned that we can drive down water and energy consumption significantly.

This practical roadmap for operationalizing the WEC nexus was developed with our partner Arcadis to identify some of the best interventions for immediate impact. Together, we engaged a community of professionals in the United Kingdom through deep dive roundtables on key aspects of the issue, including customer behavior, existing and new technologies and the policy landscape. The result will help inform new ways to retrofit and design homes and is a must-read for policymakers, industry leaders and researchers who are looking to reduce water and energy consumption. We welcome your collaboration in achieving the 50L Home Coalition's vision.

Kate Gallego,
USA Public Sector Co-Chair 50L Home Coalition, Mayor of Phoenix, Arizona

Victor Aguilar,
Private Sector Co-Chair 50L Home Coalition
Chief Research, Development and Innovation Officer, Procter & Gamble

Executive summary

The cascading and connected crises facing the world demand the testing, implementation and scaling of bold new ideas. Homes play a key role in reducing carbon emissions. The 50L Home Coalition puts a spotlight on the intertwined agenda of Water-Energy-Carbon (WEC) nexus for homes.
We led a first-of-its-kind knowledge paper in 2022, Water-Energy-Carbon (WEC) Nexus in our homes, A blind spot for climate crisis? to emphasize the embedded and complex relationship of water use with energy and carbon.

What is a 50L Home?

Achieving an enjoyable living experience with an average daily consumption of 50 liters (13 gallons) per person per day and low carbon emissions will rely on understanding water and energy use patterns, using running water when needed, using hot water when required and choosing efficient fittings and appliances. To do so requires more innovation.

The 50L Home aims to be accessible for all in the long-term. It is working toward having fittings designed to minimize water consumption and will have highly efficient appliances that use less water than manual ones. By minimizing water use, a 50L Home will contribute to lower energy use and carbon emissions, especially hot water.

Designing for the WEC nexus brings better results

True water efficiency in the home demands the consideration of the energy and carbon required to deliver, heat, remove and clean it. This will require technology and product innovations that address both, combined with strong policy and behavioral change incentives, to achieve scale and address climate mitigation and climate adaptation demands.

Multi-sector coordination needed

While the water sector has focused on water efficiency and conservation it has not invested enough in understanding the energy and carbon embedded in water use.

The primary obstacle in residential settings is the absence of a clear leader or sector driving this transition. As stakeholders overlook the hidden expenses associated with cheap water, with water and energy valued and billed separately, they have compartmentalized thinking. Framing the problem in terms of a WEC nexus can unite water and energy regulators, utility companies, property developers, local governments, technology providers, consumers and policymakers to address systemic structural challenges.

Consumer comfort equals fast and lasting change

Operationalizing WEC efficiency requires a whole home approach that fosters systems innovation and places the needs and comfort of consumers at the center.
A key challenge for stakeholders is to ensure these innovations become available and accessible to all.

Action areas

Impact at scale will depend on the pursuit of evolutions in policy, partnerships, innovation and technologies that help homes avoid the depletion of water resources and reduce emissions.

Technology

There are a range of innovative, accessible technologies, such as retrofits, that could offer savings to consumers and maximize efficiency when used in conjunction with consumable products engineered for this purpose.

The best overall technologies maximize their efficiency when paired with consumable products engineered to help consumers save water and energy. These technologies include:

- Recirculating showers;
- High-efficiency toilet flush innovation;
- Tap and shower head innovation with pressure compensating aerators for faucets;
- Water- and energy-efficient washing machines;
- Air- and water- sourced heat pumps;
- Decentralized water treatment solutions and units.

Government incentives, such as regular grants and cross subsidies, along with net-zero emissions programs are among the best ways to catalyze this innovation.

Behavior change

This transformation of water and energy use in homes depends on consumers being the primary beneficiaries, not the ones bearing the costs. However, there are steps we can take to help consumers who are ready to take action to lower their consumption and bills. Education will be key in raising awareness and enabling consumers to understand the scale and impacts of domestic consumption, its hidden costs, the benefits of WEC efficiency and the range of innovations available.

Some actions and technologies influence consumer behavior and choices:

- Smart meters showing overall water use and detecting leaks inside the home;
- More precise billing for water and electricity so consumers can see what they consume and when;
- Devices in the home that track specific water usage.

Policy

There is an equal challenge in uniting specialized policy fields to work together. Framing the problem in terms of a WEC nexus can unite change agents, including water and energy regulators, utility companies, property developers, local governments, technology providers, consumers, and policy-makers, to address issues such as:

- Creating a home labelling system for water efficiency;
- Mandatory water labels for wet appliances, fittings and fixtures and consumer products so consumers can better understand the WEC nexus;
- Train and develop professionals who know how to promote and install sustainable water and energy technologies and retrofits.
- Updated codes and standards for new home construction that align with WEC efficiency and not just energy efficiency.

The actors of change in the WEC nexus require deeper insights and evidence on how embedded water, energy and carbon are in homes and solutions that can facilitate the paradigm shift. By shining a light on the intersections of innovation, policy change and consumer education, it is possible to reach deeper collaboration to enable water and energy efficiency with no trade-offs.

Context

For 10 consecutive years, the World Economic Forum's Global Risks Report has listed water crises among the top five risks in terms of impact.[1] This has manifested in the form of Day Zero scenarios, when water supplies in cities like Sao Paulo, Chennai and Cape Town almost ran out.

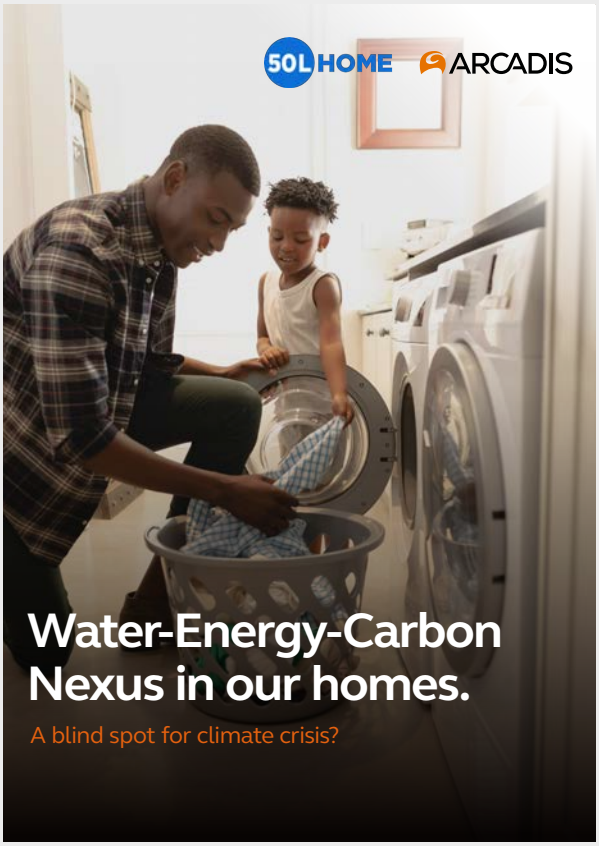
By 2025, an estimated 1.8 billion people will live in areas plagued by water scarcity, with two-thirds of the world's population living in water-stressed regions rapidly amplified by extensive domestic and industrial water use, population growth and climate change.[2] The challenge the world now faces is how to effectively conserve, manage and distribute water resources. The provision and use of water comes with a substantial carbon footprint. On a global average, every cubic meter of water consumed generates 10.6 kg of carbon emissions.[3] The water sector is lagging in the decarbonization and optimization journey compared to the energy sector. While water regulators and utilities have started to drive sustainability and efficiency on the supply side, it is imperative to innovate with demand-side optimization strategies for resource sustenance. This begins in homes.

The 50L Home Coalition's vision is to make water-efficient low-carbon living an irresistible reality for all.

The 50L Home Coalition led a paper in 2022 on the Water-Energy-Carbon (WEC) Nexus in our homes, A blind spot for climate crisis? The knowledge paper was the first of its kind to bring an understanding of how water efficiency intertwines with energy and carbon efficiency. It emphasizes the need to focus on systems-based efficiency gains in water and energy by improving consumer journeys with water use in homes. Policy enablement, behavior change and technology innovation in an array of wet appliances, fixtures and fittings, cleaning products and digital platforms that could systematically remove, reduce or reuse water and energy promote this.

Reducing domestic water use in homes has a strong business case. It will increase the resilience of water supplies, leave more water in the environment, reduce energy use and subsequent carbon emissions and help with the affordability of water and energy.

Water-Energy-Carbon Nexus in our homes.
A blind spot for climate crisis?



Can we get people to live on 50L of water per person per day?

From old questions. Scarcity

What if homes could run at 50L and low carbon, and still feel like 500L?

To new questions. Abundance.

Image: WEC Technology and Innovation roundtable in London, December 2023

To add a pragmatic lens to our vision, 50L Home conducted a series of industry roundtables with representatives from water utilities, policymakers, technology companies, advocacy groups, think tanks, marketing and communication specialists, social scientists, technical practitioners and consumers. We hosted these roundtables to better understand the barriers and enablers across key policy, technology innovation and behavior change drivers that would be critical to bringing speed and scale to the mission. We detail the key takeaways from the roundtables below.

50L Home, in partnership with the US Green Building Council California (USGBC-CA), is running its first innovation pilot in Los Angles, USA. We provided select urban homes with a range of innovative consumable products, retrofit fixtures and wet appliances that we compared to control homes that had not undergone retrofitting to understand system-based efficiency gains and behavior change effects. The pilot has been a success in demonstrating deeper understanding of consumer relationships with water inside homes and the systems that work in the background. It has also brought to light the implementation challenges in retrofit innovation, along with demonstrating the positive effects of customer education and incentivized behavior change as key enablers in adopting water- and energy-efficiency technology. This test is living proof that collaborative innovations can lead to increased water, energy and cost savings.

Preliminary and partial findings from the Los Angeles (LA) innovation trial

19% water savings in retrofitted homes during the trial vs baseline in the same homes;

24% hot water savings in retrofitted homes vs control homes;[4]

The WEC transition will require creative ways to think about systems. This action paper is a handy playbook for practitioners and collaborators to understand the bottlenecks and enablers across three key pillars:

1. Technology innovation:

A new hierarchy to assess technology and product innovations that are best in class to enable, remove, reduce and reuse water in homes and to assess their success factors for wider consumer adoption.

2. Behavior change:

The highlighting of innovative ideas to nudge people's behavior, creating consumer incentives and awareness for the faster adoption of more efficient home products.

3. Policy:

Addressing systemic and structural policy barriers and enablers to bring the mission to speed and scale. It presents unconventional partnership opportunities for the actors of change, drawing some parallel lessons from the net-zero emissions transition momentum.

For ease in understanding the water and energy consumption dynamics, we use references for the UK and London in the document.

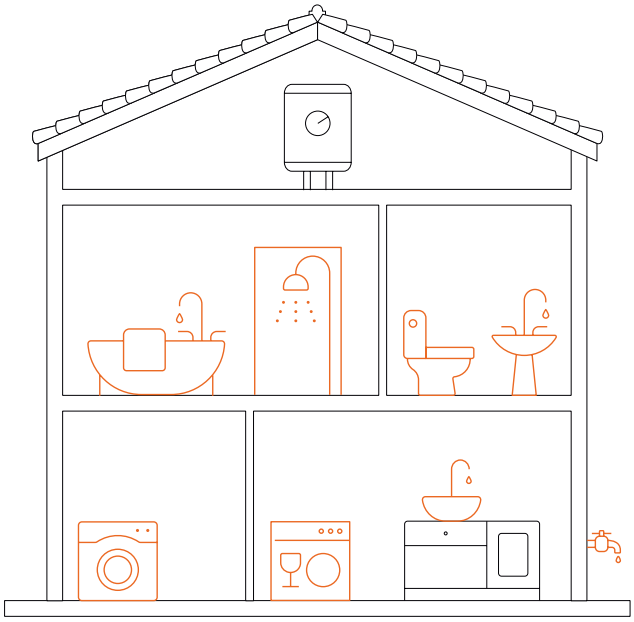
The Whole Home Approach: deeper into the WEC nexus

Humans take for granted at times the amount of water embedded in their lives. A water-efficient home is able to minimize water use, harness water for reuse, conserve energy, reduce the carbon footprint, reduce bills and enhance lives. For example, a spray-on foaming dish soap that requires only a spray, wipe, and rinse saves the water (including hot water) that would have filled a basin or run from a faucet. Hot water saved translates to energy and carbon saved, which means more financial savings for consumers.

The way humans do laundry, clean dishes, take showers and flush toilets, among others, impacts the climate.

It is important to develop greater insights into real-life water use in the home to understand the hidden impacts of habits and plan for water efficiency. For example, in the UK, the Environment Agency (EA) estimates that every person uses around 150 liters of water per day, which translates to ~350 liters of water each day for the average household. In geographic proximity, European households tend to spend 40% of their total water consumed (144 liters of water per day) on personal hygiene, in the acts of showering, etc. Toilet flushing accounts for almost a third of an average home's indoor water consumption; it's often the second highest domestic water-using device after showering. An average household in the UK flushes the toilet about 4,600 times each year. That's about 28,000 liters of water.[5] While consumer behaviour is a factor in water efficiency, it is not possible to achieve significant water savings by asking consumers to make sacrifices. It is essential to work together to create the products and policies that enable water and energy efficiency without trade-offs, without unnecessarily limiting consumer habits and behaviors.

So how does the daily consumption stack up?



Digram 1: Daily water consumption patterns

Function	Water consumed	System at work
Bath and shower	**43%**	Water heating system, shower head, sink tap heads, wash basin, personal care products such as shampoo, soap, etc., drainage
Toilet	**22%**	Toilet flushing
Washing clothes	**13%**	Washing machine, detergent
Cleaning dishes	**8%**	Dishwashing machine, dishwashing liquid, tap (when washing by hand)
Outdoor use	**7%**	Car washing fixture, garden hose, etc.
Drinking water	**4%**	Water purifier, water heating/ cooling, fittings & fixtures

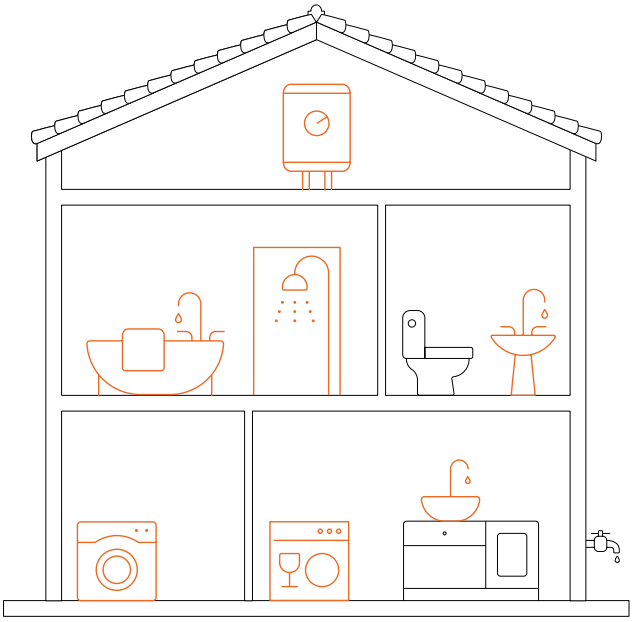
Source: Avg. water usage estimates from secondary research for UK homes from the report 'At Home With Water' by Energy Saving Trust, 2013

The water and sewage industries generate around 1.55 billion metric tons of greenhouse gases per year, approximately 3-6% of all global emissions.[6] As the need for sustainability and resilience drives conversations in the industry more than ever, water and wastewater utility decision-makers are gaining awareness of the need to become more efficient and achieve the co-benefits that efficiency brings. It is an evolving push with cost and deliberation complexities, starting with how decarbonization can and should fit into a water utility's sustainability goals.

In the UK, the water sector contributes about 6% of total carbon emissions (about 34 Mt CO2e)[7]. The EA study demonstrates that the major greenhouse gas emissions associated with the domestic "use" phase of water stemming from its supply-use-treatment cycle is 89%, with the remaining 11% attributable to utility companies in the supply and treatment phases.[8]

According to the Energy Saving Trust, household emissions from heating and hot water must decrease by 95% to reach the 2050 net-zero targets set by the UK Government. It amounts to 875 kg of CO2 per household per year, which needs to go down to 135 kg of CO2 as per the statutory UK Climate Change Committee (CCC) directives.[10]

Avg. Water Related CO2 (%) in the UK



Digram 2: Avg. Water Related CO2 (%) in the UK

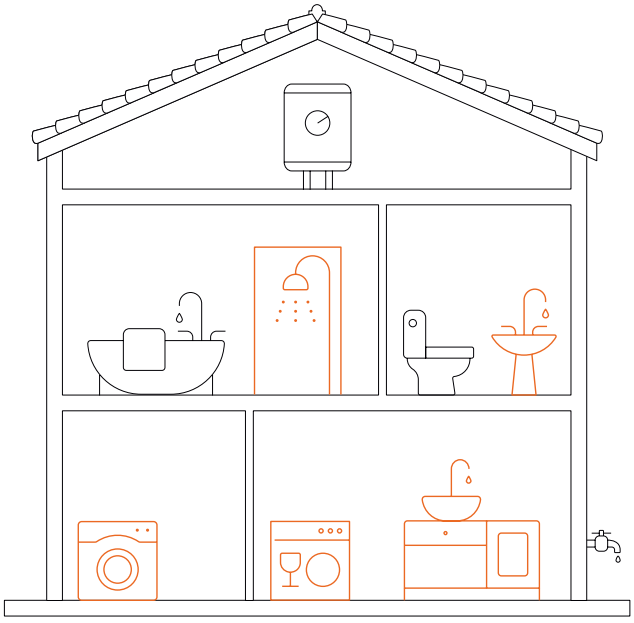
Supply-side embedded CO2 with water companies	
Water utility (as per the Environment Agency, UK)	10%
System loss (not contributing to heating)	16%
Demand-side embedded CO2 in homes	
Hot water in homes (assumed as gas boiler-based heating system)	46%
Dishwashing machine	17%
Washing machine	11%

Source: Environment Agency and Energy Saving Trust[9]

Tracking down the hot water in homes

Heating water in homes is an expensive, energy- and carbon-intensive component. For example, the demand variation depending on the home is between 20 and 222 liters of hot water a day (median of 90 liters) in the UK according to the 2024 report from the Department for Energy Security and Net Zero.[11] Considering that an average UK household uses 349 liters per day, hot water consumption is more than 25% of the total water consumed.[12] The typical hot water set point is 55°C. Behavioral insights on hot water temperature set point variation shows that 71% homes do not adjust temperature throughout the year.[13]

Hot water used at home for baths, showers and washing up also accounts for about 18% of household energy use.[14] Any hot water that goes down the drain carries energy with it in the form of heat. That means homes waste 80% to 90% of the energy used to heat water.



Digram 3: Hot water consumption estimates

Hot water use	Avg. liters of hot water per use	Hot water use (liters) per week for an individual
Showering	76 + 15 (if shampooing hair) (considering a 5 min. shower time, 15 liters used per minute as a flow rate)	532
Washing machine	35 (per cycle)	70 (considering washing machine runs twice a week)
Dishwashing	14 (per cycle)	98 (considering dishwashing happens once every day)
Shaving	8	56
Washing hands & personal care	8	56
Food preparation	19	133
TOTAL	**160**	**874**

Source: Department of Energy Security and Net Zero, UK, 2024[15]

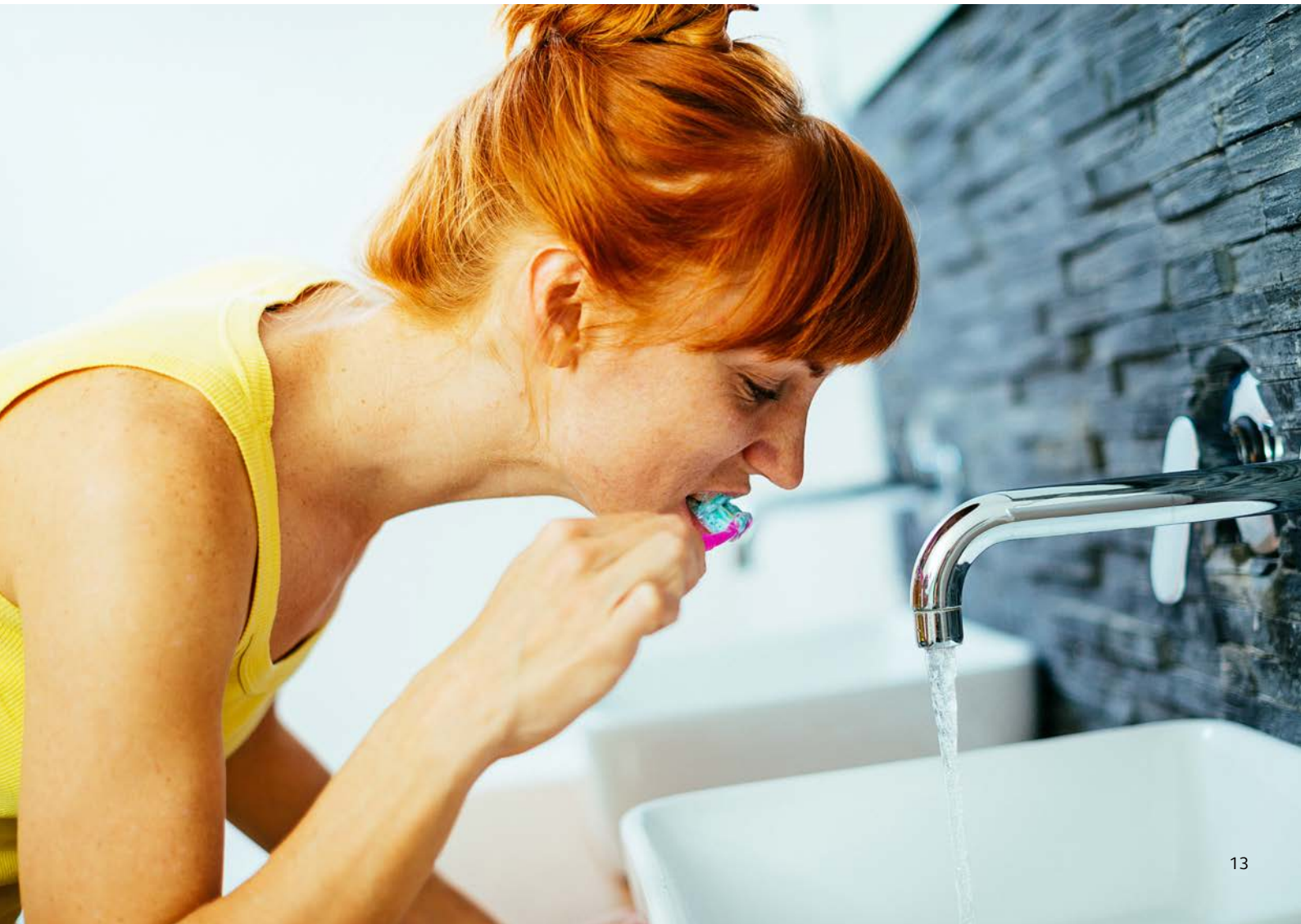
Note: Numbers in table slightly overestimated to account for some appliances which are designed for a family of four, such as dishwasher and washing machines. Estimates based on individual use.

Hot water efficiency is instrumental in the WEC nexus. The water energy model indicates that optimized hot water system design in new houses (primary pipe work, boiler location, controls, cylinder sizing, insulation and hot water distribution) could provide significant CO2 emissions reductions and water and cost savings. Retrofit solutions for existing housing stocks exist as well.

Drain-water (or greywater) heat recovery systems can solve the problem of heat loss by capturing the energy and using it to preheat the cold water entering the water heater or going to other water fixtures. This allows for the lowering of the water heater's temperature, thus reducing the amount of energy required to heat the same amount of incoming water. Such drain-water heat recovery systems cost starting at USD $500 and have a two-and-a-half to seven-year payback time.[16]

At the end of the day, the WEC nexus focuses on consumers. The social value it brings to people has immense potential in supporting them as they cope with the ongoing cost of living crisis. Energy bills have increased significantly and look likely to remain high for a significant period. The nexus enables consumers to see the cost of water in totality.

According to the Energy Saving Trust, heating water alone can account for almost one-quarter of the energy consumed in UK homes. It also accounts for 18% of an average energy bill, totaling USD $291[17] (considering an average annual electricity bill of about USD $1,600 for a family of four). This is still an underestimate since this does not count the energy used to run wet appliances. Reducing utility bills for water and energy users, and for vulnerable customers in particular, can be helpful in reducing the total cost of living in the UK and around the world.



Pillar 1
Technology innovation

The WEC nexus leverages the power of system innovation. When exploring strategies to implement demand-side resource flexibility and efficiency in homes, the incorporation of innovative water- and energy-saving products and technologies is a crucial consideration. From wet appliances to water heating systems, sanitary fittings and fixtures, digital platforms and consumable products, a range of innovation exists that can bring efficiency in water consumption and the energy use associated with it.

For instance, aerated shower heads can consume up to 50% less water and smart shower meters can encourage users to take shorter and cooler showers.

However, the widespread adoption of these water- and energy-saving products and technologies hinges on their ability to offer tangible benefits to consumers beyond environmental efficiency. Factors such as savings on water-energy bills and enhanced living are pivotal in driving consumer interest. Equally important is the accessibility of these technologies, encompassing aspects like affordability, ease of use, ease of installation and maintenance requirements.

It is essential to empower and incentivize people to adopt water-saving habits and use water-saving technologies to address the pressing issue of the WEC nexus. The continued emphasis on consumer behavior change overlooks the fact that systems working inside homes that often go unnoticed also need to become more resource-efficient. Behavior change coupled with systems change is a win-win situation for homes.

Methodological Framework

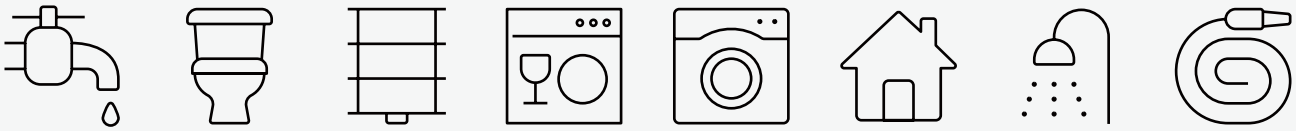
To explore water- and energy-saving technologies and products, 50L Home conducted an industry roundtable inviting experts to discuss mature and novel technologies that can enable water and energy efficiency. Following the trials, the 50L Home Working Group undertook a detailed technical analysis of various technologies and products for their ability to save water, energy and carbon and their appeal to consumers.

Whole home approach: Addressing the WEC nexus requires adaptations in all aspects of water use. This means consumption throughout the kitchen, bathroom, laundry and outdoors. Therefore, we found technologies and products with water- and energy-saving capabilities in the following areas: shower, toilet, taps, laundry, washing dishes and heating water.

Efficiency hierarchy: Technologies and products can remove, reduce or reuse water and energy. They can also provide hot water efficiency, water efficiency, energy efficiency in water, new water or new energy. When selecting technologies and products to assess, we prioritized those that provided hot water efficiency due to their ability to save water and significant amounts of energy from management of the energy intensity of heating water.

Energy used to heat water comprises a large percentage of total energy use in homes. Thus, reducing hot water consumption is key to helping achieve low-carbon homes. In addition, saving energy results in lower payments for consumers, making technologies that reduce energy consumption more economically attractive.

Range of innovations: Technologies and products that reduce water and energy fall into multiple product categories, including wet appliances, water heating systems, sanitary fixtures and fittings, personal care products, cleaning products and digital platforms Personal care products tend to be low-cost whereas wet appliances tend to be more expensive and require retrofitting but have greater water- and energy-saving capabilities.



Once we had selected 30 technologies and products, they underwent a systematic assessment where we used 28 mutually exclusive parameters that we weighted and we scored sub-parameters to create a ranking hierarchy of the technologies and products. The parameters fell under two main categories: “sustainability” and “consumer appeal”. The sustainability parameters assessed the technologies and products capable of reducing or optimizing resources such as water, energy and carbon. The consumer appeal parameters assessed the irresistibility factor of the technologies and products for consumers and, therefore, the likelihood of people purchasing them. The table below shows examples of parameters in each of these categories.

Sustainability metrics used		
1. Water savings (liter/person/day)	2. Energy savings (kWh/person/day)	3. Equivalent carbon savings (kg CO2/person/year
Consumer-centric metrics used		
4. Maturity of innovation	5. Return on investment	6. Ease of maintenance
7. Capital cost	8. Other consumer benefit	9. Market suppliers
10. Retrofit cost & ease of retrofit	11. Ease of use	12. Enhancement of lives
13. Total bill savings	14. Expected lifespan	15. Level of general awareness

We assessed the technologies and products in two stages. In the first stage, we used 14 predominant sustainability parameters. In the second stage, we used 14 predominant consumer appeal parameters. The "Terms of Reference" section of the report provides additional details regarding the method used to score the technologies and products using the parameters, along with a list of the 30 technologies and products.

Values and assumptions used to calculate values for water, energy and bill savings were:

- The average showerhead uses 12 liters of water per minute[18]
- The average shower taken is 8 minutes long[19]
- The energy required to heat water for an 8-minute shower using a gas boiler is approximately 4kWh[20]
- The average number of showers taken by an adult in the UK is six per week[21]
- The average toilet uses 8L water per flush[22]
- The average person will flush the loo 5 times a day, in their home. If using a dual flush toilet this will be one large flush and 4 small flushes[23]
- The average energy usage of a washing machine is 2.1kWh per load[24]
- The average water usage of a washing machine is 60L per load[25]
- A single person uses a dishwasher and washing machine an average of twice per week[26]
- If a person is handwashing their dishes, they will do a 12L wash per day, this requires roughly 0.7kWh energy to heat the water[27]
- The average person uses 2kWh energy to heat water for use in their home per day in the UK[28]
- The average cost of household water in the UK is 0.2p per liter (to get and remove)[29]
- The average cost of electricity in the UK is 22p kWh and the average cost of gas in the UK is 5.48p per kWh[30]
- Gas boiler efficiency is 90%

Values for water and energy savings for innovations in the dish washing category were in comparison to hand washing, with the water being heated by a gas boiler. Values for water and energy savings for innovations in the washing machine category were in comparison to using a standard washing machine.

The table below shows the innovations which scored the highest in each stage of the assessment.

Rank	Lens 1: Sustainability focus	Lens 2: Consumer appeal focus
1	Aerated showerhead	Aerated showerhead
2	Shower meter	Shower meter
3	Tap aerators	Air source heat pump
4	Recirculating shower	Tap aerators
5	2 in 1 shampoo and conditioner	Recirculating shower
6	Rainwater harvesting system	Wastewater heat recovery device(s)
7	Air source heat pump	High efficiency washing machine
8	High efficiency washing machine	2 in 1 shampoo and conditioner
9	Greywater recycling unit(s)	Supersaturated steam washing machine
10	Pressure-assisted toilet	Pressure-assisted toilet

Category
Shower
Toilet
Laundry
Dishwashing
Water heating
Taps
Other

Identifying the hero case for WEC nexus:

Using the scores awarded by the two-stage assessment, 50L Home Working Group selected six "hero" technologies and products, spread across the various areas of water use in homes. The table below shows the details and values for water, energy and bill savings for these technologies and products.

Technology/ Product	Product Type	Area of Water Use	Water savings (L/p/day)	Energy savings (kWh/p/day)	Original energy Source	Bill savings ($/p/year)	Capital cost average ($)	Payback Period (years)*
Recirculating shower	Appliance	Shower	66	2.7	Gas	135	5250[31]	9.7
Pressure-assisted toilet	Fitting	Toilet	21	0.00	N/A	20	630[32]	7.9
High efficiency washing machine + cold wash or short cycle laundry detergent	Appliance	Laundry	5.1	0.3	Electricity	37	650 + 50 (year's supply)	4.7
High efficiency dish washer + high efficiency dish washing detergent	Appliance	Dish washing	9.1	0.47	Gas	23.3	650 + 50 (year's supply)	7.5
Air source heat pump	Heating system	Water heating	0	1.3	Gas	35	4590**[33]	32.8
Tap aerators	Fitting	Other	17	0.25	Gas	22	20 (3 * $7)[34]	1

*For a household of 4

**Value assumes that the consumer uses $9844 UK grant to aid purchase

Additional values and assumptions used to calculate these values were:

- A recirculating shower uses 80% less water and 70% less energy than the average shower[35]
- Pressure-assisted toilets use 1 gallon per flush (3.8L per flush)[36]
- A high efficiency washing machines uses 30% less water than other machines and 50% less electricity.[37]
- The high efficiency dishwasher uses 10L water and 0.8kWh per load[38 39]
- Air source heat pumps are 300% efficient[40]
- According to the European University Institute, aerators can save you up to 1,274 litres of water a month[41]

Budget friendly-mature hero cases: 50L Home Working Group also selected three "low-cost hero" technologies and products using the assessment framework and placing greater weight on the cost parameters: capital cost, installation cost and maintenance cost. The table below shows the details and values for water, energy and bill savings for these technologies and products.

Technology/ Product	Product Type	Area of Water Use	Water savings (L/p/day)	Energy savings (kWh/p/day)	Original energy Source	Bill savings ($/p/year)	Capital cost average ($)	Payback Period (years)*
Water efficient showerhead	Fitting	Shower	41.1	1.71	Gas	84	25[42]	0.1
Shower meter	Digital platform	Shower	20.6	0.86	Gas	42	20[43]	0.1
Cleaning and personal care products that enable people to save water and energy	Consumable product	Multiple	10.3	0.43	Gas	21	50**[44]	0.6

*For a household of 4

**For a year's supply

Additional values and assumptions used to calculate these values were:

- A water efficient shower head reduces water consumption of a shower by 50% (to 6L/min)[45]
- A shower meter encourages the user to take a 6-minute shower rather than an 8 minute one
- 2-in-1 shampoo, and conditioner encourages the user to take a 7-minute shower rather than an 8 minute one

It is important to note that some of these technologies are relatively commonplace, especially in newly built homes; however, there are still many homes that could be more sustainable through their adoption. In addition, using these technologies and products requires the consumer to adjust their water-use habits to achieve water and energy savings. For example, they must use the shower meter to encourage them to take a shorter shower.

It is also important to note that a wide variety of cleaning and personal care products that enable people to save water and energy at home when they use them are available on the market that will have varying impacts on water and energy use, such as dishwashing liquid, laundry detergent and personal cleaning products like 2-in-1 shampoo and conditioner. Moreover, products with better performance will not require consumers to adopt compensatory habits that result in increased use of water or energy (e.g., rewashing clothes, rinsing dishes before putting them in the dishwasher, etc.). They can play a significant part in water and energy reductions, especially when used alongside water- and energy-saving technologies like appliances and fixatures and are often the most affordable way for consumers to cut down on water and energy at home.

Novel yet disruptive hero cases: Finally, the 50L Home Working Group used the assessment results to select two "innovative path-breaking hero" technologies and products. These technologies are novel and carry high costs but have transformative sustainability potential and substantial bill savings for the consumer. The table below shows the details and values for water, energy and bill savings for these technologies and products.

Technology/ Product	Product Type	Area of Water Use	Water savings (L/p/day)	Energy savings (kWh/p/day)	Original energy Source	Bill savings ($/p/year)	Capital cost average ($)	Payback Period (years)*
Wastewater heat recovery device(s)	Heating system	Water heating	0	1.30	Gas	38	660[46]	4.3
Decentralised greywater recycling unit(s)	Water system	Other	51	0	N/A	49	5910[47]	30.2

*For a household of 4

Additional values and assumptions used to calculate these values were:

- A wastewater heat recovery system can recapture and reuse instantly up to 70 percent of waste energy[48]
- A family of 4 can save up to 75.000 litres of water per year with a greywater recycling unit(s), therefore a single person can save up to 51.37L per day [49]

Enablers to encourage the adoption of water-energy-savings technologies and products

Clearly, there are many technologies and products with significant water- and energy-saving capabilities that offer consumers tangible benefits, including bill savings and improved quality of life. However, there are barriers to their adoption with speed and scale.

One of the main barriers to the widespread adoption of these technologies and products is the cost factor. This is especially prevalent for novel technologies and products that are in the earlier stages of market maturity, such as the "innovative hero" cases highlighted above. There are a handful of ways to scale these WEC technologies and products for consumers, such as:

Government incentives in the form of grants, subsidies and cross-subsidies for both supply- and demand-side players: As discussed in one of our industry roundtables, the use of government grants can reduce the burden of bearing the full cost of technologies and products, making them comparable in price with competitors and encouraging people to purchase them.

The UK government provides a grant of USD $5,000 to help people install low-carbon heat pumps in their homes. These grants and funds are vital to meeting the UK's government the net-zero emissions target and represent a key part of the strategy to tackle fuel poverty and make sure that the net-zero emissions transition is socially equitable, leaving no one behind. There has been a 25% increase in MCS (Microgeneration Certification Scheme) -certified air-source heat pump installations in the UK in 2022 following the roll out of the grant scheme.[50]

Government support (regular grants and cross-subsidies) have proven to be catalytic in encouraging market growth for technologies by energizing both the demand and supply sides as observed from net-zero emissions programs. On the demand side, subsidies can make products more affordable for consumers, increasing their willingness to purchase them. On the supply side, subsidies can incentivize producers to invest in technology research, development and production, leading to increased supply and lower prices. This dual impact can create a positive feedback loop, driving market growth and technology adoption in net-zero emissions innovations for solar, wind or electric vehicles (EVs).

Recent inflation globally has become a hurdle for energy companies focusing on renewable energy development as they are determined to transition to net-zero emissions. The UK has witnessed an increase of 66% in offshore wind project costs.[51] To combat this inflation, several countries, including the UK, have adopted tax incentives to support wind industry investments, such as the wind production tax credit (PTC) for companies producing wind energy on a per-kilowatt-hour basis, while an investment tax credit (ITC) reduces the wind project owner's tax liability based on the capital investment in the project.

Schemes are also an idea to oblige water and energy companies to subsidize technologies, with consumers sharing the cost burden through their bills. In a way, investing in demand-side water and energy efficiency and flexibility helps water and energy companies avoid those large capital investments required due to strained resources.

Schemes like the Energy Company Obligation (ECO) in the UK work by placing an obligation on medium and large energy suppliers to fund measures that improve the ability of vulnerable households to heat their homes, such as installing insulation or upgrading heating systems. Some people can also get free solar panels with the ECO4 grant.

WEC innovation would require multi-pronged policy enablement to accelerate its adoption. Increased demand for a product can lead to reduced prices over time as companies benefit from economies of scale. Lower prices stimulate further demand, creating a self-reinforcing feedback cycle of cost reduction and increased adoption.

The overall cost declines in solar PV cells – some 55% over the last decade – has largely been due to economies of scale and enabling policies, making them an economically viable form of electricity production.

The most powerful solution: system combination

Using a combination of technologies and products yields the most powerful solution for resource efficiency. For example, there are a plethora of products and technologies that enable people to save water and energy for showers, such as:

- Recirculating shower;
- Water-efficient showerhead;
- Shower meter;
- Consumer products that enable people to save water (e.g. shampoo)

The table below demonstrates the systems effects of shower, water and energy savings and costs through innovation in various combinations.

Technology 1	Technology 2	Technology 3	Total water savings (L/person/day)	Total energy savings (kWh/person/day)
Shower meter	Consumer product that enables people to save water		21	0.6
Water efficient showerhead	Consumer product that enables people to save water		30	0.9
Water efficient showerhead	Shower meter		34	1
Water efficient showerhead	Shower meter	Consumer product that enables people to save water	37	1.1
Recirculating shower			44	1.3
Assumptions and values used to calculate these values are given above				

As this table shows, some combinations of lower cost technologies create water and energy savings that are close to much more expensive technology combinations. For example, using an aerated shower head, shower meter and consumer products that enable people to save water has similar water and energy savings as using a recirculating shower for USD $45 rather than USD $5,000. It does, however, require the user to take a significantly shorter shower (5 minutes instead of 8 minutes). Therefore, there is no guarantee that consumers will see savings but will require difficult shifts in behavior. However, it does allow people with lower budgets to reach water and energy saving targets.

Using lower cost shallow retrofits or consumable products alongside deep retrofits can also have huge benefits, boosting water and energy savings for a relatively small additional price. One example is the use of a consumer product that enables people to save water to cut showering time and using a recirculating shower.

System combination also means using water- and energy-saving technologies across all the areas of domestic water use: toilet, shower, taps, washing dishes, laundry and heating water.

Pillar 2
Behavior change

Consumers are at the heart of the WEC nexus. Consumer education and advocacy are instrumental in raising awareness about WEC and encouraging behavior change. Communication needs to target different consumer groups, considering the intersectionality of age, gender, socioeconomic status, education, house ownership and ethnicity vis-a-vis the challenges faced in their water- and energy-efficiency journey.

For instance, tenants living in rental properties face challenges in accessing deep water and energy retrofit options. This is a consumer segment that requires education focusing on other retrofit options and product innovation with low barriers to entry. Furthermore, there are often little or no incentives for landlords to implement changes if they do not reap the benefits personally. Thus, the transition regularly leaves rental housing stock behind. City stakeholders such as local authorities and utilities need to be creative in designing WEC efficiency campaigns, incentives and messaging.

Understanding the barriers between WEC nexus optimization and consumers and how to bridge them.

Communicate the connection of domestic water use with the big picture: It's often the case that communities do not connect to their water supply journey as they should. There is limited awareness of water scarcity and the environmental implications of water use in homes. Due to a lack of metered billing, households have little idea how much water they consume daily. About 40% of customers in England and Wales have a water meter,[52] a number that is slowly increasing. There is a need to build the ability of consumers to fundamentally value water through a clear understanding of their own water use footprint and pattern. In one of our industry roundtables, we recognized that embedding the vitality of water efficiency into school curricula and providing information to residents through different media would help them correlate it with the impact on local rivers and water resources.

According to Water UK, 46% of people believe their household uses under 20 liters of water a day, however, in reality, the average person in the UK uses 142 liters of water a day, meaning a family of four uses roughly 550 liters daily.[53]

Making the invisible visible for consumers: Educating consumers on water and energy consumption and its hidden cost will lead to a change in behavior for some consumers. Complacency about water saving is prevalent among people living in homes without meters, where they pay a flat fee instead of by use. These individuals are more likely to underestimate their water use and its cost, meaning saving money is not an effective incentive to use water-efficient technologies. For example, in the UK, half of British households have no meter and pay a fixed charge regardless of water use. According to recent reports, a staggering 43% of domestic properties in the UK have water leaks,[54] yet most households are not aware of it inside their homes.

> 87% of respondents said that they would investigate getting a smart water meter having it fitted at no charge if it would lead to a reduction in their bills.[55]

Breaking down the real cost of water for a household in the UK

Average annual water bills are USD $545 and average annual energy bills are USD $1,786[56]
Typically, 18% of energy bills are for heating water, totaling USD $291[57]
Appliances like tumble dryers, washing machines and dishwashers account for close to 15% of electrical running costs, totaling USD $268[58]
Water cost totals are some USD $1,100 annually for a household, some 47% of the yearly utility bill.

Table 8: The real cost of water for a household in the UK

Marketing water- and energy-efficient technology and products: Many consumers are not aware of water efficiency when making purchasing decisions, as there is no standardized water labelling system to help them assess product efficiency. Moreover, it is hard to comprehend the comparison between the cost of buying a water-efficient appliance or product vs the savings they bring in terms of a lower utility bill (for both water and energy). For example, buying water-saving detergent that reduces the length of the rinse cycle and performs the same in a cold water wash saves water and reduces hot water use, reducing the energy bill significantly. While it decreases both the water and energy bills, it is hard to assess them quickly during purchasing decisions

There is also a lack of knowledge about the wide array of innovation that exists for water and energy efficiency, such as deep or shallow retrofit options, efficient cleaning and consumable products or high-efficiency wet appliances. Moreover, there is apprehension about novel and emerging technologies even if the innovation promises substantial savings. Value chain actors such as local councils, water-energy companies, appliance and product manufacturers and NGOs and local water champions need to come together to raise the WEC innovation profile.

Conveying the value for money to overcome the cost barrier: Some consumers worry that water- and energy-efficient products are more expensive, without understanding the potential savings that they can bring. Water utility rates are extremely low in comparison to energy bills, complicating efforts to make the financial case for water-efficiency upgrades. WEC stakeholders must act together to construct a lucrative business case for consumers by enabling them to understand the embedded energy savings associated with many water-efficiency improvements. For example, hand faucets and water-using appliances will have associated hot water savings that can improve the financial case for these upgrades. Another approach to make the financial case for higher cost efficiency retrofits is to package them with quicker payback upgrades and use the savings from the lower cost opportunities to pay for the more capital-intensive items.

Incentivizing behavior change and WEC adoption: Installing water-efficient technologies is important but if consumers don't use them appropriately, they can perform poorly and produce little or no savings. For example, installing a water-efficient showerhead is pointless if the user doubles the length of their shower.

Pillar 3
Policy

A key obstacle hindering the adoption of greater efficiency in the WEC nexus in residential settings is the absence of a clear leader or even sector driving this transition. Stakeholders can overlook the hidden expenses associated with cheap water, as the billing for water and energy typically happens separately, leading to compartmentalized thinking

Framing the problem in terms of a WEC nexus aims to unite key change agents, including water and energy regulators, utility companies, property developers, local governments, technology providers, consumers and policymakers, to address this systemic structural challenge. It is imperative to embrace the interconnectedness of individual and collective interests in this nexus, with consumers positioned as the focal point.

Why the WEC nexus should be everyone's agenda.

Having engaged and partnered with a diverse set of stakeholders during pilots and industry roundtables from the WEC value chain transition, we have built an understanding of the mutual interests and co-benefits of acting together.

Regulators and policymakers in water, energy and housing could play a pivotal role in driving the net-zero emissions and resource-efficiency agenda. This is crucial to increasing overall resilience, preserving water and energy resources for the future and protecting consumer affordability amid rising costs of living. Regulators and policymakers can ensure WEC is a priority across geographic jurisdictions and markets by creating enabling and binding policy frameworks such as integrated efficiency standards, innovative tariff models, grants, blended investments for the WEC transition, etc.

In the UK, the energy regulator, Ofgem, and the water regulator, Ofwat, serve the same customer base and work towards the same sustainability and resilience goals.

Water and energy utilities: Demand-side flexibility and efficiency are essential to sustaining resources, whether it's energy or water. For example, projections show the UK's public water supply will be short by 4 billion liters a day by 2050, meaning it needs to create new water abstraction systems and infrastructure.[59] Enhancing water and energy efficiency at the household level can delay the need for some large-scale infrastructure projects in the long run. This approach is also relevant for the national energy grid. Moreover, both utilities are already pursuing their respective net-zero emissions targets. By integrating the WEC agenda and adopting a holistic catchment approach, they can achieve mutual benefits.

Local councils: The abundance of social housing offers a unique opportunity to drive WEC efficiency at scale, given the consistent ownership structure.

> Local councils in the UK already have targets to decarbonize public housing. Once they enter properties to replace gas boilers, councils could also use the opportunity engage with tenants to educate them on the sustainability and financial advantages of WEC and about the opportunity to retrofit for water efficiency as well.

Technology and product companies: Aligning with WEC opens up new markets for innovation in sectors, like fast-moving consumer goods (FMCGs) and electronics manufacturers, to design commonly used products that are holistically resource efficient. Large-scale WEC transitions in homes can reduce the cost of efficient products through economies of scale. For example, simpler innovations such as an aerated shower head show significant WEC savings. However, their high cost often hampers widespread adoption. By focusing on mass implementation, for example by adopting them as standard in new construction, these innovations can become more affordable and accessible.

Retrofitting agencies and real estate developers have access to the resources and skills required for the WEC transition, such as plumbers, electricians and built environment professionals, for BREEAM- and LEED-compliant retrofits.

Academia, knowledge institutions, NGOs and think tanks can fulfil the need to gather in-depth techno-commercial evidence on the water and energy cost-saving models and those that reduce greenhouse gases for the WEC nexus. Their research can inform and drive policy and behavior change on a global scale, promoting sustainable practices and solutions. These institutions also play an important role in educating the general public and a community of professionals.

Due to competing priorities, policy change is a challenging and a slow process. With the WEC transition sitting at the intersection of climate mitigation, by reducing emissions, and climate adaptation, by enhancing water security, it appeals to a wider range of stakeholders.

> In the UK, managing water demand is already a priority for the government to address the large gap in public water supplies by 2050. To drive progress, the government has set a new legally binding target under the Environment Act 2021 to reduce the use of public water in England by 20% per capita by 2038, meaning 122 liters per person per day. This target is part of the trajectory to achieve 110 liters per person per day in households by 2050.[60]

Policy recommendations

Going forward, there must be a collaborative effort. Below are some near-term policy solutions that require action to mobilize the WEC nexus for homes.

Capitalizing on the current net-zero emissions retrofit momentum: The WEC transition complements the ongoing net-zero emissions transition for the built environment sector and revives it with a fresh outlook that brings together a whole new range of co-benefits and stakeholders.

> The UK government needs to push for the retrofitting of 300 homes every hour to meet its net-zero carbon target by 2050.[61] Upgrading homes and buildings is one of the most significant opportunities to reduce carbon emissions, as buildings account for 15% of total emissions. The UK government is already implementing waves of Social Housing Decarbonizing Funds for those below Energy Performance Certificate (EPC) band C. These funds typically target old housing stock with outdated water systems. Taking an integrated approach to retrofit solutions can enhance water and energy efficiency, maximizing the impact of these upgrades and the value for money.

Operating in silos has hindered progress, resulting in chronic underfunding. Conversely, there has been substantial funding support for the energy-efficiency agenda. The WEC nexus aims to bridge this skewed landscape with a balanced water-energy investment model. The example below from the UK illustrates the difference in size of the funding support for water efficiency vs energy-efficiency schemes for homes.

Water Efficiency Support in the UK:
In 2025 a £100m water efficiency fund to address the challenge to encourage people to use water wisely and to help water companies overcome barriers they face will be available in England and Wales.

Energy Efficiency Support in the UK:
The government is investing £12 billion in Help to Heat schemes to make sure homes are warmer and cheaper to heat in efficient manner through Boiler Upgrade Scheme, Home Upgrade Grant, Sustainable Warmth Competition, Social Housing Decarbonisation Fund, Energy Company Obligation and Great British Insulation Scheme.

Scaling the equivalent of energy performance for water efficiency in homes

Creating a home labelling system for water efficiency is a key opportunity to streamline pathways for efficiency for current and future housing stocks. Energy performance certification in the energy sector is an industry norm today. Energy-efficiency ratings can contribute to property value. These market links have given a big thrust to the energy-efficiency transition for homes. Water-efficiency performance needs a similar consideration and market framework. There is a need to consider possibilities in existing building codes and standards. This requires a holistic "label" for homes

Lenders in the UK may decline a mortgage application if the energy performance rating of the property is too low. This is especially the case if property is on a buy-to-let mortgage, as the legal minimum energy performance rating for a rental property is E.

Mandatory water labels

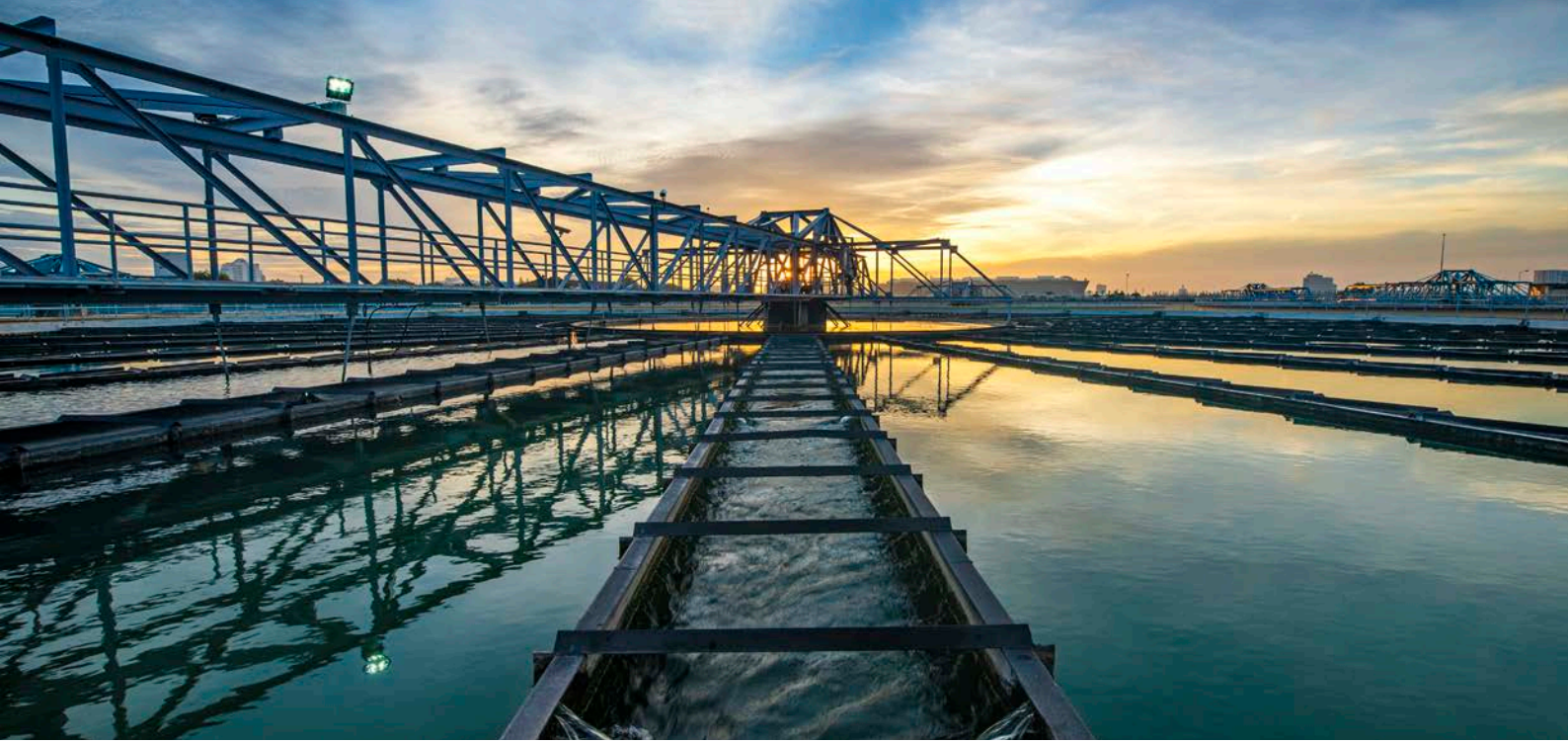
These link to minimum fitting standards for sanitary fittings and fixtures such as taps, showers, toilets, wet appliances, including dishwashers and washing machines, which are still not in many parts of the world, including the UK. While the EU pioneered the introduction of the Euro star label, an integrated label on energy- and water-efficient products, people still struggle to interpret it. For example, a consumer might buy an appliance (particularly a dishwasher/washing machine) simply because it has an A+ rating for energy efficiency even before reading the bottom half of the label. This siloed interpretation of ratings is misleading because the emphasis is on electricity use and not on water use, as demonstrated in the table below.

Energy efficient washing machine (A+ ratings)	Energy-efficient washing machine that has a shorter cycle	Energy-efficient washing machine that delivers same cleaning efficiency with short cyclers and cold wash
Energy savings only	Both water savings and energy savings	Water savings and double energy savings by avoiding hot water wash

Table 9: The siloed interpretation of ratings

With lack of water labels and awareness, it is difficult for customers to make informed choices about the water efficiency of the products they purchase or the interlinked relationship between water efficiency and energy efficiency. Research by the Energy Saving Trust indicates that a mandatory government label would lead people to adopt more water-efficient behaviors. Similar to energy labels for appliances, water labels should become the norm.[62] According to consumer surveys, almost 50% of respondents consider an energy rating as an important criterion when buying appliances. They may soon see this for other categories too.[63]

A successful mandatory Water Efficiency Labelling Scheme (WELS) linked to a minimum fittings standard has been in place in Australia since 2005. By 2017, it was already saving over 300 million liters of water per day, reducing emissions by 11 MtCO2e and lowering household bills by USD $1 billion per year. Market research with customers undertaken in 2014 for the WELS scheme in Australia suggests that customers are actively using the water-efficiency information provided by the scheme to inform decisions about what products to purchase. Since the scheme is government led, consumers have shown greater confidence in the information provided, with 87% of consumers recognizing the label and 83% viewing it as "very" or "quite" credible. The market research suggests that water efficiency is the highest or second highest consideration for customers in their purchasing decisions for products covered by the label.[64]



The UK Government aims to make water labels or eco labels mandatory by 2025, which would help consumers save money on water and energy bills under the "Plan for Water" pledge. Based on 2019 price projections, the label could help save USD $159 million on water bills, USD $188 million on energy bills over 10 years and 1,200 million liters of water a day in the UK – equivalent to 480 Olympic swimming pools.[65]

Every USD $1.28 invested in implementing the water labelling scheme in the UK could yield USD $87 in savings. The energy savings over 25 years would surpass 58 MtCo2e.[66] Mandating water labels is a cost-effective win-win affair for all.

Turbocharge the retrofit workforce for the WEC transition

There is a serious shortage in the retrofit workforce in terms of numbers and the right skills, making it expensive and creating accessibility barriers, particularly for low-income households. The sector lacks plumbers, electricians and installers who are aware or properly trained on water-energy efficiencies. It is a bottleneck in the net-zero emissions retrofit journey for homes. The water and energy sectors can resolve this by combining the workforces with integrated training and upskilling and hiring more water and energy professionals to make retrofitting more accessible for households.

Estimates in the UK show that current rates of retrofit recruitment must triple if the country is to meet its 2050 net-zero target. If they don't increase, the UK won't meet its net-zero goal until 2105.[67]

Future standards and codes

Today's building standards are insufficient to mitigate climate change or manage water scarcity. Tighter water- and energy-efficiency standards in new builds are a commendable action towards higher water and energy savings.

In the UK, to comply with existing building regulations, a property's water use must not exceed 125 liters per person per day or 110 liters per day if it is in a water stressed area.[68] Policymakers are pondering if these targets could be more ambitious. Research shows that building standards of 105 liters per day are both achievable and cost-effective in new-build homes.[69] There are plans to standardize rainwater harvesting systems, smart metering and water recycling systems for new builds. The UK government also proposes the possibility of improved water-efficiency standards for inclusion in the Decent Homes Standards that will guide all future social housing stocks.[70] Due to lack of incentive to act, these policies have not seen much of a binding effect.

Implementing innovative tariff structures

In the long run, there is a need for innovation in integrated metering and billing systems that accounts for both water and energy consumption and efficiency. One potential avenue is to consider carbon as a universal currency in designing integrated or differentiated tariffs. To implement these innovative pathways, it is important for cities and utilities to move to smart metering solutions for households that can help consumers have a dissected view of water and energy bills and critical components, such as water heating cost as part of the energy bill. These can be pivotal in nudging consumers to act on enhancing hot water efficiency, which is the focal point for WEC sustainability.

Way forward: Call for action

There are various pathways to consider to mobilize water, energy and carbon efficiency for homes. Below we summarize the call for action.

Technology innovation

- **Championing WEC innovation for consumers,** instead of just energy efficiency or just water-efficiency solutions; building hot water efficiency in homes is a game changer, it saves water and energy at the same time.
- **Stakeholders should focus on systems based on WEC efficiency gains** as there is a need to unlock higher water and energy savings through a combination of fixtures, consumable products and wet appliances for homes.
- **Making WEC innovative technologies compelling to consumers.** This includes making life easier through small enhancements that provide better cleaning, faster washing, more efficient showers (i.e. recirculating showers) while being able to appreciate them, all at a much affordable cost and return on investments compared to other contemporary product/technology options. Costs are a critical factor that would eventually come down through unconventional partnerships, government grants/ schemes and cross subsidies.

Behavior change

- **WEC education and behavior change for consumers needs to focus on four agendas**

  1. Communicating the big picture for water and energy consumption
  2. The hidden cost in homes
  3. Marketing innovation and water- and energy-efficient technology/products
  4. Conveying the value for money to help consumers understand the savings and returns on their investment.

- **Innovative nudging and incentivizing behavior change**

  WEC adoption and innovation will be vital for consumers and value chain actors, such as housing developers, retrofitting agencies, local councils, etc. and water and energy utilities in particular. The strategic placement of water and energy utilities can regulate, monitor and provide incentives for demand-side flexibility and efficiency by tapping and personifying consumption data analytics from meters/smart meters in real time through tariff restructuring innovation or other consumer behavior nudging policies.

Policy

- **Reprogramming the current net-zero emissions retrofit momentum for WEC**

  Taking an integrated approach to retrofit solutions can enhance water and energy efficiency and would help in maximizing the value for money these upgrades provide for households. There is a need to couple net-zero emissions funds and programs with water efficiency for demand-side efficiency.

- **Scaling the equivalent of energy performance ratings for water efficiency in homes**

  A holistic “label” could cumulatively assess water-energy efficiency.

- **Enabling mandatory water labels**

  Wet appliances, fittings and fixtures and consumer products could benefit from these labels and create consumer awareness of resource efficiency that considers water, energy and carbon together.

- **Turbocharge the retrofit workforce for the WEC transition**

  Combining the water and energy retrofit supply chain workforce with integrated training and upskilling and hiring more water and energy professionals would make retrofitting more accessible to households.

- **Nudging future homes standards and codes**

  Tighter water- and energy-efficiency standards in new builds are a commendable action.

- **Tackling innovative tariffs in the long term**

  Integrated metering and billing systems that account for both water and energy consumption and efficiency are the best way to do this. One potential avenue is to consider carbon as a universal currency when designing integrated or differentiated tariffs.

Terms of Reference

Technology Screening Approach:
As described in section 4 (Pillar 1 – Technology Innovation), the 50L Home Working Group undertook a detailed technical parametric based assessment of diverse range of technologies and products for their ability to save water, energy, and carbon, as well as the overall appeal to consumers in terms of quality-of-life enhancement, savings on time and value for money. In this section, a brief outline is given into how this analysis was conducted and the results gained.

The 30 technologies which were identified by the 50L Home working group, to be assessed were:

Area of water use	Long List of Technology/ Products	Efficiency Gains	Product Type
Shower	Recirculating shower	New Water (reuse/recycle)	Appliance
Shower	Shower meter	Hot Water Efficiency	Digital Platform
Shower	Aerated showerhead	Hot Water Efficiency	Fitting
Shower	2in1 shampoo and conditioner	Hot Water Efficiency	Consumable Product
Shower	Low flow shower head	Hot Water Efficiency	Fitting
Shower	Baby bathwater barrier	Hot Water Efficiency	Fitting
Toilet	Toilet cistern displacement device	Water Efficiency	Fitting
Toilet	Toilet tank fill cycle diverter	Water Efficiency	Fitting
Toilet	Dual flush toilet	Water Efficiency	Appliance
Toilet	Pressure-assisted toilet	Water Efficiency	Appliance
Toilet	Vacuum-assisted toilet	Water Efficiency	Appliance
Toilet	Dual-flush conversion kit for toilet flush	Water Efficiency	Fitting
Laundry	High efficiency washing machine (with shorter rinse cycle and power cold wash, etc)	Hot Water Efficiency	Appliance
Laundry	Aerated washing machine	Hot Water Efficiency	Appliance
Laundry	Smart washing machine	Hot Water Efficiency	Appliance
Laundry	Steam tech washing machine	Hot Water Efficiency	Appliance
Dish washing	Countertop UV light dishwasher	Hot Water Efficiency	Appliance
Dish washing	High efficiency dish washer	Hot Water Efficiency	Appliance
Dish washing	Handheld steam dish washing device	Hot Water Efficiency	Fitting
Taps	Kitchen and bathroom tap aerators	Hot and cold-Water Efficiency	Fitting
Water heating	Air source heat pumps	Energy Efficiency in Water	Appliance
Water heating	Water source heat pumps	Energy Efficiency in Water	Appliance
Water heating	Ground source heat pumps	Energy Efficiency in Water	Appliance
Water heating	Wastewater heat recovery devices	New Energy	Appliance
Water heating	Hot water recirculation systems	Energy Efficiency in Water	Appliance
Water heating	Instant water heaters	Energy Efficiency in Water	Appliance
Other	Rainwater harvesting system (for indoor use)	New Water (reuse/recycle)	Appliance
Other	Grey water recycling units	New Water (reuse/recycle)	Appliance
Other	Atmospheric water generators	New Water (reuse/recycle)	Appliance
Other	Water system leak detectors	Hot and cold-Water Efficiency	Fitting

A full list of the parameters used to score the technologies, and their rating options is given below:

Evaluation Parameter	Category	Rating Option	Rating
Carbon saving (kg/person/ year)	**Sustainability**	0-25	1
		25-50	2
		50-75	3
		75-100	4
		100+	5
Expected lifespan- Longevity of technology/ product	**Sustainability and consumer appeal**	0-8 years	1
		8-16 years	3
		>16 years	5
Market suppliers	**Consumer appeal**	Large well-established brands available	5
		Medium-sized brands available	3
		Only small brands available	1
Retrofit cost	**Consumer appeal**	High	1
		Medium	3
		Low	5
Return on investment period (years)	**Consumer appeal**	0-20	5
		20-40	4
		40-60	3
		60-80	2
		80+	1
Ease of maintenance	**Consumer appeal**	High	5
		Medium	3
		Low	1
Bill savings (£/person/ year)	**Consumer appeal**	0-30	1
		30-60	2
		60-90	3
		90-120	4
		120+	5
Health and safety concerns	**Consumer appeal**	Significant	1
		Slight	3
		None	5
Regulatory barriers	**Consumer appeal**	Yes	1
		No	5
		In some cases	3
Enhancement of ease of living	**Consumer appeal**	Some improvement	4
		No improvement	2
Absolute/ potential savings	**Sustainability**	Savings dependent on customer behaviour	2
		Guaranteed savings	5
General knowledge of existence	**Consumer appeal**	Education required	2
		Education not required	4
Availability of grants	**Consumer appeal**	Yes	5
		No	1
Typology	**Sustainability**	Remove	5
		Reduce	4
		Reuse	4

Evaluation Parameter	Category	Rating Option	Rating
Efficiency gains	Sustainability	Hot Water Efficiency	5
		Water Efficiency	4
		Energy Efficiency in Water	4
		New Water (reuse/recycle water)	4
		New Energy	4
Water savings (L/p/day)	Sustainability	0-10	1
		10-20	2
		20-30	3
		30-40	4
		40+	5
Direct Energy savings (kWh/p/day)	Sustainability	0 - 0.33	1
		0.33 - 0.67	2
		0.67 - 1	3
		1 - 1.33	4
		1.33 - 1.67	5
Maturity of product	Consumer appeal	Mature	5
		Novel	3
Single house or whole building efficiency	Sustainability	Single House	3
		Whole Building	2
		Both	5
Area	Sustainability	Kitchen	4
		Bathroom	4
		Both Kitchen & Bathroom	5
		Others	2
Permission needed if renting?	Consumer appeal	Yes	2
		No	5
		Maybe	3
Present with 50L partners?	N/A	Yes	4
		No	2
Capital cost average	Consumer appeal	£0 - £100	5
		£100 - £200	4
		£200-£1000	3
		£1000 - £5000	2
		£5000+	1
Retrofit required	Consumer appeal	Deep Retrofit	2
		Shallow Retrofit	4
		Plug In	5
Ease of use	Consumer appeal	Low	3
		Medium	4
		High	5

These parameters, their rating options and their weightages were assigned by 50L Home Coalition and Arcadis experts in collaboration. For four of the parameters (water savings in L/person/day, energy savings in kWh/person/day, carbon savings in kg/person/year and bill savings in £/person/year), they had to calculate values using various assumptions, such as the average time taken in the shower, the average water usage of a modern washing machine and the average number of times a person will flush the toilet, daily. These values were found by conducting extensive research, and the values used were those which related to the UK. Where possible, governmental studies were used.

Abbreviations

Abbreviation	Meaning
WEC	Water energy carbon
GHG	Greenhouse gases
MtCO2e	Metric tons of carbon dioxide equivalent
CCC	Climate Change Committee
CCW	Consumer Council for Water
kWh	kilowatt-hour
EV	Electric Vehicle
PTC	Production Tax Credit
ITC	Investment Tax Credit
ECO	Energy Company Obligation
PV	Photo voltaic
NGO	Non-governmental organization
ofgem	Office of Gas and Electricity Markets
Ofwat	Water Services Regulation Authority
FMCGs	Fast-Moving Consumer Goods
BREEAM	Building Research Establishment Environmental Assessment Methodology
LEED	Leadership in Energy and Environmental Design
EPC	Energy Performance Certificate
WELS	Water Efficiency Labelling Scheme
MCS	Microgeneration Certification Scheme

Endnotes

[1] World Economic Forum (2024). Global Risks Report.

[2] United Nations Environment Programme (UNEP) (2024). As shortages mount, countries hunt for novel sources of water, unep.org.

[3] WINT Water Intelligence (2022). The Carbon Footprint of Water.

[4] Data all compiled through May-July 2024, (Does not include toilet data) 50L Home Coalition LA Pilot.

[5] Energy Saving Trust (2018). At home with water.

[6] Decarbonising the Water Sector, Pictet Asset Management, 2023

[7] Ofwat (2022). Net zero principles position paper.

[8] Environment Agency (EA) (2008). Greenhouse gas emissions of water supply and demand management options.

[9] Clarke, A., Grant, N. & Thornton, J. (2009). Quantifying the energy and carbon effects of water saving – Final report. Environment Agency and Energy Saving Trust. New dwelling assumptions with gas boiler and dishwasher installed, p. 3.

[10] Energy Saving Trust (2020). Significant changes are coming to the UK heating market.

[11] Department of Energy Security and Net Zero (2024). Domestic hot-water use. Observations on hot-water use from connected devices

[12] Energy Saving Trust (2013). At home with water.

[13] Department of Energy Security and Net Zero (2024). Domestic hot-water use.

[14] Department of Energy and Climate Change (2014). UK Housing energy fact file: 2013.

[15] Estimates based on data from: Department of Energy Security and Net Zero, UK (2024). Domestic hot-water use: Observations on hot-water use from connected devices.

[16] The US Department of Energy (2010). Guide to Home Water Efficiency.

[17] Energy Saving Trust (2013) At Home with Water.

[18] waterwise.org.uk. Save Water

[19] independent.co.uk (2023). Three in ten adults have changed their shower habits in a bid to save money

[20] renewableheatinghub.co.uk (2022). Do you know how much taking a shower or filling your bath costs?

[21] independent.co.uk (2023). Three in ten adults have changed their shower habits in a bid to save money

[22] reuk.co.uk. Save Water When Flushing Toilet

[23] bladderandbowel.org. Urinary Frequency

[23] eatingwell.com (2024). How Often Should You Poop & Is It Every Day?

[25] heatable.co.uk (2024). How Much Energy/Electricity Do My Appliances Use?

[26] choice.au (2024). Which type of washing machine uses up to 70% less water?

[27] jungleculture.eco (2023). Dishwasher vs. Hand-washing Dishes: Which is better?

[28] Dept for Energy Security & Net Zero (2024). Domestic hot-water use

[29] yorkshirewater.com. Charges for customers with a meter

[30] uswitch.com (2024). Average gas and electricity bills in the UK

[31] RainStick shower

[32] thespruce.com (2023). What Is a Pressure-Assisted Toilet? Benefits and Considerations

[33] greenmatch.co.uk (2024). Air Source Heat Pump Costs in the UK: 2024 Guide

[34] diy.com. PEPTE 22mm Faucet Tap Aerator Male - Up to 70% Water Saving 4 L/min

[35] https://flow-loop.com/

[36] flushmate.com. What are Pressure-assisted Toilets, and Why Should You Install Them?

[37] surf.co.uk. Save water, save the planet

[38] which.co.uk (2024). Dishwasher vs hand washing: which is the most efficient method?

[39] domesticandgeneral.com (2023). How much does it cost to run a dishwasher?

[40] canarymedia.com (2023). Heat-pump water heaters are a winner for the climate — and your wallet

[41] savemoneycutcarbon.com (2021). What are tap aerators and how do they work?

[42] aqualogic-wc.com. Aquair Typhoon – Water Saving Shower Head

[43] lowenergysupermarket.com. Shower Timer with Flow Meter Self Powered

[44] boots.com. Head & Shoulders Classic Clean 2in1 Anti Dandruff Shampoo 250ml

[45] savemoneycutcarbon.com. How much water does a low flow shower head save?

[46] cityplumbing.co.uk. Recoup Easyfit Waste Water Heat Recovery System R-EZ-01

[47] hydraloop.com (2023). Press Release: Hydraloop® to Globally Launch the Hydraloop Concealed at the 2023 CES

[48] REHVA Journal (2020). Wastewater heat recovery systems

[49] solarimpulse.com (2023). Hydraloop

[50] MCS Foundation. Record number of heat pumps installed in UK homes in 2023.

[51] UK Government (2023). Boost for offshore wind as government raises maximum prices in renewable energy auction.

[52] Ofwat (2013). Water meter, your questions answered.

[53] Water UK (2020). Vast majority of Brits have no idea how much water they use each day.

[54] Property Reporter (2019). New report reveals that over 40% of domestic properties have water leaks.

[55] Waterwise (2021). Public attitudes towards smart water meters.

[56] The Energy Saving Trust (2013). At Home with Water.

[57] Gov.uk (2013). United Kingdom housing energy fact file: 2013

[58] Boiler Central (2024). How Much Energy Do Appliances Use?

[59] UK Government (2023). Securing England's water resources: right now, and for the future.

[60] Department for Environment Food & Rural Affairs (2023). Plan for Water: Our integrated plan for delivering clean & plentiful water.

[61] United Living (n.d.). Net Zero Retrofit.

[62] Energy Saving Trust (2019). Water labelling: every drop counts

[63] GfK (2022). Market Intelligence.

[64] One planet (2023). Water Efficiency Labelling and Standards scheme

[65] Energy Saving Trust research.

[66] Waterwise (2018). Water Efficiency Strategy for the UK.

[67] Reed (2023). We need a retrofit revolution to win the race to net zero.

[68] gov.uk (2014). Approved Document G: Requirement G2 Water efficiency

[69] Hoolohan, C. & Browne, A. (2019). Can we reduce water demand to 80 litres a day? And what can the government do to support it? University of Manchester

[70] Gov.uk (2023). The Future Homes and Buildings Standards: 2023 consultation.

Arcadis Working Group

Core

Anusha Shah

Gareth Makarek

Ishita Aryan

Naomi Roberts

50L Home Working Group and Contributors

Gregory Holliday, 50L Home

Frantz Beznik, P&G

Grace Hamilton-Burge, 50L Home

Technical Experts and Reviewer

Simon Rawlinson

Rob Banes

Luis Vergara Romero

Will Woodward

TJ Jacobs

Contacts

Gregory Holliday
Director, 50L Home & Member of the WBCSD Extended Leadership Group

holliday@wbcsd.org

Prof Anusha Shah
Senior Director, Resilient Cities & UK Climate Adaptation Lead

anusha.shah@arcadis.com