Because there is a clear link between water use and energy consumption, saving water can also save energy. The search is underway to find more efficient ways of delivering water to limit energy and water loss.

If the basic structure of the plumbing system in a home is not efficient, then the efficiency of appliances connected to it is not going to be maximized.

Ideally, plumbing systems should be designed instead of merely ‘roughed in’. Moving towards more centralized system design offers a better chance of achieving optimum efficiency.

But the question then arises as to how this rather ‘revolutionary’ approach can be effectively conveyed to stakeholders including plumbing suppliers, hydraulic designers, contractors and regulators.

The entrenched culture of the plumbing market would need to change, and greater collaboration would have to occur between various market sectors such as fixtures, piping, water heaters, pumps and valves.

In an earlier life Gary Klein ran a plumbing and electrical contracting business in Lesotho (southern Africa), and more recently he has worked as an energy specialist with the California Energy Commission.

Klein is now president of the California-based consultancy Affiliated International Management. He says one key to conserving water and energy is to minimize the time it takes to deliver hot water, and this can be achieved by the design of what he calls structured plumbing systems.

Klein believes the best way to achieve an efficient structured plumbing system is to build back-to-back and stacked bathrooms and kitchens so that a plumbing core can be created.

“Water heating is a big user of residential energy, at 15-30% of a dwelling’s total energy consumption. About 20% of stationary energy in the United States goes to water in some form.

“At the outset, questions need to be asked and conventional ways of thinking challenged. For example, have you measured the hot water demand in the facilities you are designing for? The aim should be to give people what they want (hot water) and what they expect (safety, reliability and convenience) as efficiently as possible.

“However, there are several potentially conflicting trends that have to be taken into account. Larger houses are being built while city water pressures are reducing, and more plumbing fittings are being installed but with lower flow rates.

“The result is a longer wait for hot water, less pressure, lower performance, customers who are less satisfied and increased complaints.”

The elements in a building that can affect the efficiency of a hot water system include the heater, piping, fixtures, fittings, appliance, and behavior. Interactions between them can have a direct effect on the system performance.

“There should be a focus on reducing structural and behavioral waste by increasing the efficiency of the system and improving the use of water.
"System designers should begin with the desired end in mind by careful consideration of appropriate flow rates for fixtures and appliances, pipe sizing, water heater sizing and energy supply sizing.

"For residential water pressure up to 50psi the maximum allowable velocity dictates pipe sizing, and for pressure below 35psi friction loss in the pipe dominates pipe sizing.

"Consideration of flow rate is important because the need to accommodate a high flow rate leads to a larger pipe size, which in turn means greater volume in the pipe and increased energy waste during the use and cool down phases of a hot water event.

"If the pipes are sized for increased flow, and a lower flow rate fixture is used, this can also result in energy waste during the delivery phase."

Klein says the ideal hot water distribution system has the smallest volume of pipe (combination of length and smallest practical diameter) from the source of hot water to the fixture. The source is the water heater, or sometimes the trunk line.

"For a given layout or floor plan of hot water outlet locations, the ideal system will have the shortest buildable trunk line, few or no branches, the shortest buildable twigs, the fastest plumbing restrictions, and insulation on all hot water pipes.

"Insulation will reduce heat loss, which is particularly important for low-flow fixtures and appliances, and it will also increase the time pipes stay hot between events.

"A few years ago my colleagues and I gave ourselves a challenge. How would you deliver hot water to every fixture and appliance, wasting no more energy than we currently waste and wasting no more than one cupful waiting for the hot water to arrive?

"We found five solutions, one of which - structured plumbing - is the most practical. We also learned in the process that wasting no more than one cupful while waiting at all fixtures is a tough goal to meet. Two cups is more practical.

"In other words, the aim is to improve the delivery phase to provide hotter water sooner by minimizing the waste of water, energy and time."

When looking to improve the cool-down phase between hot water events, several factors should be considered. They include where the event is in relation to the source of hot water, time until the next event, temperature of the hot water needed for that subsequent event, and volume of water in the pipe that eventually cools down.

Pipe insulation is essential for improving the use and cool-down phases of a hot water event.

A typical structured plumbing system includes a circulation loop close to the fixtures and appliances. This can be a fully heated or half-heated loop, with a dedicated (three-pipe) or a cold water (two-pipe) return line, depending on the floor plan.
Energy specialist and president of the California-based consultancy Affiliated International Management, says the key to conserving water and energy is to minimize the time it takes to deliver hot water.

"The system would also include small-volume twig lines no larger than half-inch (13mm) diameter, although a larger diameter would be needed for fittings and appliances with a high flow rate," Klein says.

"The twig lines should be no more than 10 plumbing feet (3m) long, or two cups in volume, but some exceptions could include garden tubs, washing machines, and sinks or appliances on an island on a concrete slab.

"A demand-controlled pumping system would also be installed with wired or wireless buttons or motion sensors. The pump would be activated to pre-heat the insulated line, and it would shut off automatically, usually in much less than a minute.

"Minimum R-4 insulation on all hot water pipes should ensure that water in the pipes stays hot 30-40 minutes after the last hot water event."

Such a system will minimize the waste of water, energy and time, and will provide the most flexible and cost-effective solution for today’s floor plans, resulting in high customer satisfaction.

People generally want convenience, but some crucial questions should be asked. How many water heaters are needed in a home?

"Most people think they use hot water several hours a day when the reality is under one hour. Customers can have the floor plan they want, and the plumbing system can be designed as efficiently as possible given that layout," Klein says several changes are proposed for the 2009 version of the Uniform Plumbing Code, and in California and North Carolina, seeking to improve the performance of domestic hot water distribution systems in all buildings.

Changes being considered to the code include defining piping suitable for hot water distribution, enabling use of smaller-diameter piping for fixtures with lower flow rates, requiring insulation of all hot water distribution piping and requiring buried water distribution piping to be installed in a conduit.

There are also incentive programs sponsored by water and energy utilities that provide a financial incentive for installation of structured plumbing. In addition, the California Energy Commission, which provides building and appliance standards, is developing clearer guidelines on how to structure efficient plumbing.

Klein believes greater uptake of structured plumbing systems would be achieved through incentives rather than mandatory requirements.

"Incentive points are preferable to legislation, at least initially, and once the benefits become more widely recognized the uptake should escalate. Increases in the cost of energy and water will also help. The cost of energy per annum in the average home in the US is about $300, and $100 for water - which is too low and does not encourage efficient use of these resources."

"The cost/benefit of structured plumbing can vary substantially from project to project. Actions such as changing the location of trunk lines, rerouting the plumbing and keeping the twigs as small as possible can result in substantial cost savings - in some instances customers can recoup pumping costs in a few months.

"Projects I have been involved with have resulted in the footage of pipe being cut by up to a factor of five. Consumers are better off in all cases when water/sewer and energy costs are taken into account."

Klein says payback of costs can generally be achieved within five years and in some cases within six months, particularly where the system is installed in a new construction. The benefit stream can be built into the mortgage, and the savings can be more than the marginal cost of the mortgage.

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