Cities and the Water Systems That Support Them:

Exciting Prospects for the Future

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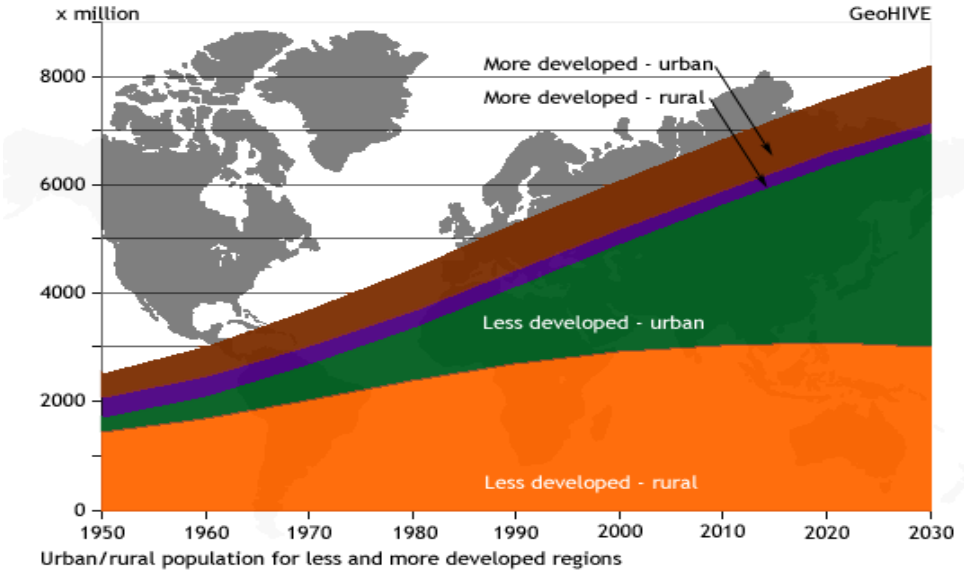
The Paradox We Face

If I were to ask my colleagues in the field of urban water, who rank among the top figure in the world, whether they believed that their predecessors had been successful in fundamentally improving the health and well-being of millions of urban dwellers, they would say absolutely.

And they would be right in saying this. The provision of safe water at the tap without interruption alongside the collection, treatment and return of used water to the environment, is at the center of the long term success of any urban area and its surrounding environment. A study of factors leading to increases in human longevity since the industrial revolution concluded that approximately 80% of the increase in longevity were attributable to water and sanitation improvements, compared with 20% related to other factors, including medicine. Thinking about this, we should be elated at the progress that has been achieved and continue in the path that we are on.

At the same time, if I were to ask the same individuals whether they would replicate the vast systems that have been developed over the last century -- if they could start from scratch from today forward – most would say no. They say that they would build tomorrow's systems very differently than in the past.

What accounts for this seeming contradiction in the viewpoints of highly experienced urban water professionals? And what are the implications for the future of a rapidly urbanizing planet – a planet that is far more under construction than already built? For example, a recent Asian Development Bank report suggested that 2050 Asia is only 30% built suggesting that in 2/3s of Asia, we are starting from scratch and could do things quite differently than in the past.



Urban/rural population for less and more developed regions

◄**Mostly Built**

◄**Under Constructions**

Let's start with the first part of the preceding question. Why do these individuals think that tomorrow's water systems should be different than in the past? The reasons are simple if you think about it, but the implications of this thought process have profound implications moving forward in time. The Victorian-era systems that serve as the template for today's water systems were developed in the context of relatively abundant natural resources, including water and nutrients, and in today's terms, a very limited set of technological options for the treatment and reuse of water, and a planet with 1/3 of today's population.

In this context, the model for water supply, sanitation and treatment was to go as far upstream as possible in abstracting water and to dispose of used water as yet untreated, as far downstream as possible. This gave rise to the so called "linear systems" which are implicitly based on the notion that we use water once (polluting it in the process), and then dispose this used water as far away as possible. The implications of this approach are systems that today's terms have some critical shortcomings. They are extremely expensive because of the upfront need to capitalization the network of a decade to come. They consume and pollute large amounts of water because of water's use as a transport vehicle for human wastes. And they require significant amounts of energy to move, and later treat, this water.

If this state was inevitable, cities would simply have to deal with the cost, resource and waste implications of this approach. And this is what cities in the developed countries have done ever since the Victorian-era.

Doing Things Differently Than in the Past

But this state is not inevitable in today's world. We have the technology to use and reuse water over and over again, as is done on a global scale in the recycling of fiber from waste paper. We know how to make energy out of used water (traditionally called wastewater) leading to a condition where used water treatment can be an energy producer instead of one of the largest consumers of electricity in many cities and towns. The implications of membrane technology on the optimum scale of water treatment plants mean that we can now keep water -- which unlike electricity is expensive to transport both in terms of network costs and electricity -- much closer to home which allows for "light" networks and an abundant potential for economically reusing water.

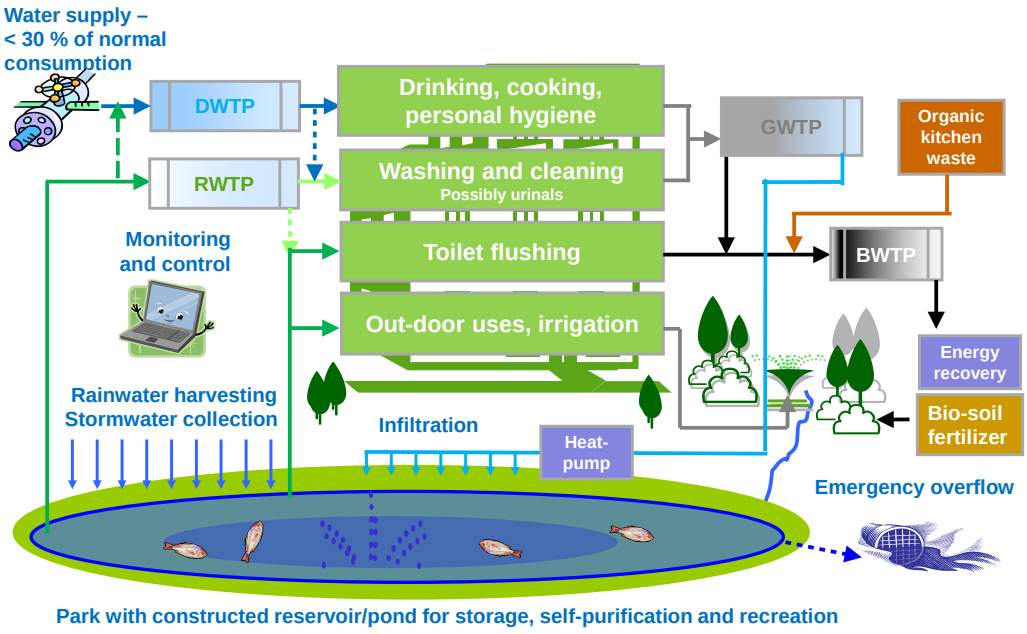
These realities allow for a very different approach to building water systems. This view is the genesis for IWA's highly acclaimed Cities of the Future program.

Many believe that the system of the future will be built incrementally in something akin to utility "neighborhoods" that are at least an order of magnitude smaller in scale than the area served by most used water treatment plants. Experts at the Technical University Darmstadt estimate the optimum neighborhood size is today 20,000 to 70,000 person equivalents. Their belief is that the utility neighborhood should be "as small as possible" because of the attendant efficiencies made possible by closing the loop, but "as big as necessary" so that economies of scale are realized in both capital and operations. They call this semi-autonomous neighborhood approach the "semi-centralized system" model.

This smaller utility neighborhood size coupled with small, highly integrated treatment plants makes possible the imbedding of these plants in neighborhoods -- invisible because they are underground, and cherished by residents because they have a small public square or a park on top. At the same time, the shrinking of the utility neighborhood will translate to a less capital intensive network and significant reductions in network energy requirements, which today account on average for 70% of a utility's energy requirements.

The integrated treatment plant that serves a neighborhood can take many different forms. However, there are shared features of the many different approaches that start with the separation of toilet-related used water from other kinds of used water (often called gray water) in new developments, commercial buildings and institutional settings. This makes possible the cost effective reuse of gray water which reduces the need for imported water by 40-60%. The second shared feature of these integrated treatment facilities is net energy production through the co-digestion of used water and food waste. Third, most approaches envision the recovery of heat from the gray water. One illustration of these integrated treatment and energy producing plants, provided by Professor Odegaard's based on work in Norway with the "smart community" program is depicted below.

Semi-Centralized Integrated Treatment Plant Elements



In such a system -- applied in new developments, commercial buildings and institutional settings -- it is not difficult to reduce the requirements for imported water by 50% through the highly cost-effective reuse of gray water while achieving other objectives. A university campus housing 35,000 students in Xian, China is a good illustration of this approach and the attendant saving in water and energy. In addition, the landscaping and water features of the campus are an integral part of the polishing of the reused gray water – a win-win solution.

For cities in which the systems are already built, the application of membrane technology can be applied in a different manner. Membrane technology allows what can be thought of as a "manufacturing" of water to any standard desired. Given this capability, communities such as Orange County, California and Denver, Colorado, return formerly used water to the ground water table below the city, following treatment processes that deliver what the Singaporean call "new water". This new water that exceeds water quality standards of many sought after environmental sources, is then distributed under the city through the aquifer and extracted where it is needed.

Finally, the innovative country of Israel has "re-plumbed" their national water system, turning to the ocean for their source of water. Again through desalination breakthroughs made possible by membrane technology and sophisticated energy recovery techniques, the country supplies its cities with desalinated water, treats the used water to very high standards and then sends this renovated water to agriculture applications in the south of the country. At present, Israel is reusing 70% of its used water, with a target reuse rate of more than 90%. Through these steps, Israel has greatly diminished its impact on the overtaxed Jordan River and enhanced their national security.

The Imperatives and Implications of a New and Different Approach in the Future

Putting these opportunities together – being able to build a system incrementally, having less capital intensive networks, being able to significantly reuse water in a cost-effective manner, and greatly reduced energy bill and carbon footprint for utilities – has profound implications in general, but in particular for the developing world which is still very much under construction and in many cases not yet started.

The compact and integrated treatment plant of the future will be mass produced with large economies of scale, different to today's custom designed plants. Accordingly, many of the operational challenges of starting and then operating today's large scale custom plants can also be greatly mitigated. Again, another big plus in the developing countries.

And just in time. The mathematics of the future of the planet are highly troubling with respect to water for food, water for cities and water for energy. We are adding 155,000 people per day to the population of the planet between now and 2050. Experts predict that 90% of an additional 1,000,000 people per week will live in what are today classified as developing countries. And 90% of the 90% will live in cities. This means that we will be adding 800,000 new residents in cities in developing countries every week for the next 45-50 years.

The new entrants will add to the already inconceivable number of people who do not have access to water at or nearby their house (about 45% of 7 billion), the 70% who are living without sewerage, and the in excess of 80% who release untreated used water directly into the environment. To solve this problem, we will need game-changing approaches. And now we can answer the original question -- why do the experts say that they would not replicate today's systems? They are too expensive, too resource intensive and therefore far too unrealistic for the healthy and sustainable build-out of urban water systems for the rest of the planet still under construction.

Does this mean they are counselling a diminished set of services for the developing countries, their cities and their residences? Absolutely not. They would say that in the developing countries, one can actually achieve comparable services at a lower cost, both in the short term and the long term. And in cities they would say, communities under construction can achieve a less competitive relationship with key partners -- agriculture and energy -- by reducing their importation of water from the environment (lowering their water footprint) and by making reused water from the cities available to both agriculture and energy.

Some of the same arguments apply in developed countries, where cities are already built. The difference is that the process in built cities will occur through remodeling, and consequently over a much longer period of time. And not all of the opportunities found in green-field circumstance can be recaptured. But it also important to remember that metropolitan areas in built environments like Los Angeles County and Shanghai, added approximately 200,000 housing units every year (a significant small city), the majority of which were in green-field circumstances.

Implementing a New Approach

In the current approach to water system development, the city is planned and developed without significant regard for the water system, with the exception of the need to demonstrate the availability of water supplies in arid communities. In this context, the water system development often reacts to the planning and development process rather than being part of it.

To realize the potential of a new approach to water system development, such as locating parks on top of integrated water treatment plants that are embedded in neighborhoods, the design of the water system has to be an integral part of the long term planning process of any city. Cities such as Melbourne, Australia and Singapore have already put this concept into practice with impressive results. For example, Singapore spatially zones key industrial facilities to be adjacent to its new water pipeline network. This results in water of a very high standard being readily available at attractive rates to water intensive industries like chip manufacturers. Singapore advances its national self-sufficiency goals, the manufacturers have an economical source of high quality water, and the whole process pays for itself. Clever.

Working with the planning process up-front allows for another objective, not yet discussed, to be realized – bringing water into the city as an architectural feature of the cities landscape design as part of the larger drainage design. Cities large and small around the world are beginning to increase what is commonly termed the “livability” of the city through such practices while at the same time being able to address both current and climate change-induced drainage challenges.

Finally, the integrated process of water management to come in systems of the future will force often separate and non-cooperative agencies administering water supply, used water collection, used water treatment, and drainage to integrate. This integration will result in lower costs, better operational capabilities, better environmental outcomes and an agency capable of fully partnering with the planning and development processes within the city.

Concluding Thoughts

It has been said that the water industry is in the midst of technological revolution, spawned by physical breakthroughs like membranes and nano-technologies, biochemical engineering breakthroughs and integrated technology breakthroughs. The irony is that many in the industry are so busy perfecting the past that they don't allow themselves to rethink the future.

Being "future ready", as Singapore says, is critical to meeting the challenges to come. Accordingly, a rich future exists for cities and their planners, developers and engineers – people who are in a great position to shape the future of their city – to take up this future-ready challenge. Not only tomorrow, but today. Not only in wealthy developed counties. But especially in lower income countries whose needs are paramount in the build-out of the planet over the next 40 years.

We are in a race between problems and their solutions. This is a race that we cannot afford to lose.