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RE-ENVISIONING OUR WATER SUPPLY SYSTEMS

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“Civilization advances”, Alfred North Whitehead once asserted, “by extending the number of important operations which we can perform without thinking of them.” By such a standard, our modern infrastructure systems have historically been a great success, for a great many western cities have been characterized by superb supply systems. Water is available on demand, and its supply network has been generally safe, reliable, efficient, and affordable. However, we may have been presumptive about our supposed advances. Infrastructure failures have become more frequent, and the specter of failed pipes, flooded streets, and the image of frightening sink holes has saturated the news and entered our consciousness.

Perhaps it is time that we reacquaint ourselves with how these remarkable systems work, how they are conceived, and how much they really matter. By this approach, we need to educate the public, and ourselves, to better appreciate what they have too long taken for granted, and how much financial responsibility each household has in maintaining the desired levels of service. An alternative strategy might be to return to a time when the presumption we so easily make about infrastructure is supported by the reality of the system's operation.

I. WATER SUPPLY 101

Historically, water infrastructure was widely developed and installed throughout the 20th century. As a result of this long history, many cities face the current challenge of managing aging mains, appurtenances, and equipment, which have become prone to leakage, failure, and are in need of costly replacement. Certainly, experience has been gained, technologies have advanced, and in the era of information, with sensors cheaper and better, more data can now be collected than ever before. Given this convenience, the task of nearly replacing entire systems can be seen as an opportunity to right the wrongs, adjust design to the new paradigms, to take a step back, and review the work of our forefathers with a critical eye. It is a chance to gain with age what perhaps matters more: the wisdom to make wise choices.

Designing, operating, and maintaining water supply systems is generally perceived as an engineering challenge. The goal is to deliver clean water to users according to standards that ensure safe and adequate service. Within the ranges allowed by these standards, the design and operation are then adjusted to meet consumer requirements and minimize (or at least constrain) costs. This obviously depends on the definition of costs, the inclusion of externalities, and the time span considered in decision-making. If the quality of the service produced by the system depends so much on what has been defined as safe, reliable, and satisfactory, then one question longs to be answered: have we defined performance appropriately, that is, are the objectives and constraints of this 'problem' correctly stated?

Nevertheless, this query is instilled with an engineering bias. A water supply system is more than a collection of engineered pieces; it is intended to meet a supply that is highly human. And because humans are complex, water demands are hard to predict, particularly considering they fluctuate moment by moment, as well as hourly, seasonally, and yearly. Thus, demand greatly depends on customers' behaviour and on their response to pricing, and technological and conservation initiatives. Water supply systems physically connect the natural source of water to the consumers, which may be residential, commercial, industrial, or agricultural, and located, perhaps, in a seemingly haphazard manner. Therefore, more is supplied than simply water. The gamut of services is what really cannot be taken for granted by the users of the system whether their concern is hydration, sanitation, cooling, increasing human comfort, aesthetic enhancement, facilitating or limiting the rate of chemical reactions, or firefighting.

> "Approximately 77 percent of Americans, excluding those that receive well water, cannot accurately identify the natural source of water used in their homes."

II. THE SYSTEM WE WANT

These systems enable various activities which drive development, as does any vital piece of infrastructure. Water supply can cease to be conceived of as a problem to solve, to become a platform of possibilities to realize. Given this awareness, we can delve into the core of the system. And for the custodians of these systems, those whose livelihoods are associated with water supply, the questions are: what are the systems in place encouraging? Are the standards, operational guidelines, water rates, cost and revenue allocation, infrastructure placing, and maintenance practices creating the feedback loops that we want?

The system is, first and foremost, built for the users. Yet the services the users require are too seldom the focus. Furthermore, characteristics of the system have the potential to alter consumer behaviour. As a result, an undesired feedback loop is created. Parameters and guidelines are established for a hypothetical group of users, negating further analysis of the potential to modify demand and supply for more sustainable flow rates and pressures; closer to user needs, instead of user wants. The system is then operated to maintain safe conditions even in emergency situations. Consequently, operating pressures may be as much as five times higher than residual requirements given the ISO fire flow standards and the American Water Works Association operational guidelines generally applied in North America. Then, residential appliances and industrial equipment are designed to work under system operational ranges or if higher pressures are required, pumps are selected based on these standards.

The variation in standards between countries, specifically fire flows, shows there is room for debate about the tension between sustainability and safety. Standards simplify the task of designing for the unknown, accounting for uncertainties and risks. However, specificity is relinquished as potential problems are generalized. For instance, water agencies in developing countries, lacking experience of their own, often apply rules from developed nations. Overdesign is the general outcome. In a Philippine case study, the reduction of the minimum water main size generated significant savings in pipe material and installation of up to 45 percent.[1] It is likely that other untapped economic and environmental opportunities exist under the veil of standards in developed countries as well.

Another important connection in the system is between water rates and demands. Water rate structures range from simple flat rates to block rates that vary according to customer type. This structure influences water demand, but not necessarily price elasticity. Each user class, and different components of demand, such as indoor and outdoor residential, or peak and off-peak usage, respond differently to rate changes. And, across the board, price elasticity appears to vary positively with rate levels.[2] Therefore, if utilities are seeking to increase revenue by raising prices, the effect of inducing a reduction in demand should not be ignored.

Since the major source of revenue for water utilities is the provision of water, the funds collected from water bills should be able to cover a multitude of uncertain future costs, operating and capital. Even though these systems have large life cycles, close to a century, financial reports and business plans are completed every five to ten years at the very least. Optimizing present revenue might not be the most advantageous alternative in the long run. Despite the large costs of reinvestment, not undertaking repairs and replacements is worse in the long run by almost any standard.[3]

Incentives should thus be aligned with the overarching performance goals. If long-term, reliable, resilient, and sustainable operation is desired, the systems' internal feedback loops should not motivate short-termism. An analysis of long-term financial results, and life cycle impacts, should become more routine. In addition to costs, other indicators of system performance include consumption, which can be benchmarked according to sector, and land use type, for example. Stakeholder opinion is another important source of information, which incorporates the often neglected demand side. Energy metrics can also be used to gauge usefulness, viability, and character of the system. Since energy is conserved, and the way it flows through systems and changes forms can be accounted for, it can be used as a key measure of the value of a traded commodity. But many of these measures are internal matters to be debated by the specialists.

Others issues are fundamentally public and require open and direct consideration. Supply systems physically connect source and user, but that does not mean the users feel or sense this connection. According to The Nature Conservancy, approximately 77 percent of Americans, excluding those who receive well water, cannot accurately identify the natural source of water used in their homes.[4] The outsourcing of so many services, especially of basic needs, such as water, food, and energy, has contributed to a disconnect with nature, a lack of responsibility towards the environment, a loss of the holistic view of anthropogenic impacts, and most importantly, a feeling of invariable inertia, a sense of impotence in improving the current situation. In these ways, we have taken too much for granted. We need to rediscover something about what is indeed under our feet.

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