The Driving Forces for Change in Wastewater Treatment

How do changes in the economic and social framework affect the future technical development of wastewater treatment? The EAWAG research group CIRUS – Centre for Innovation Research in the Utility Sector – focuses on this question in the German study "Integrated Microsystems for Supply".

A number of promising innovations, such as the separation of wastewater streams and the reuse of minimally-polluted waste water, have been discussed in wastewater treatment circles for some time. If implemented, they could result in an improvement of the currently centralized sewage and wastewater treatment systems [1]. Since, however, wastewater systems have such a long operational life-span, characterized by equally long-term investment cycles, such innovations are not easily realized. At present, there appear to be changes in the driving forces that could affect the assessment of alternative approaches and thus the future of wastewater treatment.

The goal of the research group CIRUS at EAWAG is to analyze in detail what these driving forces are and what effects they may have on wastewater treatment. The EAWAG group is collaborating with German researchers, focusing on electricity, gas and telecommunication. The project "Integrated Microsystems for Supply" is funded by the German Federal Ministry of Education and Research.

Using an extensive literature search and the results of some 20 interviews conducted with experts from the water and sanitation utilities, associations, construction companies, regulatory agencies, consumer protection organizations and research institutions, roughly two dozen factors that drive changes in this field were identified. We weighed these factors according to the impact and uncertainty concerning their potential for inducing change [2]. Some selected results are presented in this article.

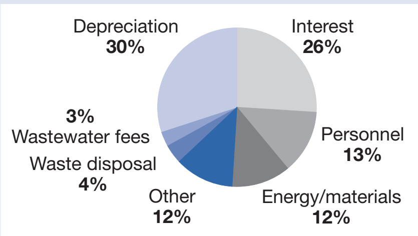

Fig. 1: Breakdown of costs in wastewater treatment [5].

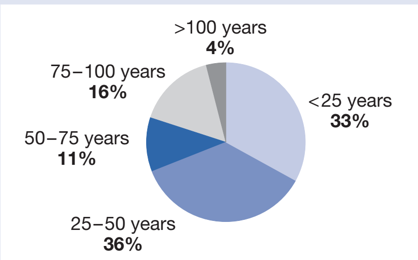

Fig. 2: Age structure of the German sewage system [10].

Fees and Fee Structures

In Germany, fees for wastewater treatment are currently calculated to cover only actual costs. Municipalities are allowed to pass on the full cost to the consumer, but are not allowed to derive any profit. In 2002, the average wastewater fee was 2.24 €/m³, which translates to an annual cost of 117 € per person [3].

Between 1988 and 1996, the fees increase after adjustment for inflation amounted to 55% [4], leveling off between 1997 and 2002. The price for drinking water must also be considered a driving force since it affects consumption and so indirectly impacts the resulting volume of waste water requiring treatment. Between 1992 and 2001, the price increase (excluding inflation) for drinking water was just under 28%.

From the perspective of the waste treatment industry, the reciprocal character of the cost vs. price structure is extremely important: In wastewater treatment, the short-term fixed costs, i.e., the costs that are independent of changes in the volume of waste water to be treated, amount to roughly 75% of the total costs [5]. Figure 1 provides an overview of the entire cost structure in the wastewater treatment sector. On the other hand, the price structure has a relatively low share of fixed elements (between 10–30% of the total bill), which is often a reflection of environmental policy and incentives for efficient use of the water resources. But this also implies that the consumer has a much higher financial saving from reduced consumption than the utility. This, in turn, leads to price increases, which are needed to cover fixed costs for the capital intensive centralized infrastructure.

Backlog on Investment

Also critical to future development will be the manner in which investments in wastewater treatment plants and other infrastructure are managed. Figure 2 illustrates that 31% of the public sewage system is older than 50 years. With an average lifetime of approximately 70 years for sewage pipes, we can estimate that between 20 and 30% of the roughly 450 000 km of sewage pipes in Germany are currently in need of replacement. According to Stein [6], immediate needs are even higher in the Eastern part of Germany, where 50% or more of the sewage system may need to be replaced. Normally, an annual renewal rate of 1.5% is deemed adequate.

This discrepancy between theoretical renewal rates and the actual replacement needs is a consequence of investments that have been delayed too long. Facing ever

Interview partner working in the area of research:

"As a private citizen, I want to use as little water as possible, not because drinking water is scarce, but because I want to pay as little as possible for drinking water and wastewater disposal. Therefore, I go out and buy a water saving toilet, a water saving washing machine and a water saving dish washer. So, my interests are, diametrically opposed to the interests of the operators of the centralized water systems – and actually, they are outside their area of influence."

Interview partner from one of the sector associations:

"… the market does not give centralized systems any special consideration … operators of wastewater treatment plants look at their system of sewage pipes and figure that everybody is forced to connect to it, so everything will come out ok. But if Matushita in Japan or Technics, Miele, Bosch and Siemens bring a wastewater-free dish washer on the market, who says that this does not throw the whole system and that everything can go into the garbage? And which politician would dare to demand that such a machine not be built? … All this has dramatic consequences for centralized systems. Meanwhile, they keep harassing those few rain water users. They have no idea what is going on in other areas, or they just don't have anything to say in those areas."

tighter financial situations, communities have cut maintenance from their budgets. In 2000, investments were at roughly 50% of what should have been spent. A significant portion of the fees collected was used for purposes unrelated to wastewater treatment [7]. With estimated replacement costs of 500 € per meter of sewage canal, and an annual renewal rate of 1.5% for the entire system, the annual investment amounts to 3.4 billion €. Replacing the 20% of the system that is older than 75 years all at once, would amount to 45 billion €. This translates to an average per capita cost of 562 €, only making up for overdue investments. This amount is almost five times the current annual per capita bill for wastewater treatment.

Population Decrease

Additional challenges for wastewater treatment planning in Germany arise from decreasing birth rates and the migration from cities to suburbs. According to current predictions, only a few German cities will have a stable population after 2015. In the eastern part of Germany, as many as 25% of the apartments could be untenanted [8].

Significantly decreasing populations cause the central water and wastewater systems to operate well below the nominal load for which they were designed, which leads to hygiene problems and technical difficulties. For example, drinking water could become contaminated with microorganisms if the retention period in the pipelines becomes too long. Regular flushing of the pipes is a possible remedy, although this would increase the cost, which in turn would have to be shouldered by a shrinking number of users.

Decrease in Water Consumption

Overall, water consumption has significantly dropped over the last few years. Between 1990 and 2001, the average water consumption per person and per day fell by 15% from 150 liters to 128 liters. These numbers include private households and small commercial operations. The consensus according to our interviewees is that the reduction is due to greater environmental awareness and to the increased cost of drinking water and wastewater treatment.

Another factor that has very recently gained importance are innovative and more efficient appliances and hardware, including water-saving faucets in showers and sinks and smaller toilet tanks, which already are widely used. They may be installed at very low cost, often just a few Euros, but have a relatively high water-saving effect. Once manufacturers of dishwashers and washing machines, in particular, discovered that water efficiency is an attractive marketing tool, water consumption for such appliances dropped significantly (Fig. 3). More recently, they have developed some pilot models of appliances that internally cycle at least part of the water they use [9].

Advances in Membrane Technology

Advances in membrane technology play an important role in further reducing water consumption. This is a so-called enabler technology, i.e., it facilitates the development of alternative systems. Due to their relatively high efficiency but small size, these membrane systems are well suited for applications in small, decentralized operations. Some of the interviewees consider progress in membrane technology to be one of the

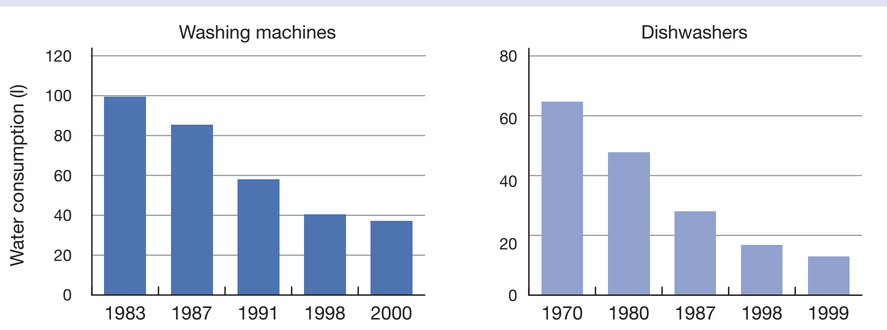

Fig. 3: Water consumption of household appliances clearly decreased in the past 20–30 years [11].

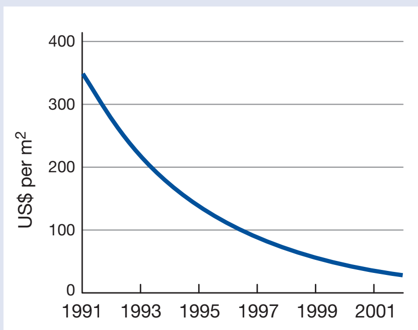

Fig. 4: Cost decrease for ultrafiltration membranes [12].

most important prerequisites for the viability of decentralized technologies. Membrane technology can, for example, increase efficiency and reduce the size of treatment systems for so-called grey water, i.e., minimally polluted water from showers and sinks. This technology could rapidly bring such recycling systems into the range of economic feasibility for households and small commercial operations. Considering that the cost per m^2 filter area has been steadily falling (Fig. 4), it seems likely that membrane technologies will soon be able to penetrate the household and commercial market sectors.

Moving Away from Centralized Solutions?

According to the majority of our interviewees, urban water management is considered a rather stable, long term-oriented and not very innovative sector. Summarizing all potential driving forces for change, however, scenarios can be developed that would lead to major change. On one hand, the mostly communal operators of water systems are faced with a rather unfavorable cost/price structure, high investment needs and tight budgets; on the other hand, the volume of waste water has decreased significantly over the past 15 years, a trend that is likely to continue in the decades ahead considering projected demographic developments, additional fee increases and new technologies. Both of these processes overlap and reinforce one another, while the wastewater treatment industry has very little influence over either [2].

Figure 5 illustrates the dynamics that the combination of these forces could unleash and summarizes how these changes could pose a serious challenge for the currently centralized systems. The proper operation, maintenance and service of an alternative, decentralized system is critical and could spawn the development of a sector, transforming former water suppliers and waste disposal operators to service providers.

It appears unlikely at this point in time, however, that the centralized water and wastewater systems will be replaced entirely by decentralized alternatives in the short- to mid-term. It is likely, though, that decentralized concepts may become established in certain niches, such as urban areas or regions where a high investment need coincides with a dramatic decrease in water demand. This would, for example, apply to newly constructed or newly rebuilt areas, which would not have to be connected to the existing sewage system, but would function as nearly zero wastewater producers, using a combination of approaches such as the recycling of process water, separation of wastewater streams, decentralized treatment of rain water, and small community treatment plants. The question which political decision makers have to face, as for example in some regions in eastern Germany, is whether or not additional investments in centralized systems are economically and technically reasonable.

No one can predict with any certainty what developments will actually take place. It is useful for the forward-looking water supplier or wastewater treatment operator, however, to study possible development scenarios in greater depth. The detailed formulation of scenarios for the development of the infrastructure and of consequences for the various actors (regulator, industry and consumer) will comprise the next phase of the project and is scheduled to be published in spring 2004.

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Further information:
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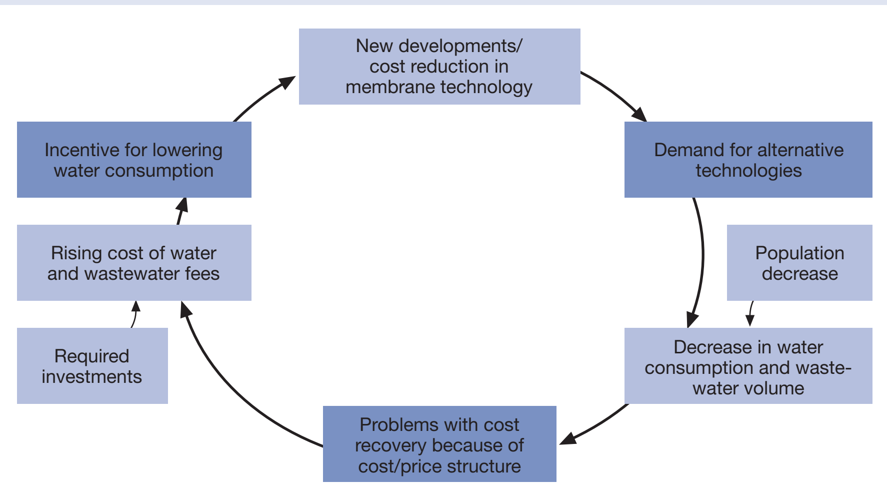

Fig. 5: Effects of the driving forces.

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