Water - Energy Linkages and Technology Challenges

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Water has always been mankind's most precious resource – there are no substitutes. The struggle to control water resources has shaped human political and economic history. Population growth and economic development are driving a steadily increasing demand for new clean water supplies and it is well documented that lack of access to clean water has major health implications. Many see the water security as the key environmental issue of the 21st century.

Water and energy issues are inextricably linked. Central to addressing issues of water security (for which a precise definition does not exist) is having the energy to extract water from underground aquifers, transport water through canals and pipes, manage and treat wastewater for reuse, and desalinate brackish and sea water to provide new fresh water sources. Other direct links between energy production and the availability and quality of water are dams for hydropower, cooling of thermal power plants, fossil fuel production and processing, and hydrogen economy.

Water and energy are the critical elements of sustainable economic development – without access to both of them economies cannot grow, jobs cannot be created, and poor people cannot move out of poverty. On a global basis, neither water nor energy are in short supply. What is in short supply is cheap energy and cheap potable water – energy and water at a price that people can afford to buy. Therefore an energy and water policy can also be expressed in similar terms: priority #1 is wise, efficient use of available supplies. Then, focus on new supplies that meet sustainability and environmental requirements.

We have to find better ways to use the water wisely, in our homes, in agriculture (such as "smart" irrigation), and in industry. Using the water wisely includes producing the potable water and cleaning the wastewater using less energy. Pumping water, pressurizing water distribution systems, pumping wastewater is a major energy consumer. By designing pumps for adequate flows, operating at dynamically changing pressures and using variable speed pumping there is a great potential for energy savings. Aeration of activated sludge systems is another major energy consumer. By automatic control of dissolved oxygen adjusted for variable wastewater loading more energy savings are possible, and as a bonus the biological activity is favored. Chemicals also require energy sources. The consumption of chemicals in terms of carbon sources for biological phosphorous removal and denitrification as well as precipitates for phosphorous precipitation can be significantly decreased by advanced instrumentation and control.

A wastewater treatment plant is not only an “end-of-pipe” solution to clean wastewater. It can also serve as an energy producer. The interest in biogas is increasing and there is a large unused potential in maximizing the production of biogas, used for both heating and as a replacement of gasoline in transportation. Recent data show that anaerobic digestion uses only some 20% of the energy content of the sewage. By-products from sewage treatment in combination with organic solid waste can provide a valuable source of energy if managed and utilized effectively. Furthermore, in cold countries the heat content of the effluent water can provide significant heating not only to the plant facilities but also to city buildings via district heating systems. In fact most wastewater treatment plants can be net producers of energy.

Detection and early warning systems are key components in a sustainable water system. The development of reliable, affordable and robust online instrumentation systems has been significant. Computing power no longer is a constraint, which means that the combination of measurements and model prediction can serve successfully in many systems. Leakages in drinking water systems can not only be detected but also localized, both in single pipe systems and in pipe networks. The combination of high speed pressure measurements and slower pressure and flow measurements makes it possible to automatically detect and localize leakages appearing as both sudden bursts and slow leakages. This can decrease a lot of costs and discomfort. Similarly, early warning systems composed by arrays of sensors in drinking water intakes can prevent severe quality disturbances into the system.

To produce clean water requires energy. Using desalination for water supply is rapidly increasing. In the Mediterranean area there is an 18% annual increase and in Saudi Arabia a 17% increase every year. This requires huge amounts of energy. At the same time, billions of people in developing countries have not yet turned on the first electrical light. For example, in Tanzania only every 5th person has access to electricity. In the rural areas even less people are connected, only one in 20. This means that the structure of electrical energy generation and distribution has to be different than in industrialized countries. Other local – often small scale - and sustainable solutions are needed. Photovoltaic devices ("solar") have a great potential for rural areas, but are of course available only during the day. Wind is another interesting alternative for rural electrification but the stochastic behavior of the wind is a problem. However, the combination of the two sustainable energy sources solar and wind offer interesting solutions. Biogas production also offers a potential. For the future we have to look for the production of clean water using clean energy sources. There is great potential in using wave energy as well as tidal water energy in combination with desalination.

Sustainable solutions require that we do not address singles issues in isolation, but have to adopt a systems approach with integrated solutions. This requires that specialists do not isolate themselves within their specialities but are open for interdisciplinary cooperation. Control and automation can contribute to improve the sustainability by smart monitoring systems, disturbance attenuation, using energy wisely and to maximize energy production. An integrated approach means that the whole system has to be considered, including pure water resources, energy consumption, water usage, wastewater treatment, water reuse, receiving water and possible energy production. Still it must be remembered that technology offers only part of the solution. The attitude towards water consumption may be the crucial ingredient. Furthermore, new approaches to financing, managing and maintaining systems must be developed, as well as approaches to involve local communities.