Looking at ICA in water through a power engineering lens

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THE WATER-ENERGY NEXUS

The linkage between water and electric utility systems can foster a number of collaborations. The combination of climate change impacting water availability and energy demand along with an energy intensive water system is a major driver in water scarce areas to integrate water and energy planning and management. Traditional water supply sources are under pressure due to droughts, environmental regulations and groundwater basin contamination. Decreased water supply increases the conflict between water for energy generation and water for direct consumption.

Both water and energy utilities are facing growing demand pressures with limited or fixed supplies. Both provide services to the same customers and have utilized many of the same planning frameworks such as benefit cost analysis, structured decision making, scenario planning, multi-criteria decision making, and least cost planning. Both electrical power and water utilities serve customers but cannot directly influence their behavior. The systems depend not only on technology, regulations, weather, time of the day or year but also on the user habits and performance. The many human interactions make the systems not only complicated but also complex. Both water and energy systems are usually invisible for the end user; they are “system centric”. It is challenging to make the consumer aware of the system and its restrictions. Now it is time to seriously consider how demand side management may influence the systems.

Today there are a number of “megatrends” that will have an impact on both water and energy systems, such as urbanization, the pace of technological change, digitization, hyper-connectivity, human longevity, increasing consumption, resource constraints, global governance structure, and cyber insecurity.

Monitoring and fault detection are of fundamental importance in any power system or water system. In both kinds of systems measurements have to take place in geographically wide areas. Methods used in a power utility can often be translated to a water utility. For example, by measuring voltages and currents in an electric transmission or distribution system it is possible to automatically detect and localize a short-current, caused for example by a thunderstorm. In a water distribution system a leakage corresponds to a short-current in a power system. Both phenomena are described by similar equations, even if the timescales are different. Obviously a water system has the extra dimension of water quality on top of the physical properties like flow rate and pressure.

ELECTRICITY AND WATER FOR PURPOSE

Today there is a dramatic change in electric power systems towards decentralization, challenging the traditional structure of “one size fits all” where the electrical power generation takes place in large power plants. An individualized customer service is developing where electric energy is supplied at various voltage levels, households to small regions. This requires sophisticated control and another level of protection and smart grids are developed at a fast rate.

Today the common thinking is that all users are supplied with the same type of water. *Water for purpose* will probably be developing fast, in particular considering the need for water reuse in water scarce regions. This will require a more elaborate water infrastructure and real time automation ensuring that adequate quality of water is delivered to the right user at all times. This will necessitate massive instrumentation and advanced communication and control.

Interconnected communication technology such as the Internet of Things (IoT) will have a great impact on infrastructure systems. Today there are more than 60 billion (10^9) IoT devices and the number continues to grow. We will probably see sensor infrastructures composed by smart sensors, cyberphysical systems and IoT measuring water quality in drinking water, distribution pressure and detecting and localizing leakages. Information in wide area sewer systems can be further elaborated to predict the best actions to meet storms and other flow rate changes. Abnormal consumption, water quality anomalies ought to be detected and data driven maintenance should be the norm.

RENEWABLE ENERGY AND HYBRID INFRASTRUCTURES

Renewable energy technologies can make a major contribution to universal access to both energy and water. Solar and wind energy have a huge potential to supply clean water, in particular in areas with no grid connection. The systems are scalable, from households to towns. In rapidly growing peri-urban areas electric power grids may be available but need to be complemented with decentralized energy sources. One aspect of this development is that the user will be much more in charge of both energy and water and the infrastructures will not be hidden in the same way. Hopefully this will lead to the “right-sized solutions” with a focus on the appropriate scale of intervention to achieve the desired outcome.

There are several research challenges in front of us utilizing the couplings between energy and water systems. We have to find a way to a future-proof circular water-smart society that is effectively and efficiently governed. Water and electric utilities can share data and identify a framework for collecting data. Future dynamic modelling of water and energy also needs taking into account the uncertainty of quantifying water and energy use. We need analysis and models that can answer questions relating to the influence of scale, such as decentralization. What strategies could be implemented to most cost-effectively reduce energy use influenced by water in the region? How should self-contained units of solar PV systems be automated to supply adequate electric power for pumps, RO units, biological treatment and other electric power consumers?

Both power engineers and water professionals work with infrastructures. Systems analysis tools can be compared when applied for networks. Centralized and decentralized systems are to be compared, both in design and in operation. On the demand management side we should aim for smart metering for electric power as well as for water. Should tariffs be time variable? For electric power it may be on an hourly or daily basis while for the water it can be made on a longer time scale.

The art and science of knowing the customers and what they truly value today and in the future will probably be a source of competitive advantage. Predictive analytics based on behavioral economics and big data ought to play an increasingly important role in the design and operation of new, adaptive, and agile services.

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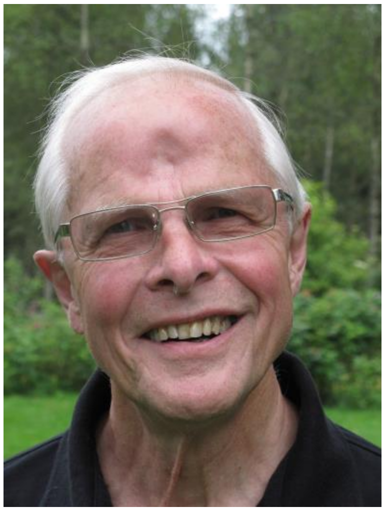

Gustaf Olsson, Lund University, Sweden, has devoted his research to applications of Industrial Automation. This includes control and automation of water systems, power production, electrical power systems and industrial processes. In recent years he has focused on the water-energy nexus, trying to understand how energy exploration, generation and use are related to water operations and consumption.

Gustaf joined the ICA speciality group at the first ICA conference in 1973. He has served as the editor-in-chief of Water Science and Technology, in the IWA Strategic Council, and in the IWA Board of Directors. He received the IWA Publication Award and is an Honorary Member of IWA as well as an IWA Distinguished Fellow.