



## ICT Frameworks - Moving Towards Smart Water Networks

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## ICT Frameworks - Moving Towards Smart Water Networks

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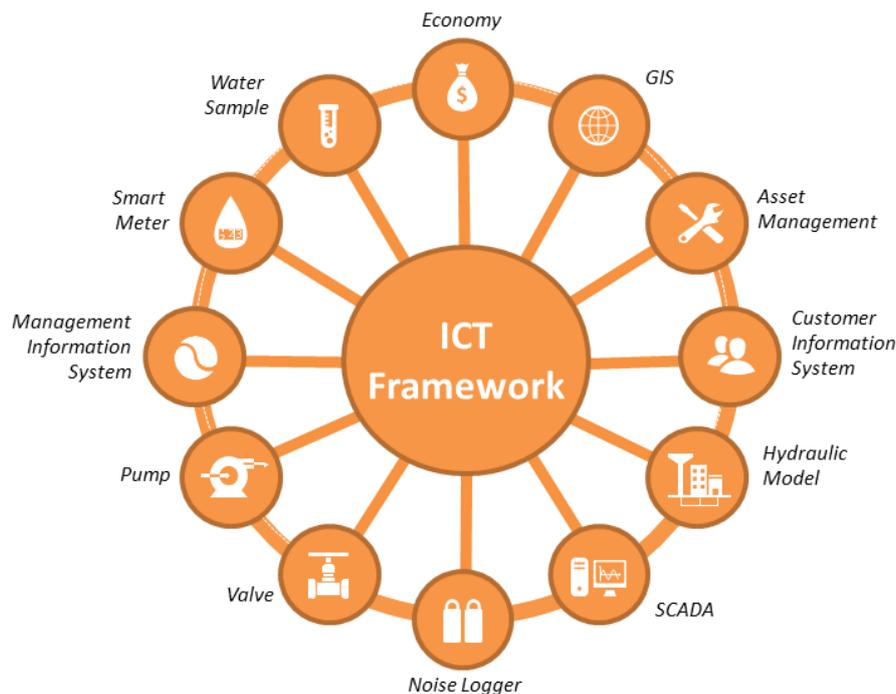
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**Abstract:** The use of ICT (Information Communication Technology) systems in water utilities as supporting tools to all levels and functions within the organization is increasing. The principles of smart water networks as defined by SWAN ([www.swan-forum.com](http://www.swan-forum.com)) are being adopted to a certain extent in most utilities in various ways and forms, often without having recognized the existence of the SWAN model. New ICT systems are often implemented as individual projects without having explored the synergetic effects that could be achieved by ensuring seamless integration with existing ICT systems within the utility. This means that a huge potential exists for efficiency improvements of the existing systems and development of new tools and techniques that will add value to the utilities. This paper describes a specific integration of ICT systems that could streamline the daily operation and presents real results from Denmark where such integrations are being implemented.

**Keywords:** Application of ICT, smart water networks, online monitoring and modelling.

**Imagine** a fully integrated ICT framework system, see figure 1, where e.g. a leak alarm from a deployed noise logger system automatically a) is aligned with information from an online hydraulic model to verify that the leak alarm is coming from a pressurized pipe and the hydraulic importance of the pipe is assigned to the leak alarm, and b) further cross referenced with the CIS (Customer Information System) to check if any critical customers are connected downstream of the pipe and how many customers would be affected by a pipe burst failure and assign this information to the leak alarm, and then finally c) verified against SCADA (Supervisory Control And Data Acquisition) and AMI (Automated Meter Infrastructure) to assess the potential leak size from real-time measurements which is also assigned to the leak alarm. This means that when leak alarms are raised from a deployed noise logger system the alarms are automatically pre-processed and correlated against other ICT systems, and indexed and rated by importance as they are being presented to the leakage management staff. This way the operation and maintenance staff can evaluate and assess such incidents immediately and with a high degree of consistency and confidence across the staff.

The concept of an ICT Framework is illustrated in Figure 1 that shows how well established interfaces should be defined and available across all ICT systems within a utility company.



**Figure 1** The concept of an ICT Framework with the most common ICT component.

This is just one example of what can be achieved by a shift in strategy from individual ICT systems to the principle of an ICT framework. Such a system can be realized, and is actually being implemented at two major utilities in Denmark as part of a large scale NRW (Non-Revenue Water) Management technology improvement programme.

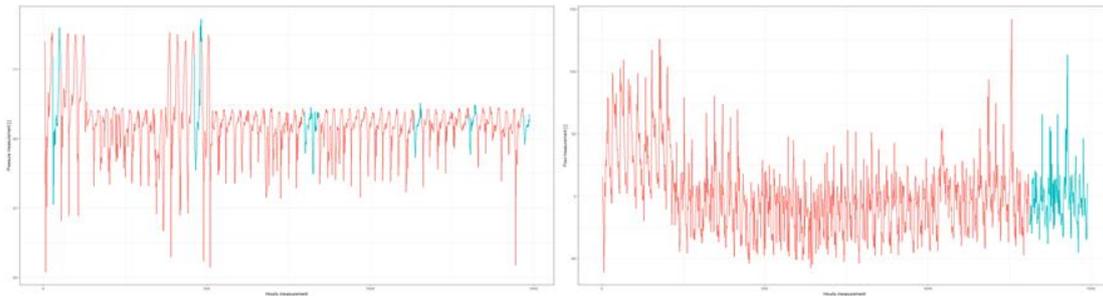
One of the major challenges that we are facing when increasing the usage of intelligent instruments, smart meters, smart water networks, big data and eventually IoT (Internet of Things) is that we fail to have established procedures and process that will evaluate the data quality of the enormous amount of data being collected.

To facilitate the task described above we will investigate whether it will make sense to conduct online water balance calculations on DMA (District Metering Area) level and if such water balance calculations can be made with enough confidence to be an integrated part of the active leakage management setup. Four DMAs at HOFOR (Greater Copenhagen Utility) and Novafos (One of the largest utilities in Denmark supplying water to 9 counties North of Copenhagen) are installed with flow and pressure meters at the DMA inlet(s) and smart meters are installed at all customers logging individual customer consumption on an hourly basis and transmitting these data to a centralized data collection system.

To conduct online hourly water balance calculations with high confidence requires a robust data collection and communication technology to be in place where only very few measurements are allowed to be missing every hour, the internal time stamp of both the inlet meters and the customer meters must be accurately synchronic and the quality and accuracy of the measurements must be very good.

A methodology has been developed to identify data anomalies and by subsequent use of artificial neural networks create substitute values for any false or missing measurements and thereby ensuring complete and consistent datasets for every hour

of the day. One result of this is illustrated in Figure 2 for both pressure and flow at one DMA inlet at Novafos.



**Figure 2** hourly pressure and flow measurements at a DMA inlet. Red are actual measurements and Blue are substitute values.

In this paper we will present how an ICT Framework has been implemented at HOFOR and Novafos, we will detail the comprehensive data collection system with associated data analyses comprising the data pre-processing as illustrated in Figure 2 as well as the data post-processing in form of continuous water balance calculations with associated confidence analysis. Data that are currently being collected will be pre-processed and used as input for the subsequent calculation of hourly water balances on DMA level. Additionally we will use individually pre-processed demand data to calculate dynamic diversity factors for the maximum hour demand to investigate reasonable criteria for pipe dimensioning similar to what is already being used in district heating systems in Denmark. The diversity factor is calculated by

$$S_{FAC}(n) = \frac{\text{Max}(\sum_n q_i(t))}{\sum_n \text{Max}(q_i(t))}$$

where S is the diversity factor,  $q_i$  is the daily hourly demand for each customer and n being the number of customers. The diversity factor reflects the fact that the maximum demand occurs at different times for each customer and by simply using the sum of maximum hour demands for design purposes will typically lead to over dimensioning of pipelines. Thus the diversity factor should be utilized to adjust for this where the diversity factor is applied on each pipeline with n being the number of customers supplied downstream the pipeline.