Water — the new oil!

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> When the well's dry, we know the worth of water. (Benjamin Franklin)

You're at home in the kitchen, it's warm outside, your mouth feels dry, you take your favourite glass, all clean and glistening in the glowing sunshine; you turn on the tap to get some cool, clear, refreshing sparkling water .... but nothing happens. Welcome to the future .... unless we change the way we manage our water.

The management of all our limited natural resources is becoming increasingly critical. Freshwater is available in abundance in some regions of the world, but is becoming increasingly scarce in others.

Ban Ki-moon, Secretary General of the United Nations, recently stated that water links the local to the regional, and brings together global questions of food security, public health, urbanization and energy. Addressing how we use and manage water resources is central to setting the world on a more sustainable and equitable path.

Traditionally in Ireland, we have been blessed with a plentiful supply of freshwater; indeed, in some cases, excesses have been responsible for tremendous damage and sadly the loss of life. Ireland even exports drinking water around the world; who would have thought that was possible thirty years ago?

But do we in Ireland, or even globally as a population, really manage our water usage? The answer is "No". Therefore, this research aims to develop novel, software based models to integrate and interpret data on water usage. The software shall be capable of providing a clear understanding of this area, both domestically and industrially and shall be suitable for optimisation in order to identify the most efficient means of utilising water within the facility being studied and hence lead to reduced water consumption.

Energy Crises and Energy Management

Historically, there have been several crises associated with natural resources, the most significant of which being those associated with oil. This has resulted in the development of systems to control the utilisation of oil, through the management of energy consumption. Typically, standards are developed to assist with these management systems, most recently a worldwide standard ISO50001 for Energy Management was released.

Adoption of a standard means that the organisation undertakes to perform its activities in a responsible and efficient manner as described in its relevant certification documentation. An initial audit is executed in order to grant certification, with follow-up audits carried out routinely. Any non-compliance is identified and corrected. Typically, this results in a well-managed, predictable and improved performance in the area covered by the standard.

Water as Energy

Now it is the turn of water, which is often referred to as "The New Oil", in a guarded and prudent manner, to take the limelight. Indeed many organisations have adopted water as a form of energy and managed it using ISO50001 the Energy Management standard, University College Cork (UCC) being one such example. UCC was awarded certification to ISO50001 late in 2011 and was the first third level institution worldwide to achieve certification, along with being the first public sector body in Ireland to be certified.

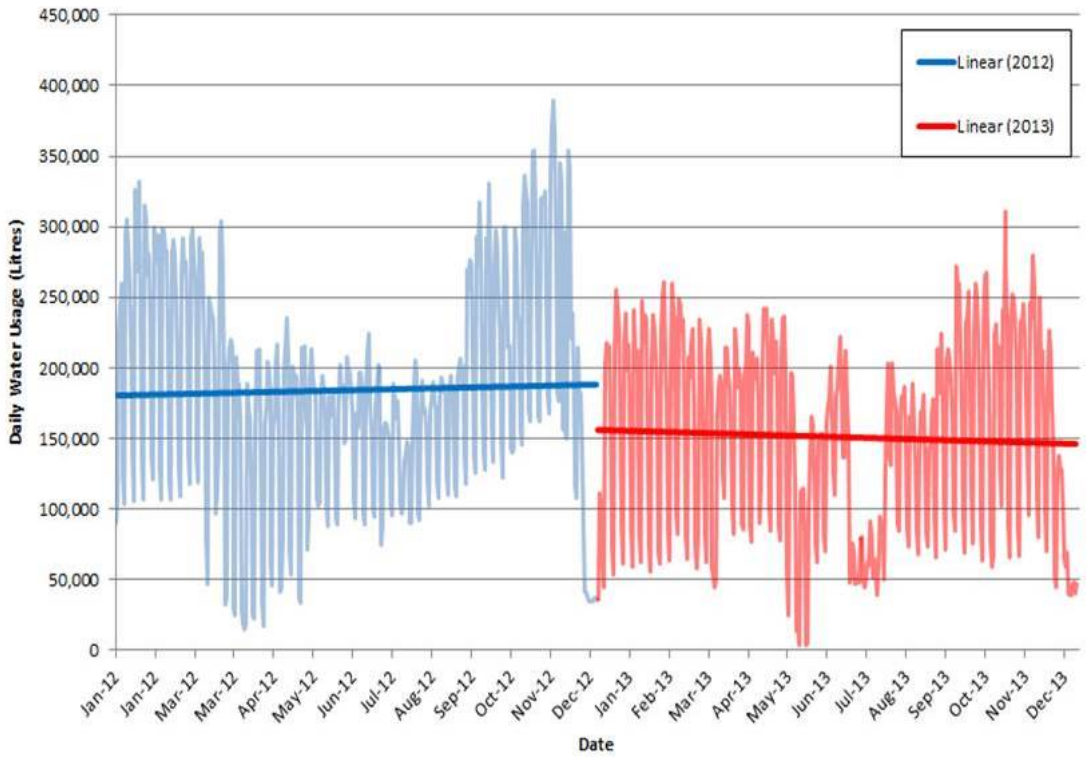

Figure 1: Water Consumption in UCC.

The graph in figure 1 illustrates the daily and linear average water consumption by the main campus of UCC since certification to ISO50001. The data shown is for the calendar years of 2012 and 2013 and includes the major consumers such as the heating boilers and sanitary facilities. The benefits of following the program have been realised through the 18% reduction in total annual consumption from 67,433,977 to 54,966,464 litres/year.

The Water-Energy Nexus

A nexus is defined as a means of connection or a link. Typically, on a worldwide basis, water, energy and food are considered as one nexus, with the water-energy link being a subsidiary of that. Aspects of the nexus include the strong interdependencies between water and energy generation and distribution, with water being required to generate electricity and electricity being required to distribute water. The excess consumption of both has had effects on climate change and subsequently on the environment. Both are undergoing a rapidly growing demand worldwide, while also serving as resource constraints. Both are subject to regional quality variability with variations in supply and demand. Internationally, energy has been included in regulated markets for a long time, while water has been added more recently. Within Ireland, Irish Water has been formed within the energy company Bord Gais and is being regulated by the Commission for Energy Regulation. Globally, and even between states in the US, water and energy supplies have been the subject of trade and security disputes, with certain regions depriving others of what they consider to be their entitlement.

Many countries have provisions made for a clean energy future, however they must also now plan for water scarcity and the two programs need to be incorporated. Energy and Water consumption are inextricably linked and the Energy-Water nexus needs to be understood and managed. In order to assist with this, the United Nations has revised its publications protocol, and the inaugural annual World Water Development Report, to be published in 2014, is themed upon “Water and Energy”.

Industrial Water Consumption

The neglect of one area of either energy supply or water supply, both internationally and indeed industrially, can have a significant impact on the other and lead to shortages with consequential effects.

Instinctively for water, quality would be the initial consideration; however, just as for a goldfish, the quantity available is also critical!

Many multi-national companies now require measures of both the quality and quantity of supply of both energy and water. Quantitative metrics are being developed in order to allow comparison between proposed locations and are being used by multi-nationals as an aid in the selection of the location for future facilities and also as an aid to the determination of which facilities to close down. One such metric is water usage effectiveness (WUE), a metric that looks at how many litres of water go into running and cooling equipment. For example, Facebook even began highlighting the WUE measure by publishing real-time dashboards on the internet that display how its data centres in the US are performing

against these metrics.

The carbon footprint of an organisation is defined as being the total of all the green-house gasses caused by the organisation. Presently, companies calculate their carbon footprint and strive to improve it by reducing their emissions. In the not-so-distant future, companies are also expected to declare a water-footprint, in a similar manner to the declaration of a carbon footprint presently. This footprint will be applicable to products, processes and organizations and will be based on life cycle assessments. It will be necessary to accurately quantify the water consumed, in a verifiable and consistent manner. In order to facilitate this, a new international standard, entitled ISO14046 Water Footprint, is being developed.

As well as efficiency, other factors such as wastage through ageing distribution networks, conservation measures and waste water treatment developments to facilitate recycling also need to be considered.

Software and the Research Topic

All management systems utilise the data that is made available to them. The constant introduction of additional meters within systems has resulted in large quantities of data being generated, with readings being taken every second if required. Virtual meters are also being employed, where real meter readings are subtracted from an overall total, in order to yield a reading for a supply which does not have a meter.

In order to receive, collate and manipulate this data, software systems are required. In my PhD research, I will develop software models to increase efficiency and thus reduce the consumption of water. It is proposed to consider water as a utility resource in a similar manner to other environmental energy streams and create a software model of the water utilisation in a large industrial manufacturing facility. Typically in a sterile manufacturing facility, mains water is taken in and treated by equipment and chemicals to provide several different water streams, such as De-ionised water, Purified water, Water for injection, Boiler feed water, Potable water etc. I propose to assign categories and values to each of the different forms of treated/processed streams based on the inherent environmental and economic impact of the stream. The model optimisation shall then identify potential changes to the existing practices of water treatment and consumption within the facility. These changes are expected to highlight and reduce the use of high value treated water and increase the use of low value water streams. The changes will also identify large consumers, which when targeted, will lead to a reduction in overall consumption. The model will be optimised using appropriate data analytic methods and novel optimisation techniques with a view to the best possible utilisation of each water stream, thus reducing the cost of water supply, the cost of water treatment, the overall

volume of water consumed and hence saving the facility money whilst also benefiting the environment.

The incoming ISO14046 Water standard and the existing ISO50001 Energy standard both require the monitoring of existing performance and also the demonstration of improvement. The software being developed as part of this research will satisfy these requirements for organisations, thus ensuring compliance with the standards which will ultimately lead to improved efficiency and reduced consumption.

Software has already been shown to be beneficial in the management of water consumption. In California, one software company has harnessed the information made available to it from the electricity meters installed on the motors driving the pumps on a large farm's irrigation system. The electricity measured by these meters represents a set of data, that when analysed correctly can be turned into a profile of when and where water is being lost in the irrigation system. Thus, without the addition of extra water meters, the existing information can be analysed to assist with water conservation. Indeed many water efficiency improvements similar to this can actually save as much energy as energy efficiency measures and at a much lower cost.

Conclusion

The UN estimates that presently one fifth of the world's population is challenged by water scarcity and that, by 2025, one quarter of the population will be affected. Water availability will become a major consideration in residential occupation and business operation around the world.

The metered cost of water is also expected to rise. In the US, commercial water rates have risen by an average of 30% over the last four years. All indicators point to the cost continuing to increase in all parts of the world.

Concerns regarding the future availability and cost of water have now stimulated interest in the management of this valuable resource. The EU Research Program Horizon 2020, commencing in 2014, predicts €500 million per year EU public investment in Water research in Europe.

Water consumption domestically, commercially and industrially needs to be managed in an effective manner analogous to that of Energy. My research will assist in this challenge by providing the software required to optimise water consumption industrially and hence contribute to the reduction in water consumption globally.

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