Improved Water Demand Forecasting to Promote Sustainable Water Management

Principal Investigator – Dr. Steven Renzetti, Brock University

Challenge

The Region of Durham in Ontario is a fast growing urban area east of Toronto and has a population of 650,000, covering an area of 2500 km2. It has a single tiered water supply system with the regional agency acting as a retailer to provide water to households, businesses, institutions and farms. In 2014 its output was 63,555 Mega Litres. The Region of Durham's water agency faces many challenges including growing demands, ageing infrastructure, water quality concerns and rising costs operations.

Forecasting water demands on a daily basis is remarkably difficult. Variables such as weather conditions, operational changes, watermain breaks, business cycles, human behaviour, economic and social factors effect water demand forecasting, but it is difficult to quantify those factors and thus difficult to make an accurate prediction. The water industry has responded to this challenge by developing sophisticated procedures for forecasting. The approaches used include Artificial Neural Networks (ANN) and time series statistical modeling, which takes into consideration all possible factors as input variables to build forecasting model. The Region of Durham has thus far relied upon ANN with mixed results. Through several years of observation, overall the ANN forecasting model can predict a relatively accurate water demand for next 24 hour period (R2 >0.7) in some pressure zones. Winter forecasting is more accurate than summer because outdoor water use is extremely variable.

An important part of the Region's recent efforts to improve the efficiency of its operations has involved the development of a significant capacity for water demand forecasting and system optimization. There is a direct link between these two aspects of the agency's operations because on a daily and weekly basis, one of the agency's most important variable costs is energy. In 2014, Durham Region spent $5.48M on electricity and $97,431 on natural gas to treat water. Energy costs for treating and pumping water and sewage consume over 65% of Durham's annual energy budget. By developing accurate forecasts of the next day's water demand, the agency is able to avoid pumping water during the day when it would be subject to OPG's peak-load pricing rules for electricity. Doing so also contributes to the agency's goal of reducing its carbon footprint.

The Region of Durham also has faced data-related challenges in its efforts to forecast demands. The existing historical SCADA data (flow, pressure, reservoir level) and weather data (temperature and precipitation) are extremely important to demand forecasting, however, sometimes the data quality is not acceptable due to data gaps, equipment failure and insufficient data (for instance, hourly rain data is not available).

Project

Municipalities in Southern Ontario typically have to manage a fifty percent (50%) increase in water use during the summer months (compared to the average winter day demand), due largely to lawn irrigation.

The objective of the proposed project is to improve the accuracy of the Region of Durham's short-term water demand forecasts. Achieving this objective will enhance the sustainability of the agency's operations by reducing water withdrawals, electricity expenditures, chemical usage and the agency's carbon footprint. Given the magnitude of summertime demands, the opportunity to enhance the sustainability of the agency's water supply infrastructure is enormous. In cooperation with Region staff, the research team will carry out the statistical analyses of sophisticated time series water demand forecasts and identify the best representation of climate-related information in order to improve the agency's short-run water demand forecasting capacity. The project will also supervise the implementation of a household survey in the area that will identify the determinants of households' outdoor water uses. Thus, the research seeks to improve the information base regarding water demands in order to increase the efficiency of decision-making by the water supply agency.

Subsidiary objectives include wider dissemination of these forecasting methods to other water supply agencies throughout Canada.

Outputs

Anticipated Outputs include:

- Complete estimation of ARIMA water demand models and comparison to the ANN-generated forecasts.
- Development and assessment of the alternative dryness indicators.
- Administration of household survey to investigate drivers of outdoor water demands.
- Articles and manuscripts to trade press and academic journals.
- Report to partner.
- Presentations at academic and industry conferences or workshops.
- Presentations at industry association annual meetings and technical workshops.

Outcomes

The project aims to achieve the following outcomes:

- Changes in the water demand modeling efforts used by Region of Durham to forecast water demands and an expected improvement in forecast efficiency. In the short run, this direct outcome should lead to cost savings through lower pumping and, as a result, decreased energy use. In the long run, the direct outcome will create the opportunity for the Region to reduce its water supply infrastructure spending by better forecasting the location and timing of future water demand growth.
- The objective of the planned presentations at industry association annual meetings and technical workshops is to inform other water suppliers of the methods and

results of the proposed project; to demonstrate the benefits of improved water demand forecasting and to indicate the training and technical skills required to implement forecasting. Thus, the intended outcome is that other water supply agencies adopt the water demand forecasting methods, improve their forecasting accuracy, and reduce their operating costs

Research Team and Partners:

Research Team:
Dr. Steven Renzetti, Brock University

Partners:
Region of Durham - Joe Li, Environmental Engineer

Highly Qualified Personnel (HQP):
TBD