Literature Review

Water Use Feedback Processes for Industrial, Commercial and Institutional Water Users

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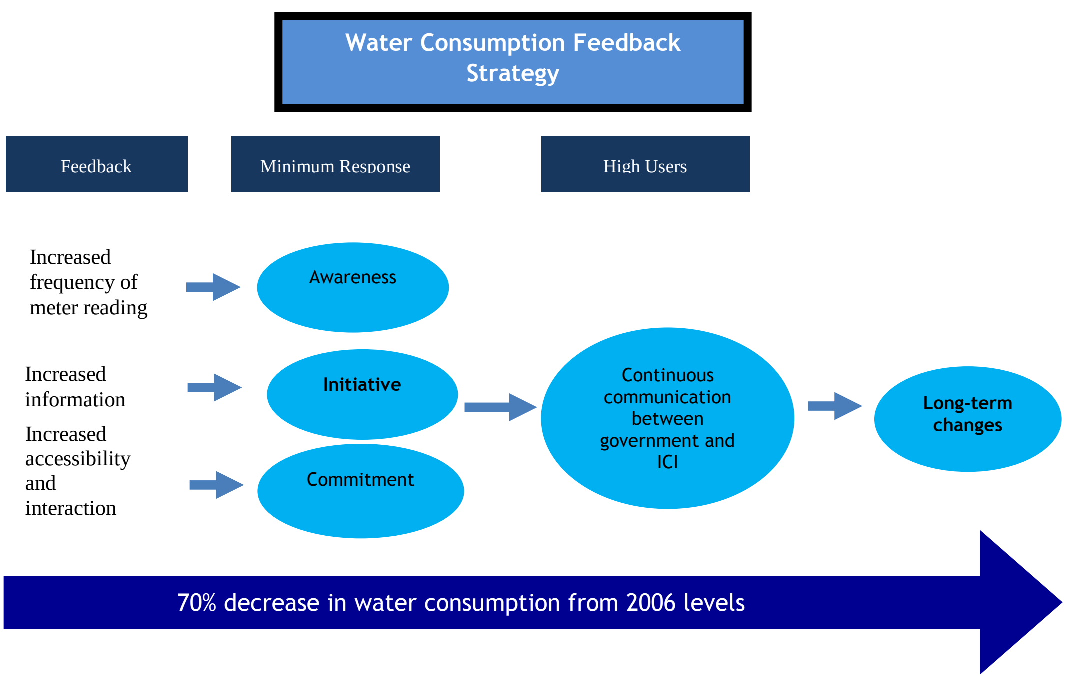
Executive Summary

A business case has been developed to promote the implementation of a new water use feedback system. The City of Vancouver is supplied by reliably clean water from the Seymour and Capilano reservoirs. The City generally also experiences over 1000 mm of rainfall per year. Though water supply is currently not of primary concern for citizens or government officials, it has been recognized that changes in water consumption should take place now in order to accrue long-term benefits. Climate change developments bring uncertainty. July 2013 was the driest month in decades in Vancouver. Weather anomalies such a this, as well as studies on population growth suggest that Vancouver may experience water scarcity in the future. Reducing the average per capita water demand of the City will contribute to cost savings from deferred infrastructure developments. Goal 8 of Vancouver's 10 Greenest City Goals shows an interest in decreasing water consumption by 33% by 2020. Current trends suggest that this may be possible, and even further reductions in water consumption could be expected by 2050.

The proposed three-phase feedback system would allow for a steady and cost efficient increased awareness of water as a resource. This awareness with various incentives is expected to encourage water conservation. In response to the gradual increase in information sharing and ICI interest, it is expected that there will be a decrease in water consumption. A free water auditing program is also expected to promote water conservation efforts. The new feedback structure would require new staff, as well as resources for new metering infrastructure and website development. Over the long-term significant changes in behaviour, and technological innovation is expected as well as a 10-20% decrease in ICI water consumption within 10 years.



The following literature review represents Part 1 of a two part report and presents the background research for the new feedback structure.

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Acknowledgements

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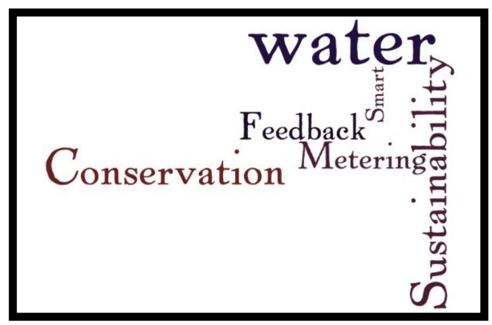
1 Introduction

The purpose of this literature review is to create an understanding of water use feedback strategies and their effectiveness in reducing water consumption. Due to the lack of academic literature, particularly for Institutional, Commercial and Industrial (ICI) water users, information was integrated from the energy sector and energy conservation literature. The summary identifies key points of reference from various fields spanning behavioral economics, conservation psychology, business operations and human-computer interactions from computer science. Though there are some significant developments in conservation research, much of the data is conflicting, and impractical to compare due to the lack of standardization within and among fields. The literature was further substantiated through the analysis of public documents and interviews with officials from seven North American cities/regions and the energy provider for the Province of British Columbia. The water feedback structures and the response of the water consumers of the respective cities permitted the identification of patterns in successful behavior.

Many municipalities throughout Canada are experiencing the consequences of inefficient and wasteful water use. Studies focused on water consumption have shown that the Canadian average per capita water use is one of the highest in the world (EC, 2010). Water metering has been accepted as a step towards more conscientious resource use (Infraguide, 2003; BCWWA, 2012). Metering can support the efficient operation and management of the precious resource. As expressed by Salman and Quraeshi (2008) "We measure what we value and we value what we measure". In British Columbia, municipalities are close to achieving universal metering for non-residential water consumers (BCWWA, 2012). Though the frequency of metering continues to increase year-by-year throughout Canada, there is no standard in place for successful feedback systems or incentive packages.



Encouraging Industry, Commercial and Industrial (ICI) water users to consider and reduce their water consumption is a complex matter. Eliciting these changes requires the appreciation of cultural, habitual and technological knowledge in relation to water use. Researchers have studied the effects of diverse feedback interventions, however due to variations in experimental groups, climates, income levels, education levels and test group size it can be difficult to generalize results from one study to another.

Efforts encouraging municipal water use reduction hold many benefits for a community, as high freshwater withdrawals can lead to environmental degradation and social difficulties in the short and long-term. Consequences include the decreased security of access to safe potable water supplies for future generations (BCWWA, 2012). Water use feedback systems can stimulate feelings of accountability from consumers for their behavior. Feedback analysis can also support governments in finding high and low users and system leakages (Infraguide, 2003). There are no known academic publications on feedback for ICI water consumers, however, experiences from different cities have shown that improved, interactive and innovative feedback structures can encourage the reduction of consumption. Interests seem to be focus on curbing spending and reducing their environmental footprint (*see section 4)*. Additionally, positive publicity that can come from water conscious behaviour could improve relationships with their consumers and the government in sustainability driven cities, states and or provinces (WBCSD, 2009; BCWWA, 2012).

Overall reductions in water use can minimize or even eliminate the need for municipalities to invest in new water supply infrastructure (e.g. desalination plants, new reservoir construction, new piping) (Infraguide, 2003; Brandes, Maas and Reynolds, 2006; Rouse, 2006). The focus on social infrastructure rather than potentially damaging physical infrastructure has been suggested as the ideal, most sustainable way to manage a population's water needs (Brandes, Maas and Reynolds, 2006; Stewart et al., 2010; Fielding et al., 2013).

> *"Efforts encouraging municipal water use reduction hold many benefits for a community… [it] can minimize …the need for municipalities to invest in new water supply infrastructure…"*

The municipal water users are generally organized into Residential, Industrial, Commercial and Institutional (ICI) and Agricultural users (EC, 2011). Metering is not evenly dispersed throughout each of these segments. Despite the increased connectivity of the ICI sector, the majority of research in the field of water metering is from residential housing (Wilhite 2007; Assen et al., 2010; BCWWA, 2012). A review of the literature suggests that testing households is preferable to businesses and organizations. In a household, the consumer with financial responsibility is likely to also receive and pay bills and have a direct influence on other household members. The household unit is smaller and so less complicated to understand.

The diversity of the management structures of ICI reduces the ability to reproduce or develop standards for feedback delivery for that sector of water users. The lack of data has also contributed to the lack of knowledge on successful conservation behaviour and if it can be attributed to particular feedback methods. In larger organizations, departments may be disassociated from one another, reducing the connection between actions and utility costs. Accounting departments managing water and electricity bills may not be communicative with operations or building management teams. Additionally, ICIs can be very different sizes and also have different functions (Wilhite, 2007; Aasen et al., 2010). Winn and Angell (2000) proposed that businesses in particular could be organized into groups that make use of four distinct 'greening' strategies. Some organizations are only motivated by external forces, guidelines and fines, while others develop their own initiatives to decrease their consumption of raw materials (potable water included).

Though, there is little information on the 'best practice' for giving feedback to water users (Infraguide, 2003). Studies throughout Canada have implied that universal metering systems can reduce residential and ICI water consumption by 15-30% (Infraguide, 2003; Environment Canada, 2011). On average throughout Canada, flat-rate consumers use 457 l/c/d while metered consumers use 269 l/c/d (Infraguide, 2003). In BC flat-rate water users consume about 383 l/c/d, while those with metered volumetric water rates use about 14% less, or 330 l/c/d (BCWWA, 2012). British Columbia focused studies have shown less of a decrease in consumption, presumably in part due to the access to high quality water with one of the lowest per meter^3 costs in Canada.

Infraguide (2003) suggests that high ICI consumers should be billed at least once per month. Metering and their appropriate feedback systems can have a significant influence on water use in the short term. It is expected that effective feedback systems are important parts of the process of activating deeper cognitive mechanisms and influencing long-term changes in behavior (Ellis and Gaskell, 1978Corral-Verdugo (2003) revealed when consumers live in areas of water scarcity and acknowledge this deficiency; it encourages their water conservation efforts.

In the fulfillment of its Greenest City Goals (*Figure 1*), the City of Vancouver aims to reduce its per capita water consumption by 33% from 2006 levels. In 2006, the total water use of Residents, ICI and Agricultural users was calculated to be 583 litres per capita per day. By 2012 water consumption already decreased by 16.6%. This follows a steady trend seen in the historical data. The litre/capita/day water use of the City of Vancouver has decreased by 36.4 % since 1986 when it was 764 l/c/d (*Figure 2*).

Figure 1 – The Greenest City Action Plan of the City of Vancouver © Greenest City Action Plan

There is no clear information on the source of the downward trend in consumption per capital. It has been suggested that the change is largely linked to the integration of water efficient technologies, mild summers and an overall increase in sustainable thinking. Nonetheless, water consumption habits are not considered to be a major issue of concern for residences or ICIs (Vancouver Budget, 2013). This can be attributed to the City's reliable fresh water resources, bordering water bodies and an annual precipitation generally between 1000-1500mm (Weatherstats, 2013). Despite the relatively steady decrease in water use per capita, the trend lines produced by the historical data suggest that it is not sufficient for fulfilling Vancouver's Greenest City Goals (*Figure 2*).

There have been significant steps forward in the development of feedback for resource consumption in the City of Vancouver. The majority of innovation has been focus on energy conservation, and recycling efforts. The feedback currently given to water consumers is limited to quarterly bills that include water use, volumetric costs and sewerage costs. This information is only given to consumers with water meters i.e. a few residences and all ICI users. This leaves opportunities to develop feedback systems and benefit from the water savings and improvement in government/ICI relations.

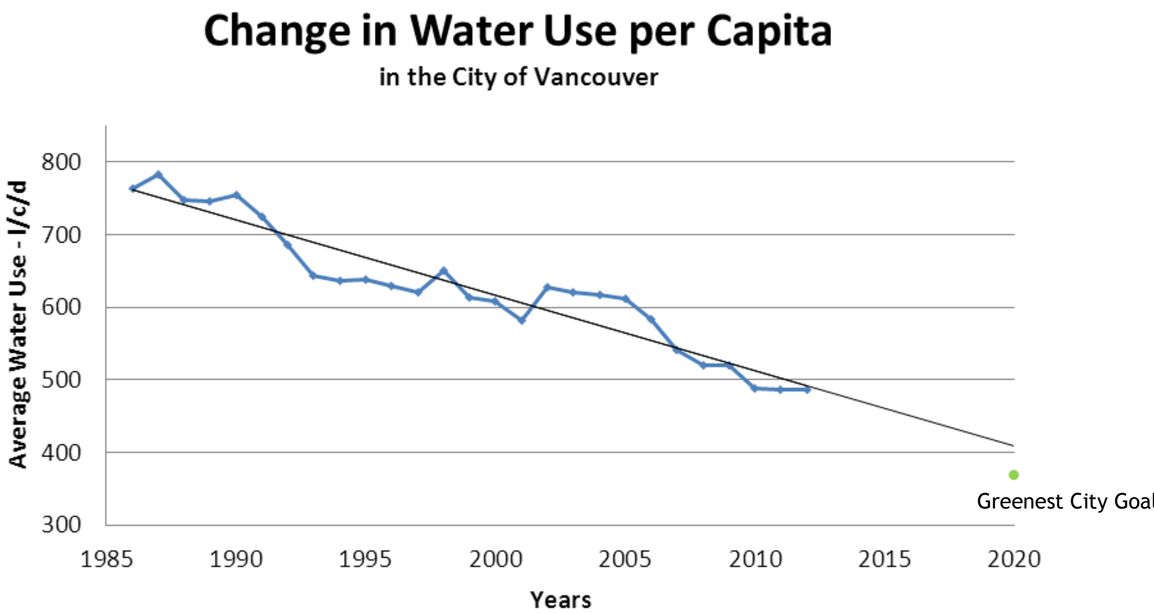


Figure 2 – The graph shows the change in use in Litres per Capita per Day (l/c/d) for the population of the City of Vancouver. The trend-line suggests that rates of water use have been decreasing for almost thirty years.

Research on various feedback methods in resource management literature has shown that there is a general conservation effect from increased information on consumption patterns (Vine et al., 2006). Research and government reports often build on the assumption that giving feedback on the quantity used will increase public concerns (Babooram and Hurst; 2010; City of Surrey, 2013). This is supported by the main principles of behavioral economics (Wei, 2008). These principles suggest that when people are given clear and correct information, they will also make appropriate decisions. It is expected that people will do what is 'right', in this case conserve a precious natural resource. Studies have suggested that the strongest motivator for long-term behavioral changes is the feeling of responsibility. Additionally, people are thought to be interested in seeing the direct benefits of their personal commitments (Dawnay and Shah, 2005). It is useful to consider these issues when revising feedback structures and selecting methods potentially applicable to the Vancouver context.

One of the difficulties with feedback literatures is that publications are relatively scarce and at times conflict each other (Vine et al., 2012). The guidance of economic principles could also be considered a flaw in the literature. Some studies focus on setting the right price and information campaigns. These projects assume that high costs and moral prerogatives are the key motivators to reducing water use (Inman and Jeffrey, 2005; Ryan and Wang, 2012). Coltrane et al. (1986) expressed that literature in resource consumption behavior may be interpreted very differently when a consumer's own comfort and convenience take priority over cost avoidance and moral guidelines. The significance of this must be considered. Various forms of water consumption feedback often trigger resource saving behavior. Studies that look at long-term influences explain that people occasionally return to their base-line after the shock of a new system wears off, even if prices remain high and resources are dwindling (Abrahamse et al., 2005). A particular study from Australia (Fielding et al, 2013) showed that even with the most modern feedback methods, Smart Metering, participants returned to their baseline water usage 12 months after the end of the study. This however,

Researchers from water, electricity and gas conservation fields have suggested a large array of methods with which consumers could be engaged to curb their consumption. Unfortunately, there are no indications that studies exist with more than three years of data. In order to review results over longer timelines, short analyses were conducted of various cities in North America. Successful projects that have achieved long-term reductions in water use by their populations can be informative and supportive for the development of Vancouver based guidelines. Concurrently, one must consider that it is difficult to directly correlate the different strategies with their results.

Obstacles

Lack of Data on:

- Water use feedback
- ICI and government interaction
- Best practices
- Long term developments

Disproportionate Focus on:

- Energy consumption
- Residences
- Appliance specific analyses
- Pricing as main control

The interest in feedback methods and their influence on water usage has grown over the last decade. However, there remains a lack of publications on water use feedback systems and their successes and failures. For example, over 90% of papers from environmental psychology are focus on residential electricity usage (Wilhite et al., 1999; Froehlich et al., 2010 pp). Due to this, information from publications on electricity metering were integrated into the discussion of feedback methods. Electricity metering provides a thorough database of decades of studies to draw comparisons and make connections to the water field (Darby, 2006; Shepherd et al., 2006; Froehlich et al., 2012). In making these mergers between fields, attention must fall on the disparities between the two different resources (Endter-Wada et al., 2008). Water is an essential resource, UNWater expressed that the average person requires a minimum of 20-50 litres of water per day for food, water and sanitation purposes. Water is generally considered an inelastic good i.e. because water is a *need*, higher prices should be expected to have a relatively small influence on its consumption. Though 50 litres may be the minimum needed per capita per day, modern appliances add many dozens of litres to activities that can rarely be compromised eg, use of the toilet, washing hands. There are also fewer technologies in the home that use water than use energy. Energy, on the other hand is never used in and of itself. The use of energy is the consequence of other behavior; turning on lights, heating/cooling, entertainment, transportation and even water. This water/energy nexus must be considered in the discussion of their consumption. Researchers have expressed that feedback can be effective for reducing water consumption; however the results are less conclusive than those from electricity (Peterson et al., 2007; Willis et al, 2010; Froehlich et al., 2012)

The following review summarizes ideas from different perspectives in order to develop a holistic understanding of water conservation. The initial analysis covers insights on the motivation behind conservation, and then an introduction is given to sustainability integration in the business world. The studies focal point lies in the description and results of various feedback measures found in the academic literature. Ultimately, case studies of diverse North American cities and Canadian provinces allow the reader to understand the results of feedback measures in practice (*figure 3*).

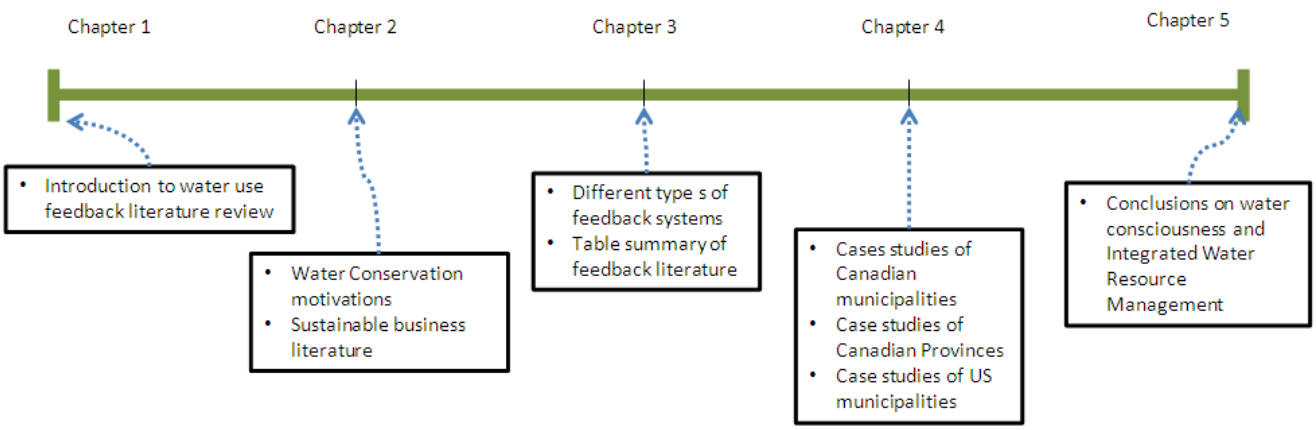


Figure 3 – The set up of the literature review

2 Water Conservation Motivation

2.1 Insights from Water and Energy Literature

Before discussing the various strategies that have been used by researchers and governments, it is useful to consider the drivers of water consumption patterns. The fields that have approached conservation needs have derived insights from very different perspectives (Endter-Wada, 2008). As expressed by Gregory and Di Leo (2003), there are a wide range of influencers that need to be considered including “environmental concerns, knowledge, opportunities to conserve, reasoned influences, attitudes, intention …unreasoned influences, habits, routines, situational influences, income, education, household characteristics and environmental issues.” Understanding motivation can support the categorization of the feedback methods and how they may or may not achieve environmentally proactive behavior.

Lockton et al. (2008) expressed that it must be *easy* to conserve a resource or take part in an environmentally friendly activity. The ease of participation can increase the interest of resource users. This would suggest that the best way to reduce water use is through the implementation of ecofriendly technologies. When water efficient infrastructure is in place conservation becomes the default option that does not require extra consideration, and wastage must be an explicit decision. Other researchers have suggested that for initiating real social changes, feedback systems must force the user to interact with information and consequently think about their actions. The technological fixes, may reduce daily water use eg through low flush toilets and low flow showers and sinks (*Figure 4)*, but many cities have found that those changes are marginal and do not provide the long-term shifts in behavior through the maturation of the consumer. Peterson et al. (2007) also expressed that efficient technologies are unlikely to solve environmental crises. They found that people need to be changed in order for them to appropriately use the new technologies. On the other hand, research by Geller, Erickson and Buttram (1983) suggested that investing in new water-saving devices were effective in educating users in their water consumption. Making the decision or conforming to new regulations to replace toilets can be effective in raising consumer consciousness.

Figure 4 – Water efficient sinks in the Olympic Village, City of Vancouver BC © Vancouver Media Gallery, 2009

Some researchers suggest that wasting behavior and disassociation with the environment are components of human nature (De Young, 1996; Corral-Verdugo et al., 2002). This perspective indicates that attempting to elicit conservation behavior may often be fruitless. The theory explains that individuals are focused on maximizing profits for themselves, even when it might be detrimental to others. Due to common disparities between the life-style of different people, it is vital for conservation efforts to be inclusive, and encourage the development of the community as a whole. It has been considered appropriate for environmental policy to step in to enforce restrictions on extraction and enjoyment of resources in order to adequately and equitably manage the environment. A study on water consumption in Mexico, found that motivation to conserve water was sparse when it was believed that neighbours were not thrifty in their usage (Corral-Verdugo et al., 2002). Water use reduction efforts must attempt to approach the whole population. The development of a common goal would allow for the protection of resources without the intensification of wedges between social groups.

Lessons can be learned from understanding the self –preservation efforts of most resource users. Various studies have pointed towards the need to show users how conservation benefits their own lives (Whilite et al., 1999; Kappel and Grechenig, 2009; Froehlisch et al., 2012). The research of Mcmakin, Maloone and Lundgren (2002) shows that people are the most comfortable when they can interact with data in personalized formats, and understand the direct connection between an action and their utility bills. This would point towards the need for direct feedback formats that allow people to feel responsible for their contribution to the urban water cycle. In the Mccmakin et al. (2002) study, the participants were motivated to do the 'right thing'.

"It has been suggested that responses to resource use feedback can be predicted by personal attitudes, world views and values for the environment…"

Some research has indicated that there are distinctly different initiators for environmentally friendly life-styles. It has been suggested that responses to resource use feedback can be predicted by personal attitudes, world views and values for the environment (Gray, 1985; Gregory and Di Leo, 2004, Gilg and Barr, 2005; Dolnicar et al., 2012). Some people behave egoistically. They make decisions based on their own personal and economic well-being and a consideration for how their life might improve through behavior changes. Others make decisions because of convenience. Some water users want to help others, and are influenced by the idea that their actions will support other people's water access. The water use of eco-centric consumers is motivated by a drive to support and protect the environment.

Eco-friendly users believe that there is an intrinsic value in protecting the earth. This demographic is believed to be relatively small, in comparison with those driven by egotistical cost saving and or comfort creating goals. This demographic is also the most likely to become involved and committed to environmentally friendly life-styles (*Figure 5)*. Long-term environmentally friendly behavior is believed to come from external and internal motivators. This theory of environmental understanding was expressed through the results of a study by Kappel and Grechenig (2009). Their review of four different households indicated that people who consider themselves eco-friendly were more likely to express an interest in continuing water conservation after the completion of the experiment. The less eco-conscious participants may be more likely to make short term changes to their water use.

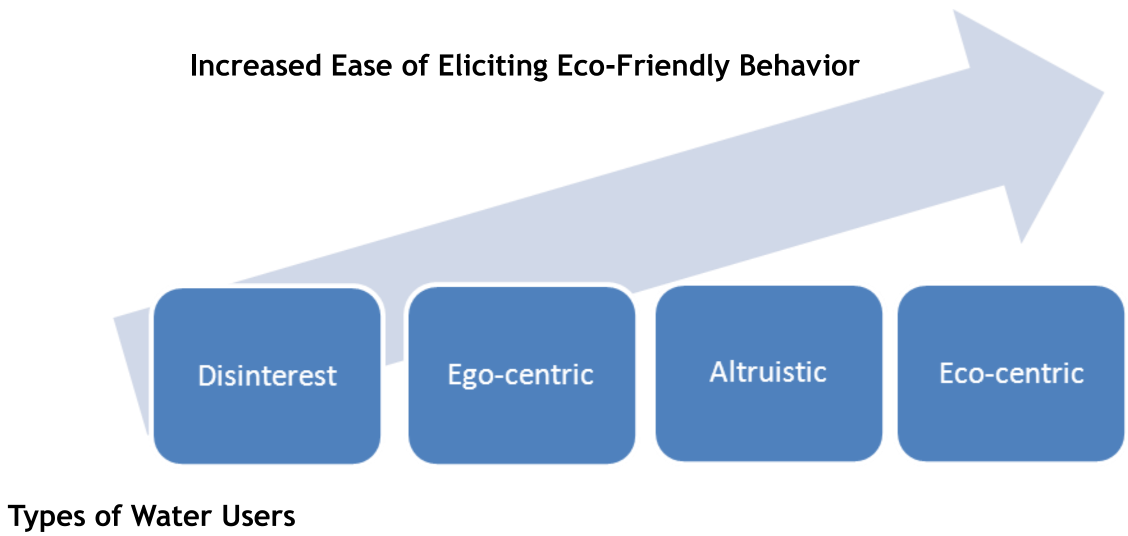


Figure 5 – The different types of attitudes towards water use and differences in difficulty of influencing their behavior to support water conservation

Other studies have found the opposite, suggesting that beliefs are not strongly correlated with water conservation behavior (Syme, Nancarrow and Seligman, 2000). Instead some results express that water consumption is connected to demographic and locational factors eg household size, gross income, rainfall, temperature, the irrigation system in use (Kantola, Syme and Campbell, 1982; Aitken, Bruvold and Smith, 1988; Endter-Wada et al., 2008; Froehlich et al., 2012). This implies that educational and awareness programs directed at creating environmental consciousness may not be useful for the initiation of considerable changes in water use (Kappel and Grechenig, 2009). Aitken et al., (1994) found in an Australian study, that water consumption in their experimental group was linked to the family size, and the household values. The wealthier participants of the study were in the most expensive households and were the highest water users. This was also reflected in a study by Corral-Verdugo (2002) in Mexico. Wealthier households can afford higher water bills, and may actually reduce their concern for the issue, due to their financial ability to overuse the resource. On the other hand studies by Van Liere and Dunlap, (1980) and Wilhite and Ling (1995) suggested that people with a high income were more likely to conserve energy and be considerate towards the environment *(Figure 6*). This was in part associated with the concerns for social responsibility, higher levels of education and the ability of the highly educated to easily comprehend their utility bills.

Conflicting Resource Use Patterns

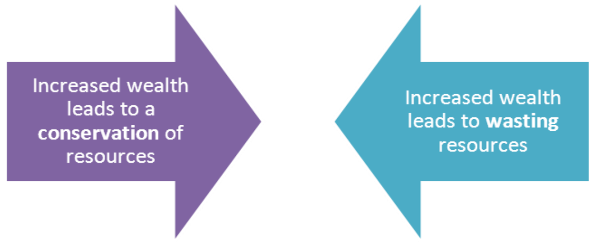


Figure 6 - Many results from resource conservation literature conflict, one example are the study results from Aitken et al, (1994) and Wilhite and Ling (1995)

In 1990, Svenson published the idea that decision-making can be organized into distinctive categories with different methods of processing information. The theory recognized the differences in decision-making in relation to the extent to which the decision maker uses their own value system in the decision i.e. attitudes, motivations, drivers (Svenson, 1992) (*Figure 7)*. Svenson expresses the significance of purely habitual behavior that is repetitive and unconscious, in comparison to in-depth thought processes. Automatic processes, such as showering, washing dishes or laundry are considered to function outside of attitudinal norms (Gregory and Di Leo, 2004). The value systems of many people are believed to conflict with habits and lifestyles. Once confronted with the contradiction, people generally attempt to reduce the incompatibility. This suggests that the most important component of feedback is purely that it exists and that it is constant. This way people cannot ignore their wasteful water consumption when they assume they have an ecofriendly lifestyle. Due to the importance of habitual behavior, repetitive conditioning techniques could be used to make conservation behavior more automatic. These different ideas and strategies can be used alone or together in an attempt to create the most effective long lasting changes in consumer behavior.

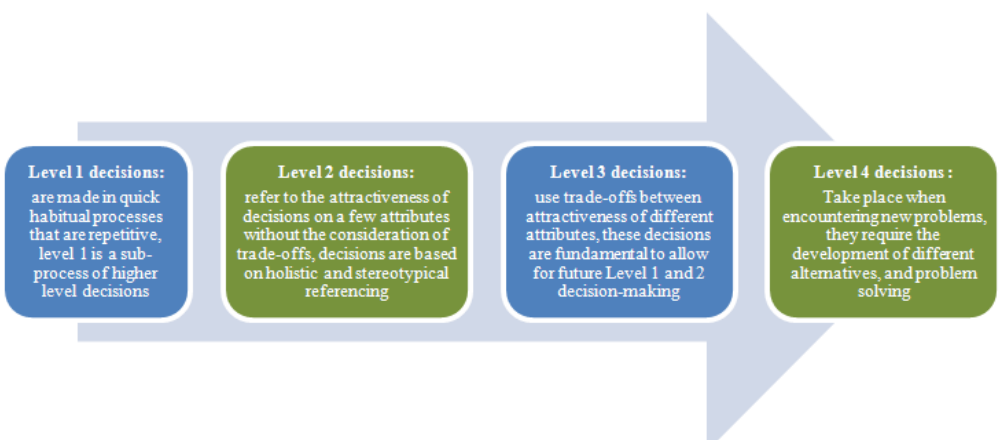


Figure 7 – The different levels of decision making as defined by Svenson (1992)

Cialdini (2007) expressed that feedback strategies could be categorized into six different tools for influencing social behavior. He indicated the different processes of; reciprocation, commitment, consistency, social approval, authority, liking and scarcity. In order to make use of these approaches, Arroyo et al. (2005)

suggested seven different principles for the development of physical interfaces. Each principle is thought to influence behavior through increased cognitive levels. The principles are (from lowest to highest cognitive levels): value added designs, automation, just-in-time prompts, positive and negative reinforcement, adaptive interfaces and social validation. They suggested, that especially for the eliciting behavioral changes for sinks, it was useful to consider more complex persuasive techniques that do not reduce the functionality of the technology.

Human Interests	Recommended Approach	Categorization
Comfort and ease	Water efficient infrastructure	Inadvertent feedback
Self-improvement	Historical data, immediate updates, information on positive influences	Direct feedback
Environmental conservation	Information on environmental benefits, tips on conservation methods	Indirect feedback
Social norms	Comparative data,	Indirect feedback
Alignment between values and actions	Regular updates, tips on conservation methods, clear information	Direct feedback

2.1.2. Business Focused Literature and Case Studies

There is scarce research on the relationship between ICIs and water utilities. ICI metering and feedback processes are also unclear due to the large diversity in the sector. Economics and operations management literature suggests that the goals of any business are to increase the efficiency of their systems, and optimize the utilization of resources. This identifies the natural overlap between business development and sustainability goals. Descriptive case studies specific to sustainability initiatives, express clear patterns in motivation. Businesses can be very different in product and organization, yet express homogenous interests in reducing costs, improving consumer and government relations, and caring for the future (WBCSD, 2009). With these motivators in mind, it is also useful to distinguish the strategies, which businesses use to integrate sustainable decision making into their processes.

Business Sustainability

Initiated by:

- Executive level commitments
- Government regulations/fines
- Supply chain commitments
- Consumer pressure
- Employee motivation

Some theoretical research and case studies might suggest that corporate greening should ideally start with the awareness and commitment of top management. The drive of executive levels of an organization can lead to responses to environmental issues, spear-head policy changes and inspire the implementation of sustainability throughout the entire corporate structure (Carrolls, 1979). However, the integration of environmentally friendly decisions is not that straight forward, and the collaboration and swaying of top management may not always influence the behavior of an entire organization. A study by Winn and Angell (2000), expressed a far more diverse array of complexity within organizations after a study of twelve different firms in Germany.

Winn and Angell (2000) distinguished four different processes with which businesses make environmental decisions. The categories suggested are *Deliberate Reactive Greening*, *Emergent Active Greening*, *Unrealized Greening*, and *Deliberate Proactive Greening*. Each of these approaches suggests the need for different incentive structures and feedback methodologies.

Organizations with a *Deliberate Reactive Greening* approach have a low policy commitment to environmental issues. Their decision making in the environmental realm is also considerably more passive than that of other organizations. The reluctance of top managers and unclear processes, make these organizations difficult to convince. Generally, when environmental collaboration is seen as a detriment to a consumer product and or a wrench in the gears of an efficient machine, only strict regulations and fines can motivate change. *Emergent Active Greening*, on the other hand describes an organization that is proactive in implementing corporate sustainability policy. Their suppliers and research and development have environmental concerns integrated into their management. In this case the top management is uninterested in environmental issues, and has not supported the thorough dissemination of the ideal throughout the different departments. Management directed marketing would be recommended to initiate change within the organization. The reverse is true for an organization with *Unrealized Greening*. In this group, top managers are highly committed, but the lack of communication and collaboration with suppliers and departments prevent the proactive integration of green ideas. Organizations with *Unrealized Greening* can also be those that publically announce sustainability ideals, but avoid actual actions. Here environmental/resource use feedback must be directed towards middle managers, and should ideally express the personal gains available.

The Burke-Litwin model is also an interesting way to consider the integration of sustainability ideals into the change management of an organization. The Burke-Litwin model (1992) suggests that there are 12 main components that must work together in order to create long lasting change throughout an entire organization. Water conservation, can be pursued as a specific environmental measure, but it can also be implemented as part of a larger paradigm shift, that aims to accept sustainability as the new status quo. Though the model recognizes the importance of the top-down approach of decision-making, it also identifies the significance of bottom-up motivation. This was also expressed by Butler in Mintzberge et al. (1990) who said that decision making is at times a diffused process. The Burke-Litwin Model also expresses the power of the 'external environment' that could be considered a catalyst for change. The 12 step model, seen below (*Figure 8),* might explain the length of time and collaborative effort required in order to influence the running of an organization. When developing feedback this model may be considered a guide to strategize the targets of a specific program.

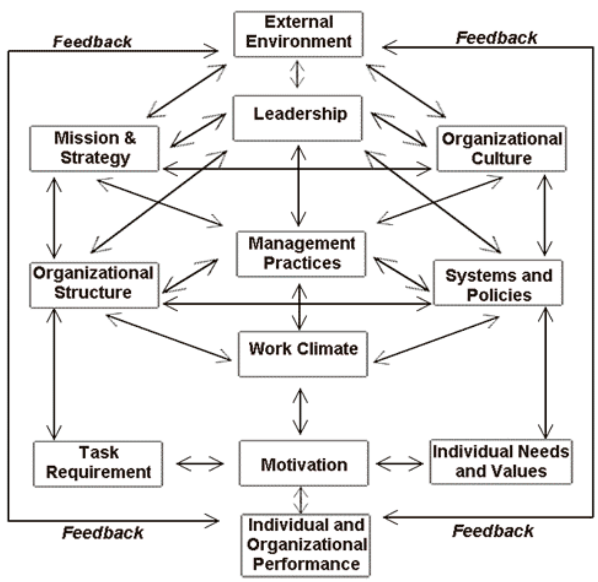


Figure 8 – The Burke-Litwin model can be useful for the conceptualization of sustainability change management

3. Different Feedback Methods

3.1 A Summary of Feedback Methods

There are many different types of feedback available in order to trigger environmentally friendly behavior. Below in is a summary of feedback methods from electricity conservation expressed by Darby in 2006. Subsequently, research from Vine et al. (2012) and Froehlich et al. (2012) are used to indicate the most effective feedback methods. Section 3.2 develops the literature review on these key methods.

Direct Feedback	**Indirect Feedback**
Available on demand, learning by looking • *Self-meter-reading* • *Direct displays* • *Interactive feedback via a PC* • *Pay-as-you-go/keypad meters* • *'Ambient' devices* • *Meter reading with an adviser, as part of energy advice* • *Cost plugs or similar devices on appliances*	Raw data processed by a utility • *More frequent bills* • *Frequent bills based on readings plus historical feedback* • *Frequent bills based on readings plus comparative/normative feedback* • *Frequent bills plus disaggregated feedback.* • *Frequent bills plus detailed annual or quarterly energy reports*
Inadvertent Feedback	**Utility-controlled Feedback**
Learning through association with the resource • *New energy using technologies* *Increase observation of energy use and shifts in thinking*	The utilities study of the consumer • *Utility-controlled feedback via smart meters, with a view to better organize management*
Energy audits	
Understanding the energy of a building • *undertaken by a surveyor on the client's initiative* • *undertaken as part of a survey for the Home Information Pack* • *carried out on an informal basis by the consumer using freely available software, eg carbon calculators*	

Reviews of successful studies in electrical and water feedback methods found patterns suggesting that the most influence on consumer behavior can come from:

- Frequent updates
- Digital displays
- Clear, simple and appealing displays
- Interactive displays
- Different options for comparisons eg time periods and neighbors
- Customized information
- Appliance specific information
- Connections made to goals
- Feedback given with advice

(Froehlich et al., 2012; Vine et al., 2012)

3.2 Lessons from Feedback Literature

3.2.1 Comparison Standards

3.2.1.1 Historical Standards

Research by Froehlich et al. (2012) suggested that the most successful feedback methods included historical comparisons. This type of feedback, where a consumer is shown their current water use level in relation to their past usage and or average usage, seems to be easy to understand and useful for making environmental decisions that reduce consumption. This type of comparative data would allow consumers to see how their water use changes and how these changes influence costs (Kappel and Grechenig, 2009). As individuals are generally interested in understanding how water conservation can benefit their own lives, historical comparisons can be encouraging. Information that portrays historical trends can reduce the confusion or misunderstanding that might come with the singular figures found on many bills. The variations in use of the terms Units, Gallons, Litres, Cubic meters and or Cubic feet also have been found to add to the confusion when people analyse their water bills and costs. Though there is no exact figure of how much people *should* be using, a more general understanding that they are using more than average or less than average can increase the effectiveness of the message. In a study in the UK conducted by (Lockton et al. 2008), it was found that the historical information about their water use was the most "readily recalled" piece of information from the water bills.

3.2.1.2 Normative Standards

Next to personal historical data, researchers have found that there are interesting responses from consumers when they are given information about the water or energy usage of their neighbours. It is believed that the effect of peer pressure can be more effective than the cost-saving potential of conservation. Being able to see comparisons to a group mean, allows for a social reinforcement of decision-making. This awareness of comparative performance can alter behavior due to issues of pride or shame. Witnessing the conservation efforts of others can be a key component to committing to pro-environmental behavior (Corral-Verdugo, 2003; Lockton et al., 2008). Empirical evidence from the study of businesses has shown that peer comparisons can lead to labor productivity. This can be initiated through ranking alone, even without coupling them with financial incentives (Roels and Su, submitted).

Placing social pressure on participants may however, also cause undue stress and discomfort. Information sharing that is too detailed could also lead to people feeling as though their privacy is lost (Froehlich et al., 2010). The type of normative averages one might show would require the categorization of the water users. Users may reject the categories they are placed under or compared to. If they feel unfairly judged or penalized, eg an office buildings hosting many servers being compared to other office buildings, they may feel demoralized and become uncooperative (Roels and Su, Submitted).

Some studies have shown, that when people are informed of their 'below average' water consumption, they may increase their usage to conform to the average. This is called the boomerang effect. There are, however, cultural factors that weight in on the success of comparative scores. In energy studies it was found that people in the Europe are the most interested in viewing their own historical data (Vine et al., 2012). On the other hand, some evidence has shown that American, Norwegians and Japanese respond positively to receiving insights on their neighbour's energy consumption (Wilhite and Ling, 1995; Darby, 2006).

3.2.1.3 Goal Comparisons

Many studies have suggested that consumption behavior will not change if no efforts are allocated towards setting internal or external goals. If participants are disinterested in changing their behavior or being 'sustainable' in their actions, then no amount of input or feedback can have a significant influence on their usage patterns. Encouraging goals setting, either through intrinsic decision making or external guides can give people a reference point. This will improve motivation as consumers can monitor how they either move towards or away from the goal. A study by Kuznetsov and Paulos (2010) showed that their participants were interested in knowing an 'ideal' score or what their consumption was supposed to be. Earlier research by Becker (1978) in the analysis of energy consumption showed that setting high goals was more effective than lower ones. Test subjects given low goals, felt very little need to develop behavioral changes to outperform the goals. Setting high aspirations (20% reduction in energy use) required the development of new habits and led to changes in energy consumption.

Insights on goal setting suggest comparisons (either normative or historical) should be given along-side a goal for the resource consumer. Self-set goals are the most effective; however it is difficult to guarantee that the consumer would set the 'right' goals. An oft cited study on electricity use by Schulz et al. (2007), found from their sample that very simple injunctive messages showing approval or disproval (moving toward or away from a goal) for consumption patterns was enough to encourage positive conservation behavior and offset the boomerang affect mentioned in section 3.2.1.2.

3.2.2 Billing Frequency

Billing is an indirect method of communicating water use. The time lag, and data processes involved in billing systems can lead to users feeling disconnected with their resource consumption. Froehlich et al. (2012) and Corral-Verdugo et al. (2003) argue that receiving more reminders about their water use can be an important step towards water use reduction. Shorter time intervals between an activity and a bill can lead to an improved understanding of the consequences and their actions (Van Houwelingen and Van Raaij, 1989; Arroyo et al., 2005; Vine et al., 2012). Reducing the time between feedback allows people to target their repetitive habitual behavior and make long-term changes (Corral-Verdugo, 2003). Canadian 'Best Practices' for encouraging water use reduction suggest that heavier water users should be billed more regularly (Infraguide, 2003).

3.2.3 Customization of Conservation Tips

Results of interviews by Froehlich (2010) propose that water consumers might resist conservation measures if they do not know how to further increase their water use efficiency. Therefore, teaching water conservation methods is an important component to initiating conservation behavior (Corral-Verdugo, 2003). Researchers have proposed consumer specific conservation tips that connect to specific lifestyles can improve their connection with the resource (Wilhite and Ling, 1995). Consumer appropriate feedback can support ego-centric motivations that aim to fulfill personal needs/wants. In Sweden, a computer game was used to educate teenagers about their energy consumption behavior (Lockton et al., 2008). The computer game allowed the user to navigate a typical household according to their interests and at their preferred pace. This game did not test the changes in energy conservation in the teenagers own homes, but expressed that the game was helpful in the development of mental models and awareness. This is an important component in developing behavioral modifications (Bang et al., 2006).

3.2.4 Aesthetics and Presentation of Bill

Though the aesthetic appeal of a bill or display is subjective, it is important to invest time in the development of the layout (Kappel and Grechnig, 2009). Fizpatrick and Smith (2009) also expressed that design considerations were important when attempting to integrate new knowledge into a household. People become less interested in interpreting data when the presentation is considered unappealing. Overall, very few studies have considered the importance in the design of their feedback. In 2006, Fischer proposed that there are only two *comparative* studies expressing the importance of the details of imagery, graphs, labels, colors and design on bills. A few years later, with the developed interest in online and home displays, Arroyo et al. (2005), Stewart et al. (2010) and Froehlich et al. (2010, 2011, 2012) published on the importance of effective designs.

Wilhite and Ling (1995) published one of the first large scale three year studies on bill presentation. They studied 1450 households in Norway. The researchers organized the household into three different experimental groups. From the group presented with a ‘simple’ bill, 36% expressed complete agreement with the statement, “I am satisfied with the layout of my bill”. The group that was presented a bill with a graphical representation of their water use, and included comparative scores between years, expressed a 51% agreement with the same statement. Though there was an increased interest in more creative bills, the experimental group with more information did not decrease their resource use.

Bar and pie graphs are easier to understand than textual data. It has been recommended that text should be used together with diagrams and tables to increase the effectiveness of the bill (Fischer, 2006). In cognitive psychology it has been found that people will place the highest weight to ‘vivid’ information that is concrete and personalized.

The majority of water use bills include the amount of water used, the corresponding cost, and the wastewater costs. Adding information about energy costs could also encourage water conservation behavior. Many people are unaware of the water-energy nexus. Studies have found that hot water use can account for 9.1% of a household energy bill (Energy Information Administration, 2001). Supporting the recognition of this connection through the inclusion of water based energy costs, could influence the way people relate to their water use.

3.2.5 Attempting Direct Feedback through Different Delivery Methods

Direct feedback is believed to be far more effective than indirect feedback that involves time delays and aggregate scores. Using direct communication between a water meter and the water meter user can support the connection between water use and utility costs. Darby (2006) suggested that the implementation of a direct feedback system alone can result in saving energy savings of 10%. In a review of electricity reduction feedback strategies Fischer (2006) found that the most effective feedback studies were computerized. Using computerized and online systems may offer the best way to communicate with resource users in an interactive manner.

3.2.5.1 Home Displays

Home Displays have been implemented in both test groups and government projects. A Home Display is generally made up of a monitor that shows data, directly collected from the water meter. Various types of home monitoring systems allow people to track the amount of energy and water they use, as they use it. Behavioral economics suggests that if people have all the information at the right time, they will make the best decisions. Consequently, utilities will be conserved and costs will be reduced.

In theory, Home Displays are an effective way of creating awareness. Unfortunately, encouraging water consumers to interact with their displays is a tricky issue. When people feel uncomfortable with instantly updating information they are likely to ignore the technology. Kappel and Grechenig (2009) expressed that displays need to be aesthetically pleasing and present the information in an easy manner that does not require high cognitive concentration. Dawnay and Shah (2005) similarly expressed that the average person will avoid computation when possible. Home Displays developed for the Olympic Village in the City of Vancouver, were rarely used, improperly maintained and or block from view by residents (Enerpro Systems, 2013).

Froehlich (2012) recommended that Home Displays should be placed in highly trafficked areas of the home. Through this method inhabitants can be constantly reminded of their water use habits. The problem with highly visible screens is that they may lead to loss of privacy. Visible monitors, with simple and easy to read visuals would make it easy for guests to see people's water use, and follow their behavior even when they are not in the room. Therefore, even if Home Displays offer direct feedback, these systems can be complex, invasive and expensive with little improvement to water consumer behavior.

3.2.5.2 Online Platforms

Research from energy metering has proven that consumers find interactive computerized feedback very stimulating (Bang et al., 2006; Fischer, 2006; Vine et al. 2012). Analysis of different feedback methods in electricity metering found that the largest reduction in energy use came from direct computerized information sharing (Darby, 2006). Online platforms allow for a wide range of possibilities for reviewing long-term data, following trends, and creating tailored solutions for individual users (Froelisch et al., 2010). This method of sharing resource consumption information has not been readily used for water. Until now there are no 'best practices' in place for developing the effective use of online technologies (Stewart et al., 2010). Outside of experimental settings, data on the effectiveness of computerized systems for water use is not quite clear. A major difficulty lies in motivating water consumers to look at the website, before assumptions can be made on their interaction with the data and consequent conservation behavior.

> "Research from energy metering has proven that consumers find interactive computerized feedback very stimulating…this method of sharing resource consumption information has not been readily used for water……"

Online systems generally require meters with short intervals between measures and a high accuracy, in order to provide real time data that creates a basis for decision-making. A website is less intrusive than an in-home display and allows users to check up on their water use from any location with internet access. In a Danish study, where results were communicated through email and sms there as an average reduction of energy use by 3% (Vine et al., 2012).

A study on American university students by Peterson et al. (2007) provided insights on the reaction to complex feedback systems. The study distributed conservation information, posters and brochures to the students. Peterson et al. also offered feedback on personal and normative consumption rates. The student test groups were also given financial incentives and online platforms to review their data. Though, the conservation of energy decreased significantly over the time of the study, overall the students only reduced their water consumption by 3%. For Peterson et al.'s (2007) post-study survey, 55% of participants responded that they would willingly decide to view a website with graphs depicting real-time consumption.

3.2.6 Appliance Specific Measurements

Another type of direct feedback involves very specific information on the appliance level. Modern indoor plumbing systems can make water seem plentiful even in locations of water scarcity. Triggering awareness during habitual activities like showing and washing hands may lead to significant lifestyle changes. Energy consumption literature has suggested that giving immediate appliance specific feedback can have a significant effect on consumption (McCally and Midden, 2002). The user is able to monitor their own consumption, as it happens through devices that can be built into an appliance (Lockton et al., 2008). The success of appliance monitoring can be seen in both the energy and water fields (Ueno, 2005; Knox and Cutts, 2007). In fact, most research on encouraging water use reduction has been focused on the specificities of sink and shower use even though these two water fixtures only make up around 22% of residential water use (Froehlich, 2012).

Kuznetsov and Paulos (2010) installed displays on showers in four private homes over three weeks. The water use displays were very simple and only showed different colors according to the water use baseline. Red, yellow and green were used to show when water use was above average, average or below average respectively. Through the use of this device, people reduced their water use significantly. The participants interacted with their device and showed an instinctive aversion to the red light.

Kappel and Grechnig (2009) tested out the prototype of a new shower monitoring device. It was made up of an LED system that was water proof and would light up as the shower progressed. There were no numerical scores or water use averages on display. For every five litres of water used, one LED would light up. The prototype was installed in four households with nine occupants. Due to the simple design, even the child in the study showed an interest in the product. On average the participants reduced their water use in the shower by 10 litres.

3.3 Case Study Table Summaries

A comparison of different feedback structures for both energy and water consumption over the last 13 years can support the understanding of the complex mechanisms, and the very diverse and conflicting results that have been found. A reflection of the Peterson et al. (2007) study offers an interesting summary of many different feedback methods for both water and energy consumption. The research on conservation measures and responses took place in a university in America. It focused on comparing the performance of two different test groups of student during a conservation competition. One group was the ‘high resolution’ group. This group of students received updates through an automated data monitoring system with real time web-based feedback on energy and water use. This website was updated every 20 seconds and data was displayed in time-series graphs. There were also computer kiosks temporarily installed in the lobby with real-time feedback systems. Some of the floors of the dormitories were also offered floor specific data. The ‘low resolution’ group was only given weekly updates on their utility consumption. Both groups were supplied with educational materials describing the environmental impact of electricity and water consumption, and were given an incentive to conserve by offering a free party to the winning group.

The study showed a large difference between the two groups. Overall, during the two weeks of the competition there was a 32% reduction in electricity use. Those with high-resolution systems reduced their energy use by an average of 55%, while the average low-resolution student reduced their energy consumption by 31%. Overall, water consumption was only reduced by 3%. This variation in conservation may be connected with the competition itself, as it was named the ‘Dormitory *Energy* Competition’. The wording of the project may have confused the goals and led to a bias towards energy consumption. Additionally, it may suggest that there was an overload of information, and students became selective opting to focus on energy issues. This suggests that even a system with the most innovative, direct feedback methods might not be successful. An audience could be overwhelmed with the dozens of components that might make up sustainability initiatives. Furthermore, it might suggest that there is less capacity for drastic changes in water conservation, due to the needs of regular habits connected to hygiene.

3.3.1 Comparing the Processes and Results of Energy Studies

(Darby, 2006, Fischer, 2008; Spitzer, 2010; Vine et al., 2012) * hh=household *fb=feedback

Study	Location	Sample group	Duration	Feedback system	Results
Henryson et al., 2000	Sweden	600-1400 hh	3 years	electricity bill design preferences	Consumers want to have their bills based on their consumption and have it include historical and normative comparisons and practical electricity saving tips
NIE 2002	UK	26hh	12 months	Mobile pre-paid meters with displays	4% reduction from control group
McCalley and Midden, 2002	The Netherland	100 people	20 washing cycles	Feedback given after each washing cycle win combination with goals	10-21.9% reduction in energy use

	s				
McMakin et al., 2002		1231 hh	1 year	Personalized information on ways to conserve the use of heating	Hh save 10% in energy in comparison with the baseline (electricity and gas)
McMakin et al., 2002		175 hh	4 months	Personalized information on ways to conserve the use of Air-conditioning	Hh used 2% more energy in comparison to the baseline
McCalley and Midden, 2002	-	100hh	20 washing cycles	Feedback and goal setting (self-set goals and externally enforced goals) on use and temperature of washing machine	Feedback in combination with goal setting was more effective than only feedback, people with self-set goals saved 21.9% and those with externally set goals saved 19.5%
Sernhed et al, 2003	Sweden	1000 hh	-	Survey	Consumers find their bills difficult to understand. People want a bill with their actual consumption as well as a graphical representation of their consumption
Wood and Newborough, 2003	UK	20hh	14 months	Directly over energy cost Indicator (ECI)	3-14%
Hydro One 2004-2005	Canada	424hh	-	Monitoring	6,5%
Sal River Project, 2004	USA	2600hh	-	Monitoring	12.8%
Mack and Hallmann, 2004	Germany	30 hh	10 months	Weekly written responses	Reduction during process (2.9%), reduction in post process 1.5-3.6%
Molser and Gutscher, 2004	Switzerlan d	48 hh	4 weeks	Feedback in the form of daily self-readings. Different combinations of advice and goal setting. And evaluations through weekly meter self-reading	Reduction of 1.1-10.9% Control group reduction of 4.8% After procedure reduction of 18.1-21.9%
Staats et al. 2004	-	150hh	8 months	Information individual and comparative feedback, in addition to electricity and gas, also included water, trash, food and transportation	Gas 20.5% , electricity 4.6% water 2.8%, trash 32,1%
PG&E/SCE/SDG &E, 2004	USA	61hh	-	Monitoring with a special energy saving technology and time variable tariff system	No significant results
Country Energy 2004-2005	Australia	200hh	-	Monitoring, and time based tariff system	8%
Crossley (IEA), 2005	S	1200hh	-	A time based tariff system	12-14% reduction
NIE, 2005	UK	100hh	-	Time based tariff system, and a	11% reduction from night peak use when the pricing-signal was included
Puget sound energy, 2005	USA	300,000 hh	-	Time based tariff system	5% reduction from peak times
Gulf power company, 2005	USA	3000 hh	-	Time based tariff system	22% reduction from control group
SWALEC, 2005	UK	100+ hh		Intelligent time based tariff system	25% reduction from peak times
Martinez and Geltz, 2005	USA	61hh	-	Intelligent time-based tariff system	Overall reduction in use
Ueno et al., 2005	Japan	19 hh	28 days	Computer tool with daily feedback about costs and consumption, a monitoring of the use of the computer tool and a survey	Energy use reduction 12% electricity reduction of 17%
Karbo and Larsen, 2005	Denmark	3000 hh	-	Online tool with comparative feedback over consumption and costs	-
Mountain, 2006	Canada	505 hh	2.5 years	A portable monitor with feedback, consumption in KWH, dollars and CO2 output per hour,	6.5% from the baseline
Benders et al.,	The	127hh	5 months	Web-based feedback system	8.5%

2006	Netherlands				
Uneo et al. 2006	Japan	9 hh	40 days	An interactive tool with daily updates on their use and costs	Energy use was reduced by 9%. With feedback reduction of 12%, without fb a 5% reduction
Benders et al. 2006	The Netherlands	137hh	-	Interactive webpage	8.5% cut in energy
Duennhoff and Duscha, 2008	Germany	4500 hh	6 months	A pamphlet included in the electricity bill with comparisons with neighbours and advice on reduction strategies. Partially with a combination of personal advice, with mail survey before and after the research	5% reduction from all the groups, with an insignificant difference from the control group

3.3.1 Comparing the Processes and Results of Water Studies

Study	Location	Sample group	Duration	Feedback system	Results
Arroyo et al. 2005	USA	No test	-	Different ambient displays for sinks, distinguishing hot and cold water use, and more than average use	-
Petersen et al., 2007	USA	218 students	2 weeks	Website, pamphlets, financial incentives, comparative data	32% reduction in electricity use 3% reduction in water use
Kappel and Grechenig, 2009	Austria	4hh	3 weeks	Feedback on use in the form of an ambient LED display in the shower	Environmentally friendly people: reduce water use, and change behavior, willing to make permanent changes Unsustainable group: decreased use temporarily, without continuation Overall decrease of 10 litres per use
Stewart et al, 2010	Australia	No test	-	A web-based knowledge management system – to identify leakages, provide real time data supply, and storage needs, discharge volumes, water use history, comparative usage, - tips for reducing consumption, restrictions, cost implications	-
Laschke et al, 2011	Germany	2 families (6 people)	31 days	A shower calendar, - a personalized feedback system concept for reducing shower consumption. Login before shower, - no water education	Family discussing showering, friendly competition Parents decrease use significantly Increase in use or same as average from children
Kuznetsov and Paulos, 2010	USA	4 showers in three private apartments	Three weeks	Numeric Shower (NS) display –average and current usage Ambient Display (AD)– red and green lights	NS – no change from two participants, average reduction of 2 gallons or more in two households AD – average reduction of 2 gallons for all participants
Willis et al. 2010	Australia	151 hh		An alarming meter attached to shower head. Shows digital reading of shower, flow rate, duration and temp. after a set time it will start beeping.	Mean of 27%water use reduction in the shower Discovering a 1.65 year payback period for shower device
Fielding et al., 2013	Australia	221 hh	4 months	Households organized into 4 different groups. 1 – control group, 2- information only group given postcards with information on how to save water, 3- Descriptive norms provided information other households, and more ways to save water, 4 – Water end use feedback provided participants with how much water was use overall in hh and in specific parts of the home, participants received individualise postcards how to decrease water use, and updated people when leaks were detected	Overall groups 2,3 and 4 had an average decrease in water use of 11.3 liters per person per day, after a year of test post intervention water use returned to pre-intervention average

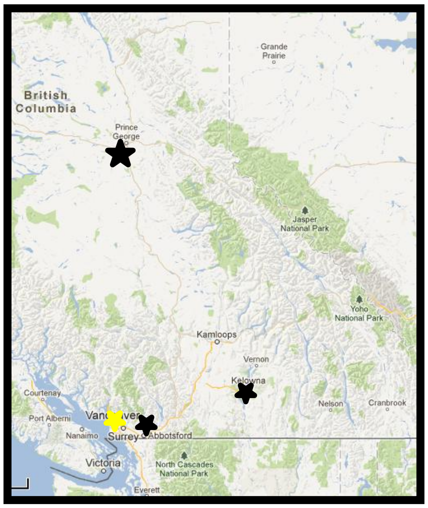
4 Case Studies of Different Provinces, Cities and Regions

Each of the cities was selected for particular elements in their history, population behavior and governmental decision-making. The City of Kelowna was considered an interesting case because they have a Universal Metering system in place, and managed to reduce their water use by over 20% over a 3 year time period. An unsuccessful example can be seen from developments at the City of Prince George. This city was selected due to their serge in water extraction during a time where the population decreased. In terms of future perspectives and initiatives, the City of Abbotsford was a particularly useful case study due to their implementation of smart water meters. Smart Meters allow for regular updates that are sent directly from the water meter to a central database. This removes the need for manual water meter reading. Smart Meters offer the opportunity to connect people with real time data, yet very few cities have invested in the implementation of this technology. Though the Region of Peel is located in the Province of Ontario, it was thought to be of interest for the review, as the Regional government invested heavily in physical water infrastructure in 2004. Before reviewing the US, a brief summary is give of the experience of BC Hydro in British Columbia. BC Hydro is responsible for decades of campaigns directed towards energy conservation. Recently, in 2011, the energy provider began the replacement of all energy meters with Smart Meters, influencing their consumer's ability to engage with their own data. Within the United States of America only three cities were selected based on their successes in eliciting long-term reductions in water use from its citizens and the ICI sector.

4.1. Canadian Municipalities

There are many insights and corresponding recommendations that come from academic literature. There can be further understanding of various feedback methods and their influences through real life case studies and their lessons. A number of cities were selected that have implemented water meters and corresponding feedback systems (*Figure 9* and *Figure 10*). The resulting influence on peoples' water use, suggest that methods not only encouraged reducing water wastage but also initiated habitual and attitudinal change (Shepherd et al., 2006; City of Denver, 2013).

Different countries have different results, and studies deal with different subsets of people, and different time spans. Even within Canada, municipalities vary considerably in size and access to water resources. The majority of municipalities in Canada have implemented various regulations on building codes, developed educational material to promote conservation, collaborated with community groups, and developed fiscal measures for metered water systems. In their 1998 study, Waller and Scott found that 63 of the 64 municipalities interviewed had developed water conservation initiatives. The main reasons that municipalities approached water use was to raise awareness of water as a resource, to defer water treatment capital costs, and to defer water supply and wastewater treatment capital costs. A report on Canadian municipal conservation initiatives by the Canada Mortgage and Housing Corporation expressed that water conservation initiatives have successfully saved cities millions of dollars (CMHC, 2001). Unfortunately, many municipalities have only recently begun their water use feedback programs and often do not have detailed data on the different actions taking place. Feedback processes are usually coupled with awareness campaigns and their effectiveness can be influence by many external contributors. Due to the lack of exact data, it is important to note that behavioral changes can not directly be attributed to the structure of the feedback alone.



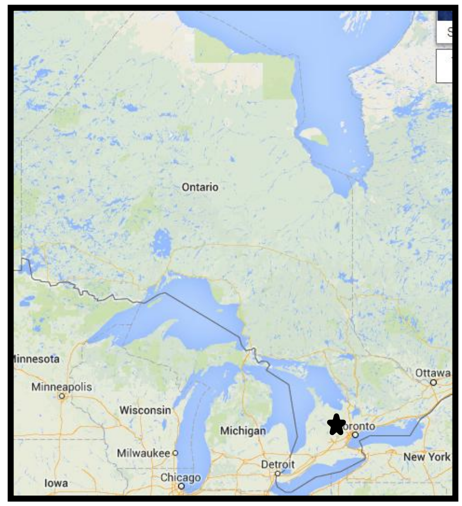


Figure 9 - Map of British Columbia and Ontario– Black markers indicating Cities of interest, and the yellow marker identifying the City of Vancouver © maps.google.com/British Columbia

4.1.1 City of Kelowna

The City of Kelowna is an example of a successful water reduction scheme. In the late 1980s the City began discussions on the implementation of a water metering system. Though the population was not suffering from water constraints at the time, the City realized that their population was one of the 10 highest water users in Canada (Kelowna, 2009). In addition to the high consumption rates per capita, Kelowna was experiencing a rapid population growth rate, as the popularity of the region had been on the rise. It was predicted that the water use trends would require the construction of new water supply infrastructure projects worth more than $40 million. The flat rate system did not make people feel connected with their water use. With these considerations in mind, a water conservation program was adopted by the local council in April of 1992 (Shepherd et al., 2006). After an over 4 year time period, water meters were installed for all water users by 1998. The goal was to achieve a 20% reduction in residential consumption and a 10% reduction for commercial and multi-family residential areas from 1996 levels (OBWB, 2008).

Fact Sheet

City Name:
City of Kelowna

Population size:
117,000 (2011)

Feedback scheme:
1 year of mock bills
Monthly billing

Situation:
No water crisis, this initiative represented pre-emptive action to curb high consumption in order to avoid future investment in new water supply infrastructure
Cryptosporidium outbreak in 1996

Results achieved:
2000 - Average per capita consumption dropped 24.29% from 1996 levels
Long term influence unclear from literature

Future plans:
Water Sustainability Action Plan calls for a further *15%* reduction by *2012*

After installation, there was a grace period where consumers were given the opportunity to become accustomed to the new system. They learned how the new bill would look, and to what extent the prices would increase. People were seen to react immediately when they knew their water use would be tracked. From the original flat rate system, the City of Kelowna changed the prices to a simple constant volumetric rate. Costs were higher for single family homes than for commercial users. After spending months collecting data from the meters, a new increasing block rate pricing plan was organized. The average water user would be paying almost as much as their previous flat rate bill and only the heavy users would be penalized. The system included a fixed flat rate depending on their meter radius, and an additional block rate. With the new tiered pricing system there was another drop in water use. The research showed that the biggest water use was summer outdoor water use, and so conservation efforts were directed towards these issues, in an attempt to ‘smooth out’ peak water use periods.

By 2000, it was found that overall average per capital consumption had dropped by 24.29% (Shepherd et al., 2006). More recent results from Kelowna (2009) show that current reduction from 1996 levels are around 20%, even though the region has had an over 25% jump in population (OBWB, 2008). Due to the positive results of their actions, the 2007 Water Sustainability Action Plan, encouraged the water consumers of the City to further reduce water use 15% by 2012. It planned to do this through enhancing costumer education through marketing. Additionally, their plan has suggested making development permits contingent on water demand management.

Kelowna also wants to reduce water leakages, implement stricter bylaws on efficient fixtures, and develop new water reuse facilities (Kelowna, 2009).

The monthly bills issued by the utility offer the usage organized into the different tiered costs. The bill also includes a bar graph showing the usage over the last 12 months. There is interest in including comparisons with water use from the previous years as well. On the bill is a web address to an online system where people can access their information and go back to see their entire history and the pricing comparisons. The online system allows people to interact with their bill and see how their water use influences their utility costs. There is a positive response from the people who make use of the system but unfortunately very few people actually access it. This mirrors the messages from the literature that express people's interest in easy processes that do not require any extra action or reactions. Without directly provided motivation, it is unlikely that the websites provided will be used efficiently. Due to the successful reduction in water use, a new billing system is being considered that will reduce the billing from a monthly to bi-monthly system, in order to reduce costs.

Though the City of Kelowna has put out a mandate for high efficiency indoor plumbing, their specific experiences have led them to believe that conservation in indoor water use is marginal, no matter what the efforts. This was understood to be true for both housing and ICI users. There is a certain amount of water consumers require to do business, or go on with their day-to-day lives. The outdoor use was the most wasteful and provides the most opportunities for conservation without influencing the quality of life, eg like asking people to shower less, or flush the toilet less (Water Kelowna, 2013).

4.1.2 City of Prince George

The predicted maximum water use trends of the City of Prince George suggested that the two main wells of the city would reach capacity within 20 years. It has been mandatory for Industrial, Commercial and Institutional water users in the City of Prince George to use water meters since 1996. In response, by 2005, 89% of ICI users were in compliance with this regulation. Unlike cities in the lower mainland, Prince George reported a 3.7% decrease in population between 1996 and 2001. During this time period Prince George also experienced a 17.36% increase in water extraction. Residential users began implementing water meters on a voluntary basis in 2005. The metering then became compulsory in 2008 (Metering, 2007). The first year of water meter implementation continued with a flat rate system, and then changed to volumetric.

The City was finding that their water consumers had a disregard for their water use. Their residential consumers used about 70% of water, and the ICIs used 21% of the water. In 2005 the City of Prince George set up a Water Conservation Program. They aimed to reduce residential water consumption by 20% (based on 2004 levels) and overall water consumption by 15% within a 10 year time period. It was important for the City of Prince George to not only save costs from new water supply infrastructure, but to also educate their people on the sources of water and the importance of conserving it. The City of Prince George wanted to protect their environment from exaggerated water extraction.

Fact Sheet

City Name:
City of Prince George

Population size:
76,000 (2011)

Feedback scheme:
Water Wise Workers – a bike team travel from home to home and business to business providing tips, distributing information and monitoring compliance.

Situation:
Expecting a shortage within 20 years
High wastage from outdoor use

Results achieved:
Between 1998 and 2001, one region 'Nechako' decreased their consumption of water by 37%

Future plans:
Reduce overall water consumption by 15% by 2015

The meters in place in the City of Prince George use radio frequency with automatic reading. This information can be picked up through a mobile data collection system. This leads to a 25% reduction in reading time. The metering came together with stricter restrictions on sprinkler usage and other outdoor water usage. Additionally, educational programs were implemented in schools, and were presented to the public. Metered ICI and households receive their bills four times per year. The community is also given water tips through the Water Wise Workers program. This is a bicycle team that travels from business to business and gives advice for free on reducing water. This team also give information on water metering, restrictions, and monitor the compliance of ICI (Prince George, 2005). Figures show that between 1999 and 2009 water use continued to increase in the City of Prince George despite water meters and water use regulations (Mypg, 2009). The population has one of the highest per capita water uses per day, with the average person using over 450 litres (Mypg,2009).

4.1.3 City of Abbotsford

The City of Abbotsford hired consultants to conduct a study on water use and available supply in 2006. The results of the study expressed a concern with the ability to continue filling water use needs. It was believed that their water sources would not be able to fulfill the projected water demand in 2031. Signs from 2007 and 2009 showed a clear basis to the concerns as the peak day demands during those years were 98% of the water supply capacity. In the City of Abbotsford, 54% of the water use is residential, 16% is used by ICIs and 13% is agricultural. Lastly, 17% is non-revenue water (usually leakages) (ourwatermatters.com; 2012). In Abbotsford the average per capita water use is 281 litres per day. Of this, 23% is outdoor water use, which is a figure disproportionally high for British Columbia.

To combat the concerns of water supply, the City began a three-branched system that tackled supply and demand management simultaneously. This was made up of increasing the efficiency of their current water supply, developing new water supply infrastructure and extracting from new sources and thirdly the plan involved reducing water consumption. Water supply was increased significantly through the connection to new water sources (eg wells, lakes) and adding feed lines reservoirs to increase their capacity. AMEC consulting suggested that the City's water demand should still be reduced by 27% to contribute to water crises avoidance (Abbotsford Water Quality Report, 2012).

Fact Sheet

City Name:
City of Abbotsford

Population size:
133,000 (2011)

Feedback scheme:
A bi-monthly bill
Real time consumption history through contacting Engineering department at City hall
Rebates for high efficiency toilets/washing
Free assessments

Situation:
Functioning at water system limits in 2007
Predicted water shortage by 2031

Results achieved:
By 2012, 33% reduction in PDD, and a 12% reduction in ADD from 2007 levels.

Future plans:
Goal is up to reduce water use by 27% by 2015. This will be attempted through landscape and irrigation by-laws, regulations on retrofits, new rounds of water audits and increasing costs

From 1995 onwards, the City of Abbotsford had a universal metering. However, over time the accuracy of the meters decreased considerably. The old meters had to be read by hand, and so each meter reading was a time consuming and expensive process. In 2010, the City of Abbotsford began their smart metering program. The replacement of all their meters with Smart Meters took two years. By the end of 2011 every property receiving water from the city's water system had a smart meter in place (Ryan and Wang, 2012). The Smart Meters uses radio frequency that is picked up by antennas and collected by the city. The Smart Meters collect information to the nearest litre, every hour. The frequency of water bills increased from once per year to bi-monthly. Though it took some time to get accustomed to the new system, people found the bills easy to understand. Along with the bi-monthly utility bill, the City of Abbotsford includes insets with the average use of other residents. Residences and ICI users primarily receive the same insert. Some programs, like the free water audits are organized specifically for ICIs.

The upgrade to a Smart Meter system in 2010, was more expensive in terms of its implementation. However, in the long-term it is expected to that the Smart Meters will decrease the costs connected to actual reading of the meters. They will additionally support the proper valuation of the water being used, and so increase revenues. Though water consumers receive bills every two months, they are able to access their own water use history by contacting the Engineering department in the city. The population of the city make regular use of this hotline, and show a particular peak in interest after they receive their bi-monthly bills. These various demand side efforts are believed to have influenced the water use. Since 2007 there has been a 33% reduction in *Peak Day Demand*, and a 12 % reduction in *Average Day Demand*.

Even with the increasing block rate structure it was found that 75% of residential customers were paying less than their usual flat rate. So their water use habits were saving them money. There were some heavy water users who suffered the consequences of the steep pricing structure. Their complaints led to pricing returning to a volumetric rate by 2012. The ICI water consumers were paying a declining block rate, and so were being charged considerably less than residential consumers. This pricing structure was retained from pre-metering times in order to encourage ICI consumers to stay in Abbotsford. This pricing structure led to discomfort from the public, and also did not encourage ICI users to conserve. As of June 9th, 2013, the City of Abbotsford, with ICI consultations approved a new uniform volumetric pricing structure (Water Abbotsford, 2013).

4.1.4 Region of Peel

The Region of Peel is a Regional Municipality in Southern Ontario, it is part of the Greater Toronto Area. The Region of Peel has taken part in Canada-wide recognized initiatives to develop its water system. In 2004 the Region invested $600 million in order to expand its waterworks. The capacity of the wastewater and water treatment facilities was increased in order to accommodate the consumption habits of the steadily growing population. In the Region of Peel there are a number of options available to support the development of conservation behavior from residences and ICI consumers. The Region of Peel developed a12 year water efficiency plan, that was expected to cost $33 million, and defer the costs of $112 million of infrastructure (Goucher, 2008). In 2011, however, the region upgraded this plan to a Water Efficiency Strategy that had very different main goals. The Primary Objectives of the WES became reducing peak day water demand, meeting water efficiency goals, keep residential per capita water use in line with other cities in the Greater Toronto Area. They WES also hoped to continue to support businesses to more effectively manage their water demand, and reduce water loss through leakages. Their WES aims to increase water efficiency as much as possible, however, during the upgrade to a strategy program, the Region of Peel realized that supply-side measures would still need to be developed.

Fact Sheet

City/Region Name:
Region of Peel

Population Size:
1,296,000 (2011)

Feedback scheme:
Self-reading recommended
ICI High consumers billed monthly,
Low consumers (less than 100,000 gallons/month) billed quarterly
Free audits(indoor and outdoor)
Toilet rebates

Situation:
There exists a concern for water supply to support its growing population

Results achieved:
20% of ICI water users sustain their water reduction

Future plans:
"meet as much of its increasing water demands as possible through the implementation of water efficiency programs."

The Region of Peel has two main programs for the ICI sector. They are the Internal Water Audit and the Outdoor Water Audit. The Internal Water Audit provides the ICI water user with a report detailing different process changes and the corresponding decrease in water use and cost savings. The Region has found that from the organizations that participate in the auditing programs since 2007 about 20% have completed the proposed processes changes and upgrades and have been issued rebates. There are far more organizations who are interested in implementing the recommendations of the audits, or are currently in the process. However, investing in water conservation projects is a long term process that involves careful budgeting and the commitment of different levels of executives. The Outdoor Water audit has been more successful. It focuses on irrigation practices and the installation of 'smarter' control systems. Of the facilities participating in the program approximately 50% undertake recommended changes.

The Auditing process delivers a report, to the ICI water user that identifies the increased water efficiency potential of their organization. When the auditing began, the Region of Peel focused primarily on the ICI water users with the highest consumption of water. The organizations were called individually and asked if they would like to make use of the service. After over 5 years, the Region of Peel, now receives requests from companies to to take part in the auditing program. Once the Auditing process is complete and the organizations understand their different options, the Region offers a rebate in order to subsidize the equipment upgrades and other changes. The ICI sector is encouraged to make use of these services in order to reduce their water bills, reduce their gas bills (from heated water), and to increase the environmentally conscious component of their image (Water Peel, 2013). The most popular process is upgrading the cooling systems. Upgrading from cooling through water use, to air cooling, or water recycling can save very large quantities of water. The pay back of this investment is also relatively quick and so many ICI water users have been encouraged to take part in the upgrade and make use of the rebates available.

4.2 The Energy Sector

4.2.1 The Province of BC

The energy provider of British Columbia is BC Hydro. The energy efficient goals have been developed and integrated into residential life styles and the ICI sector. In 2011 BC Hydro began the replacement of all of its meters with Smart Meters. Between 2011 and 2013, 97% of buildings in the province were already retrofitted with the new technology (1.9 million installed). BC Hydro has seen considerable decreases in energy consumption over this 2 year time period.

With the new Smart Meters, consumers receive an energy bill every 2 months. The cost of energy is distinguished through a two-tiered pricing scheme. Energy consumers can make phone calls at any time to ask about their bill. They can also go online and access their information freely. There are no official figures available yet on the popularity and use of the website. The consumer’s online account shows an hourly breakdown of the consumption and also allows for a comparison with aggregate scores and averages. The information is stored indefinitely.

BC Hydro offers recognition to high energy savers from the ICI sector. The BC Hydro website includes a link to a page to all the organizations participating energy saving strategies. When organizations commit to different initiatives and officially take part in energy saving measures they can earn ‘Power Smart Milestone Plaques’. Organizations who collect the most plaques have the opportunity to be recognized during the biennially distributed ‘Power Smart Excellence Awards’. Certain initiatives are only made available to organization who have the participation of senior management. Different auditing programs have a score card system, where a company has the opportunity to rank its own energy efficiency in order to pinpoint areas with potential for change. The Power Smart program also has a variety of funding opportunities available to assist people in their planning.

The precision and speed of Smart Meters permits offers a unique advantage to regular resource use tracking. Nonetheless, the implementation of Smart Meters has also been considered very controversial. Residents were misinformed on some issues, and some of the misunderstandings were believed to be intensified by the media. One of the primary fears was associated to the radio frequency released by the Smart Meters. Many BC residents were led to believe that the radio signals were linked to cancer growth. However, the Smart Meters have been tested, and are thought to be no more dangerous than mobile phones. At times, people also feel that they are uncomfortable with the hourly updates and the ability of BC Hydro every detail of their household activities. Though, there is the capacity to see the amount of energy used within a household, the Smart Meters do not indicate the appliance in use. Even so, consumers worry about their privacy and the potential threats detailed data collection (BC Hydro, 2013).

4.2.2 The Province of Ontario

Similar to the Province of British Columbia, the Province of Ontario has recently implemented Smart Meters for energy consumers. Announcements were made by the Ontario Premier in 2004, and a few months later the Ontario Ministry of Energy began the development of their implementation plan. As of December 2012, 4.79 million smart meters were installed in Ontario (99.97% of eligible customers). The cost of this endeavor was approximately 1 billion dollars. Due to the recent implementation of the Smart Meters and the new pricing system, there is insufficient data on the impact of the meters (Ministry of Energy, 2013). Pilot studies with Smart Metering systems and three different pricing structures made possible only with Smart Meter information, showed interesting results. There was a major variation in load shifting from peak-use times depending on pricing structure and seasons from the test group. On average, however, electricity use across three different price groups was reduced by 6% (Ontario Energy Board, 2007).

Smart Meters are a key component in the transition to a Smart Grid system. The Smart Grid supports energy providers in pinpointing times of peak energy use, in order to assist in the development in ‘time-of-use’ pricing. The use of Smart Meters also supports the response times to power outages. Ontario’s Minister of Energy outlined a ‘Green Button’ initiative in 2012 that promotes the use of a system allowing customers to have standardized and secure access to their own energy use information. There are also plans to collaborate with smart phone app developers to create an easy method to connect to and manage energy use. For both residential and small business customers bills include historical information allowing for the comparisons between billing periods. Other billing details are decided on individually by the 77 Local Distribution Companies (LDC) in the Province. Due to the many different LDCs in Ontario providing millions of energy consumers, it is difficult to express specific patterns in billing and information dispersal that are the most effective in influencing consumer behavior (Ministry of Energy, 2013).

4.3 Municipalities in the United States of America

Various developments in the US have suggested moves towards water conservation promoted on both the Federal and State levels. A focus here is on the developments in Seattle, Portland and Denver, three cities that have been recognized for considerable changes in the consumption habits of their residences and businesses (*Figure 10)*. Particularly, the review of the City of Seattle is very informative for the study of Vancouver. The City of Seattle has a similar climate, and rainfall patterns. It also has similarities in terms of the perspectives and environmental consciousness of its residents.

Figure 10 - Map of North America – The Black Markers indicate Seattle, Washington, Portland, Oregon and Denver, Colorado and Yellow Maker indicates Vancouver, British Columbia © maps.google.com/North America

4.3.1 City of Seattle

The City of Seattle has managed exceptional reduction in per capita water consumption over the last 50 years. Their gross water in 2012 was less than the gross water consumption in the 1960s despite the doubling of their population. Their conservation programs have been in effect for over 25 years and were motivated by the desire to avoid the investment in new water supply infrastructure. In the year 2000, the City of Seattle developed a Saving Water Partnership (SWP) in order to stabilize water demands for a ten year time period. The partnership was made up of the City of Seattle retail service area and a group of 17 utilities. Costs were expected to be $ 55 million (USD) but ultimately only cost $35 million. The various initiatives that were put in place led to savings of 9.56 million gallons per day despite the 9% increase in population. In the mass distribution of surveys, 84% of Seattle water users interviewed expressed that they utilize their historical data to track if their use and consumption has changed.

Due to the clear successes of their programs, the City of Seattle expected to continue to be in a position of water security for many decades. The *Saving Water Partnership* has been labeled one of the most successful utility-led water conservation programs in the USA.

Fact Sheet

City Name:
City of Seattle

Population size:
634,000 (2012)

Pricing scheme:
Constant Volumetric rate
With Peak Summer rates

Feedback scheme:
Free audits
Selection of high users
Advice sessions
Awards

Situation:
The City of Seattle is not water scarce

Results achieved:
The need for a new water supply source was extended from the 2020s to beyond 2060

Future plans:
The Seattle water Supply System Operating Board selected a regional conservation target of 15 mgd of cumulative average annual savings from conservation between 2011 and 2030

Water use reduction was aimed at preserving high-quality drinking water and eliminating wasteful water behavior. One part of the plan involved the promotion of water efficient washing machines and low flush toilets. Commercial water users were targeted through partnerships with energy utilities, trade groups, equipment vendors, and targeted recruitment and involvement of businesses. ICI users were recommended to take on more water efficient technologies, as well as develop more efficient landscape irrigation programs. Teachers in local school were offered workshops and given educational materials and presentations. So the SWP targeted residences, ICI, and the youth.

Calculations have shown that more than half of the savings from the program came from residential indoor measures. This included the implementation of efficient washing machines, showerheads, toilets and faucets. The second largest savings came from the commercial sector. This area managed to cut water use from the production process and from restroom facilities. The water meters have indicated that the third largest water saving came from increased frugality of residential landscaping (Seattle Water, 2013).

Seattle's strategy has specifically focused on high water users from industry. After finding the largest water wasters the city approaches them to show them opportunities for saving money and water. They found that most of the ICI sector was willing to comply to changes in their water use system if they could indicate a two year payback, with a long-term reduction in costs. One research center managed to reduce their water use by over 90% through the installation of a localized wastewater treatment facility next to their center.

Many years of experience have suggested that the most effective way to involve ICI users is through the involvement of people in executive levels and persistent messages. When CEOs become aware of water wastage and potential cost saving opportunities they are more likely to promote conservation within their organizations. There must be a clear message that organizations will benefit from their sustainable decision making. There were also many incentive offered. The most efficient organizations have the potential to be mentioned in a local business magazine. Additionally, there are many financial incentives like discounts and rebates. Organizations are also able to call a hot-line to receive tips on water saving.

Though many ICIs have shown an interest in upgrading toilets, improving their requirement, and making use of technical assistance, the City of Seattle found that they needed to implement specialized strategies for what they call 'Ethnic Businesses'. The review of water use changes clearly showed that small scale organizations (often restaurants) owned by ethnic minorities were the least likely to be involved in conservation behavior. In order to approach these issues, the City of Seattle actively seek out and encourage these organizations to get involved through funding.

4.3.2 City of Portland

The City of Portland has enjoyed exclusive and free access to the Bull Run River water shed (Yudelson, 1998). Despite, the steady and reliable water supply, in 1992 Portland experienced a five month drought that exposed their lack of water use control mechanisms. Water rationing was implemented, and patrols were developed to insure that users stayed within the appropriate limits. After the 1992 drought, residential water use reduced from 87 gallons per capita per day (*329.33 l/c/d*) to 62 g/c/d (*234.70 l/c/d*) in 2007.

The City developed new plumbing codes, and high efficiency toilets, urinals, showerheads, and sinks were believed to significant contributors to water use reduction. New consumption based block pricing was also implemented. In 1999, seven years after the drought, consultants were asked to review the programs in place and develop new options to encourage increased water conservation from residences and ICI users.

The City of Portland provides water conservation information to homeowners, commercial property managers, landscape, professionals, gardeners and children. For residential water users the City has developed a number of community events, presentations, websites, summer radio campaigns, school assemblies and even set up a children clean water festival (Portlandoregon, 2010). The City was also involved in the mass distribution of information and water conservation devices. Particularly, the bathroom was a target for the various programs, as the City of Portland offered toilet displacement bags, toilet fill-cycle diverters and leak detection tablets. When water consumers receive their bills, they often include ‘bill stuffers’ which give water conservation advice.

Fact Sheet

City Name:
City of Portland

Population size:
587,000 (2012)

Pricing scheme:
1994 – Flat rate to consumption based

Feedback scheme:
In 2000
ICI users:
Surveys, rebate programs, alliances, courses, recommendations for new technologies, grants, and technological advice

Situation:
Water secure,
Shocking drought in 1992

Results achieved:
Water use reduced from 87g/c/d in 1992 to 62 g/c/d in 2007

Future plans:
Between 2008-1018
Partnerships with the Office of Sustainable Development
Provide evapotranspiration data to customers
Provide technical assistance to ICI accounts
Test new water efficient and water reuse technologies
Develop educational workshops
Web education
Develop investment fund for ICI that incorporate water reuse

The website they have developed offers information on water conservation strategies prepared for the ICI sector as well as residential users. The website offers information on water quality and offers information and advice on reducing water use. The conservation page has been identified as the most popular page on the water bureau web site (Portlandwaterbureau, 2008).

The City’s successes have been attributed to collaborations with different stakeholders, and the diversity of their plans. Technical assistance has been offered to businesses, industry and government buildings since 1993.

In the beginning of the program the City of Portland focused on the top 15% of water users that accounted for 85% of water consumption within their categories. The technical program surveyed water use on site, and gave customers ideas and support for improving the sustainability of their building usage. The survey supports the detection of water leaks and water wastage. The technical assistance program also involves courses and recommendations for new technologies (Portland Water, 2013).

The City has also developed the Businesses for an Environmentally Sustainable Tomorrow (BEST). This program gives education and free evaluations to local businesses. Other programs involve competitive grants, and small business advisories and alliances (Portlandoregon, 2010).

4.3.3 City of Denver

The City of Denver has a very different climate from Vancouver. Denver, is primarily hot and dry, and has regularly experienced droughts over the last 10 years. Their metering system and feedback methods have been so successful and integrated into the local consciousness, that they have been able to avoid damage to the quality of life of consumers even through their most difficult drought seasons. The City of Denver has encouraged changes in its populations that have rarely been repeated in other municipalities in North America. Denver's water consumers adapted to conservation needs and fulfilled 60 year targets in just 20 year time. This example may be of further support to Vancouver actors.

Denver has had difficulties with droughts for many decades. The weather patterns are likely to be unpredictable, further droughts were inevitable, and the population has been increasing steadily. To combat this, Denver Water decided to develop new water management plans to encourage their population to consider their water usage and water wastage throughout every aspect of their lives (Metering Denver, 2013).

Drastic measures were taken in order to ensure that the future droughts would not cause damage to people's livelihoods. A large campaign was started called 'Use only what you need'. For drought years this slogan is upgraded to 'Use even less'. Posters were displayed in the city, and other eye-catching installments were place throughout the streets of Denver to encourage its residents to always have their consumption patterns in mind. Bills began to be issued every month and free audit programs were offered to support people's conversion to water saving methods and technologies. The Denver Water website also added an online platform for people who want to review their water use history (*Figure 11*). There were also contracts and financial incentives given to those who invested in new water saving equipment (Bizjournal, 2013). Over 1.5 million dollars were paid as rebates for residences who replaced their toilets and washing machines with water efficient technologies.

<u>Fact Sheet</u>

City Name:
City of Denver

Population size:
619,000 (2011)

Pricing scheme:
Declining block rate structure

Feedback scheme:
Bills every month
Free audit
Rebates and incentives
Accessible charts on water history online

Situation:
Severe drought in 2006, reservoirs at 70% capacity

Results achieved:
By 2008 water consumption was reduced from 211gallons/c/d (798.7 l/c/d) to 172 g/c/d (651.09l/c/d).

Future plans:
Original plan 22% reduction by 2050,
Update 22% reduction by 2016

Denver's original plan, established in 1997, was to reduce the city's water consumption rates by 22% by 2050. Fortunately, consumers responded better than expected. Within 10 years commercial users and restaurants cut their water use by 19% and industrial users cut their water consumption by 15% (Bizjournal, 2013). Between the year 2000 and 2008, water consumption rates fell from 211 gallons per capita per day, to 172 gallons per capita per day (Fong, 2009). Due to the positive outcome showing a consistent change in behavior over a 10 year time span, Denver changed its goals. Since 2007, the Greenprint (or sustainability plan) set the target decrease in consumption of 22% to be achieved by 2016 (Fong, 2009).

Denver Water is confident that the ICI sector can cut their water use by a further 20% (Bizjournal, 2013) within the next few years. Denver has paid hundreds of thousands of dollars to the ICI sector for the support of their water saving projects and instalment of water efficient technologies. There are many projects in place that will further reduce the consumption of water significantly. The success of their rebate program seems to be connected to the fact that the water saving plans must demonstrate their effectiveness within a 12 month time period in order for the organization to receive their financial incentives (Metering Denver, 2013).

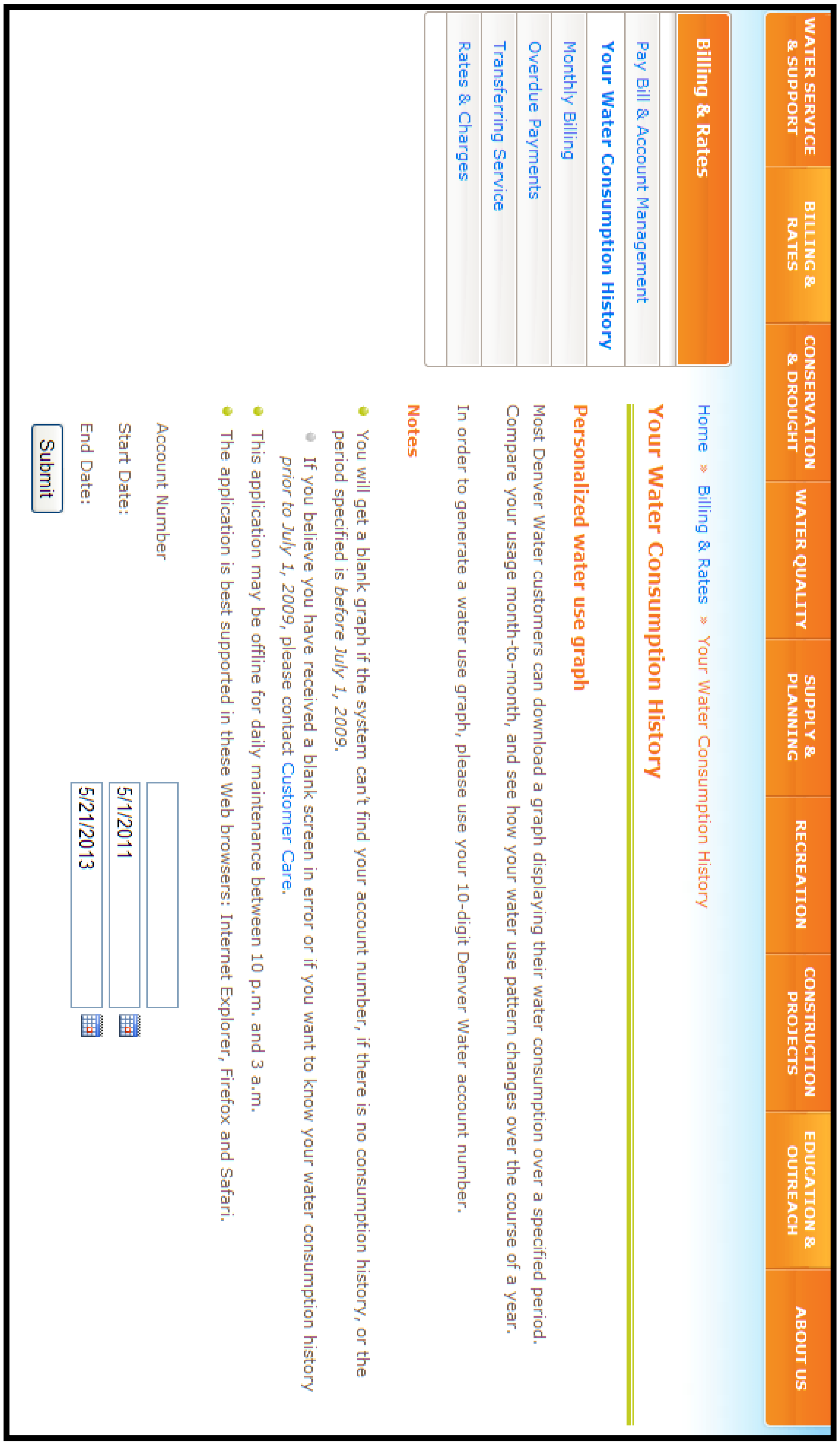


Figure 11 – Water consumption history available for most water users in Denver © http://www.denverwater.org/

5 Conclusion

The feedback literature provides a large spectrum of ideas and methodologies that can be used to influence water users. Energy and water use feedback was used to gain an understanding of the field of resource management. Overall, studies have suggested that feedback on resource use can reduce consumption up to 20%. These results are clearer from tests conducted on energy use. Water use seems to be less responsive to price changes and changes in feedback systems. However, research clearly indicates that the largest reduction in resource use comes from having direct feedback through online systems or interactive displays. Energy literature, focused on residential consumers provided the largest source of information. There exists very little public or academically published data on Institutional, Commercial and Industrial (ICI) water users and their responsiveness to municipal programs.

A better understanding of ICI water consumers was gathered through interviews and public documents produced by cities throughout North America. Real life, large scale implementation of different feedback methods were reviewed to understand the different impacts that can take place over long-term commitments. Though, it may be difficult to offer a clear evaluation of each of their methods and the distributed influences of their approaches, some patterns can be identified. Each city must be considered with its own strengths and weaknesses, the size and variation within its population and its geographical and hydrological resources. The successful cities all raised awareness through increased frequency of bills and or the development of awareness campaigns. New formats for sharing information through online platforms and informative pamphlets were used to increase the knowledge of the consumer. This attempted to develop further interest and initiate action from the consumer. The auditing program also seemed to be very important for the decrease in water use. Auditing involved professional interaction between governments and ICIs in order to indicate the areas were water could be saved as well as to provide personalized cost saving estimate. As found in the literature on sustainable businesses, organizations often show a great interest in conserving resource if it also translates to reduced costs (especially in the short-term), and improved relationships with the government and public.

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