Water-Energy Nexus Survey Summary Report

The Illinois Section American Water Works Association (ISAWWA) Water Efficiency Committee

Pilot Project March 2012
About the Water-Energy Nexus Survey

The Water-Energy Nexus Survey is a pilot project undertaken by the Illinois Section AWWA Water Efficiency Committee to better understand the energy intensity (kWh/MG)\(^1\) and energy cost of Illinois’ water supply. For this purpose, energy intensity is best explained through the concept of the water-energy nexus, a term used to describe the dynamic relationship between water and energy (Figure 1). One example of this relationship is the interdependence of energy to produce water and water to produce energy. This survey was developed and distributed statewide to begin gathering data that quantifies the first part of this relationship — how much energy is used to produce the State’s water supply. As utilities work towards higher system efficiency, understanding the role and cost of energy from pump to faucet can be useful in short and long-term planning, assessing infrastructure needs, and projecting future revenue requirements.

The focus of this survey is solely on water supply and the energy consumption and cost from withdrawal, conveyance, treatment, and distribution; wastewater was not considered at this time. The goal of the survey is to use the results as an educational tool for utilities interested in increasing their system’s overall efficiency, recognizing that saving energy saves water and vice versa. Additionally, the survey heightens awareness about the water-energy nexus with the purpose of moving toward better integration of these resources in the communities and counties throughout the State of Illinois.

\(^1\) Kilowatt hours per million gallons of water.
This survey is one of the only statewide initiatives in the United States to gather water utility level energy use and cost data.

Survey respondents spent $29.7 million and 388 million kilowatts to pump 398 trillion gallons of water. That's enough energy to provide 101,570 Illinois residents with electricity for a year!

Among survey respondents, energy costs on average ranged between 8-15 percent of a water utility's operating budget, with the maximum reported at 38 percent. Water and energy efficiency measures can save money over time.

In a 2008 regional survey of public water suppliers, funding, aging infrastructure, and energy costs ranked as the top three out of 12 possible challenges currently facing public water suppliers.

Why You Should Be Interested

- This survey is one of the only statewide initiatives in the United States to gather water utility level energy use and cost data.
- Survey respondents spent $29.7 million and 388 million kilowatts to pump 398 trillion gallons of water. That's enough energy to provide 101,570 Illinois residents with electricity for a year!
- Among survey respondents, energy costs on average ranged between 8-15 percent of a water utility's operating budget, with the maximum reported at 38 percent.
- Water and energy efficiency measures can save money over time.
- In a 2008 regional survey of public water suppliers, funding, aging infrastructure, and energy costs ranked as the top three out of 12 possible challenges currently facing public water suppliers.

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4 See Table 9.

Related Research, Data Collection, and Program Integration

At the national level, the water-energy nexus is gaining attention by a number of entities, non-profit and government alike. This attention is well deserved considering the U.S. Geological Survey estimates that energy production in the United States requires more water than any other sector, nearly 49 percent (201,000 million gallons a day) of total withdrawals is used for thermoelectric power. Although the large majority of this use is non-consumptive, approximately 23 gallons per kilowatt-hour on average is thought to be consumed. On the other hand the River Network’s 2009 report, The Carbon Footprint of Water, estimates that water-related energy use accounts for 13 percent of the United States’ total electricity consumption, nearly 520 million megawatt-hours annually. In their report, the River Network takes a step beyond quantifying water related energy use to encompass the carbon footprint of water by calculating associated CO2 emissions, estimating the energy intensity of varying water sources and wastewater treatments, and identifying and estimating the energy intensity of water end-uses such as heating water for household uses.

At the state level, the California Energy Commission concluded that as of 2005 California’s water cycle from source to disposal uses 19 percent of the state’s electricity and 32 percent of the state’s natural gas energy. Closer to home, the Public Service Commission of Wisconsin (PSC) collects energy intensity data (total kWh/MG pumped) from water utilities and calculates annual statistical benchmarks. This data is then used to estimate future revenue requirements for rate cases. Table 1 displays the energy intensity data for 2010, organized by customers served.

<table>
<thead>
<tr>
<th>CUSTOMERS SERVED</th>
<th># OF UTILITIES</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
<th>AVERAGE</th>
<th>MEDIAN</th>
</tr>
</thead>
<tbody>
<tr>
<td>Over 4,000</td>
<td>98</td>
<td>21.30</td>
<td>6,502.72</td>
<td>1,809.54</td>
<td>1,820.43</td>
</tr>
<tr>
<td>1,000-4,000</td>
<td>145</td>
<td>184.73</td>
<td>6,401.20</td>
<td>2,036.11</td>
<td>1,877.66</td>
</tr>
<tr>
<td>Fewer than 1,000</td>
<td>317</td>
<td>0.79</td>
<td>15,560.16</td>
<td>2,157.01</td>
<td>2,334.13</td>
</tr>
</tbody>
</table>

Table 1. Wisconsin water utilities’ total kilowatt hours of electricity per million gallons (kWh/MG) pumped, 2010
Lastly, the U.S. Environmental Protection Agency (U.S. EPA) Region 5, in partnership with the Indiana Department of Environmental Management (IDEM), is working on a pilot program that involves an in-depth look at energy data within a select group of water utilities. Table 2 shows preliminary results of energy intensity (kWh/MG) data for three selected water utilities. The pilot program will conclude with a summary report, success stories from the 10 participants, and relevant tools to assist water utilities with energy management.\(^{11}\)

Table 2. Preliminary energy intensity data for select Indiana water supply utilities, 2010

<table>
<thead>
<tr>
<th>INDIANA UTILITY</th>
<th>MGD</th>
<th>KWH/MG IN 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of Bloomington Utilities</td>
<td>14</td>
<td>2,198</td>
</tr>
<tr>
<td>Mishawaka City Utilities</td>
<td>8</td>
<td>1,653</td>
</tr>
<tr>
<td>Valparaiso City Utilities</td>
<td>4</td>
<td>1,981</td>
</tr>
</tbody>
</table>

kWh/MGD=kilowatts per million gallons per day

At the county level, the Santa Clara Valley Water District in California saved an estimated 159 billion gallons of water from 1992-2008 as a result of conservation and recycling. An additional energy savings of 1.82 billion kilowatts of energy was also realized yielding a reduction of 429 million kg of CO\(_2\). This reduction represents the equivalent of providing electricity to 265,000 households and removing 78,000 passenger cars for one year.\(^{12}\) From national to local levels, the water-energy nexus is being incorporated into water-related research as well as being utilized in water conservation and efficiency programs as an additional resource savings.

This survey differs from the above examples because it focuses not only on the energy intensity (kWh/MG) but also the direct and relative cost of that energy. In addition, the data collected from the survey allows the committee to estimate water loss and its associated energy cost.

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11 For more information: contact Louann Unger, Sustainable Water Infrastructure Coordinator, EPA Region 5, Water Division, Unger.Louann@epamail.epa.gov or 312.353.5089.

Data Collection and Outreach

All survey respondents were requested to provide data for calendar year 2010 to allow for a more accurate comparative analysis. The survey requested the following information from water utilities:

- Number of service connections (total and residential)
- Population served
- Water Source
  - Total annual production
  - Total annual billed-metered/accounted for (authorized consumption)
- Energy
  - Total annual energy consumption (electricity and gas)
  - Total annual energy cost (electricity and gas)
- Total operating expenses (not including capital or depreciation expenses)
- Treatment Type

All data is self-reported and was collected either through an online or paper survey instrument. The committee recognizes the limitations and the potential for unavoidable errors associated with using self-reported data. Follow up contact was made where possible to confirm data sets and to fill in omissions. It should be noted that data collected through this survey will remain anonymous and will not be publicly attached to any particular utility but rather consolidated by water source and utility size.

In the absence of a statewide entity or structure that collects and analyzes water utility energy data, the committee used existing channels to distribute the survey. From May to December 2011, the committee reached out through the Illinois Section AWWA member lists, committee member contacts, water-related professional organizations, and local government organizations. On August 5, 2011 the committee also hosted a webinar to assist water utility personnel with the completion of the survey. As an incentive to participate, respondents were offered a customized report outlining their utility’s analysis based on their submitted data. Additionally for each completed survey, the committee made a donation in the name of the participant to Water for People (www.waterforpeople.org) totaling $440.
Survey Respondent Summary

In December 2011, the committee began to analyze the data. In total, 52 surveys were received of which 44 had usable data. Several respondents exited the survey before completing the energy usage questions making analysis of the data impossible for all respondents.

The 44 respondents:
- Represent 5.378 million people, about 42 percent of Illinois’ total population. Chicago accounts for 2.7 million of the population in this statistic.
- Derive from 17 of the Illinois’ 102 counties
- Cover a variety of utility sizes:\n  - Small (n=18)
  - Medium (n=15)
  - Large (n=7)
  - Wholesaler (n=4)

14 Size differentiation defined in Survey Metrics section.
Survey Metrics

After data collection, the data were then analyzed using several metrics to assess a few, simple hypotheses concerning water-related energy use among water supply utilities in Illinois. The metrics include:

- Total annual cost of electricity (in dollars)\textsuperscript{15}
- Electricity costs as a portion of total annual operating expenses (as a percent)\textsuperscript{16}
- Energy intensity of water production, electricity only (kWh/MG)\textsuperscript{17}
- Energy costs for water production (electricity and gas, dollars/MG)\textsuperscript{18}
- Per unit cost of electricity (in dollars)\textsuperscript{19}

The resulting analysis was then organized according to two utility characteristics: relative size and water source. For size, large (>15,000 service connections), medium (5,000 to 15,000 service connections), small (<5,000 service connections) and wholesaler classes were used. For water source, surface water,\textsuperscript{20} groundwater and Lake Michigan classes were used. For each subset, the mean, minimum and maximum were determined independently and are displayed in Tables 3 through 12 below followed by an analysis summary. In an effort to produce a higher quality data set, outliers were calculated for each individual table. A data point was deemed an outlier if the numerical value was greater or less than 3 standard deviations from the mean. Additional data points were taken out at the discretion of the committee based on best professional judgment.

\textsuperscript{15} Direct survey question, no calculation.
\textsuperscript{16} Calculated by dividing total annual electricity cost by total annual operating expenses (does not include capital or depreciation expenses).
\textsuperscript{17} Calculated by dividing total annual electricity consumption (kWh) by total annual water production in million gallons/ year.
\textsuperscript{18} Calculated by dividing total annual electricity cost by total annual water production in million gallons/ year.
\textsuperscript{19} Calculated by dividing total annual electricity cost by total annual energy consumption (kWh).
\textsuperscript{20} Does not include Lake Michigan utility data.
### Utility Size

#### Table 3. Total annual cost of electricity ($)

<table>
<thead>
<tr>
<th>UTILITY SIZE</th>
<th>NUMBER OF RESPONDENTS</th>
<th>MEAN</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>7</td>
<td>$983,510</td>
<td>$133,015</td>
<td>$1,793,293</td>
</tr>
<tr>
<td>Medium</td>
<td>15</td>
<td>$247,732</td>
<td>$1,455</td>
<td>$829,181</td>
</tr>
<tr>
<td>Small</td>
<td>17</td>
<td>$37,633</td>
<td>$1,335</td>
<td>$262,156</td>
</tr>
<tr>
<td>Wholesaler</td>
<td>3</td>
<td>$1,647,705</td>
<td>$190,922</td>
<td>$3,262,345</td>
</tr>
</tbody>
</table>

#### Table 4. Electricity cost percent of annual total operating expenses (%)

<table>
<thead>
<tr>
<th>UTILITY SIZE</th>
<th>NUMBER OF RESPONDENTS</th>
<th>MEAN</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>7</td>
<td>8.0%</td>
<td>1.9%</td>
<td>15.7%</td>
</tr>
<tr>
<td>Medium</td>
<td>10</td>
<td>9.0%</td>
<td>1.9%</td>
<td>18.3%</td>
</tr>
<tr>
<td>Small</td>
<td>16</td>
<td>7.5%</td>
<td>1.0%</td>
<td>23.7%</td>
</tr>
<tr>
<td>Wholesaler</td>
<td>3</td>
<td>13.2%</td>
<td>3.9%</td>
<td>25.0%</td>
</tr>
</tbody>
</table>

#### Table 5. Energy intensity of water production, electricity only (kWh/MG)

<table>
<thead>
<tr>
<th>UTILITY SIZE</th>
<th>NUMBER OF RESPONDENTS</th>
<th>MEAN</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>7</td>
<td>1,621</td>
<td>218</td>
<td>3,171</td>
</tr>
<tr>
<td>Medium</td>
<td>15</td>
<td>1,560</td>
<td>75</td>
<td>6,361</td>
</tr>
<tr>
<td>Small</td>
<td>17</td>
<td>2,912</td>
<td>110</td>
<td>12,890</td>
</tr>
<tr>
<td>Wholesaler</td>
<td>3</td>
<td>1,946</td>
<td>1,308</td>
<td>2,554</td>
</tr>
</tbody>
</table>

#### Table 6. Water production cost from energy, total cost = gas+electricity ($/MG)

<table>
<thead>
<tr>
<th>UTILITY SIZE</th>
<th>NUMBER OF RESPONDENTS</th>
<th>MEAN</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>7</td>
<td>$178</td>
<td>$84</td>
<td>$285</td>
</tr>
<tr>
<td>Medium</td>
<td>15</td>
<td>$140</td>
<td>$6</td>
<td>$462</td>
</tr>
<tr>
<td>Small</td>
<td>17</td>
<td>$314</td>
<td>$44</td>
<td>$1,272</td>
</tr>
<tr>
<td>Wholesaler</td>
<td>3</td>
<td>$174</td>
<td>$114</td>
<td>$218</td>
</tr>
</tbody>
</table>

#### Table 7. Utility unit electricity cost ($/kWh)

<table>
<thead>
<tr>
<th>UTILITY SIZE</th>
<th>NUMBER OF RESPONDENTS</th>
<th>MEAN</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>6</td>
<td>$0.09</td>
<td>$0.05</td>
<td>$0.13</td>
</tr>
<tr>
<td>Medium</td>
<td>14</td>
<td>$0.09</td>
<td>$0.06</td>
<td>$0.15</td>
</tr>
<tr>
<td>Small</td>
<td>17</td>
<td>$0.10</td>
<td>$0.01</td>
<td>$0.16</td>
</tr>
<tr>
<td>Wholesaler</td>
<td>3</td>
<td>$0.09</td>
<td>$0.08</td>
<td>$0.10</td>
</tr>
</tbody>
</table>

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1. For size, large (>15,000 service connections), medium (5,000-15,000 service connections), small (<5,000 service connections) and wholesaler classes were used.
2. *Number of respondents after outliers removed.
3. Percentage may be artificially low due to electric utility subsidy (not fully billed or metered for energy use) or other unreported/unforeseen factors.

**kWh** = kilowatt hours; **MG** = million gallons
**Water Source**

Table 8. Total annual cost of electricity ($)

<table>
<thead>
<tr>
<th>UTILITY WATER SOURCE</th>
<th>NUMBER OF RESPONDENTS</th>
<th>MEAN</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>17</td>
<td>$92,037</td>
<td>$1,335</td>
<td>$430,435</td>
</tr>
<tr>
<td>Lake Michigan</td>
<td>16</td>
<td>$254,421</td>
<td>$1,455</td>
<td>$1,489,847</td>
</tr>
<tr>
<td>Surface</td>
<td>8</td>
<td>$845,405</td>
<td>$183,040</td>
<td>$1,622,072</td>
</tr>
</tbody>
</table>

Table 9. Electricity cost percent of annual total operating expenses (%)

<table>
<thead>
<tr>
<th>UTILITY WATER SOURCE</th>
<th>NUMBER OF RESPONDENTS</th>
<th>MEAN</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>17</td>
<td>7.6%</td>
<td>3.3%</td>
<td>14.8%</td>
</tr>
<tr>
<td>Lake Michigan</td>
<td>12</td>
<td>8.2%</td>
<td>1.0%</td>
<td>25.0%</td>
</tr>
<tr>
<td>Surface</td>
<td>8</td>
<td>14.6%</td>
<td>2.6%</td>
<td>38.0%</td>
</tr>
</tbody>
</table>

Table 10. Energy intensity of water production, electricity only (kWh/MG)

<table>
<thead>
<tr>
<th>UTILITY WATER SOURCE</th>
<th>NUMBER OF RESPONDENTS</th>
<th>MEAN</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>17</td>
<td>2,844</td>
<td>1,014</td>
<td>6,361</td>
</tr>
<tr>
<td>Lake Michigan</td>
<td>17</td>
<td>866</td>
<td>75</td>
<td>2,554</td>
</tr>
<tr>
<td>Surface</td>
<td>7</td>
<td>2,019</td>
<td>218</td>
<td>3,538</td>
</tr>
</tbody>
</table>

Table 11. Water production cost from energy, total cost = gas+electricity ($/MG)

<table>
<thead>
<tr>
<th>UTILITY WATER SOURCE</th>
<th>NUMBER OF RESPONDENTS</th>
<th>MEAN</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>17</td>
<td>$293</td>
<td>$105</td>
<td>$725</td>
</tr>
<tr>
<td>Lake Michigan</td>
<td>17</td>
<td>$94</td>
<td>$6</td>
<td>$218</td>
</tr>
<tr>
<td>Surface</td>
<td>8</td>
<td>$586</td>
<td>$151</td>
<td>$3,336</td>
</tr>
</tbody>
</table>

Table 12. Utility unit electricity cost ($/kWh)

<table>
<thead>
<tr>
<th>UTILITY WATER SOURCE</th>
<th>NUMBER OF RESPONDENTS</th>
<th>MEAN</th>
<th>MINIMUM</th>
<th>MAXIMUM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater</td>
<td>18</td>
<td>$0.10</td>
<td>$0.06</td>
<td>$0.16</td>
</tr>
<tr>
<td>Lake Michigan</td>
<td>16</td>
<td>$0.12</td>
<td>$0.07</td>
<td>$0.40</td>
</tr>
<tr>
<td>Surface</td>
<td>7</td>
<td>$0.07</td>
<td>$0.01</td>
<td>$0.13</td>
</tr>
</tbody>
</table>

kWh=kilowatt hours; MG=million gallons
4 For water source, surface water (does not include Lake Michigan utilities), groundwater and Lake Michigan classes were used.
5 *Number of respondents after outliers removed.
6 Percentage may be artificially low due to electric utility subsidy (not fully billed or metered for energy use) or other unreported/unforeseen factors.
Analysis Summary by Utility Size

Variations in the metrics according to size show some meaningful trends. As expected, total annual cost of electricity is directly related to utility size, with wholesalers paying the most and small utilities paying the least. The mean electricity portion of annual total operating expenses for all sizes is relatively within the same range: 7 percent to 13 percent, with the maximum at 25 percent. The mean energy intensity of water production and mean water production cost from energy both show that smaller utilities use more electricity per unit and pay more per unit of water produced than do large, medium or wholesaler utilities, perhaps a result of economy of scale. Finally, for the per unit electricity cost, we might assume that all utilities would pay about the same amount per kWh. However, it is likely that individual contracts, varying energy providers, and municipal partnerships can account for the variance in prices.

Analysis Summary by Water Source

In analyzing data by water source, there are also some potentially meaningful trends. For example, the data suggest higher water production cost from energy per unit of water for surface water utilities, followed by groundwater and Lake Michigan utilities respectively. This could be a result of the varying infrastructure or pumping and treatment requirements for each water source. For example, it is estimated that the energy required for treatment and distribution of potable water for the majority of utilities ranges between 250 kWh/MG to 3,500 kWh/MG.\(^2\) This wide range appears to take into account such variations like water quality conditions that may require more energy intensive treatment methods such as ion exchange.

Furthermore different water sources dictate different pumping needs. For example, groundwater requires energy to be pumped to the surface and can range between 40 and 80 kWh to lift one million gallons of water 10 feet, depending on pump efficiency.\(^2\) Pumping water to the surface is an additional energy requirement (beyond pumping for distribution) that does not apply in surface water and Lake Michigan communities. To this point, the energy intensity of water production is the highest for groundwater utilities followed by surface water and Lake Michigan utilities respectively.

Correlations in the remaining metrics are not as strong. For instance, the total annual cost of electricity seems much higher for surface water and Lake Michigan than groundwater. A similar situation likely exists for the electricity cost portion of the total annual operating expenses. However, these metrics are more likely a function of both utility size and water source rather than solely water source. Finally, for the per unit electricity cost, the conclusion is the same as in the Analysis Summary by Utility Size in the previous section.

Some utilities, including many whose water source is Lake Michigan, purchase finished water from a wholesale provider. In these cases, the data does not include the energy embedded in that purchased water. Furthermore, some communities pump and treat raw water while others purchase already treated water. These treatment variations affect a utility’s energy consumption. Additionally, it should be noted that a small number of these communities rely on multiple sources for their water supply. For the sake of simplicity, the analysis was calculated using only the primary water source. Statistics for surface water are based on the fewest respondents, thus the apparent trend might be a result of too small a sample size rather than a real trend observed in the data.

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\(^2\) Assumes optimum pumping efficiency at 75% (4.2 kWh/MG/1 ft lift) and low efficiency at 40% (7.9 kWh/MG/1 ft lift). Bevan Griffiths-Sattenspiel and Wendy Wilson, 2009. The Carbon Footprint of Water. River Network. http://www.rivernetwork.org/resource-library/carbon-footprint-water Originally sourced from the University of California Cooperative Extension, Tulare County.
Water Loss and Associated Energy Costs

Aside from utility size and water source, water loss may be another contributing factor to higher energy intensity and energy-related water production costs for some Illinois’ utilities. For the purpose of this survey, we defined water loss as the difference between annual water production and annual billed/metered/accounted for water (authorized consumption). Utilities spend money and resources to pump and treat water that is essentially “lost” in the distribution system. This can be the result of leaking infrastructure often referred to as “real losses” or a result of meter inaccuracies, data handling errors, and unauthorized consumption often referred to as “apparent losses.”

Both real and apparent losses contribute to what is known as “non-revenue water.”

This is water that a utility is paying to produce that is not producing revenue. While accounting for every drop of water is difficult if not impossible, decreasing the amount of water loss in a utility’s distribution system can help limit revenue loss and also decrease the associated embedded energy consumption and cost. Water efficiency strategies such as leak detection and repair, advanced metering, timely meter replacement and repair, billing system maintenance, and regular water audit practices can help reduce water and energy loss.

For these reasons, the committee decided to add two additional metrics: water loss as percent of total annual water production and energy cost associated with that water loss. The data is displayed by utility size in Tables 13 and 14 and water source in Tables 15 and 16.
Analysis Summary for Water Loss by Utility Size

As expected, water loss and total annual energy cost of water loss is greatest for large utilities, followed by medium and small respectively. One reason for this could be varying miles of pipe, with large utilities having the most miles of pipes and associated potential for leaks and small utilities having the least miles of pipes and associated potential for leaks. Wholesalers show the least amount of water loss on average; however, this could be due to the low number of respondents. It should be noted that age and composition of pipes was not collected with this dataset but would also contribute to water loss, among other factors.

Analysis Summary for Water Loss by Water Source

Although water loss is more likely a factor of pipe age and composition, mileage of pipes, utility size and billing and metering practices than water source, the survey data shows that on average surface water utilities’ water loss percentages are almost double groundwater and Lake Michigan utilities. Additionally, the total average energy cost of water loss for surface water utilities is much greater than other water source utilities in all three calculations of mean, minimum, and maximum. This is likely a result of overall higher percentages of water loss (Table 15) and higher overall water production cost from energy among water sources (Table 11). It should also be noted that surface water utilities had the lowest respondent rate of all water sources which could contribute to the potential trend in the data.

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26 For size, large (>15,000 service connections), medium (5,000-15,000 service connections), small (<5,000 service connections) and wholesaler classes were used.

27 *Number of respondents after outliers removed.

28 For water source, surface water (does not include Lake Michigan utilities), groundwater and Lake Michigan classes were used.
Summary of Findings

- On average, the energy cost percent of a utility's total annual operating expenses is generally consistent regardless of utility size.
- Small utilities tend to use more and pay more for energy per unit of water when compared to larger sized utilities.
- Surface water utilities tend to dedicate a higher percentage of their annual operating budget to energy cost and tend to have higher water production cost per unit of water than groundwater and Lake Michigan utilities respectively.
- Survey respondents reported 22,501 million gallons of water loss in 2010, equating to a loss of $2 million in energy costs alone.
- On average, large utilities tend to have higher percentages of water loss and have the highest associated energy costs of water loss.

City of Chicago

The City of Chicago's data was separated for analysis due to the relative size of the system compared to other respondents. Chicago provides Lake Michigan water to approximately 5.3 million people: 2.7 million in the city and 2.6 million in 125 suburban communities covering a total of 806 square miles. The City produces 773 million gallons a day: 289 million gallons a day for the city and 484 million gallons a day for suburban communities. The water system contains 4,200 miles of water mains and over 600 miles of water mains 16 to 60 inches in diameter. Data presented here give an overview of the system's energy and water use. More detailed analysis is needed to fully understand energy use in a complex system of this size. Table 17 shows the survey metrics for the City of Chicago.

Table 17. Metrics

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Cost of electricity ($)</td>
<td>$12,220,909</td>
</tr>
<tr>
<td>Electricity cost percentage of annual total operating expenses*</td>
<td>3.9%</td>
</tr>
<tr>
<td>Energy intensity of water production, electricity only (kwh/MG)</td>
<td>573</td>
</tr>
<tr>
<td>Water production cost from energy (gas and electricity, $/MG)</td>
<td>$92</td>
</tr>
<tr>
<td>Utility unit electricity cost ($/kwh)</td>
<td>$0.08</td>
</tr>
</tbody>
</table>

* Chicago also relies on natural gas for pumping. Natural gas is not included in this calculation.


For example a municipality could appoint one staff member to be responsible for collecting, analyzing, and reporting data on an annual basis to a utility manager, mayor’s office or other budget authority.
Recommendations for Future Water-Energy Nexus Study

This project not only provided the committee with a first round of energy intensity and cost data but also provided a valuable learning experience about data-related utility and municipal billing practices. Many local variables such as the placement and number of electricity meters affect how this data can be reported and managed. Additionally nearly a third of the respondents that began the survey online stopped at the energy portion. Many of the utilities had to coordinate with their finance department for energy usage and cost numbers to complete the survey. A few utilities are subsidized by electricity companies meaning some of their energy use is neither metered nor billed at the local level. Some utilities use natural gas in addition to electricity but did not know how many units or the associated cost. Finally for some respondents, it was challenging to calculate data for the calendar year due to staggered billing cycles and frequency. For these reasons, the committee has concluded:

• A consistent and comparable data collection methodology is needed across Illinois and nationally to gather and track water and energy data at the utility level and also to establish benchmarks.

• Greater collaboration is needed between energy and water utilities and within municipal departments in terms of data sharing, tracking, and auditing.

• More integrated research is needed on water and energy operations at the utility level.

• More education and outreach to utilities, public officials, and the general public is needed on the water-energy nexus and how it can improve efficiency at the utility level.

• Energy data could be provided to customers via a utility’s annual water quality report (consumer confidence report).

• More detailed breakdowns of energy use data throughout each step of the water supply process is needed.
Next Steps for a Water Utility

For a water utility, continuing to track water and energy data can be a benefit for short and long-term planning, assessing infrastructure needs, and projecting future revenue requirements. This survey is only the beginning of what a water utility staff member, manager, or team could do to better understand the relationship between their energy and water use. To further explore this connection, the committee recommends interested water utility personnel:

- Contact the Finance Department to gather monthly electric bills and match the bills with pump stations, motors, and other water facilities using electricity. Make sure the electric bills are accurate based on estimated electric usage. Occasionally, electric meters are not properly addressed for the intended facility, or they may have electric usage readings that are not properly calculated.

- Review the pump curves and motor efficiencies with a qualified engineer, or pump manufacturer especially in those utilities with energy intensive appurtenances (motors and pumps). Many utilities make system improvements without adjusting the pumping equipment. Perhaps there are new overhead tanks or transmission mains that require more efficient pumping equipment. Many utilities have older motors and perhaps an upgrade to the motor would make it more efficient.

- Talk to neighboring utilities, if practical, to discuss annual energy costs and electric suppliers. Perhaps they have resources to guide your decision in purchasing electricity, or can assist with pumping practices, i.e. time of day, type of motors used (Variable Frequency Drive (VFD), etc.).

- Discuss the option of off-peak pumping with your utility engineer. Perhaps your electric supplier has reduced rates available. Even curtailing your electric usage for a few hours could make a difference in energy costs.

- Perform leak detection and repair practices on a regular basis to identify and reduce water loss.
Next Steps for the Water Efficiency Committee

As stated above, the purpose of this survey was to begin looking into the energy intensity and cost of Illinois’ water supply. Continued data collection and research is necessary to fully understand this issue in Illinois. This pilot project is the first attempt to analyze the data received throughout this process. The committee will present these findings at the WaterCon 2012 Conference in Springfield, Illinois Thursday, March 22nd at 9:30 a.m. The committee is seeking additional participation from Illinois’ water supply utilities to increase the number of survey respondents and cover a larger portion of the state’s population.

The survey can be found online: https://www.surveymonkey.com/s/isawwa-water-energy-nexus. All surveys must be completed by June 1, 2012.

In future iterations of this survey, the committee may wish to explore additional metrics such as calculating the associated greenhouse gas emissions of energy use or focusing on how treatment type can affect energy use.

Have questions? Interested in participating?
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For Continued Learning

Water-Energy Nexus
http://allianceforwaterefficiency.org/blueprint.aspx?terms=water+energy+nexus


http://idmodeling.com/pumpenergysavings/


National Conference of State Legislatures, Overview of the Water-Energy Nexus in the U.S., 2009. Link cannot be provided at this time.


http://www.rivernetwork.org/resource-library/carbon-footprint-water

http://www.rivernetwork.org/water-energy-nexus

http://www.sandia.gov/energy-water/docs/121-RptToCongress-EWwEIAdcomments-FINAL.pdf

http://water.epa.gov/infrastructure/sustain/energyefficiency.cfm


Water Loss
http://www.awwa.org/Resources/WaterLossControl.cfm?ItemNumber=47866&navItemNumber=48159

http://www.awwa.org/Resources/WaterLossControl.cfm?ItemNumber=48511&navItemNumber=48158

U.S. Environmental Protection Agency, Office of Water.  
Control and Mitigation of Drinking Water Losses in Distribution Systems, November 2010.  
http://water.epa.gov/type/drink/pws/smallsystems/upload/Water_Loss_Control_508_FINALDEC.pdf
This document was designed by the Chicago Metropolitan Agency for Planning on behalf of the Illinois Section American Water Works Association Water Efficiency Committee.

The Chicago Metropolitan Agency for Planning (CMAP) is the region's official comprehensive planning organization. Its GO TO 2040 planning campaign is helping the region's seven counties and 284 communities to implement strategies that address transportation, housing, economic development, open space, the environment, and other quality of life issues. See www.cmap.illinois.gov for more information.

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