ComEd Energy Efficiency Program

# COOLING TOWER STUDY:

## Energy and Water Savings of Alternative Cooling Technologies in ComEd's Service Territory Executive Summary

**Release Date**
June 30, 2022

**Prepared for**
Commonwealth Edison Company

**Prepared by**
The Alliance for Water Efficiency and Pacific Northwest National Laboratory
Under PNNL Agreement No. 71685



ComEd An Exelon Company | powering lives

PACIFIC NORTHWEST NATIONAL LABORATORY
*operated by*
BATTELLE
*for the*
UNITED STATES DEPARTMENT OF ENERGY
*under Contract DE-AC05-76RL01830*

**Printed in the United States of America**

**Available to DOE and DOE contractors from the**
**Office of Scientific and Technical Information,**
**P.O. Box 62, Oak Ridge, TN 37831-0062;**
**ph: (865) 576-8401**
**fax: (865) 576-5728**
**email: reports@adonis.osti.gov**

**Available to the public from the National Technical Information Service**
**5301 Shawnee Rd., Alexandria, VA 22312**
**ph: (800) 553-NTIS (6847)**
**email: orders@ntis.gov <https://www.ntis.gov/about>**
**Online ordering: http://www.ntis.gov**

## ACKNOWLEDGEMENTS

This project was developed as part of the Emerging Technologies offering within the ComEd Energy Efficiency Program under internal project number P-0484. The Alliance for Water Efficiency and Pacific Northwest National Laboratory produced this report for the ComEd Emerging Technologies team with overall guidance and management from Kelly Gunn and Steven LaBarge. For more information on this project or to request the full report, contact EmergingTech@ComEd.com.

## LEGAL NOTICE

# EXECUTIVE SUMMARY

Commonwealth Edison (ComEd) tasked the Alliance for Water Efficiency (AWE) and Pacific Northwest National Laboratory (PNNL) to establish baseline water and energy use estimates from the existing cooling towers in the ComEd service territory, and to estimate potential water savings and energy impact (savings or increase) for select add-on water treatment technologies and alternative cooling technologies throughout ComEd's service territory. PNNL estimated there are more than 3,500 facilities with over 8,250 cooling towers across the ComEd service territory requiring roughly 4.7 billion gallons of water per year and nearly 153 GWh annually to provide industrial and commercial heat rejection and comfort cooling, as shown in Table 1.

Table 1. Annual Baseline Water and Energy Use Estimates from Cooling Towers in the ComEd Service Territory

| | **Baseline Estimates**[1] |
|---|---|
| Number of Counties Modeled | 25 |
| Number of Facilities with Cooling Towers | 3,506 |
| Number of Cooling Towers | 8,259 |
| Cooling Capacity, thousand tons | 2,708 |
| Annual Cooling Load, million tons/year | 2,086 |
| Consumptive Water Use, Mgal/year | 3,561 |
| Non-Consumptive Water Use, Mgal/year | 1,123 |
| Total Cooling Tower Water Use, Mgal/year | 4,684 |
| Cooling Tower Energy Use, GWh/year | 152.6 |

The baseline water use estimate from cooling towers was determined by running the Cooling Tower Estimating Model (CTEM) for all 25 counties in ComEd's service territory and aggregating the results. The baseline energy use was determined based on industry standard coefficients of performance (COP) for cooling towers (6.8x heat rejected to energy consumed) applied to the CTEM cooling tower load estimates.

1 CTEM estimates include a +/-4.5% baseline uncertainty

 

Using the baseline water and energy use estimates from CTEM, the analysis team investigated the water savings and energy impact potentials of eight select add-on and alternative technologies, as directed by ComEd[2]. The aggregated energy impact for the intervention scenarios includes the potential increases in annual energy demand to implement the alternative technologies as well as the ComEd energy credits (resulting from upstream and downstream imbedded energy savings) obtained from source water and wastewater demand reductions.

Utilizing existing market study results provided by ComEd, multiple scenarios were analyzed using a custom forecast market penetration model for the selected technologies. The model results were optimized for net energy savings potential (including water credits) to project the most beneficial set of technologies for ComEd to consider for further program evaluation. Based on the results of previous incentive and rebate programs offered by ComEd, the analysis team used 8% as the target market penetration rate for the alternative technologies and used a flat (0%) anticipated growth for the cooling demand for the foreseeable future (based on historical territory consumption data and ComEd guidance).

Through the initial screening phase of the study, the PNNL modeling team found the three most promising scenarios to be salt-based ion exchange, water recapture systems, and adiabatic cooling technologies. Based on these results, these three alternative technologies were selected for more rigorous performance and life-cycle cost analysis and market evaluation considerations that looked at potential barriers and enabling characteristics.

The in-depth economic analysis performed after the initial screening process projects total investment cost including capital equipment, installation, operation, maintenance, and end-of-life costs of the selected alternative and add-on cooling tower technologies, determining the life cycle costs (LCC) and payback period (PBP) for potential water conservation incentive programs. The goal of this analysis was to determine which of these intervention scenarios is the most cost-effective for the ComEd service territory.

Of the three systems selected for detailed economic analysis and the model input parameters entered for the ComEd service territory, the only technology with a positive net savings for all scenarios modeled was salt-based ion exchange. Table 2, below, provides a summary of the life-cycle cost analysis, clearly indicating that

2 Add-on water treatment technologies: salt-based ion exchange, advanced oxidation, cooling tower water recapture, and continuous monitoring and partial softening; Alternative cooling tower technologies: thermosyphon hybrid cooler, hygroscopic cooler, adiabatic cooler, and plume abatement system; Water treatment technologies only reduce the non-consumptive water use while the alternative technologies can reduce both consumptive and non-consumptive water use.

only salt-based ion exchange is currently cost effective.

Table 2. LCC Results by Scenario and Technology

| Scenario | Technology | Net Savings (2021 $) | Savings-to-Investment Ratio | Simple Payback (Years) |
|---|---|---|---|---|
| Full life, not installed at same time | Water recapture system | -$466,527.87 | -0.07 | N/A* |
| | Salt-based ion exchange | $48,822.91 | 5.95 | 2.11 |
| | Adiabatic cooler | -$206,072.32 | 0.10 | 208.66 |
| Full life, installed at same time | Water recapture system | -$379,027.87 | -0.08 | N/A* |
| | Salt-based ion exchange | $48,822.91 | 5.95 | 2.11 |
| | Adiabatic cooler | -$167,832.72 | 0.12 | 173.88 |
| Reduced life | Water recapture system | -$455,608.50 | -0.04 | N/A* |
| | Salt-based ion exchange | $23,894.13 | 3.42 | 2.11 |
| | Adiabatic cooler | -$218,215.48 | 0.05 | 208.66 |

*In the case of the water recapture system, the annual savings are negative, leading the SIR to be negative. Given the annual losses, payback also never occurs.

The analysis team also modeled break-even scenarios, to help determine thresholds at which a technology becomes cost-effective. Table 3, below, provides a summary of the break-even analysis for each of the three alternative technology intervention options chosen for in-depth cost analysis.

Table 3. Break-even Total Installed Costs, Electricity Prices, and Water Prices, by Scenario and Technology

| Scenario | Technology | Break-even Total Installed Cost (2021 $) | Break-even Electricity Price (2021 $/kWh) | Break-even Water Price (2021 $/kgal) |
|---|---|---|---|---|
| Full life, not installed at same time | Water recapture system | -$29,027.87 | -$72.14 | $211.63 |
| | Salt-based ion exchange | $58,689.57 | $20.93 | -$7.79 |

| | | | | |
|---|---|---|---|---|
| | Adiabatic cooler | $23,365.28 | -$1.29 | $42.81 |
| Full life, installed at same time | Water recapture system | -$29,027.87 | -$58.60 | $173.91 |
| | Salt-based ion exchange | $58,689.57 | $20.93 | -$7.79 |
| | Adiabatic cooler | $23,365.28 | -$1.04 | $36.82 |
| Reduced life | Water recapture system | -$18,108.50 | -$116.18 | $361.95 |
| | Salt-based ion exchange | $33,760.80 | $16.90 | -$5.52 |
| | Adiabatic cooler | $11,222.12 | -$2.32 | $71.72 |

The break-even results reported in Table 3 shed further light on this and help to illustrate how much the analyzed variables could change before changing the sign of the net savings calculation for each technology. For example, as indicated in the first row, with the water recapture system, even if it were free, that would be insufficient to make it cost effective. Rather, the total installed cost would need to fall to less than -$29,000 (i.e., a site would need to be paid over $29,000 to install it, even if it was free) for the system to become cost-effective. Alternatively, if the electricity price fell to -$72.14/kWh (i.e., the utility paying an extremely large subsidy to use electricity), that would improve the water recapture system's net savings to the zero level. Both these values are a strong indication of how far the technology is from being cost effective under current assumptions.

Moving to the second row of Table 3, the situation is much different for the already cost-effective salt-based ion exchange technology. Even if the total installed cost increased to over $58,000, the technology would remain cost-effective. Similarly, the electricity price would need to increase to nearly $21.00/kWh before the technology lost cost effectiveness. Regarding water price, the value of the provided water savings would only fall sufficiently to make the technology not cost effective if the water price fell to below $-7.79/kgal (i.e., even if the water utility paid a site as much as $7.79/kgal to use water, salt-based ion exchange would still be cost effective).

Table 4, below, provides a summary of the estimated annual savings for salt-based ion exchange, including the energy impact with and without the embedded energy saving from water and wastewater reductions. Table 4 also provides the hypothetical energy and water savings potential if there was 100% adoption of this technology throughout ComEd's service territory.

Table 4. Annual Energy and Water Savings for Salt-based Ion Exchange

| Technology | Technology Electricity Use (kWh/500-ton cooling tower)[1] | First-year Water Savings (kgal/500-ton cooling tower) | Embedded Energy Savings from Water Savings (kWh/500-ton cooling tower)[2] | Net Energy Impact (kWh/500-ton cooling tower)[3] | Net Water Savings Potential (Mgal)[4] | Net Energy Savings Potential (MWh)[4] |
|---|---|---|---|---|---|---|
| Salt-based ion exchange | -217 | 198.1 | 625 | 408 | 1,073 | 2,209 |

[1] This is the energy use, or added energy, the technology will use annually.
[2] Includes the annual energy savings from water and wastewater reductions.
[3] This is the difference between the embedded energy savings and the energy used by the technology.
[4] This is the savings potential if there is 100% adoption of the technology and is calculated by determining the number of 500-ton cooling towers needed to meet the annual cooling demand estimated for ComEd's service territory.

The last layer of analysis the PNNL team undertook was to create a method to consider adoption barriers and enabling factors for the three intervention options included in the life-cycle cost analysis. Two different scoring approaches were used to evaluate key adoption barriers for each of the alternative technologies analyzed in the LCC analysis. The results of this analysis also indicated salt-based ion exchange has the easiest path for adoption throughout ComEd's service territory based on the known and perceived market barriers investigated and evaluated.