Technology Fact Sheet

Commercial HVAC Technologies and Controls

Project funded by Minnesota's Conservation Applied Research and Development Program

About This Fact Sheet Package

Evergreen Economics created a series of fact sheets for the Minnesota Department of Commerce to highlight energy-saving technologies being developed and tested using public R&D funding in California. This fact sheet package addresses three emerging commercial HVAC technologies that can reduce commercial building energy use through HVAC controls and efficiency.

For more information about these fact sheets, please contact Ingo Bensch, bensch@evergreenecon.com, or Mary Sue Lobenstein, marysue.lobenstein@state.mn.us.

Fact Sheet Topics

California's Electric Program Investment Charge (EPIC) grant program has supported hundreds of studies to advance clean energy technologies. We examined several that our initial screening process identified as most promising for Minnesota and developed fact sheets for the applicable technologies. Status updates shown in the fact sheets are current as of summer 2019.

This Fact Sheet Package:

Commercial HVAC Technologies and Controls Fact Sheet Package

- Ultrasonic Anemometer
- Integrated Building Control Retrofit Package
- Optimized Hybrid Cooling Controls

Other Fact Sheet Packages:

New Wastewater Treatment Technologies

- Raw Wastewater Filtration Cloth Depth Filters
- Novel Staged Anaerobic Fluidized Bed Membrane Bioreactor
- Biofiltration as an Advanced Primary Treatment Method
- Biological Double-Efficiency Process (BDP)

Emerging Technologies in Food Services and Groceries

- Electric Plug Load Savings Potential of Commercial Foodservice Equipment

Program Adoption Insights from Consumer Studies

- Customer-Centric Approach to Scaling Retrofits in Low-Income Multifamily Buildings

Additional technologies being investigated can be found on the California Energy Commission's Energy Innovation Showcase website (http://innovation.energy.ca.gov).

Ultrasonic Anemometer

The Center for the Built Environment at the University of California-Berkeley has developed a low-cost ultrasonic anemometer that can be used indoors and in HVAC ducts to measure airflow metrics. This technology is expected to be available for $20 to $100 and offer improved operational data communicated wirelessly to HVAC control systems and operators. Such data could allow for reduced airflow when ventilation requirements have been met, greater temperature setbacks while maintaining comfort, and identification of system anomalies or failures. The project team estimates potential savings of 10% to 15% of a building's HVAC usage and technology applicability in between 25% and 75% of commercial buildings.

Problem Addressed:

Excess ventilation and operational constraints due to lack of distributed sensor feedback about airflow.

Status

The project team completed prototypes of an indoor and duct sensor and was testing them in 2018. A project report is expected in 2019.

Next Steps and What to Watch

The next step is most likely development of these products for the marketplace. UC-Berkeley had included several industry partners in this effort, at least two of which are active in the HVAC industry (Price Industries and Vigilent).

Energy Savings Potential

Lifetime Energy Savings

- Point estimate: 0.9 TWh
- Range: 0.3-2.8 TWh

Assumptions and Inputs

- Annual commercial HVAC consumption: 2.5 TWh
- Tech. applicability: 25%-75%
- HVAC energy use reduction: range: 10%-15%
- Adoption rate: 20%-50%
- Measure life: 20 years

For More Information

EPIC grant project: Very Low-cost MEMS-based Ultrasonic Anemometer for Use Indoors and in HVAC Ducts

- Summary at the California Energy Commission's Energy Innovation Showcase website (http://innovation.energy.ca.gov). (Search for project by EPIC grant project name.)

Contacts

- California Energy Commission Agreement manager: Heather Bird, heather.bird@energy.ca.gov, (916) 327-3094
- UC-Berkeley contact: Edward Arens, earens@berkeley.edu, (510) 642-1158

Optimized Hybrid Cooling Controls

The Electric Power Research Institute is testing the use of an intelligent HVAC controller that processes signals from building sensors and system feedback to maximize system efficiency. This particular study is applying the controller to the optimization of variable refrigerant flow and indirect evaporative cooling for the optimal mix. The control system utilizes cloud-based optimization using weather, grid conditions, and occupancy (CO2) as inputs to optimally operate the hybrid system. (For Midwestern applications, such a controller would need to be configured to optimize hybrid cooling solutions for humid climates.)

Problem Addressed:

Lack of control technology to effectively integrate multiple cooling approaches optimized based on existing conditions.

Status

As of the end of 2018, baseline conditions were being measured at three project sites in California where this system will be tested. The study is scheduled to be completed in 2020.

Next Steps and What to Watch

Key items to watch are the in-field performance of the controller at producing cooling energy savings during testing. A separate analysis for the Midwest may be required to assess its potential to optimize hybrid cooling in humid climates.

Energy Savings Potential

Lifetime Energy Savings

- Point estimate: 0.3 TWh
- Range: 0.1-0.9 TWh

Note: High uncertainty. A Midwest-specific analysis would be needed to determine savings potential for hybrid systems for humid climates.

Assumptions and Inputs

- Annual commercial cooling consumption: 1.2 TWh
- Tech. applicability: 20%-50%
- Cooling energy use reduction: 10%-15%
- Adoption rate: 20%-50%
- Measure life: 20 years

For More Information

EPIC grant project: Climate appropriate HVAC Systems for Commercial Buildings to Reduce Energy Use and Demand

- Summary at at the California Energy Commission's Energy Innovation Showcase website (http://innovation.energy.ca.gov). (Search for project by EPIC grant project name.)

Contacts

- Bradley Meister, brad.meister@energy.ca.gov, (916) 327-1722
- Project recipient contact: Ram Narayanamurthy, rnarayanamurthy@epri.com, (650) 855-2419

Integrated Building Control Retrofit Package

The California Lighting Technology Center at the University of California-Davis is developing and testing a retrofit package for commercial buildings that integrates and optimizes control of lighting, fenestration, and space-conditioning systems under a single, unified platform. Initial estimates through computer simulations by the project team show energy savings potential of up to 37% percent of commercial building lighting and HVAC energy use. The control system allows for integration of existing end-use technologies and controls using added sensors and a master controller, and allows for optimization of comfort and energy use based on space occupancy and environmental conditions.

Problem Addressed:

Efficiency losses when HVAC, lighting, and fenestration controls do not coordinate.

Status

The UC-Davis research team has tested the system in a laboratory setting and had planned to install it in a UC-Davis building in 2019 for demonstration and performance monitoring and evaluation. Results on energy performance and occupant satisfaction should be available in 2020. Final report expected in 2020 or 2021.

Next Steps and What to Watch

Key items to watch are the in-field performance of the controller at producing electrical savings and comfort during testing, as well as market response once the study is concluded. The algorithms and system details will be publicly available, but it remains to be seen which market actors will integrate the controller in their offerings or promote the technology to building decision-makers.

Energy Savings Potential

Lifetime Energy Savings

- Point estimate: 2.2 TWh
- Range: 0.4-11.1 TWh

Assumptions and Inputs

- Annual commercial HVAC and lighting consumption: 3.7 TWh
- Tech. applicability: 25%-75%
- Energy use reduction: 10%-40%
- Adoption rate: 20%-50%
- Savings persistence: 20 years

For More Information

EPIC grant project: Pilot-Scale Evaluation of an Integrated Building Control Retrofit Package

- Summary at the California Energy Commission's Energy Innovation Showcase website (http://innovation.energy.ca.gov). (Search for project by EPIC grant project name.)

Contacts

- California Energy Commission project manager: Felix Villanueva, felix.villanueva@energy.ca.gov, (916) 327-2206
- UC-Davis contact: Cori Jackson, cmjackson@ucdavis.edu, (530) 747-3812

Technology Fact Sheet

New Wastewater Treatment Technologies

Project funded by Minnesota's Conservation Applied Research and Development Program

About This Fact Sheet Package

Evergreen Economics created a series of fact sheets for the Minnesota Department of Commerce to highlight energy-saving technologies being developed and tested using public R&D funding in California. This fact sheet package addresses four new wastewater treatment technologies that reduce electricity consumption, often by reducing the need for aeration in the secondary stage of treatment.

For more information about these fact sheets, please contact Ingo Bensch, bensch@evergreenecon.com, or Mary Sue Lobenstein, marysue.lobenstein@state.mn.us.

Fact Sheet Topics

California's Electric Program Investment Charge (EPIC) grant program has supported hundreds of studies to advance clean energy technologies. We examined several that our initial screening process identified as most promising for Minnesota and developed fact sheets for the applicable technologies. Status updates shown in the fact sheets are current as of summer 2019.

This Fact Sheet Package:

New Wastewater Treatment Technologies

- Raw Wastewater Filtration Cloth Depth Filters
- Novel Staged Anaerobic Fluidized Bed Membrane Bioreactor
- Biofiltration as an Advanced Primary Treatment Method
- Biological Double-Efficiency Process (BDP)

Other Fact Sheet Packages:

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Raw Wastewater Filtration Cloth Depth Filters

The Cloth Depth Filter (CDF) is an emerging water filtration technology that aims to reduce the energy input needed during the secondary biological wastewater treatment process through filtering out biosolids beforehand. The implementation of CDFs as a primary filtration step is projected to result in a higher rate of biosolid removal as well as the reduced need for aeration and activated sludge processing, two steps that when combined account for 40% to 60% of total wastewater treatment plant electricity consumption. The study demonstrated the application of CDFs at three California wastewater treatment plants: the Linda County Water District, the City of Manteca, and the Los Angeles County Sanitation District, as well as a pilot demonstration in the Rock River Water Reclamation District in Rockford, Illinois.

Problem Addressed:

The energy heavy aeration and activated sludge processing steps that account for 40% to 60% of wastewater treatment plant energy consumption.

Status

The project team has completed its demonstration of the CDF filters at three California wastewater treatment plants as of March 2019.

Next Steps and What to Watch

A final report is currently in the works. The next step is the introduction of these products to the marketplace. Kennedy/Jenks Consultants is currently developing a website to introduce CDFs to the market as well as track the technology's progress.

Energy Savings Potential

Cumulatively Persisting Energy Savings

- Point estimate: .2 TWh
- Range: .06 –.5 TWh

Assumptions and Inputs

- Annual total energy use for target wastewater treatment plants: 0.127 TWh/yr
- Secondary aeration accounts for 40%-60% of treatment cycle energy use
- Electrical savings in secondary aeration stage of 25%-45%
- Adoption rate: 25%-75%
- Measure life: 20 years

For More Information

EPIC grant project: Raw Wastewater Filtration to Increase Organic Removal Efficiency and Achieve Significant Electrical Savings

- Summary at the California Energy Commission's Energy Innovation Showcase website (http://innovation.energy.ca.gov). (Search for project by EPIC grant project name.)

Contacts

- California Energy Commission project manager: Anish Gautam, Anish.Gautam@energy.ca.gov (916) 327-2382
- Kennedy/Jenks Consulting contact: Onder Caliskaner, ondercaliskaner@kennedyjenks.com

Biofiltration as an Advanced Primary Treatment Method

Raw waste water filtration or biofiltration is an alternative wastewater treatment model that aims to save overall wastewater treatment plant energy consumption through replacing conventional primary wastewater clarifiers with wastewater filters to reduce downstream energy use. This project is quantifying the water savings and electrical energy reduction that can be achieved by biofiltration based on demonstration results at the Linda County Water District wastewater plant. This project will provide the cost and performance data to evaluate the benefits from sustained, full scale validation testing, including quantification of electrical energy savings, determination of water savings, organic solids removal efficiencies, operation and maintenance and design criteria, independent monitoring and verification and technology transfer. According to preliminary results from the pilot study at the Linda County Water District wastewater plant, biofiltration has the potential to decrease later stage aeration energy inputs by 45% to 60% while increasing gas production and treatment capacity.

Problem Addressed:

The energy intensive secondary aeration process in wastewater treatment.

Status

Project in progress. Pilot project ongoing at the Linda County Water District wastewater plant.

Next Steps and What to Watch

Final study report is scheduled to be released in March 2021.

Energy Savings Potential

Lifetime Energy Savings

- Point estimate: 0.3 TWh/yr
- Range: 0.1-0.7 TWh/yr

Assumptions and Inputs

- Annual total energy use for target wastewater treatment plans: 0.127 TWh/yr
- Secondary aeration accounts for 40%-60% of treatment cycle energy use
- Electrical savings in secondary aeration stage of 25%-75%
- Adoption rate: 25%-75%
- Measure life: 20 years

For More Information

EPIC grant project: Biofiltration as an Advanced Primary Treatment Method to Achieve Substantial Energy Savings

- Summary at the California Energy Commission's Energy Innovation Showcase website (http://innovation.energy.ca.gov). (Search for project by EPIC grant project name.)

Contacts

- California Energy Commission project manager: Kevin Mori, (916) 327-1475
- Kennedy/Jenks Consulting contact: Onder Caliskaner, ondercaliskaner@kennedyjenks.com

Biological Double Efficiency Process (BDP)

The Biological Double Efficiency Process is an alternative to the separate anoxic and aerobic tanks conventionally used in secondary wastewater clarifiers. Combining state-of-the-art aeration technology, airlift circulation/dilution technology, and an integrated all-in-one bioreactor model, the BDP simultaneously achieves nitrification/denitrification and accomplishing the work of two separate anoxic and aerobic tanks. According to initial estimates from a study on BDP technology, the technology has the potential to reduce 50% of aeration required for secondary treatment as well as reduce necessary wastewater treatment plant (WWTP) capital by 30%, necessary land for WWTPs by 50%, and WWTP maintenance costs by 50%.

Problem Addressed:

The high capital costs, land footprint, and energy costs associated with conventional activated sludge processes.

Status

Project is ongoing. Final report in the works.

Next Steps and What to Watch

The recipient is on budget and schedule and is working on securing the air and water permits. Final report is expected in April 2020.

Energy Savings Potential

Lifetime Energy Savings

- Point estimate: 0.25 TWh
- Savings range: 0.04-0.7 TWh

Assumptions and Inputs

- Annual total energy use for target wastewater treatment plants: .127 TWh
- Secondary aeration accounts for 40%-60% of treatment cycle energy use
- Electrical savings in secondary aeration stage of 25%-75%
- Adoption rate: 15%-65%
- Measure life: 20 years

For More Information

EPIC grant project: Biological Double-Efficiency Process as an Advanced Wastewater Treatment Method to Achieve Substantial Energy and Water Savings

- Summary at the California Energy Commission's Energy Innovation Showcase website (http://innovation.energy.ca.gov). (Search for project by EPIC grant project name.)

Contacts

- California Energy Commission project manager: Michael Lozano, Michael.Lozano@energy.ca.gov, (916) 327-1425
- Recipient Project Manager: Ben Chi Wai Chow, Benchow@bdpenvirotech.com, (626) 215-5587

Novel Staged Anaerobic Fluidized Bed Membrane Bioreactor

The Novel Staged Anaerobic Fluidized Bed Membrane Bioreactor is an emerging technology that uses anaerobic bacteria to filter industrial wastewater. Anaerobic-based facilities require less space than aerobic-based ones and may produce 30% less solid waste. For the study, an anaerobic system was demonstrated at the Silicon Valley Clean Water (SVCW) treatment facility, replacing the aeration step in the filtration process. The system is projected to filter 30% more bio-solids than conventional systems while reducing energy consumption and environmental impact for the wastewater plant. The filtered higher quality water is also being demonstrated as a potential source of local water supply through the use of reuse treatment trains.

Problem Addressed:

Conventional wastewater systems are based on 100 year-old technology that is energy intensive (3% of electricity nationwide), produces bio-solids, and neglects the value of wastewater as a reliable water supply.

Status

Initial reports are currently being reviewed. The study is on track to being completed by March 1, 2021.

Next Steps and What to Watch

Publication of study's finding in a peer reviewed trade journal and, eventually, market availability through vendors such as Suez. The SVCW website (www.svcw.org) and the Codiga Resource Recovery Center website (https://cr2c.standford.edu) can both be used to follow the progress of this project.

Energy Savings Potential

Lifetime Energy Savings

- Point estimate: 0.2 TWh
- Range: 0.1-0.5 TWh

Assumptions and Inputs

- Annual total energy use for target wastewater treatment plants: .127 TWh/yr
- Electrical savings of total treatment energy use: 10-40%
- Adoption rate: 20%-50%
- Measure life: 20 years

For More Information

EPIC grant project: Maximizing Energy Efficiency and Reducing Bio-solids Waste from New Anaerobic Wastewater Treatment Technology

- Summary at the California Energy Commission's Energy Innovation Showcase website (http://innovation.energy.ca.gov). (Search for project by EPIC grant project name.)

Contacts

- David Weightman, (916) 327-1631
- Recipient Project Manager: Eric Hansen, Ehansen@svcw.org, (650) 832-6228

Technology Fact Sheet

Program Adoption Insights from Consumer Studies

Project funded by Minnesota's Conservation Applied Research and Development Program

About This Fact Sheet Package

Evergreen Economics created a series of fact sheets for the Minnesota Department of Commerce to highlight energy-saving technologies being developed and tested using public R&D funding in California. This fact sheet package summarizes a study that developed multifamily retrofits designed for high adoption rates.

For more information about these fact sheets, please contact Ingo Bensch, bensch@evergreenecon.com, or Mary Sue Lobenstein, marysue.lobenstein@state.mn.us.

Fact Sheet Topics

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Customer-Centric Approach to Scaling Retrofits in Low-Income Multifamily Buildings

The customer-centric approach to retrofit projects demonstrates an approach to scale residential retrofits specifically tailored towards low-income multifamily buildings. The approach is based on energy efficient retrofit packages developed for the project that are non-intrusive to occupants and have the potential of reducing energy use by 30% to 40%. The project also provides new data, analysis, and designs for cost-effective integrated demand side management retrofits such as advanced HVAC, smart thermostats, plug load controls, LED lighting, and heat pump water heaters for residential communities, all designed to minimize tenant disruptions. This study is intended to help California reach its goal of reducing energy use in existing buildings by 50% by 2030 through actionable approaches for affordable multifamily buildings.

Problem Addressed:

Low income and Multi-family are two of the most important retrofit targets, yet have been historically underserved.

Status

The research team has completed installation of efficiency measures and has begun a 12-month monitoring and commission period in Ontario, CA.

Next Steps and What to Watch

Final report in progress. Fresno site installations are underway.

Energy Savings Potential

Lifetime Energy Savings

- Point estimate: 0.9 TWh
- Savings range: 0.1-5.1 TWh

Assumptions and Inputs

- 2016 Minnesota Low Income Multi-family building electric load: 1,695,686 MWh
- Technology applicability: 25%-75% of buildings
- Energy savings when applied: 30%-40% of electric consumption
- Adoption rate: 20%-50%
- Measure life: 5-20 years

For More Information

EPIC grant project: Customer-Centric Approach to Scaling Integrated Demand Side Management (IDSM) Retrofits

- Summary at the California Energy Commission's Energy Innovation Showcase website (http://innovation.energy.ca.gov). (Search for project by EPIC grant project name.)

Contacts

- California Energy Commission project manager: Felix Villanueva, felix.villanueva@energy.ca.gov, (916) 327-2206
- Recipient Project Manager: Andra Rogers, arogers@epri.com, (650) 855-2101

Technology Fact Sheet

Emerging Tech in Food Service and Grocery

Project funded by Minnesota's Conservation Applied Research and Development Program

About This Fact Sheet Package

Evergreen Economics created a series of fact sheets for the Minnesota Department of Commerce to highlight energy-saving technologies being developed and tested using public R&D funding in California. This fact sheet package addresses a study that assessed the electric plug load savings potential of emerging plug-load reducing technologies for the commercial food service sector.

For more information about these fact sheets, please contact Ingo Bensch, bensch@evergreenecon.com, or Mary Sue Lobenstein, marysue.lobenstein@state.mn.us.

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Electric Plug Load Savings Potential of Commercial Foodservice Equipment

The Electric Plug Load Savings Potential project is a market analysis of the quantity and types of unventilated commercial food preparation equipment in common use and the savings potential from alternatives. The study monitored 10 commercial food service facilities and 52 appliances over 19 appliance types and concluded that smart conveyor toasters, induction soup warmers, and modular insulated hot-food holding cabinets offered the greatest savings potential. Energy savings were found to justify early retirement programs.

Problem Addressed:

Commercial foodservice facilities are among the largest energy consumers within the commercial building sector and consume as much as five times more electricity per square foot than any other commercial building type.

Status

Final report complete. Available on Fisher-Nickle website at https://fishnick.com/cecplug/SVP_Plug_Load_Field_Monitoring_and_Replacement.pdf

Next Steps and What to Watch

Utility CIP programs serving commercial foodservice facilities should consider the potential role of such technologies as smart conveyor toasters, induction soup warmers, and modular insulated hot food holding cabinets.

Energy Savings Potential

Lifetime Energy Savings

Savings after baseline equipment was replaced by the updated appliance.

- Savings estimate: 0.09 TWh
- Savings range: 0.04-0.15 TWh

Assumptions and Inputs

The most prominent foodservice appliance savings potentials:

- Conveyer Toasters: 1.8-2.2 kWh/day
- Soup Wells: 0.2-0.6 kWh/day
- Holding Cabinets: 2.3-6.3 kWh/day

Market and measure assumptions:

- Appliance lifespan: 5 years
- Days of operation a year: 200-300
- Food service sites in Minnesota in 2019: 10,681

For More Information

EPIC grant project: Electric Plug Load Savings Potential of Commercial Foodservice Equipment

- Summary at the California Energy Commission's Energy Innovation Showcase website (http://innovation.energy.ca.gov). (Search for project by EPIC grant project name.)

Contacts

- California Energy Commission project manager: Bradley Meister, brad.meister@energy.ca.gov, (916) 327-1722
- Grant Recipient Project Manager: David Zabrowski, dzabrowski@fishnick.com, (925) 866-5614