Demonstrating the Potential for On-Site Electricity Generation From Food Waste Using Containerized Anaerobic Digestion Units

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BACKGROUND

Forty percent of food is lost or wasted across the food system life cycle and most goes to the landfill (Gunders, 2012).

- Landfills release methane gas, a potent greenhouse gas (**GHG**), into the atmosphere as food waste degrades
- Anaerobic digestion (**AD**) is an alternative to landfill disposal—it can treat food waste and produce electricity, heat, and fertilizer
- Hauling food waste to centralized landfills and centralized AD systems generates GHGs from the transportation
- Decentralized AD systems may reduce environmental and economic impact compared to conventional AD systems

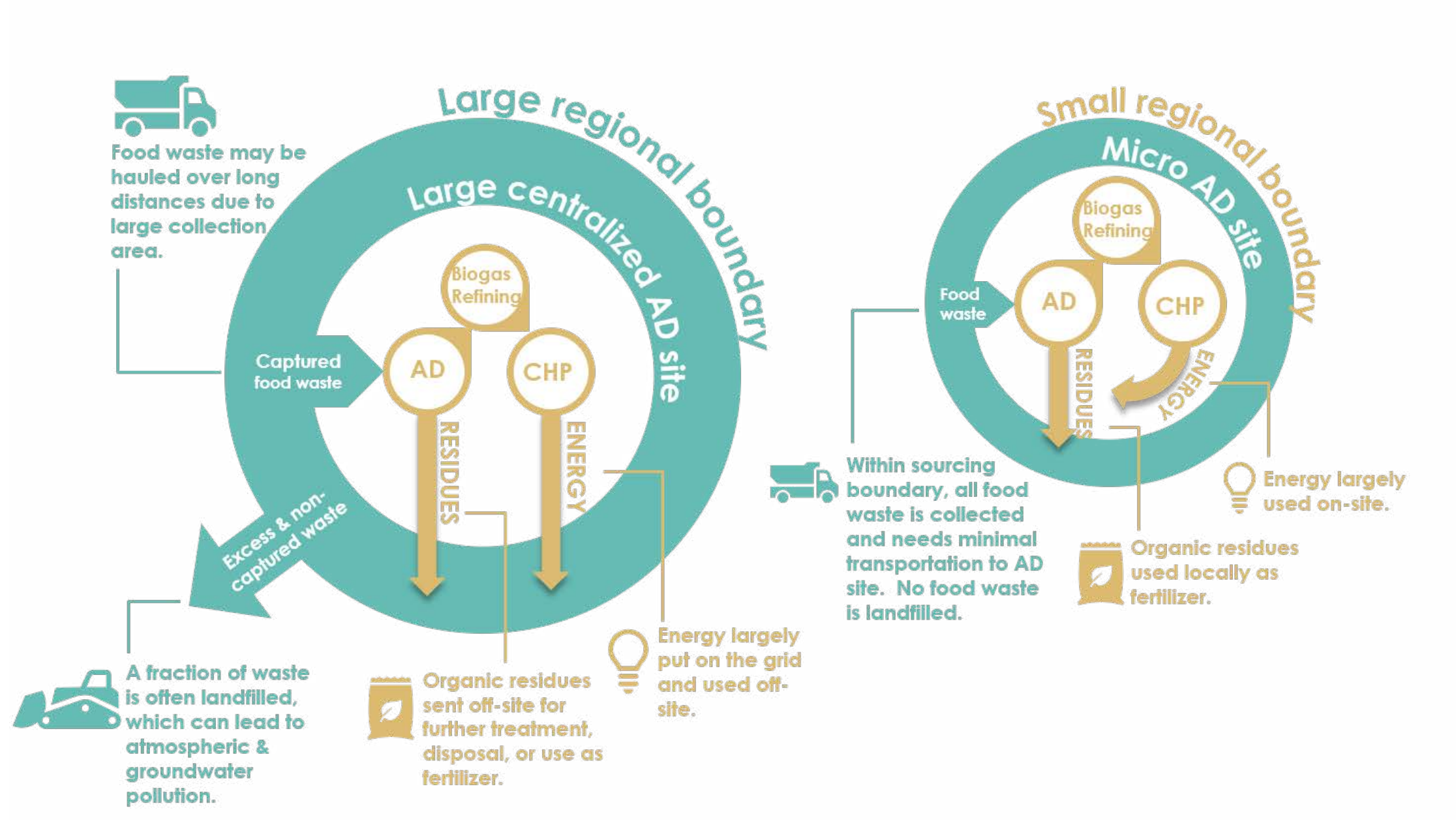

Figure 1. *System and scale of proposed AD technology relative to large-scale, centralized AD*

GOALS

Increase the deployment of cost-effective, small-scale AD systems to reduce environmental impact.

Objectives:
- Install and operate innovative, AD solution to process food waste
- Monitor and enhance pilot AD system performance
- Evaluate technology benefits
- Outreach and knowledge transfer

RESULTS

Figure 2a. *Small-scale containerized AD unit. This image shows 5 digesters, 1 gasholder, a mouth unit, command unit, and a CHP unit.*

Figure 2b. CHP Unit

Containerized AD units installed at cold storage facility owned by Lineage Logistics in Oxnard, CA.

System capability:
- Treat up to 6,700 lbs/day (min. 70% food waste)
- 64 kW combined heat and power (**CHP**) system generates
  - 479.5 MWh/year electricity
  - 27,740 therms of heat energy

PROJECT BENEFITS

Deployment Scenarios	Electricity Savings (MWh/year)	Cost Savings ($/year)	Demand Reduction (MW)	GHG Emissions Reduction - CO_2e (M metric tons/year)
1% Market Penetration	35,370	$5.38M	450	9,967
50% Market Penetration	1,768,500	$269M	22,500	498,365
100% Market Penetration	3,537,000	$538M	45,000	996,730

Table 1. *Estimated cost and emissions benefits to ratepayer from electricity savings achieved by small-scale AD systems (SCE, 2013). 1% market share represents 5400 homes in California.*

Figure 3. *Food waste collected from local enterprises, including grocery stores, restaurants, and cafeterias. Food waste collected is considered non-recoverable for human consumption. Proposed project area of less than 7 mile radius includes severely disadvantaged communities.*

Levelized Cost of Energy (LCOE)

Figure 4. *Levelized cost of energy scenarios for small-scale AD-CHP systems for food waste. Baseline represents current food waste-based systems, Pilot represents current small-scale AD-CHP technology, COMM includes commercialization efficiencies from scaling technology production, ITC represents the Federal Investment Tax Credit, and SGIP represents California's Self Generation Incentive Program.*

DISCUSSION

The current LCOE for the small-scale AD system is $471/MWH. After increased commercialization efficiency and financial incentives, the LCOE becomes competitive at $180/MWH. Additionally, based on electricity savings alone, this system can generate up to $538M cost savings and 996,730 M metric tons CO_2e GHG emission savings each year.

CONCLUSIONS

Decentralized, small-scale AD systems have the potential to produce positive local benefits from the "low-value" food waste stream. These systems can jointly optimize waste management and renewable electricity, heat, and fertilizer production for local California communities and additionally lead to cost savings for ratepayers.

As this system becomes more widely adopted, the levelized cost of energy will become economically competitive with existing technology in the market with some investment in scaling the production and installation. This technology may also provide additional environmental benefits, including reduced GHG emissions.

REFERENCES

- Gunders, D. (2012). Wasted: How America Is Losing Up to 40 Percent of Its Food from Farm to Fork to Landfill. Washington, DC.
- SCE electricity pricing forecast, 2017 commercial estimate: http://www.energyca.gov/2013_energypolicy/documents/demand-forecast/mid_case/

SPONSORS

California Energy Commission

In collaboration with
- Biodico Sustainable Biorefineries
- SEaB Energy
- U.S. Naval Base Ventura County.

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Estimating Groundwater Extraction with Electricity Data

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OBJECTIVES

This study tests the feasibility of using the Efficiency Lift Method (**ELM**) to estimate groundwater extractions to estimate groundwater withdrawals from both individual wells and from collections of wells over a large spatial area, and identifies the best data sources available to perform this estimate.

BACKGROUND

Agricultural water use is believed to be the leading cause of groundwater overdraft in California, but regulators are currently unable to estimate groundwater extraction and develop water budgets due to lack of installed flow meters. Previous studies have identified a relationship between pump energy consumption and groundwater extraction, and have shown that the ELM can produce reliable estimates of groundwater extraction when given reliable data. The ELM (***see Figure 1***) estimates water volume extractions based on the relationship between pump energy consumption, overall pump efficiency, and the total dynamic head (**TDH**) of the pump system (***see Figure 2***). Recent advancements in the availability of data required by this method have made the ELM a viable approach to large-scale extraction estimation.

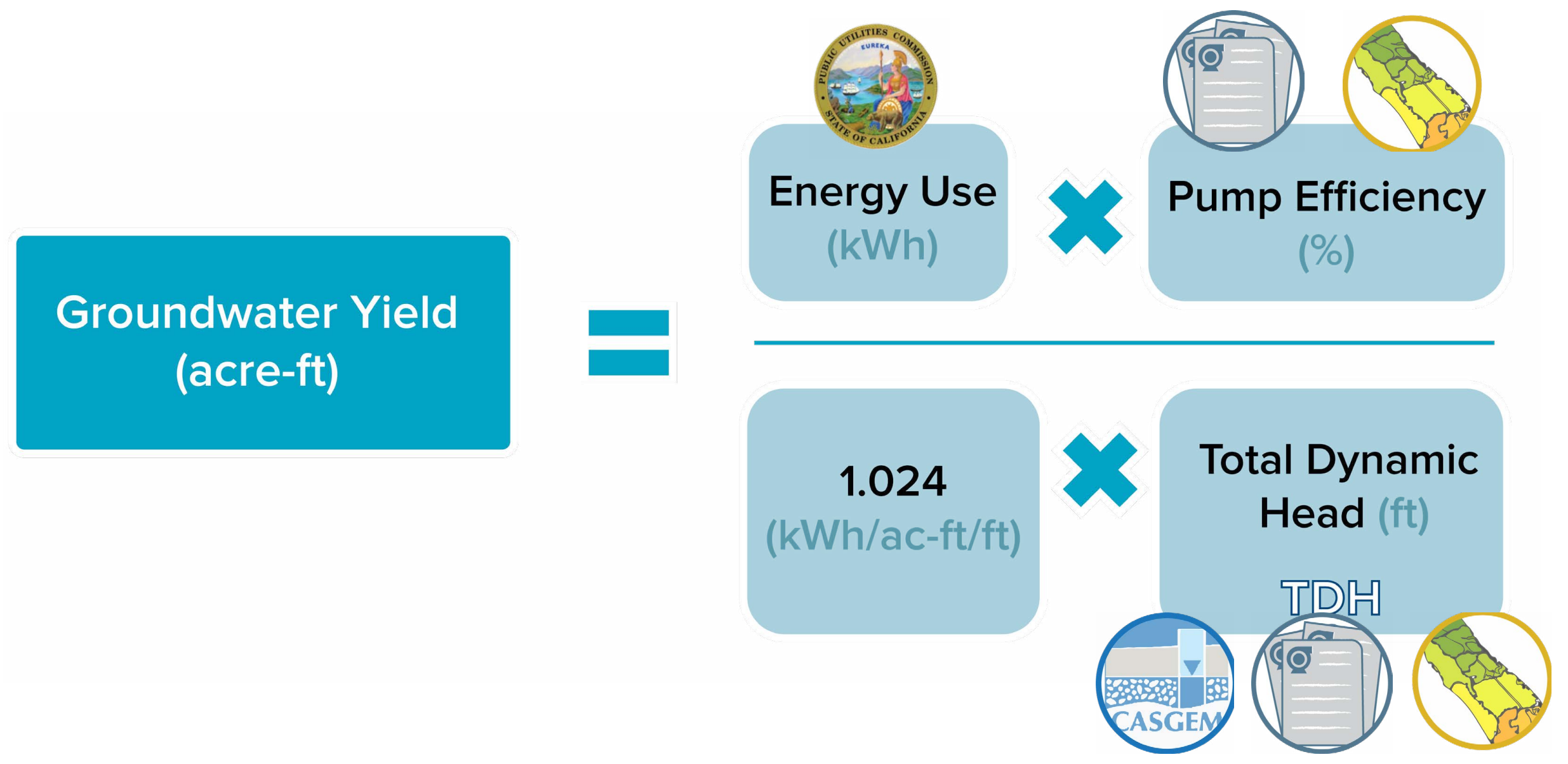

Figure 1. *The Efficiency Lift Method (ELM) and their data sources*

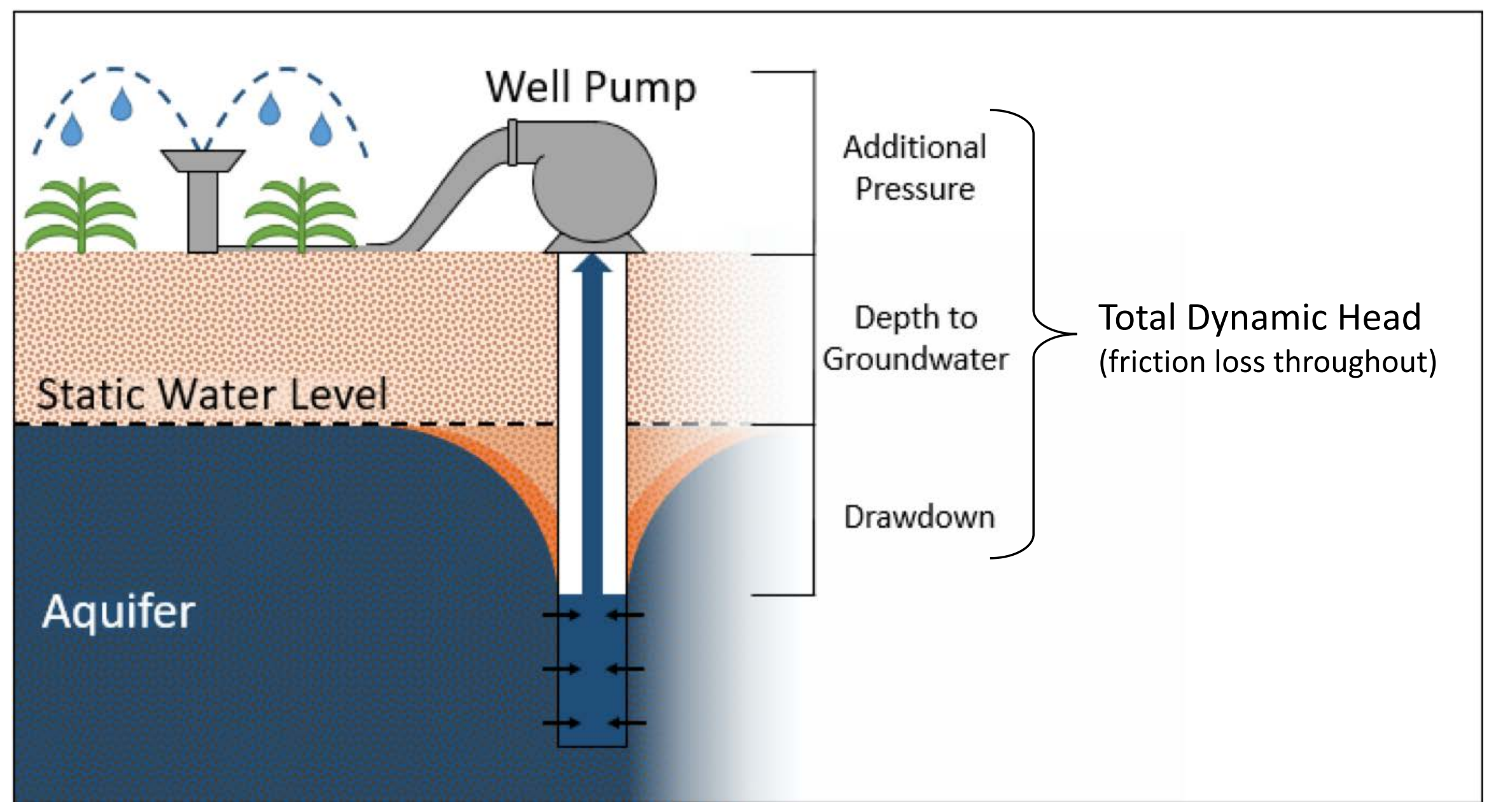

Figure 2. *Components of Total Dynamic Head (TDH), represented by a cross-section of an agricultural well*

MATCHING DATA NEEDS TO SOURCES

Energy data available from energy utilities

California Energy Data Request Program (EDRP)
Established by 2014 CPUC Decision

Pump efficiency and TDH have many sources

pump-specific ↕ general

Pump Test Reports
Results of one-time tests include pump efficiency and TDH

CASGEM Well Monitoring Data
Spatial dataset of test wells allows us to estimate depth to groundwater at any location and any point in time

The Theis Equation
Drawdown can be estimated based on pumping operations and aquifer characteristics

Regional Averages
Regional averages developed from farmer surveys provide rough estimates of pump efficiency and TDH

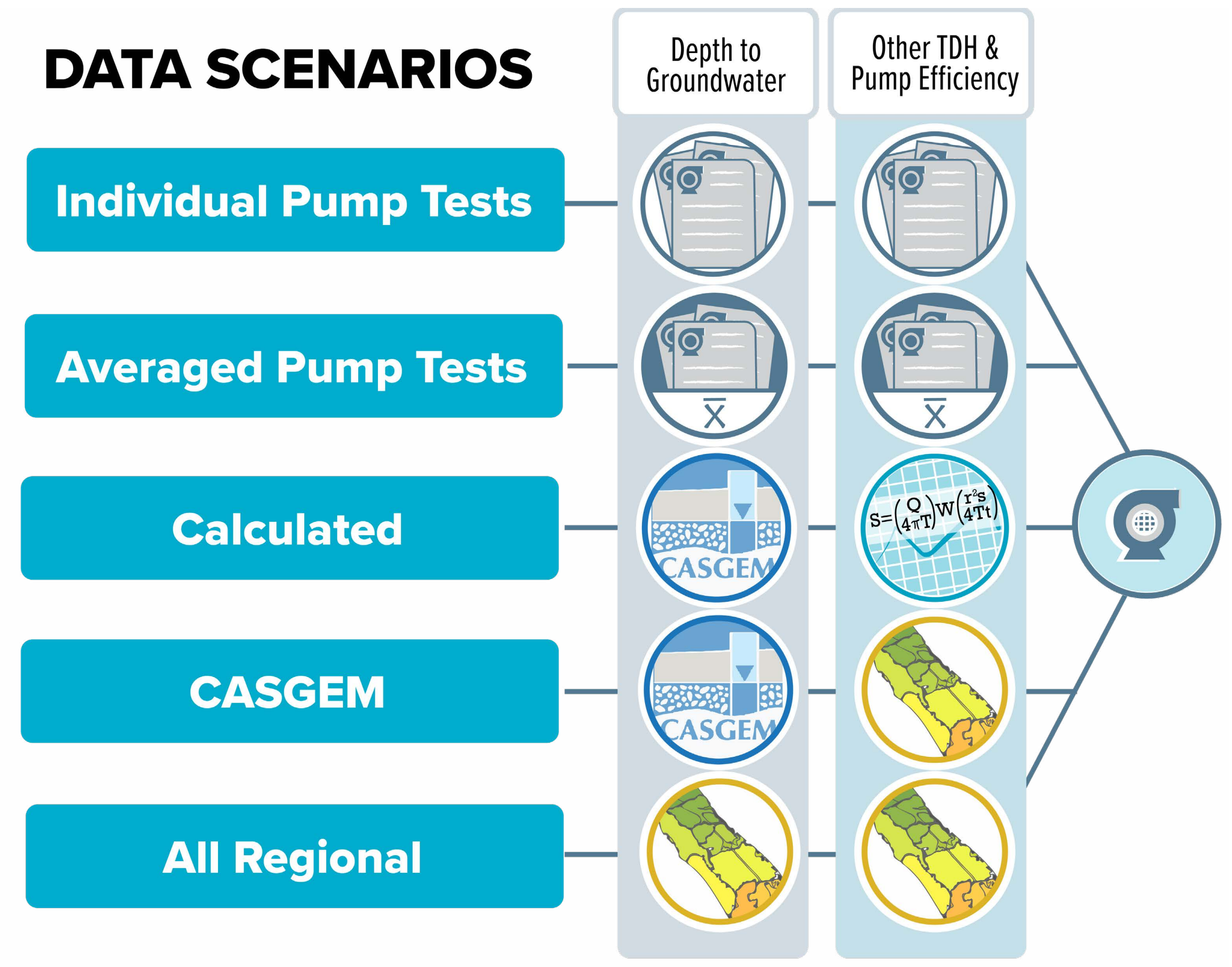

Figure 3. *Five Data Scenarios created using the pump efficiency and TDH data sources*

ELM ACCURACY v. DATA SCENARIOS

Specific datasets provide best accuracy for individual wells
The individual pump test scenario produced the lowest error, 13.5% on average, when estimating individual well groundwater extraction for each month (***see Figure 5***)

Aggregating annual estimates significantly improves accuracy
Annual estimates are more accurate than monthly estimates for all Data Scenarios, and reduce the error to 5% on average for the Individual Tests scenario (***see Figures 4 and 5***).

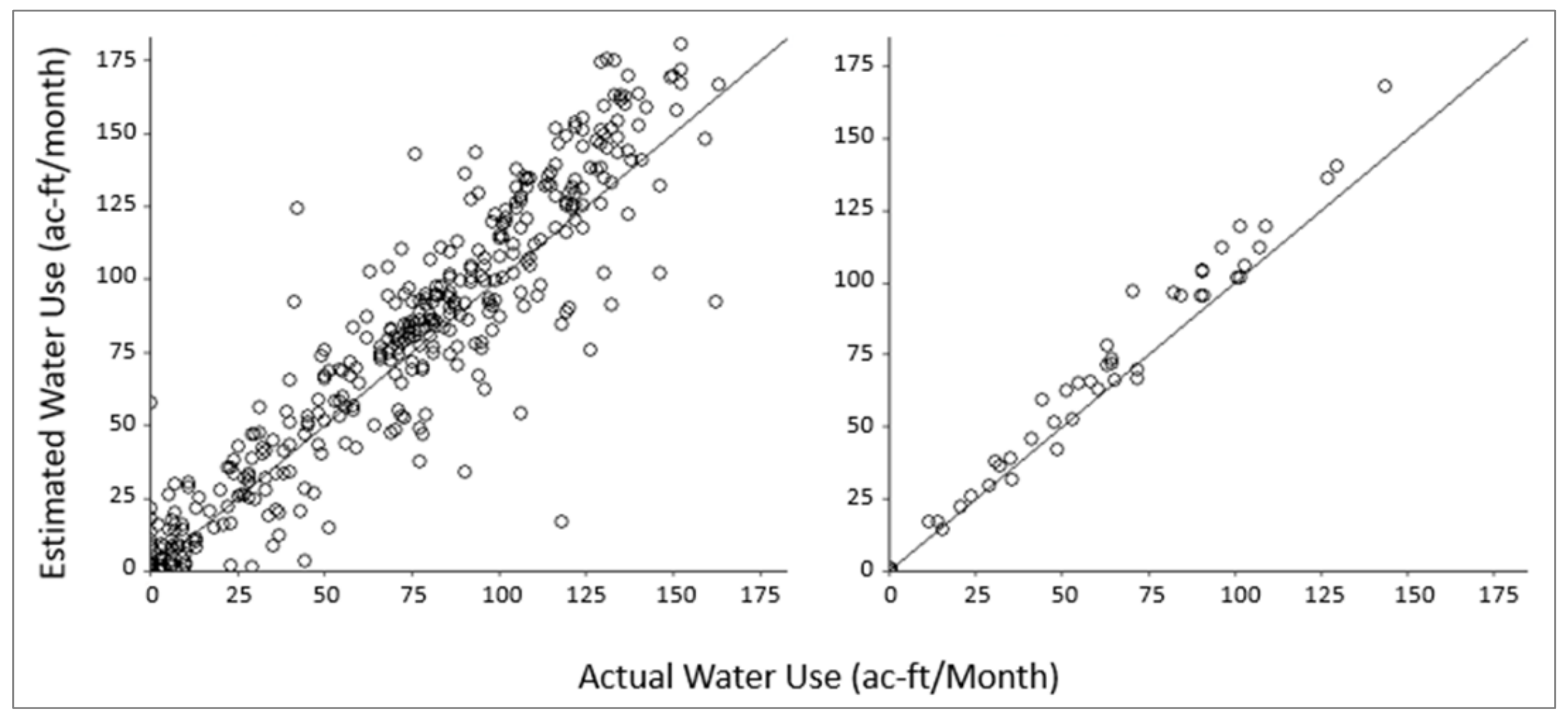

Figure 4. *Estimated versus measured water use per well per month (left) compared to per well per year (right) for the Individual Tests approach.*

Individual pump tests are not needed when estimating extractions from a collection of wells
The "Averaged Tests" scenario produced the lowest error for a collection of wells at 3.3%, compared to a 5.5% error for the "Individual Tests" scenario.

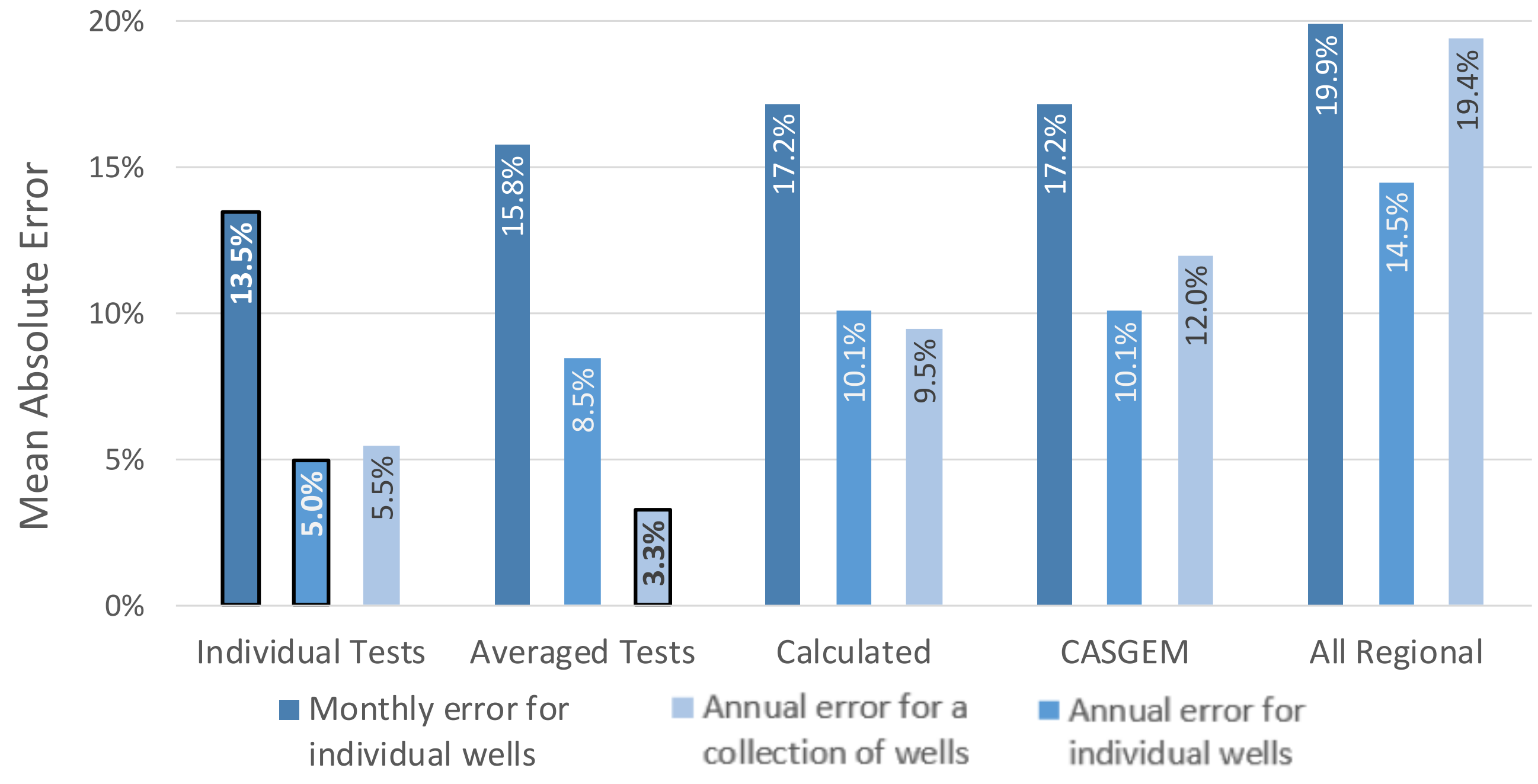

Figure 5. *Average error rates on three scales for each Data Scenario. The lowest error rate for each scale is highlighted.*

ACKNOWLEDGEMENTS

Angiola Water District & California Department of Water Resources

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Investigating the Spatial Distribution of Food Waste in Los Angeles County: A Critical Cartographic Approach

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[1]Geography Graduate Group, [2]Department of Food Science and Technology, and [3]Center for Water-Energy Efficiency

OBJECTIVES

The purpose of this study is to develop a methodology to spatially refine 2014 California Department of Resources Recycling and Recovery (**CalRecycle**) waste characterization data and update it to 2017

BACKGROUND

This research is part of a larger study that aims to develop a strategy for efficient deployment of anaerobic digester (**AD**) facilities at various scales using the spatial distribution of food waste (**FW**) generated in California.

- California Senate Bill (**SB**) 1383 calls for diverting 75% of organic waste from landfills by 2030 as part of a larger mandate to reduce greenhouse gas (**GHG**) emissions
- Anaerobic digesters are used throughout California to convert FW into biogas, substantially reducing GHG emissions however, more will be needed to handle the increased FW diversions due to SB 1383.
- Small-scale, containerized digesters are an option to treat FW from localized sources, reducing GHG emissions associated with FW transport to regional treatment facilities.
- Utilizing waste production data from the 2014 CalRecycle Statewide Waste Characterization Study, spatial variation in FW generation can be estimated to determine optimal anaerobic digestor locations.

CalRecycle data uses employee counts from incorporated Cities to estimate FW data, aggregating all unincorporated areas. By using employee counts from Cities and Census Designated Places (**CDPs**), the spatial distribution of FW production can be more accurately modeled.

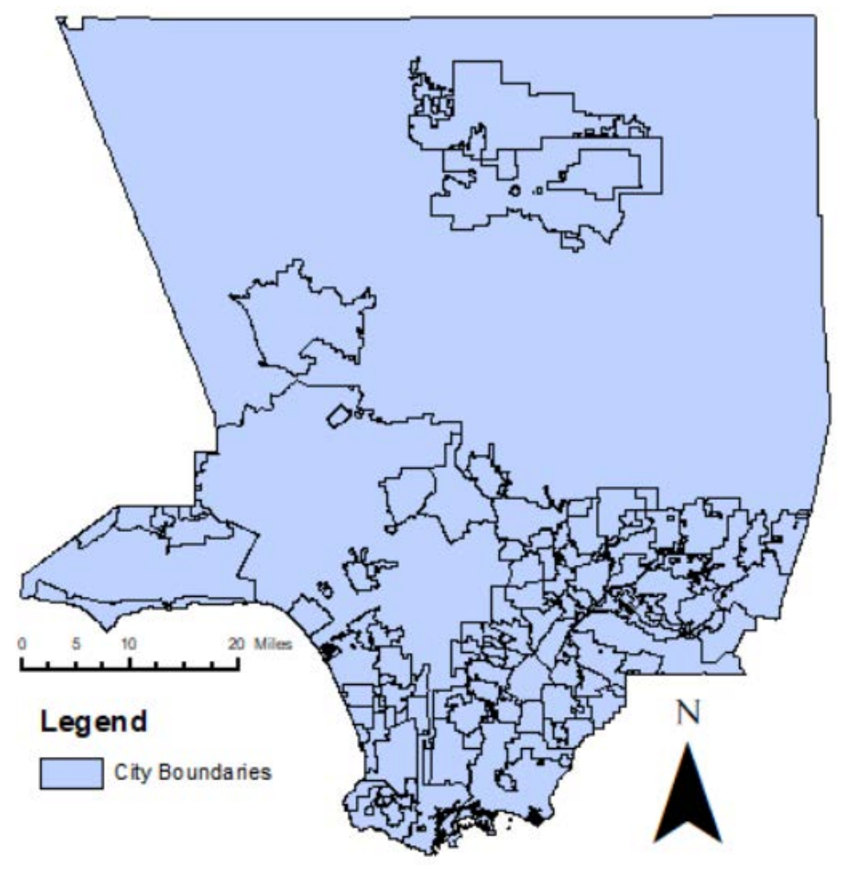

Figure 1. *CalRecycle incorporated Cities with aggregated unincorporated areas*

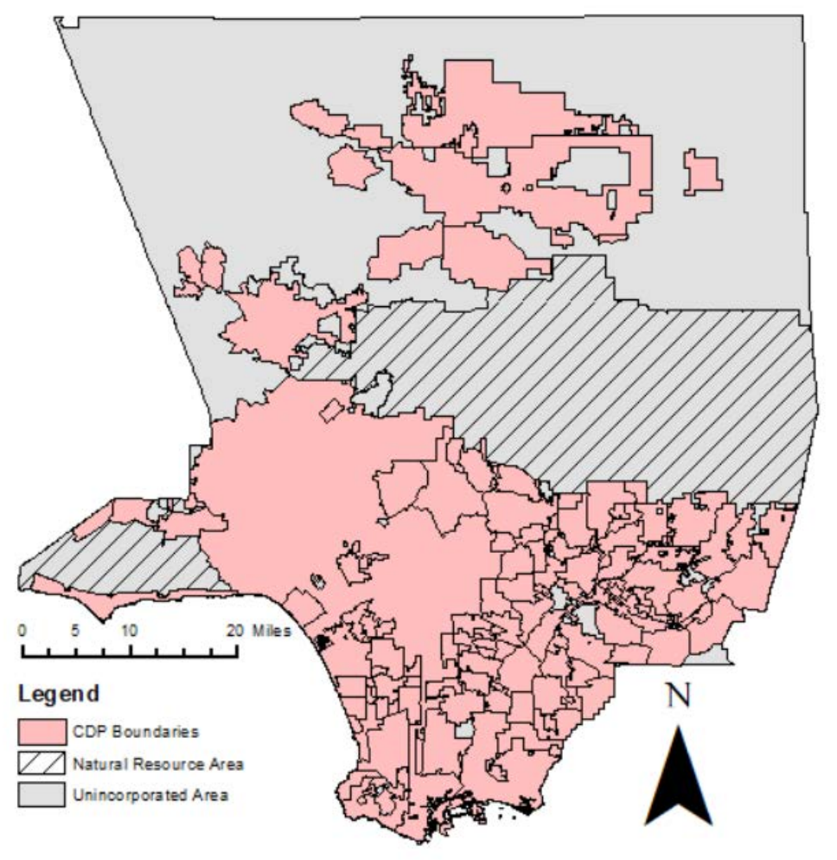

Figure 2. *Incorporated Cities with Census Designated Places (CDPs)*

METHODS

The methods used in this study are adapted from the 2014 CalRecycle Generator Based Waste Characterization Study (**WCS**).

- The WCS calculated Tons Per Employee Per Year (**TPEPY**) value for FW generation

Two datasets from California Employment Development Department (**CalEDD**), along with CalRecycle TPEPY values, are used to estimate FW generation in CDPs within Los Angeles County unincorporated areas.

Using the following equation, food waste for each industry group in each CDP can be calculated

$$\frac{\text{Employment Inds. Group}_x}{\text{Total LA Co Employment}} * \text{Employment CDP}_Y * \text{TPEPY}$$

RESULTS

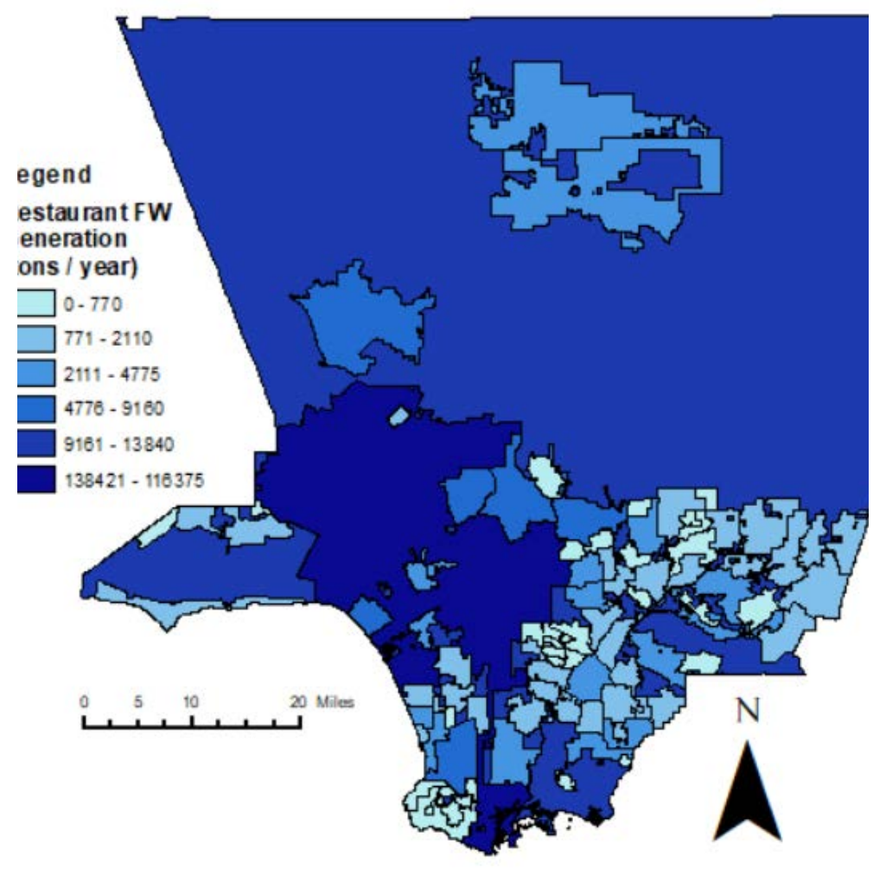

Figure 3. *Restaurant FW generation using CalRecycle data*

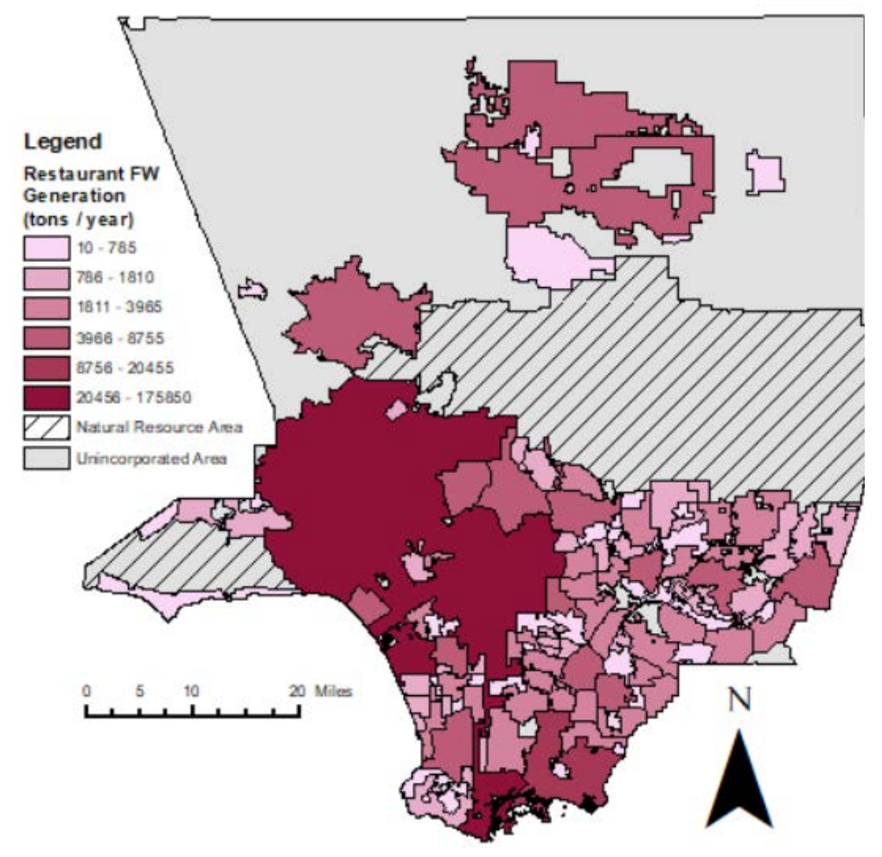

Figure 4. *Restaurant FW generation using CalEDD data*

For confidentiality, CalRecycle suppresses some data, therefore some jurisdictions have 0 FW generated, using CalEDD data fills those gaps.

CalRecycle aggregates unincorporated areas in its data, overrepresenting FW generation in natural resource and other less inhabited areas

CONCLUSIONS

CalRecycle is a valuable resource for waste management data however, more spatially refined data is needed.

Using CalEDD data and CalRecycle methodology, more spatially refined data can be generated.

Spatially fine FW data is needed to determine optimal locations and appropriate scale for AD facilities throughout California.

MOVING FORWARD

The next step is to determine locations for AD systems based on FW generation.

By utilizing actual FW generation rates, AD capacity, and transportation routes, an AD strategy can be developed that maximizes coverage and minimizes AD deployment

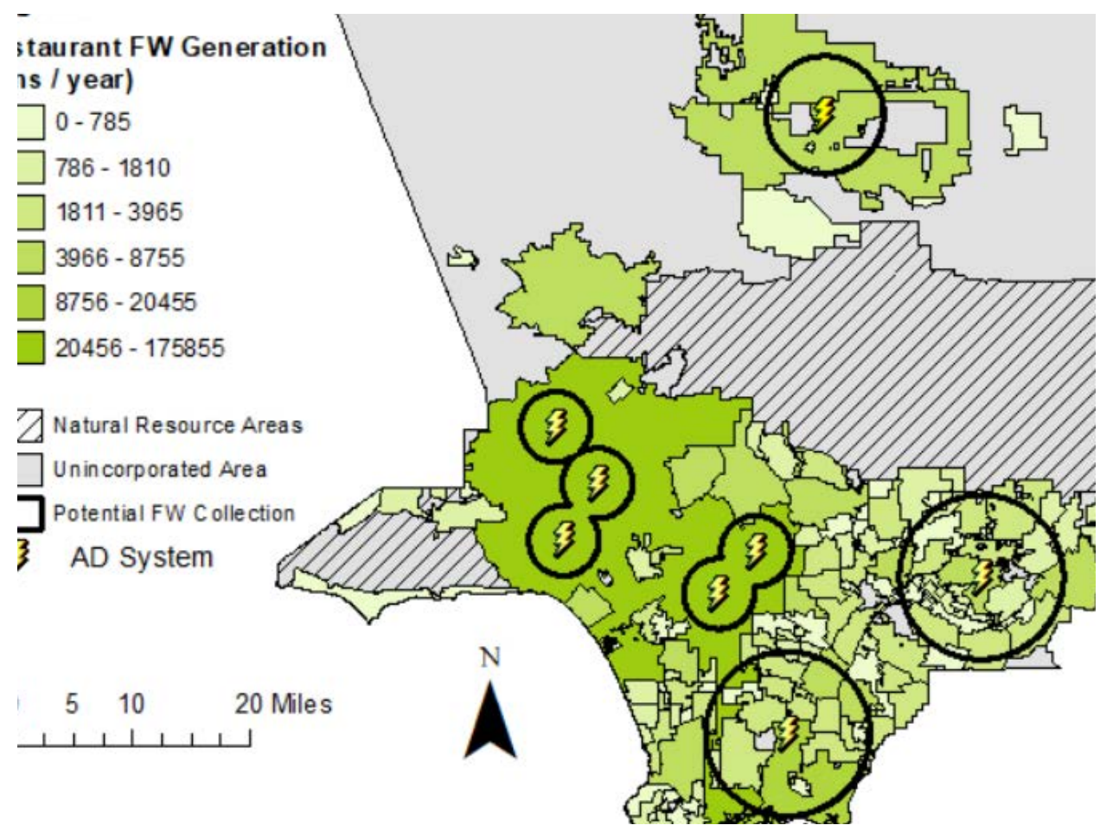

Figure 5. *FW generation with potential AD system locations*

REFERENCES

- California Department of Resources Recycle and Recover. 2014 Generator-Based Characterization of Commercial Sector Disposal and Diversion in California. 2015.
- California Employment Development Department, Labor Market Information Division. Monthly Labor Force Data for Cities and Census Designated Places (CDP) . 2015.
- California Employment Development Department, Labor Market Information Division. Los Angeles Long Beach Glendale MD. Industry Employment & Labor Force by Month. 2015.

ACKNOWLEDGEMENTS

California Energy Commission

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Reducing Electricity Grid Imbalances through Energy Demand Management of Water Delivery Infrastructure

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Drew Atwater, and Frank J. Loge

ABSTRACT

The feasibility of a water supply utility to perform energy load shifting into periods of energy imbalance on California's statewide energy grid was investigated for the reclaimed water distribution system operated by the **Moulton Niguel Water District** (**MNWD**) using an offline hydraulic model. The energy generation, curtailment, and **greenhouse gas** (**GHG**) emission trends of California's statewide energy grid operated by the **California Independent System Operator** (**CAISO**) were investigated to determine the key time periods to target with energy load shifting. The offline simulation demonstrated that it is possible for water delivery utilities to shift energy loads to address statewide energy imbalances.

INTRODUCTION

As energy sources in California have shifted towards solar and wind power, short-term intermittent changes to energy production are leading to an imbalance between energy supply and demand. Energy imbalance is currently managed with the practice of *curtailment*, where the CAISO sells excess electricity at modified production costs **(Figure 1)**. *Overgeneration*, which occurs when excess electricity is not completely consumed or curtailed, has the undesirable potential to reduce the reliability of electricity supply. One way to reduce the impact of overgeneration is to shift energy consumption to eliminate energy imbalance (Jan Paul Action, 1983).

This "load shifting" approach, referred to in the energy sector as Demand Management, presents a unique challenge in the case of California's energy-intensive water system which accounts for nearly 20% of the state's electricity use, with pumping for water distribution, supply, and conveyance alone representing nearly 5%. If water utilities had the tools and knowledge to shift energy consumption into periods of renewable energy generation, they might be able to reduce their GHG emission and simultaneously reduce the energy imbalance in the statewide energy grid.

SPONSORS

California Energy Commission
Moulton Niguel Water District

REFERENCES

1. Jan Paul Action, B. M. M., Rolla Edward Park, Mary E. Vaiana. (1983). Time-of-Day Electricity Rates for the United States (R-3086-HF).
2. Price, J. (2017). CAISO Locational Marginal Pricing at Individual Production Sources, Data Request: California ISO.
3. CAISO. (2017). Historical Production and Curtailment Data. Production and curtailment data reported at five-minute intervals from May 1, 2014 to May 31, 2017.

METHODS

Time Periods to Target. Problems of energy imbalance, including curtailment **(Figure 2)** and overgeneration **(Figure 3)**, have grown in magnitude since 2014 while occuring at consistent, reliable hours. Meanwhile, the Locational Marginal Prices **(Figure 1)** of electricity generation operated by the CAISO captures increased occurances of high and negative pricing which indicate growing imbalance on the statewide energy grid.

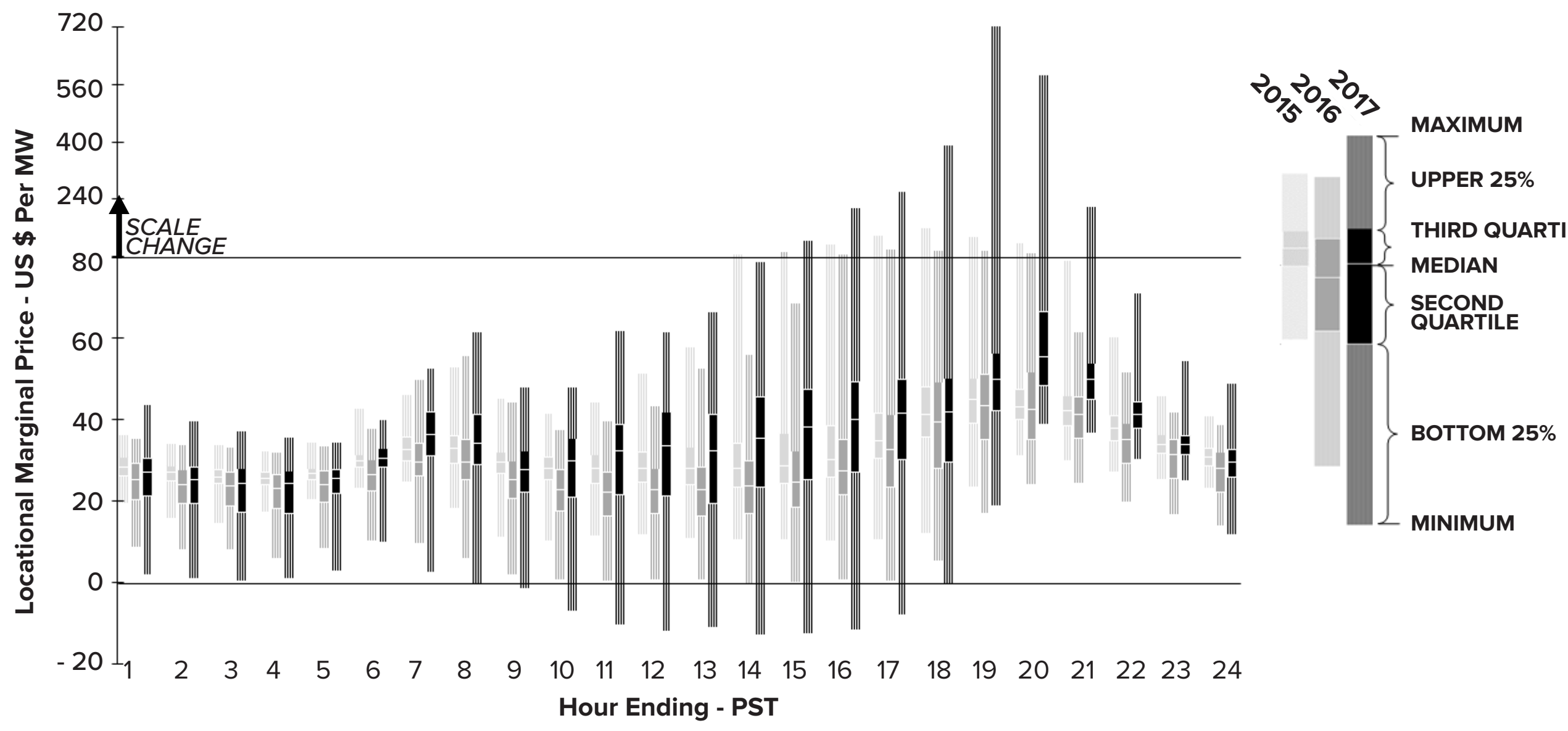


FIGURE 1 Observed statistical distributions of the Locational Marginal Pricing (LMP) values generated by CAISO from Janunary 2015 to September 2017 at all participating generating units. **Data Source:** California Independent System Operator (Price, 2017)

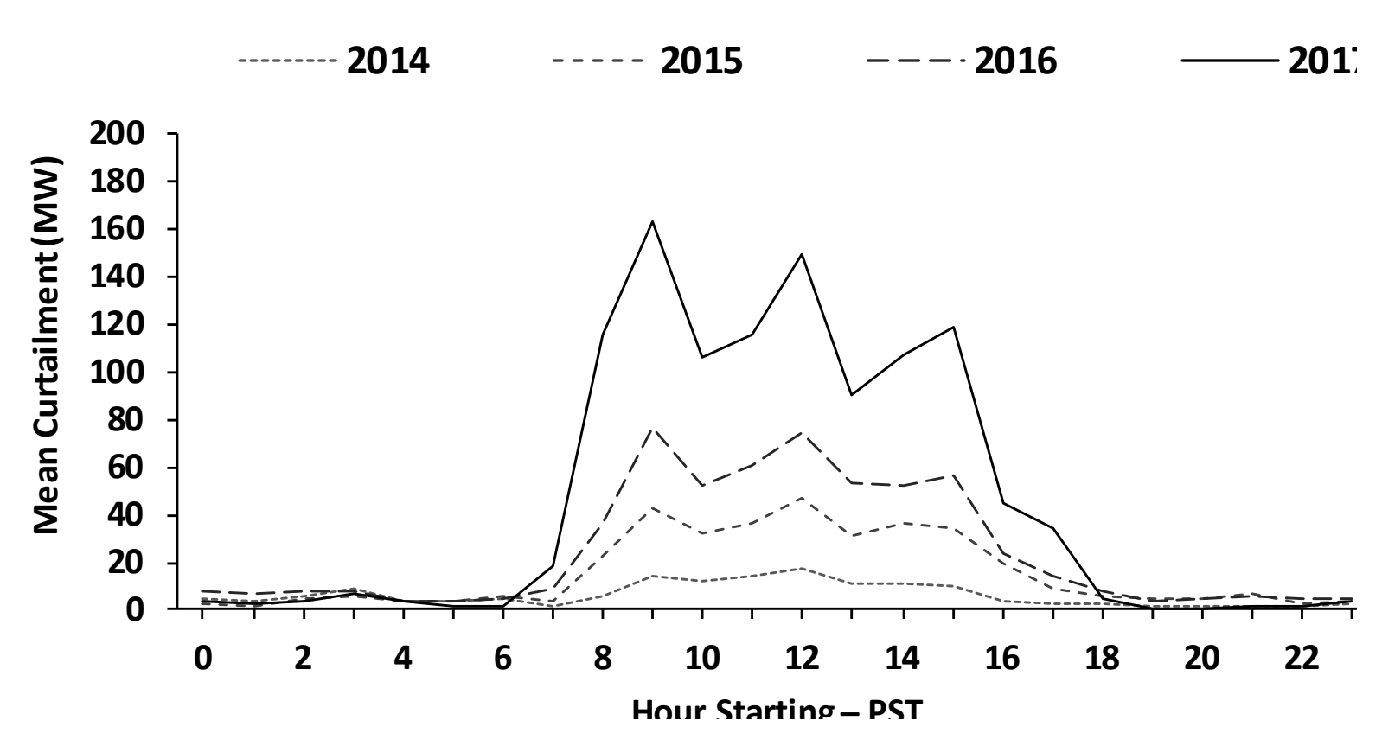


FIGURE 2 Observed statewide scheduled curtailment. **Data Source:** California Independent System Operator (CAISO, 2017)

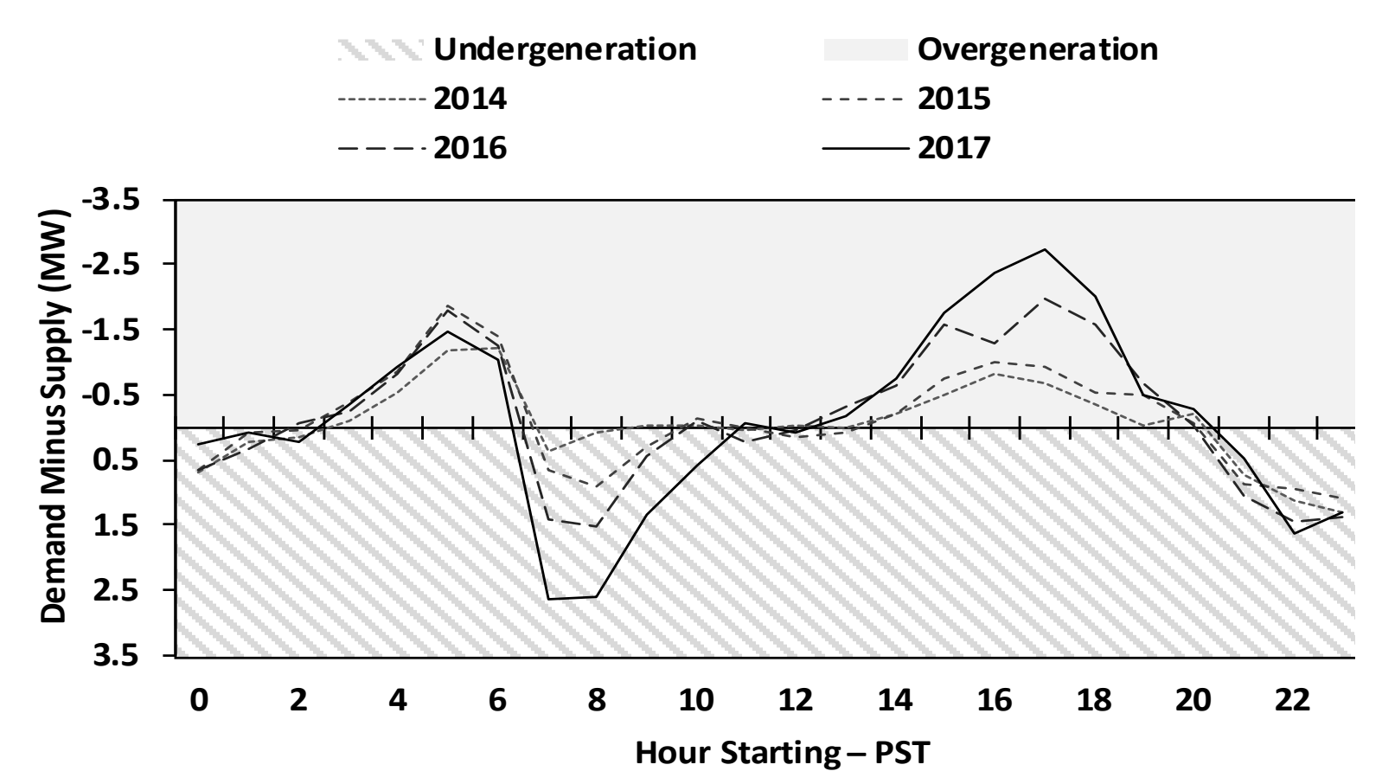


FIGURE 3 Observed statewide overgeneration. **Data Source:** California Independent System Operator (CAISO, 2017)

Offline Energy Load Shifting. Leveraging a hydraulic water distribution model developed to accurately simulate the reclaimed water system operated by the MNWD, potential control and operating schemes of system elements, including pumps and valves, were simulated. By utilizing optimization procedures within the hydraulic modeling software, energy load shifting was simulated by replacing the existing cost of purchasing electricity at MNWD with similar-cost energy rates which promoted energy consumption at new time periods. These optimizations were repeated under new water customer demand profiles (Shifted Demands) to simulate the impact of water demand shifting on the success of energy load shifting.

FIGURE 4

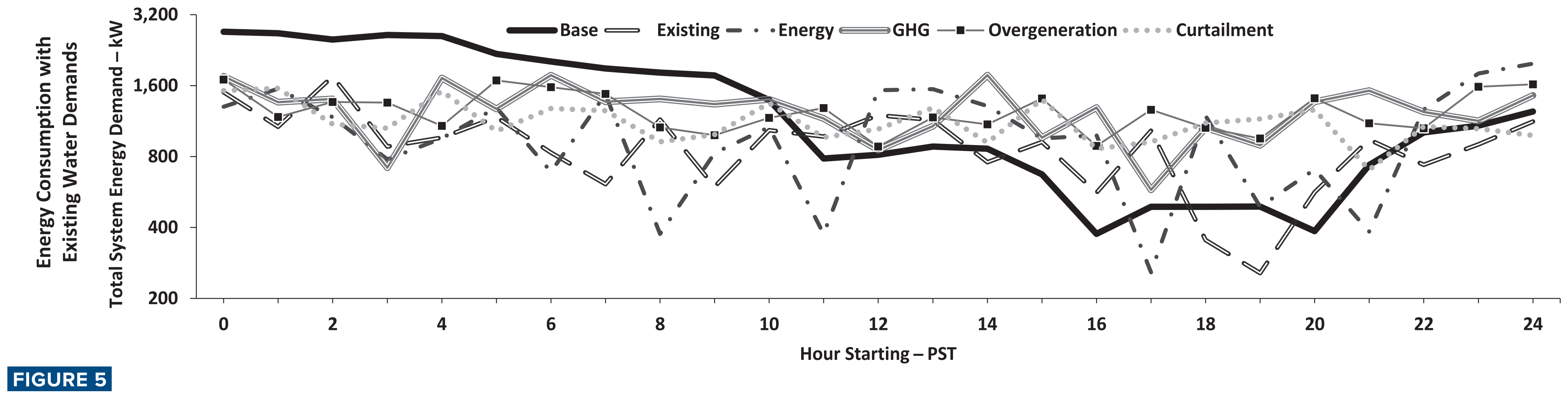
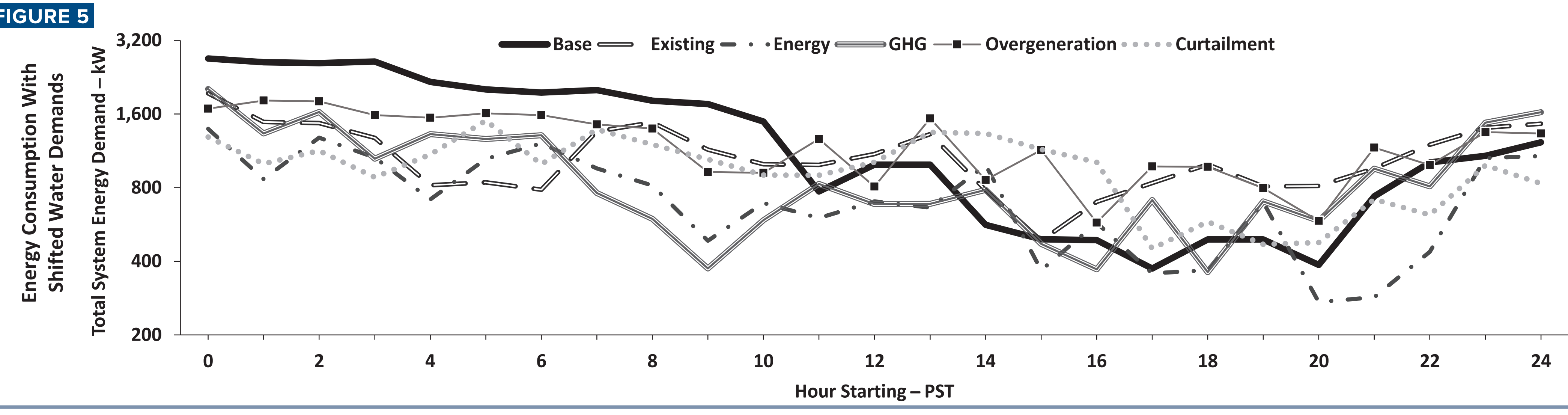


FIGURE 5



RESULTS

Energy load shifting was demonstrated to achieve several objectives: minimize operating costs under existing energy rates (Existing), minimize total energy use (Energy), minimize total emissions produced to meet demand (GHG), maximize use of scheduled curtailed energy (Curtailment), and respond to unscheduled overgeneration (Overgeneration). The utilitywas capable of increasing energy demand from 10am–Midnight; and decreasing energy demand from Midnight–10am **(Figures 4 and 5)**. Generally, further energy savings and load shifting were possible with water customer demand shifting.

Highly dependant on the load shifting objectives, the total energy use (MWh) and total associated emissions (mTCO$_2$) of operating the water system were reduced by 7% – 44% and 11% – 46%, respectively **(Figure 6)**.

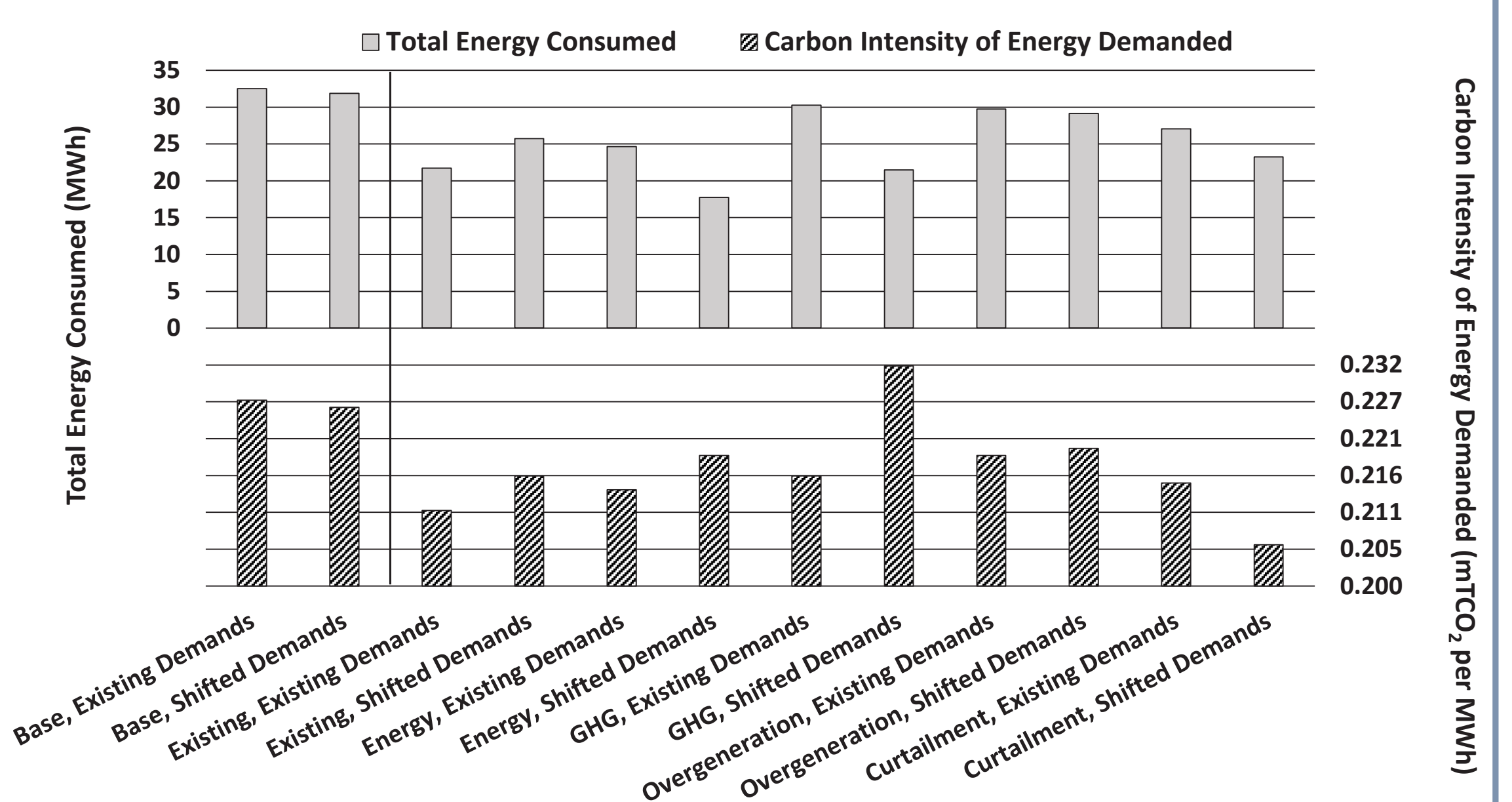


FIGURE 6 Performance of all optimizations in comparison to the base operating conditions (left). Total energy consumption (top) and aggregated carbon intensity of the eectricity generated to meet energy demand (bottom) for the 24-hour simulations.

CONCLUSIONS

Energy load shifting for water delivery infrastructure is plausible and can produce short payback periods which reduce operating costs for a water utility. However, significant concerns relating to the repeatability and complexity of optimized operating schemes indicate the need for future research into both the technology and methodology. The results of this study suggest that rules-based operating configurations developed from groups of optimized operating schema may be a fruitful direction of research to achieve this multi-objective challenge.

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Water Energy Nexus in Informal Water Systems

Yasmina Choueiri, Geography Graduate Group, University of California, Davis

RESEARCH FOCUS

Water and energy are interdependent systems. Research projects usually study their nexus in conventional water systems by identifying the correlation between water and energy of large scale supply systems and residential water systems.

This research looks at the water energy nexus in informal water systems.

CONVENTIONAL WATER SYSTEM / WATER ENERGY NEXUS

Extraction → Treatment → Storage → Use → Wastewater → Recycling → Use

Energy is used at all phases of conventional water distributions systems

Residential Demand Side

CO_2 Emissions

Energy Bills

INFORMAL SYSTEMS

> “Ever-shifting relationship between what is legal and illegal, legitimate and illegitimate, authorized and unauthorized”
> (Roy, 2009).

- Usually fills the gap of a failing system or infrastructure
- Stems from weak governance
- Complex: legal and illegal
- Coined in 1970 (Hart): informal employment in Ghana
- Flexible and Resilient

Water

Wastewater

Solid Waste

Energy

Transportation

Public Spaces

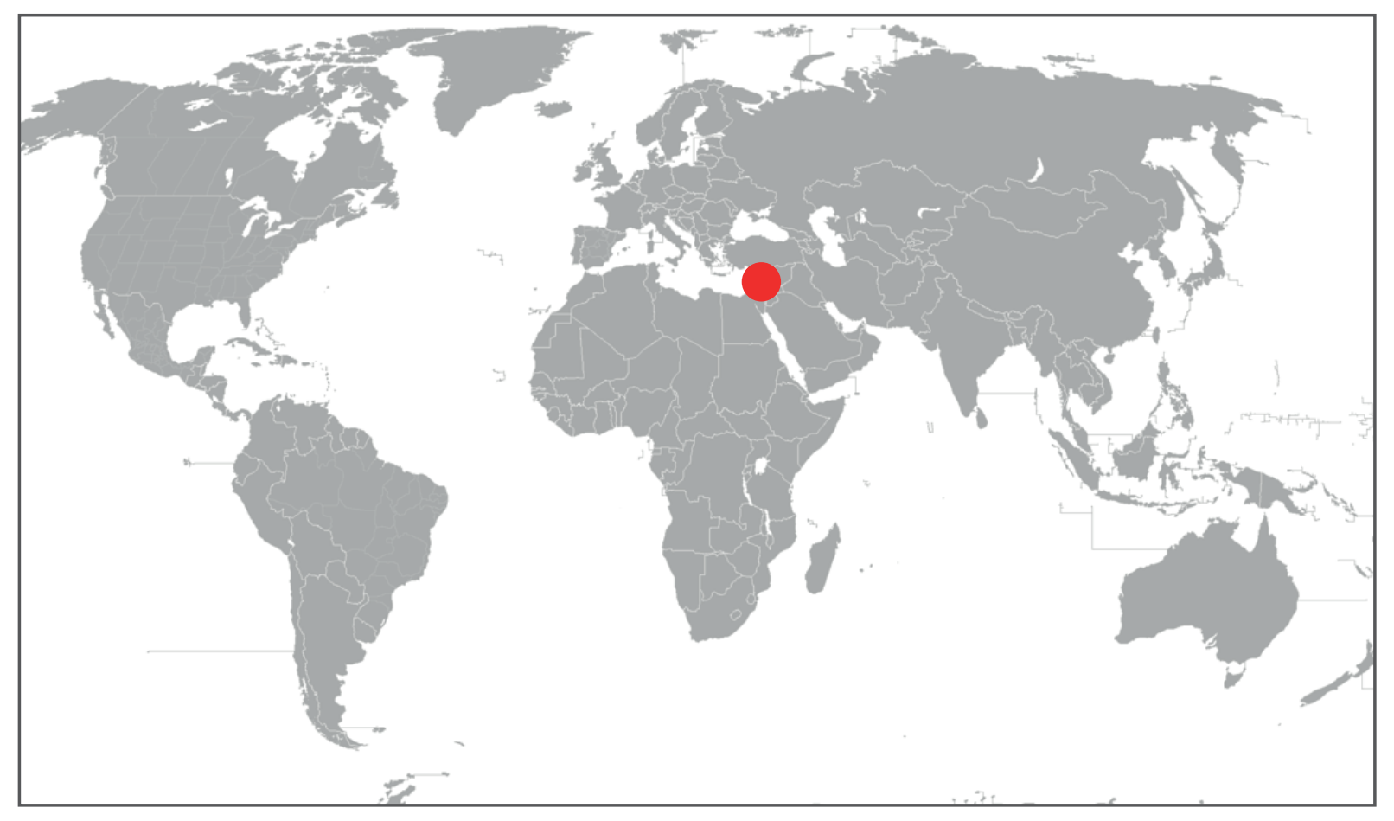
CASE STUDY: INFORMAL WATER SYSTEMS IN LEBANON

Alternative water sources:

Water Trucks

Wells

Bottled Water



The Lebanese water system: between formal and informal

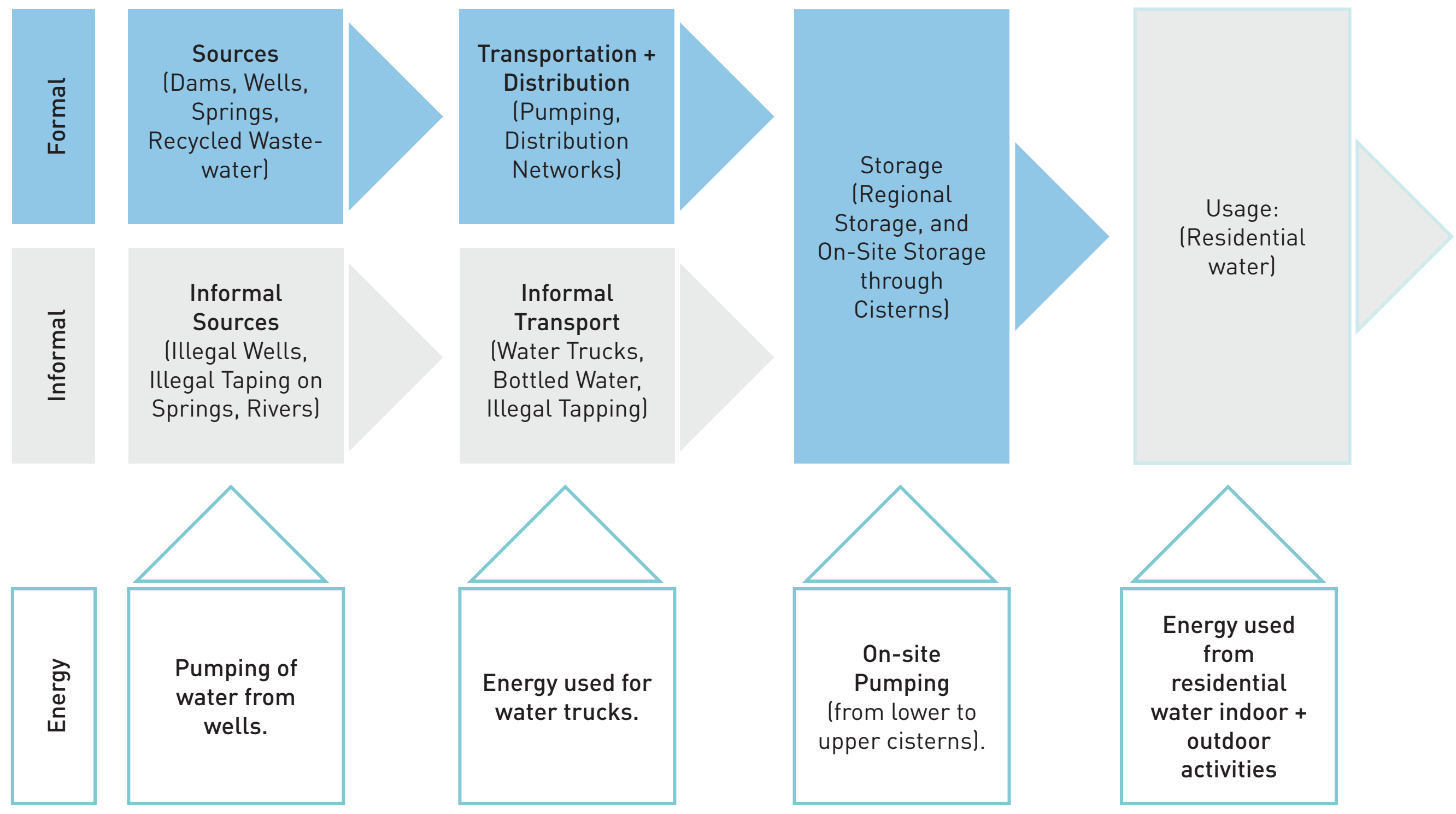
Water supply is intermittent -- few hours every other day: **households can receive as little as 0.065 m^3 per day.**

IMPACTS

Environmental
Depletion of Resources

Economic
300% increase in $

Social
Affordability



Formal	**Sources** (Dams, Wells, Springs, Recycled Waste-water)	**Transportation + Distribution** (Pumping, Distribution Networks)	Storage (Regional Storage, and On-Site Storage through Cisterns)	Usage: (Residential water)
Informal	**Informal Sources** (Illegal Wells, Illegal Taping on Springs, Rivers)	**Informal Transport** (Water Trucks, Bottled Water, Illegal Tapping)		
Energy	**Pumping of water from wells.**	**Energy used for water trucks.**	**On-site Pumping** (from lower to upper cisterns).	**Energy used from residential water indoor + outdoor activities**

INFORMAL WATER-ENERGY NEXUS IMPACTS

Energy from Trucks and on-site Pumps

Diesel Oil consumption and CO_2 Emissions

CONCLUSION

Informality is everywhere!
Daily power outages -> private generator that provides electricity to households.

What about the correlation between informal energy systems and water use?

Further Research

Beirut, the capital, suffers from 3 hours of power outages per day
-> Households’ water activities use approximately 12.5% of electricity from private generators

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California's urban water conservation mandate delivers bonus energy and greenhouse gas savings

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STUDY OVERVIEW

In April 2015, the Governor of California mandated a 25 percent statewide reduction in water consumption (relative to 2013 levels) by the more than 400 urban water utilities in California. The UC Davis Center for Water-Energy Efficiency analyzed the water use data reported by the utilities to the State Water Resources Control Board during the 12-month mandate and assessed the resulting electricity and greenhouse gas (GHG) emissions reductions associated with reduced urban water infrastructure operations.

The results show that the State succeeded in reducing water use by a total of 24.5% relative to the 2013 baseline. The total electricity savings linked to water conservation are approximately 11% greater than the savings achieved by the investor-owned electricity utilities' (**IOU**) efficiency programs for roughly the same time period, and the GHG savings represent the equivalent of taking ~111,000 cars off the road for a year.

ENERGY SAVINGS FROM WATER CONSERVATION

Energy savings from reduced water use was estimated utilizing two different energy intensity metrics (the energy required to deliver a unit of water to the end-user) for the water supply portfolios associated with the ten hydrologic regions of California, "Total" and "IOU" (**Figure 1, (b) and (c)**). **Total energy intensity** refers to the total electricity consumption utilized for water sourcing and delivery, regardless of the electricity generating institution. **IOU energy intensity** refers only to the electricity consumed by the water infrastructure that was generated by an investor-owned utility. This is a critical distinction because of the over $1 billion available annually for IOU allocated energy efficiency programs (per California Public Utility Commission policy) which is a potential funding source of water-energy conservation programs.

TAKE AWAY

The cost of achieving integrated water-energy-GHG savings through water conservation are shown to be cost competitive to existing programs that specifically target electricity or GHG reductions. These results support including direct water conservation in the portfolio of program and technology options for IOU energy efficiency programs and the GHG Revolving Fund. Furthermore, the results reveal a strong incentive for water and energy utilities to partner on opportunities for combined resource savings at a shared cost; and, for the associated regulatory agencies to support these partnerships through aligned policy measures and targeted funding initiatives.

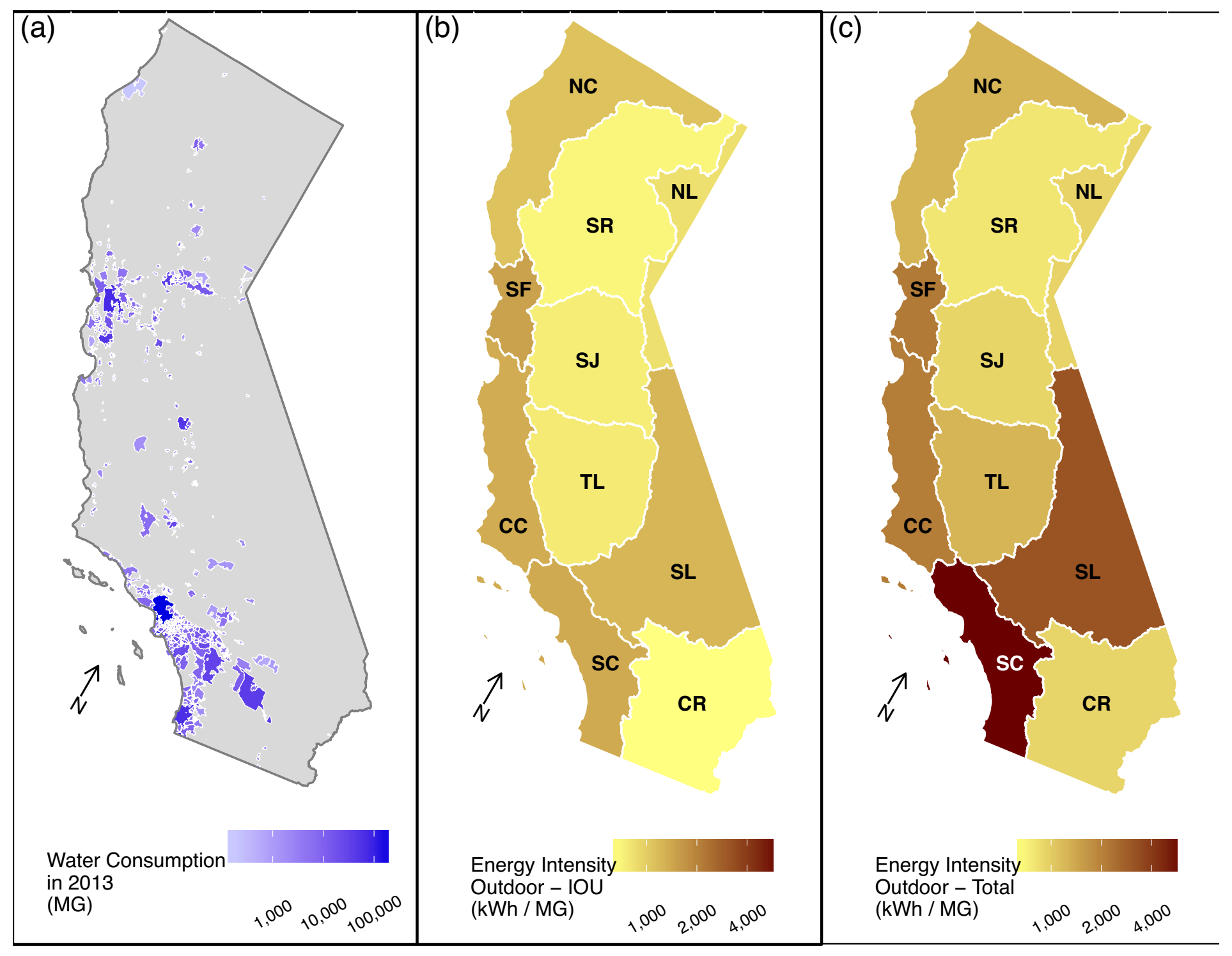

Figure 1. *Water consumption by urban water supplier service area (a), and IOU energy intensity (b) and Total energy intensity (c) by California's hydrologic regions.*

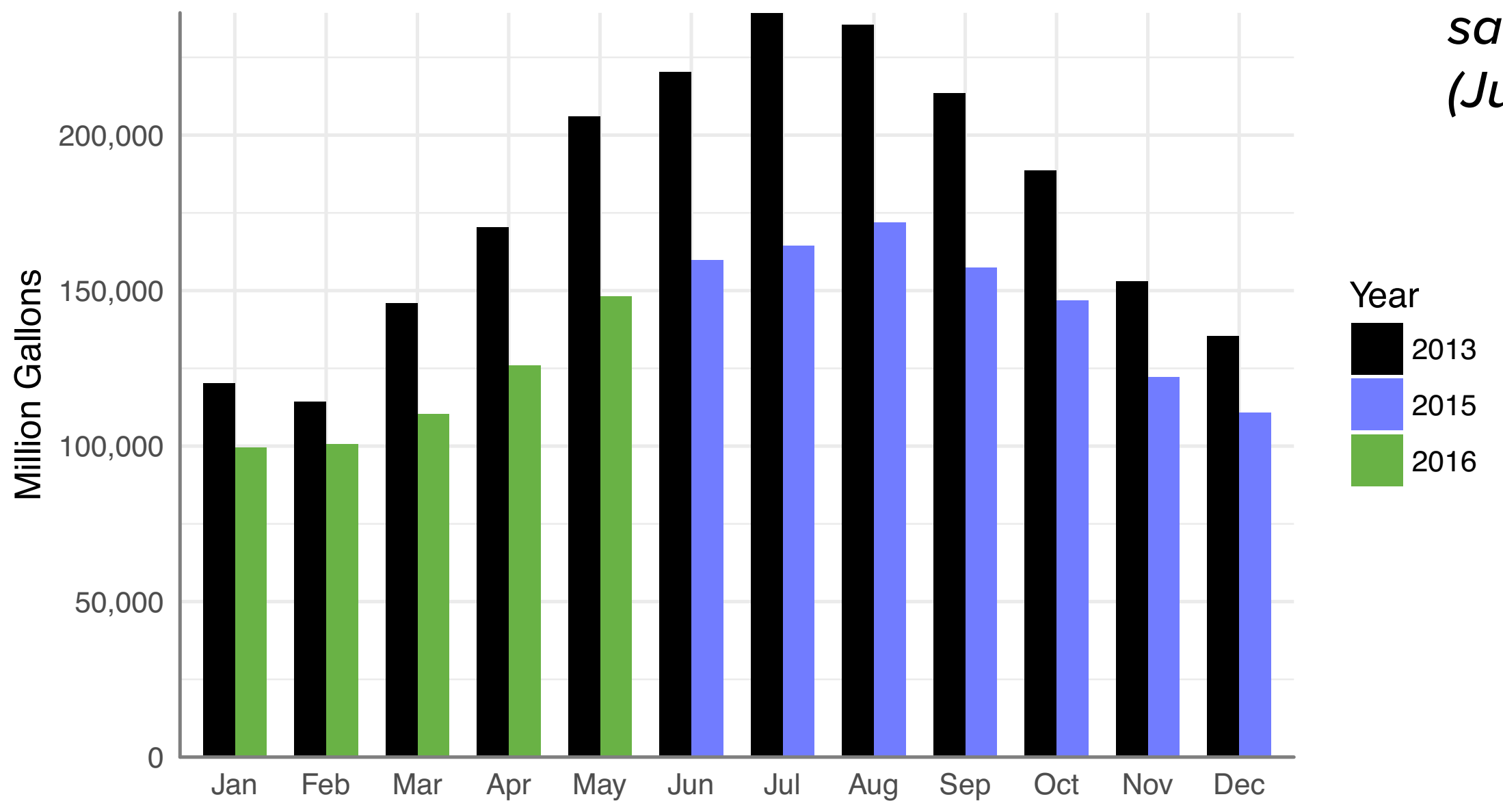

Figure 2. *Reported monthly water deliveries (June 2015 - May 2016) relative to 2013 baseline values*

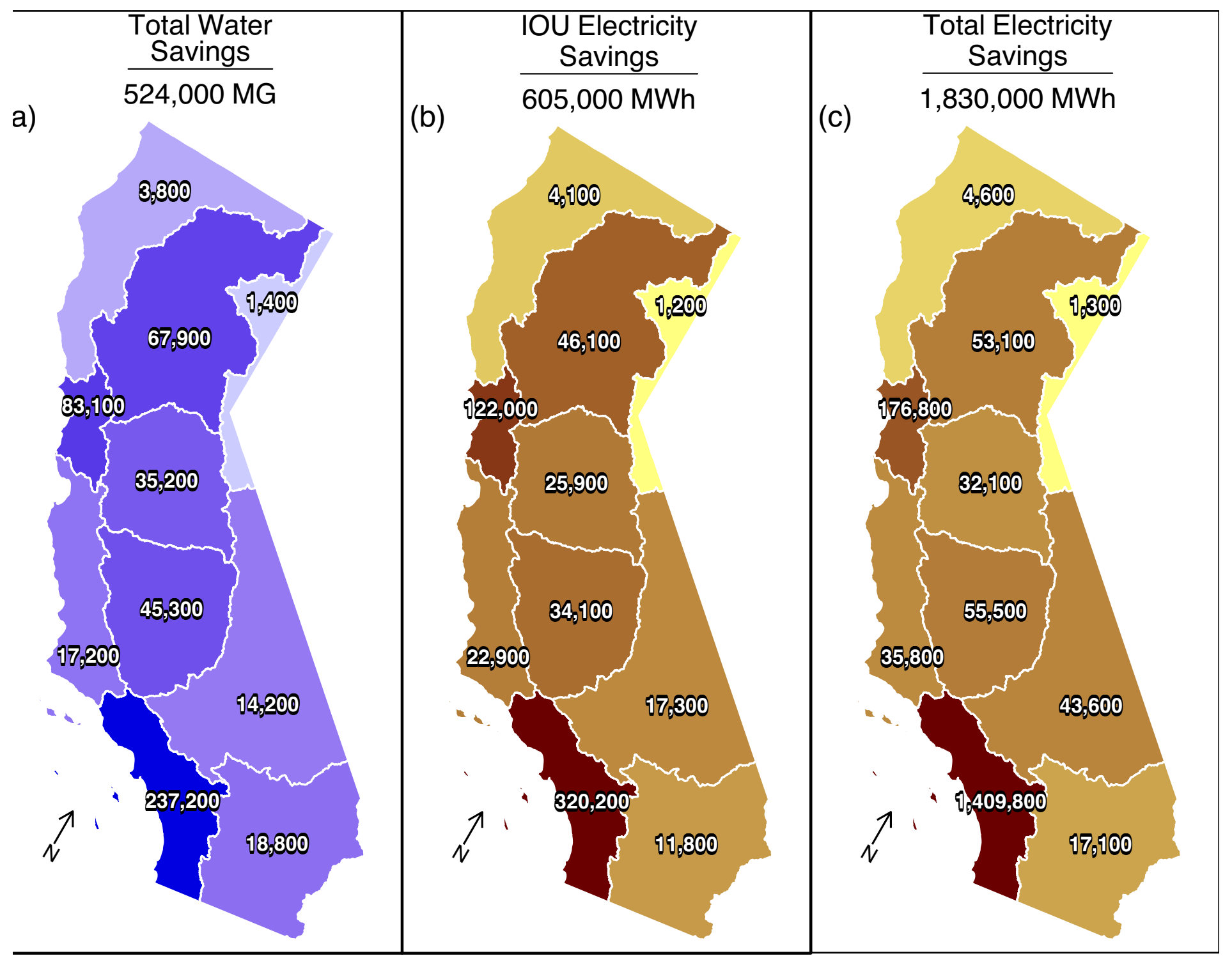

Figure 3. *Observed water savings - 24.5% reduction from the baseline (a), estimated IOU electricity savings (b), and estimated total electricity savings (c) achieved over the duration of California's urban water conservation mandate*

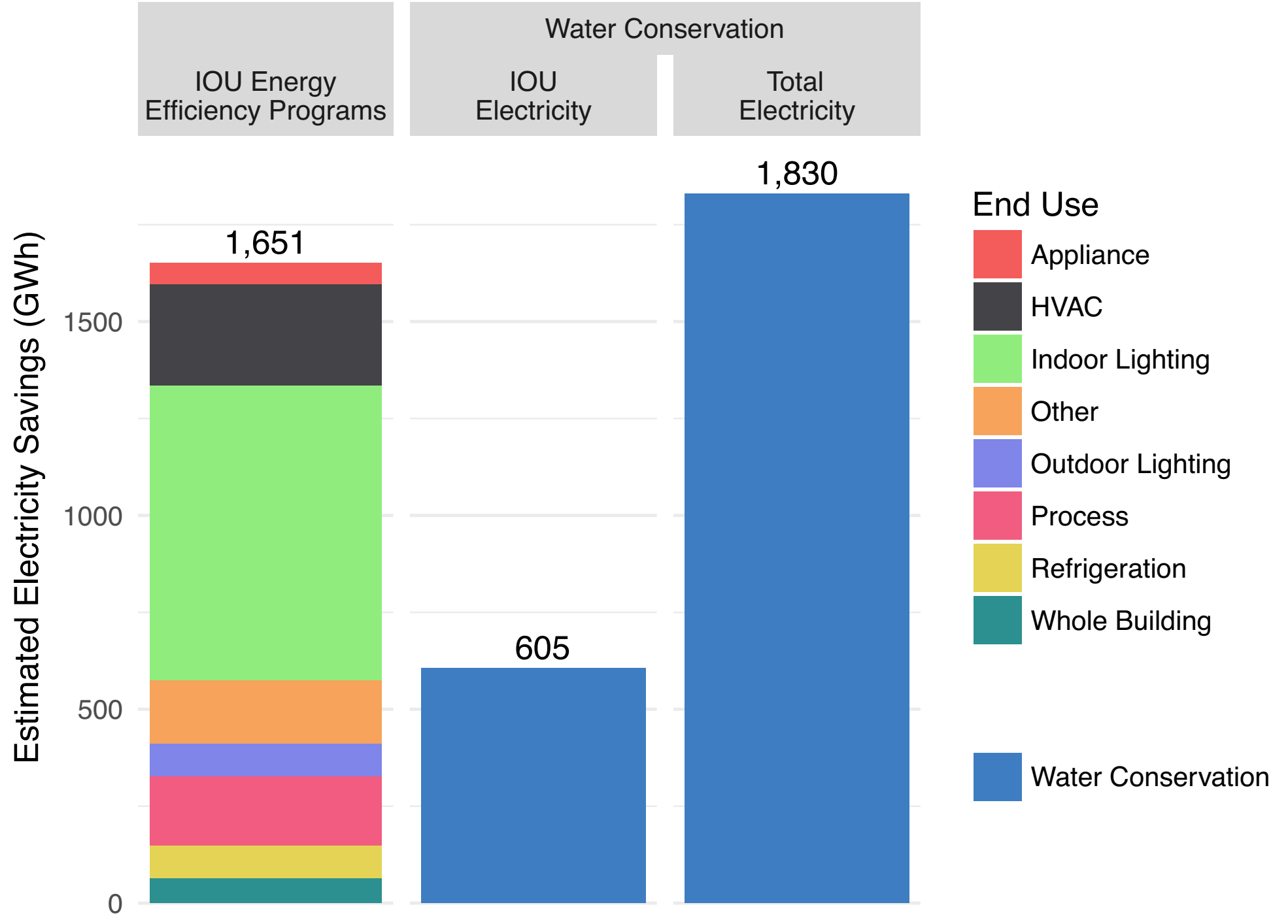

Figure 4. *Electricity savings from IOU EE programs (July 2015 – June 2016) by end-use category vs. estimated electricity savings (IOU and total) from statewide water conservation (June 2015 – May 2016)*

Table 1. *Total GHG Emissions Savings by Hydrologic Region.*

Hydrologic Region	MT CO_2e Saved
Central Coast	*10,210*
Colorado River	*4,870*
North Coast	*1,310*
North Lahontan	*380*
Sacramento River	*15,510*
San Francisco Bay	*50,400*
San Joaquin	*9,160*
South Coast	*401,790*
South Lahontan	*12,430*
Tulare Lake	*15,810*

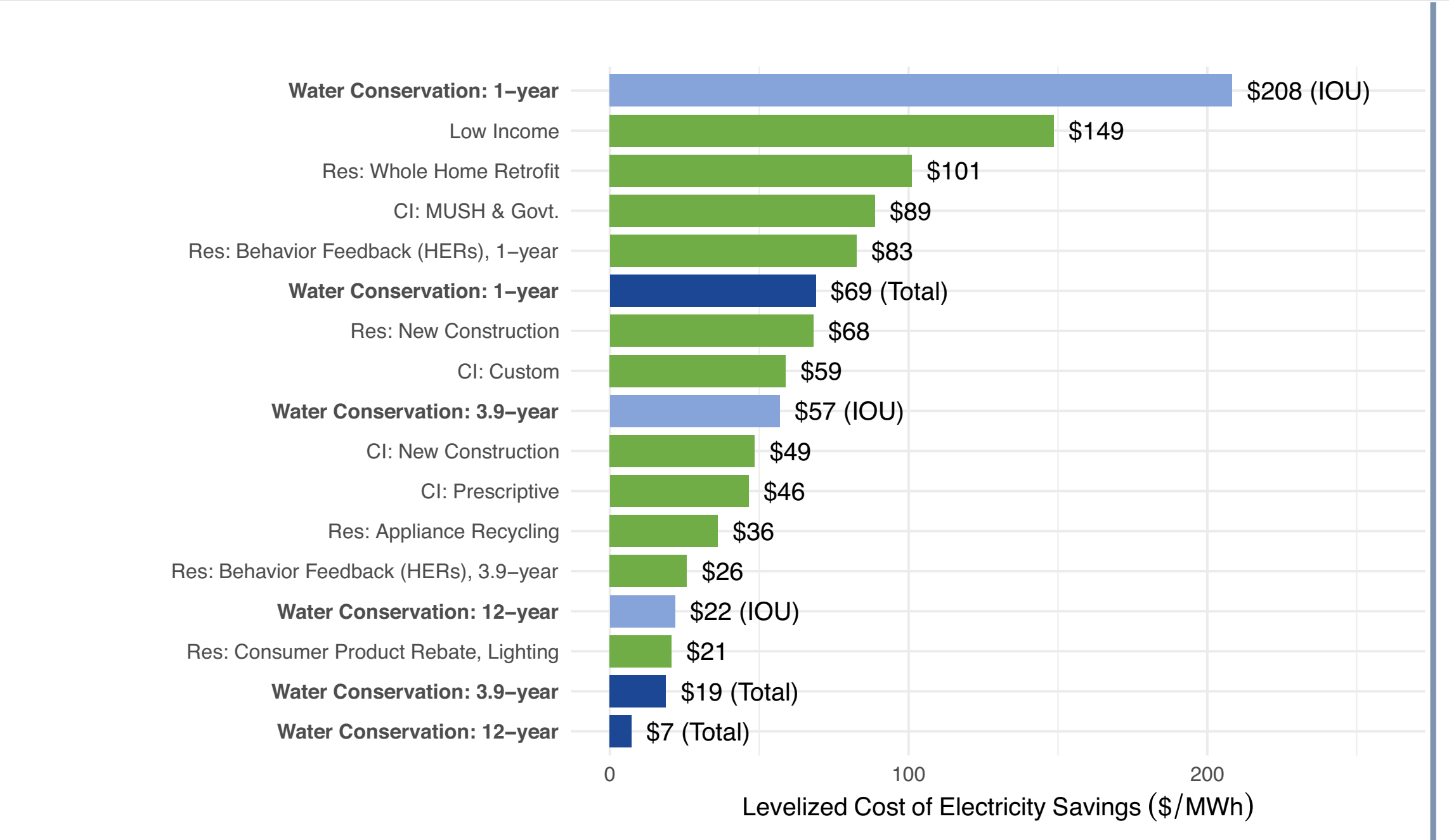

Figure 5. *Comparison of the levelized cost of electricity savings achieved through statewide water conservation relative to other energy efficiency programs (adapted from Hoffman et al (2015)). Notes: "Res" = Residential; "CI" = Commercial, Agricultural, and Institutional; "MUSH" = Municipalities, Universities, Schools, and Hospitals; and "HERs" = Home Energy Reports.*

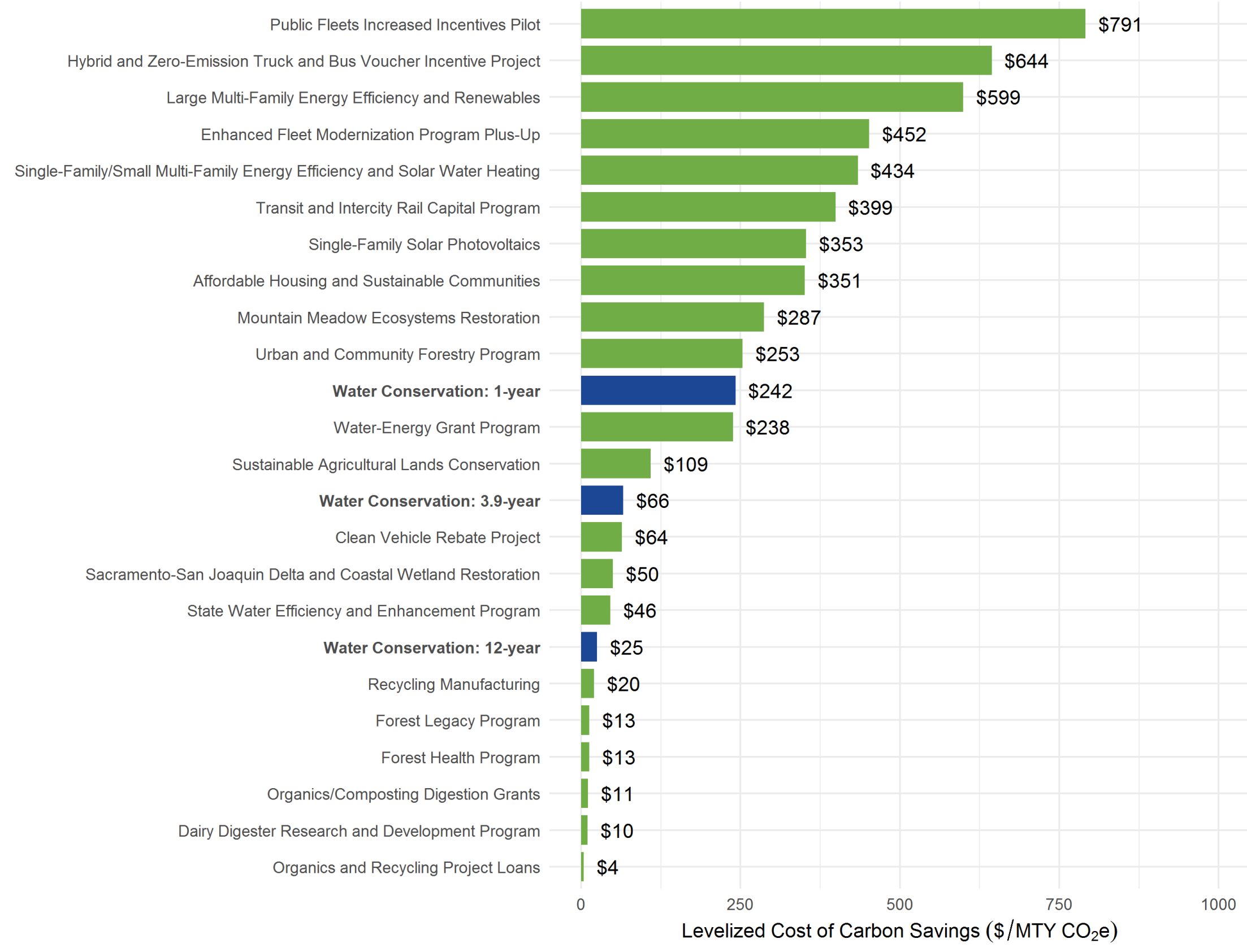

Figure 6. *Comparing the levelized cost of saved GHGs savings achieved through statewide water conservation relative to GGRF program investments (CARB (2016a)*

REFERENCES

- CARB 2016a Annual Report to the Legislature on Investments of Cap-and-Trade Auction Proceeds – 2016 (Sacramento, CA: California Air Resources Board (CARB))
- Hoffman I M, Schiller S R, Todd A, Billingsley M A, Goldman C A and Schwartz L C 2015 Energy Savings Lifetimes and Persistence: Practices, Issues and Data (Berkeley, CA: Lawrence Berkeley National Lab (LBNL))

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Advancing Demand Response in the Water Sector

Frank Loge, Principal Investigator • Erin Musabandesu and Gregory Miller, Graduate Student Researchers

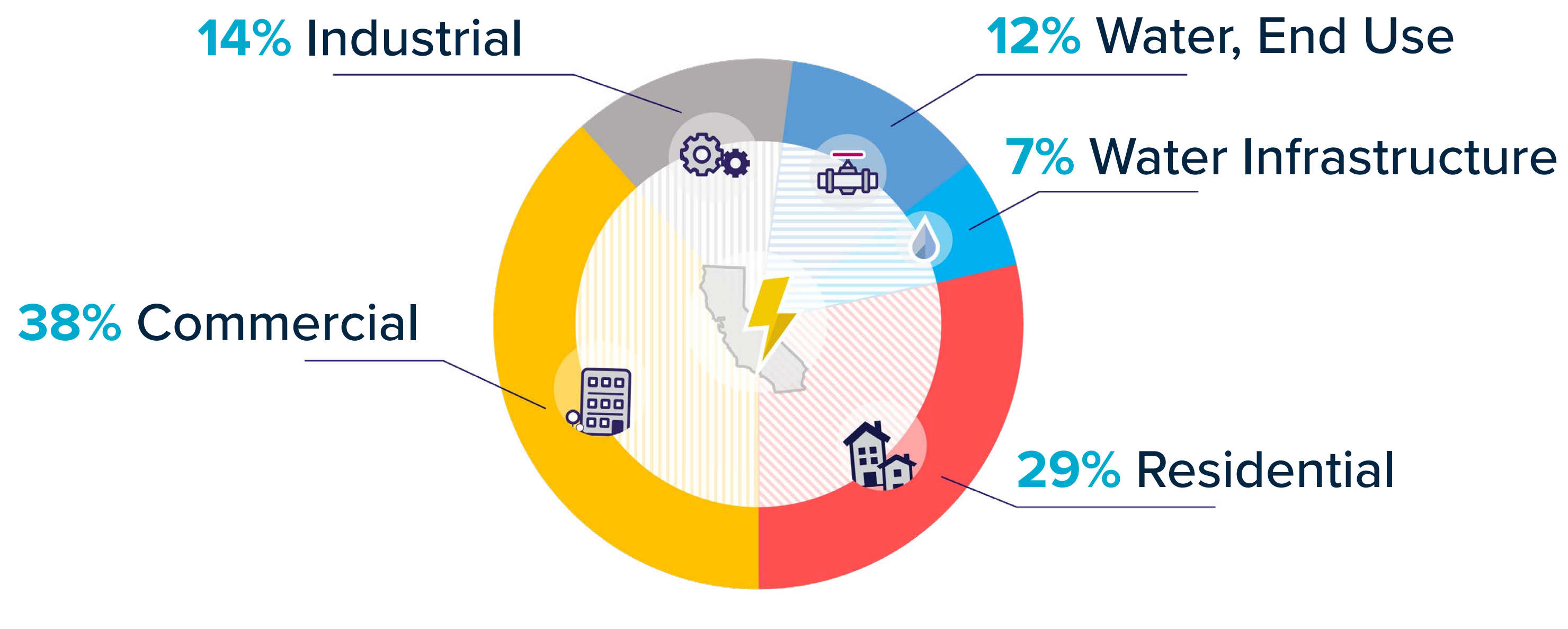
STATE OF CALIFORNIA ENERGY COMMISSION

Project Purpose

To enable energy demand response in the water sector through **technological advancement**.

Why the Water Sector?

- **Water infrastructure** accounts for **7% of energy use** in California. In 2017, it was estimated that water distribution systems used roughly 1,150 GWh of energy.
- Water systems typically operate with coinciding water and energy demands. However, water systems have potential for energy demand flexibility.

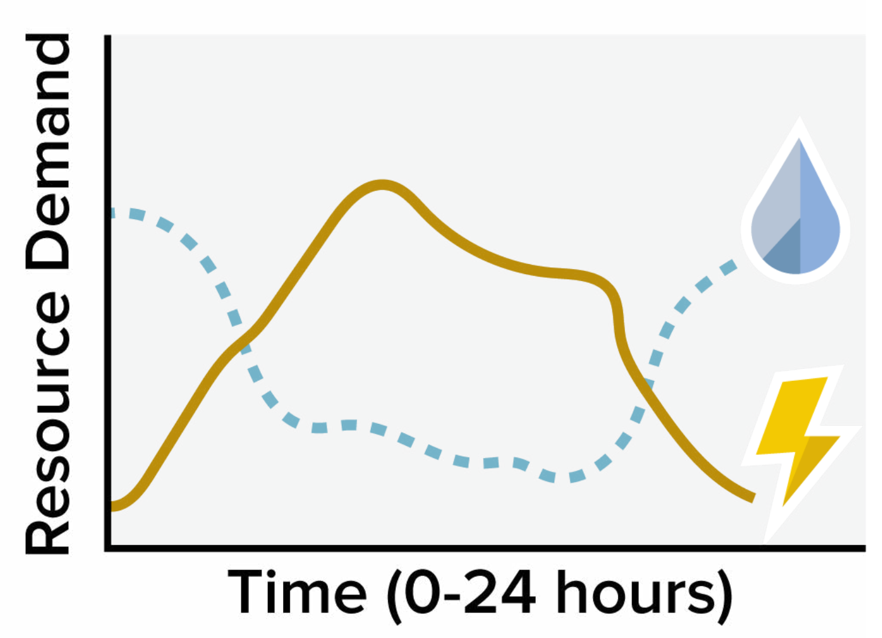


Breakdown of statewide electricity use in California.

Innovative Solution

This project will:

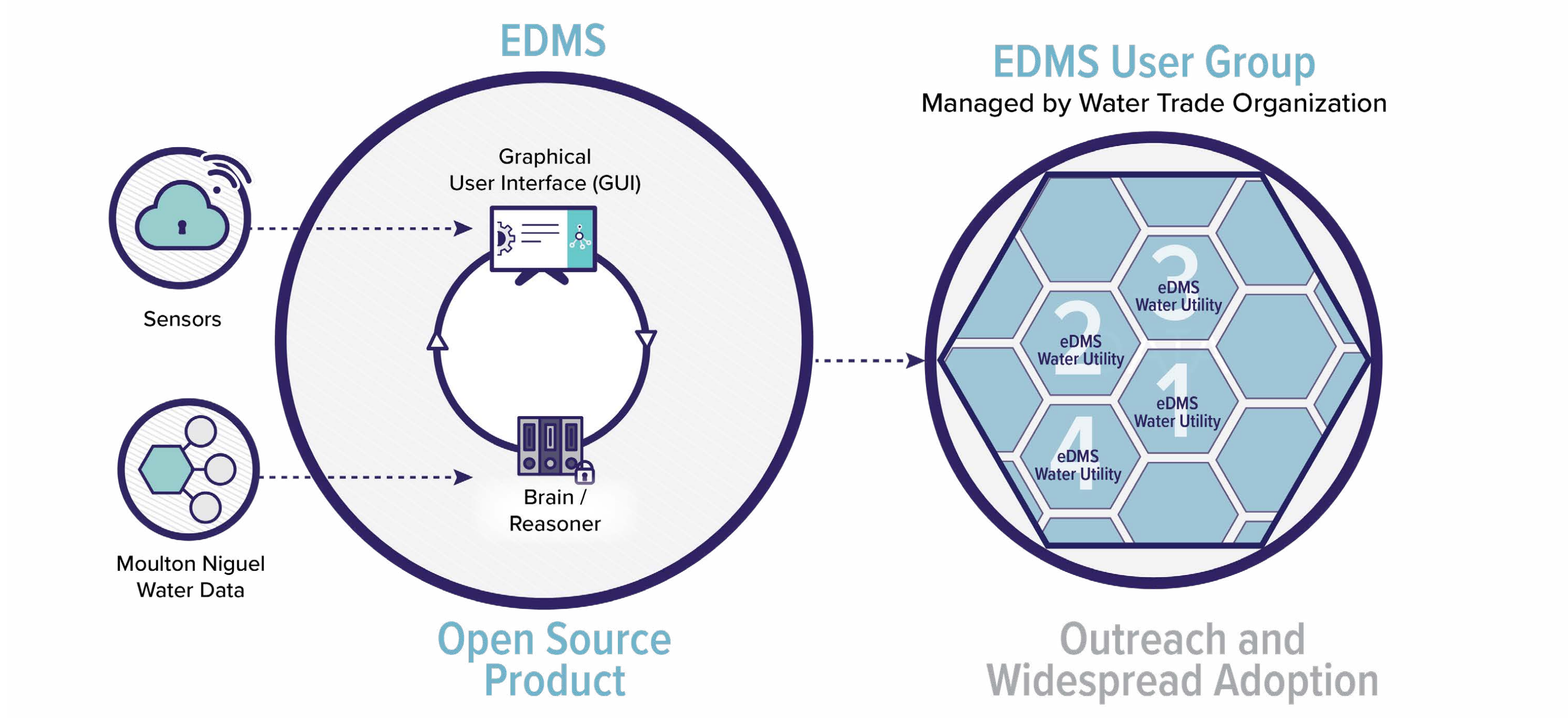
- Develop an **Energy Demand Management System (EDMS)** that enables water utilities to participate in energy load shifting to respond to various energy rate programs
- Pilot the EDMS to optimize energy while continuing to meet customer demands for the Moulton Niguel Water District **(MNWD)** drinking and recycled water systems which serves over **170,000 customers** in Southern California



Water system energy loads can be shifted with modified water storage and pumping operations.

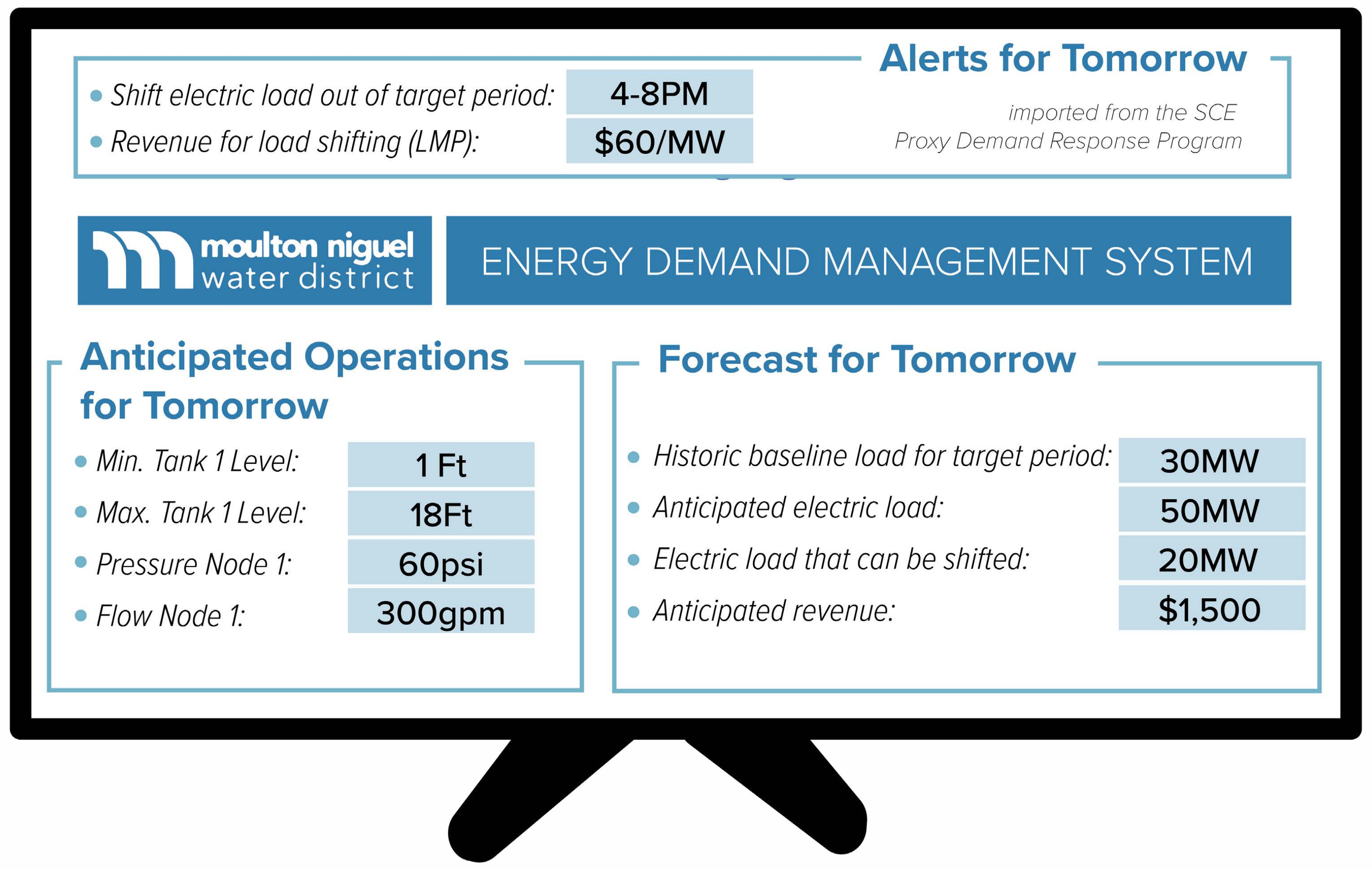
Energy Demand Management System

The proposed EDMS **provides forecasted operating recommendations** based on a selected energy rate programs by utilizing: real time and historical water system operation data, a hydraulic simulation model, optimization algorithms, operation analytics, and energy rate program data. The EDMS will be produced as an **open source software** and released to the public with widespread outreach activities.



EDMS Software Architecture Overview

An EDMS user interface will allow water utilities to **visualize how forecasted operations compare to real operations** – with recommended adjustments to optimize energy demand and costs.



Alerts for Tomorrow

- *Shift electric load out of target period:* 4-8PM
- *Revenue for load shifting (LMP):* $60/MW

imported from the SCE Proxy Demand Response Program

moulton niguel water district

ENERGY DEMAND MANAGEMENT SYSTEM

Anticipated Operations for Tomorrow

- *Min. Tank 1 Level:* 1 Ft
- *Max. Tank 1 Level:* 18Ft
- *Pressure Node 1:* 60psi
- *Flow Node 1:* 300gpm

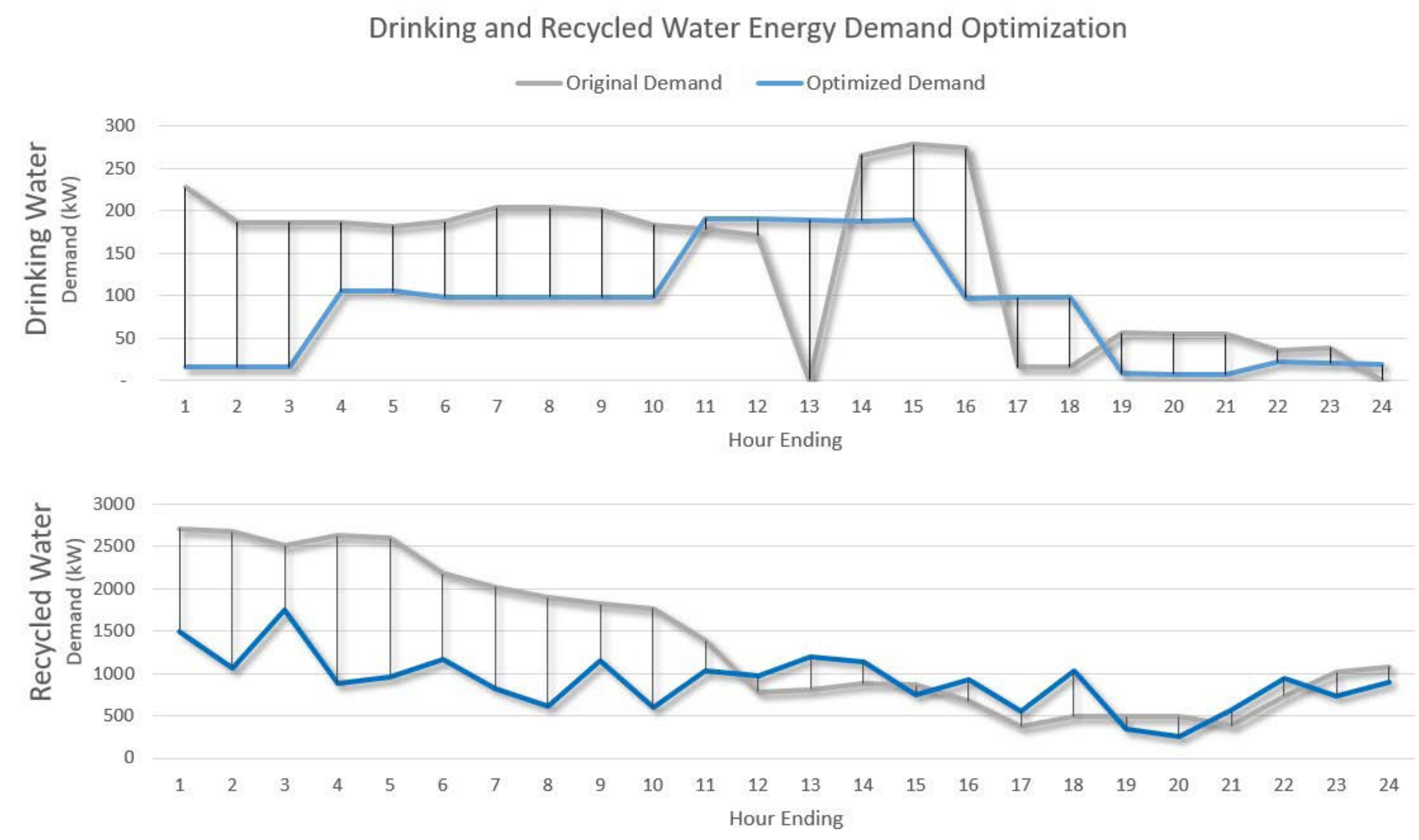
Forecast for Tomorrow

- *Historic baseline load for target period:* 30MW
- *Anticipated electric load:* 50MW
- *Electric load that can be shifted:* 20MW
- *Anticipated revenue:* $1,500

Example prototype of the EDMS graphical user interface.

Preliminary Results

A preliminary analysis of the MNWD water systems' energy demand flexibility was conducted by optimizing operations to the average hourly 2017 California Independent System Operator wholesale electric pricing.



Energy-Cost Optimization Simulations for the Drinking Water and Recycled Water Systems produced reductions to peak energy demand and total energy usage. The Drinking Water System shifted the majority of energy usage to periods of reduced greenhouse gas emission factors.

The drinking water system shows greater energy load shifting flexibility and energy efficiency potential, but is much less energy intensive than the recycled water system.

Optimized Scenario	Drinking	Recycled
Energy reduction	39%	34%
Emissions reduction	42%	36%
Emissions reduction from efficiency	92%	96%
Emissions reduction from load shifting	8%	4%

Energy-Cost Optimizations Results Summary

Statewide Impacts/Path Forward

Analysis will identify grid benefits that would be realized if the EDMS is scaled statewide. It has the potential to:

- **Balance** current **oversupply** of renewable energy
- **Reduce statewide electricity use** over 400 GWh/yr
- Help integrate new electric vehicle charging loads without adding distribution capacity

UC Davis will partner with a water trade organization who will help develop and support an EDMS Water Utility user group to encourage statewide adoption.

UC DAVIS
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Energy and Water Savings from Onsite Water Reuse in the Wine Industry

Frank Loge, Principal Investigator • Amanda Rupiper, Graduate Student Researcher

STATE OF CALIFORNIA
ENERGY COMMISSION

Project Objective

Quantify the potential **water and energy savings** by utilizing an onsite reverse osmosis **(RO)** treatment system to recycle and reuse water at Jackson Family Wines **(JFW)**.

Technology Demonstration

The Vibratory Shear Enhanced Process **(VSEP)** technology will be used to **treat barrel wash wastewater** for **onsite reuse.** This project is unique in the following ways:

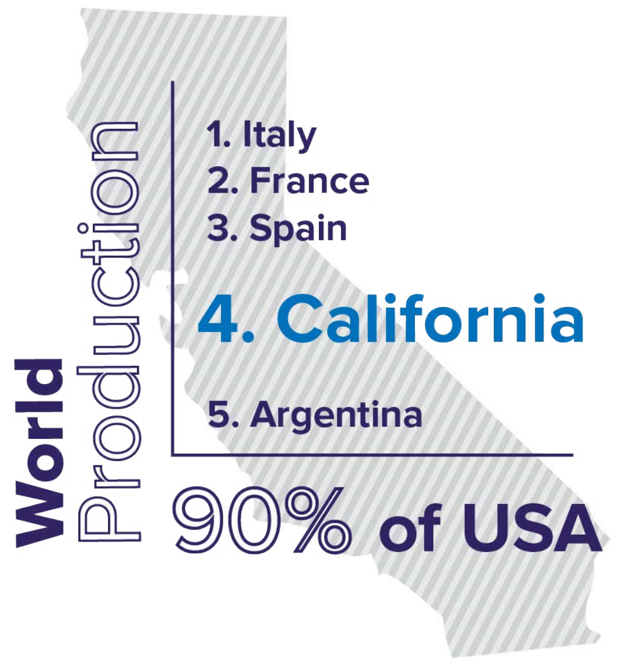
- **VSEP treats its own reject stream**, resulting in higher water recoveries (up to 90%) than conventional systems
- This will be the **first application of a vibratory RO membrane** and the first demonstrated reuse of non-potable water **for indoor processing at a winery**

VSEP water recycling technology demonstration at the winery

Barrel washing line at the winery

Why a Winery?

- California is a global leader in wine production
- **The JFW facility** in Sonoma County **accounts for 2%** of the wine production in California



Winery Water-Energy Life Cycle

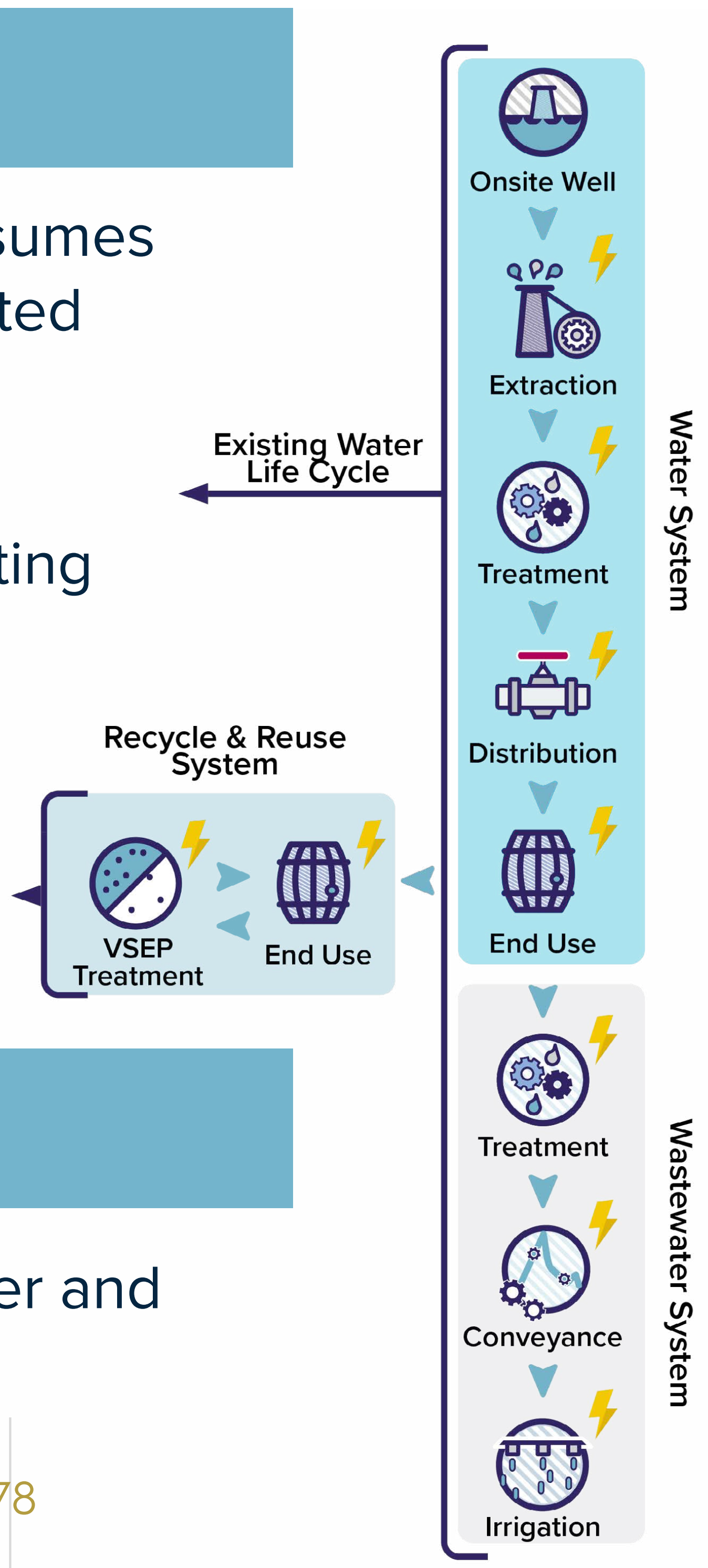
Every step of the water life cycle at the winery consumes energy. When water is reused, many of the associated energy requirements are in turn eliminated.

Existing Life Cycle:

Energy is consumed through every step of the existing **water** and **wastewater systems**.

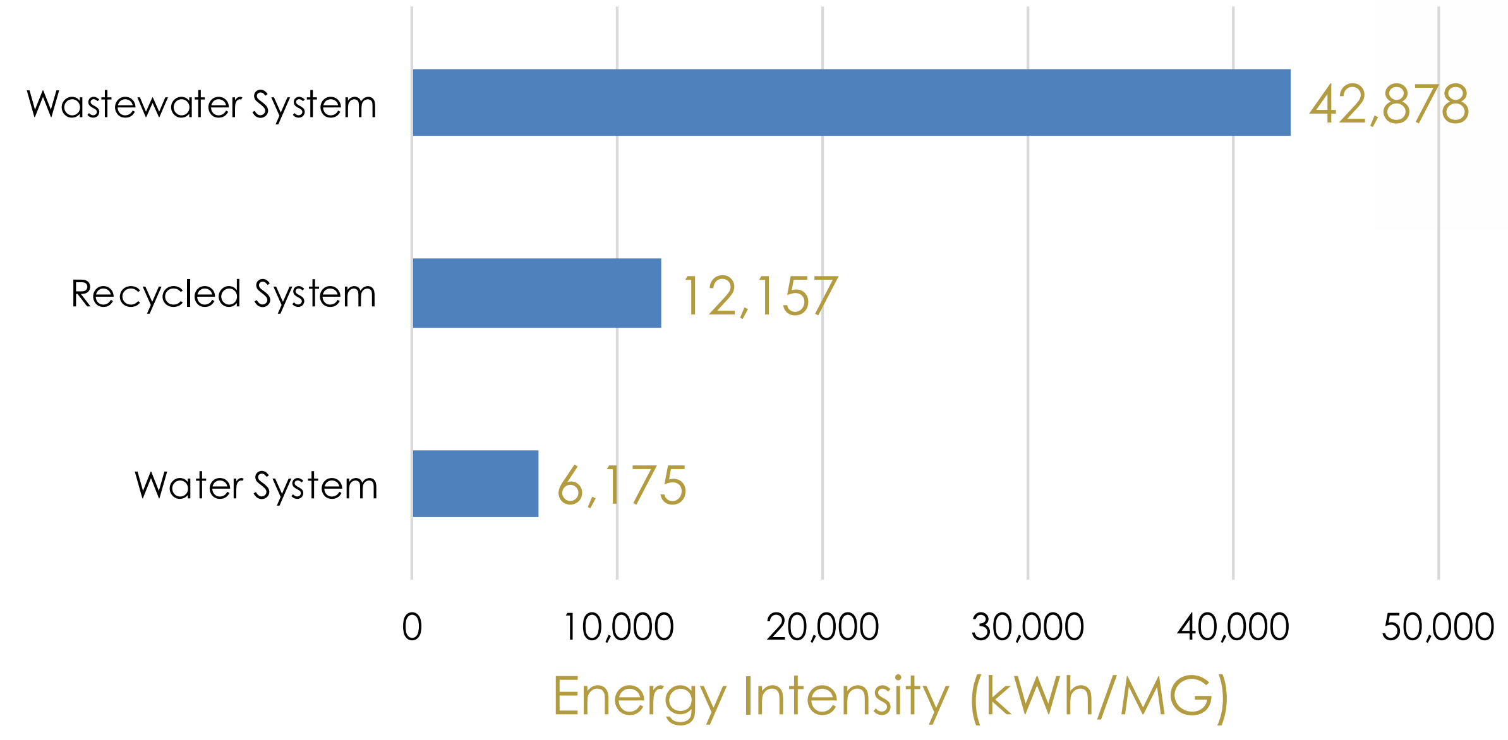
Proposed Reuse Life Cycle:

Recycling and reuse **eliminates the energy** requirements of the existing water and wastewater systems.



Energy Intensity

Energy Intensity **(EI)** is the energy required to deliver and treat a unit of water onsite.



Energy intensity of the individual water and wastewater systems at the winery

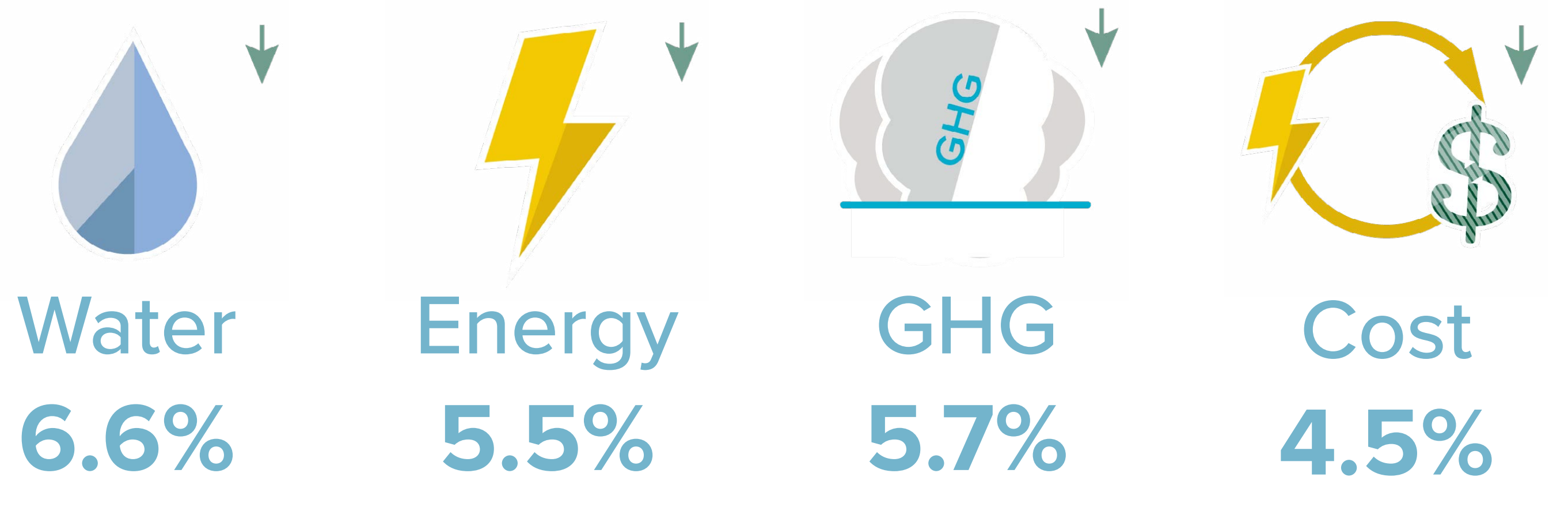
The wastewater system has a high EI. The recycled water configuration can treat up to 90% of the wastewater and only utilizes 25% of the energy needed for the wastewater system.

	Existing Conditions	Post Water Recycling	% Difference
Freshwater Use (GPY)	1.6M	160K	90%
Energy Use (kWh/y)	67K	25K	63%

Water and energy reductions as a result of onsite water recycling

Projected Resource Savings

1.5MG of water per year are utilized for barrel washing alone. **Using VSEP to recycle 90% of that water** would result in a **facility-wide reduction** of potable water demands by **6.6%**.

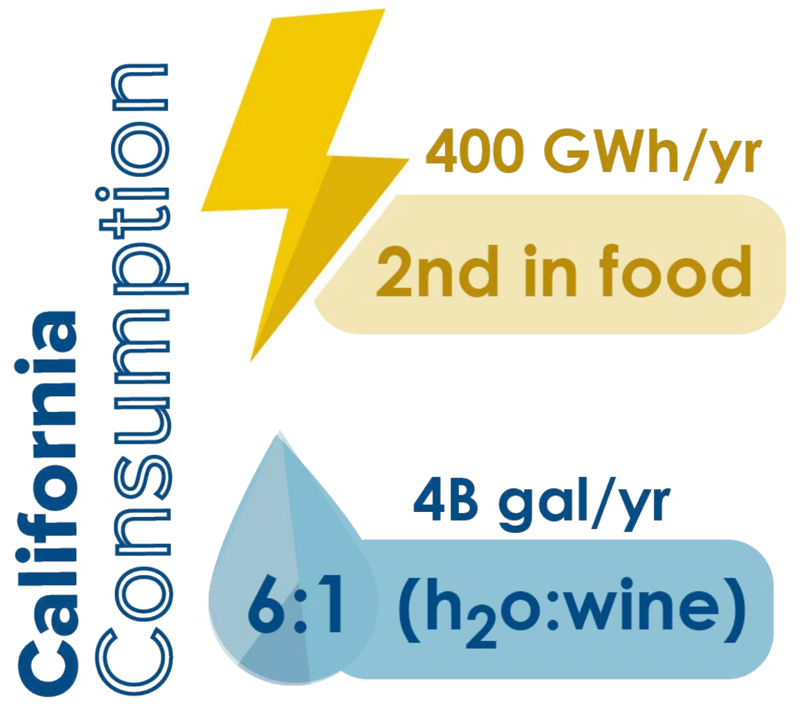


Water	Energy	GHG	Cost
6.6%	5.5%	5.7%	4.5%

Facility-wide projected savings

The Path Forward for California

The success of this project will **open a path** to onsite reuse for other progressive industries **by demonstrating** the potential **benefits and safety** of these systems to regulators, businesses, and consumers. **Water intensive industries** in California can reduce **fresh water consumption** while also **reducing energy use** and in turn, reducing GHG generation. For the wine industry alone, uptake of onsite technologies could result in annual water savings of up to **3.6 billion gallons**.



Resource consumption of the California wine industry