UCDAVIS
CENTER FOR WATER-ENERGY EFFICIENCY

Advancing Water-Energy Information and Analytics

Center for Water-Energy Efficiency
University of California, Davis

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- CWEE Background
- CA water-energy
- Energy efficient water utilities
- Energy efficient water users
- Advancing IT solutions

CWEE
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Background

UC DAVIS
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- Part of UC Davis Energy "U-Hub":
  - Institute for Transportation Studies (ITS)
  - Energy Efficiency Center (EEC)
  - Western Cooling Efficiency Center (WCEC)
  - Plug-in Hybrid Electric Vehicle Center (PHEV)
  - CA Lighting Technology Center (CLTC)
- Established 2011
- Mission:
  - "to research, develop, and disseminate efficient technologies and effective policy for integrated water and energy conservation."

Center for Water-Energy Efficiency

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Affiliate Sponsors

- Los Angeles Department of Water and Power
- Microsoft Corporation
- Pacific Gas & Electric
- Southern CA Edison
- Southern CA Gas Company
- San Diego Gas & Electric

Research Partners

- Austin Water
- Burbank Water & Power
- CA Department of Water Resources (DWR)
- CA Energy Commission (CEC)
- CA Institute for Energy and the Environment
- CA Public Utilities Commission (CPUC)
- CA State Water Resources Control Board
- Cynthia and George Mitchell Foundation
- East Bay Municipal Utility District (EBMUD)
- Glendale Water & Power
- IBM
- Metropolitan Water District
- Otay Water District
- OSIsoft
- San Diego County Water Authority
- WaterSmart Software
- Wexus Technologies

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* ASCE CA water infrastructure report card

Capital Investment Gaps

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State Energy Efficiency Program Funding

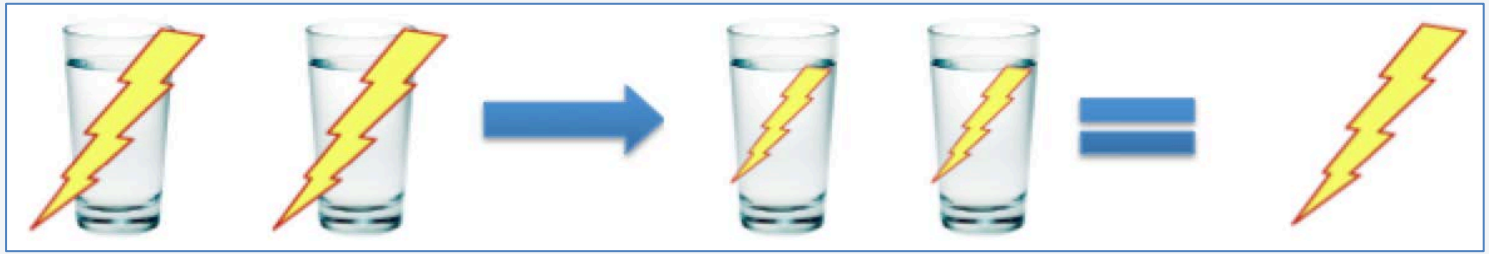
$1B/yr

State Water Efficiency Program Funding

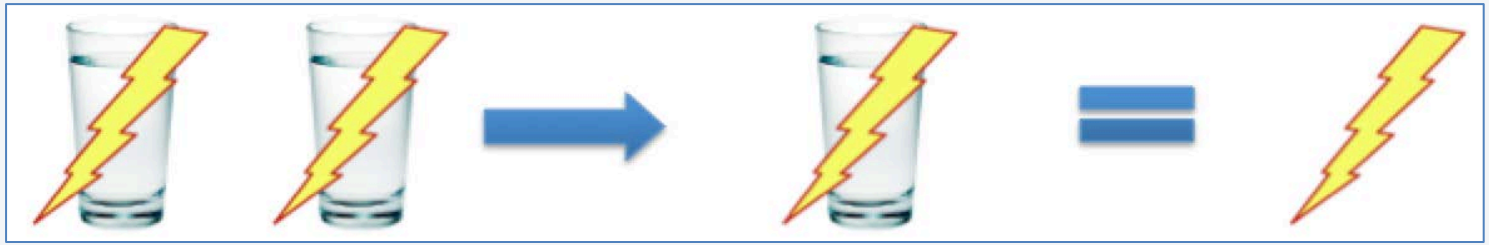
~$0/yr

Capital in the Energy Sector

Energy Efficiency of Water System



Energy Savings through Water Efficiency



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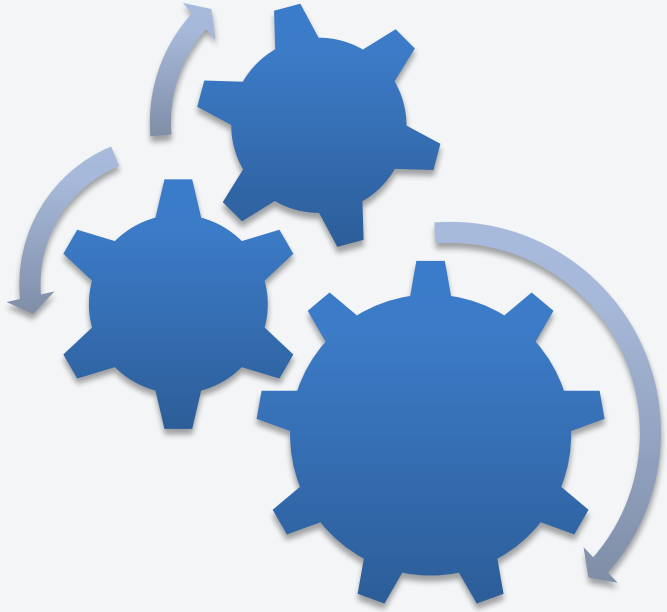
- Water supply and water use efficiency
- Unstable water rate structures
- Capital investment gaps
- Complexity of water data
- Capital abundance in the energy sector
- Energy value of water
- Data security obstacles



Summary

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- California leading state in water-energy activity
  - Water conservation act (2009)
    - 20% reduction by 2020
  - CPUC energy efficiency
  - Carbon cap & trade: AB 32
  - Coordinated government agencies
    - WET-CAT

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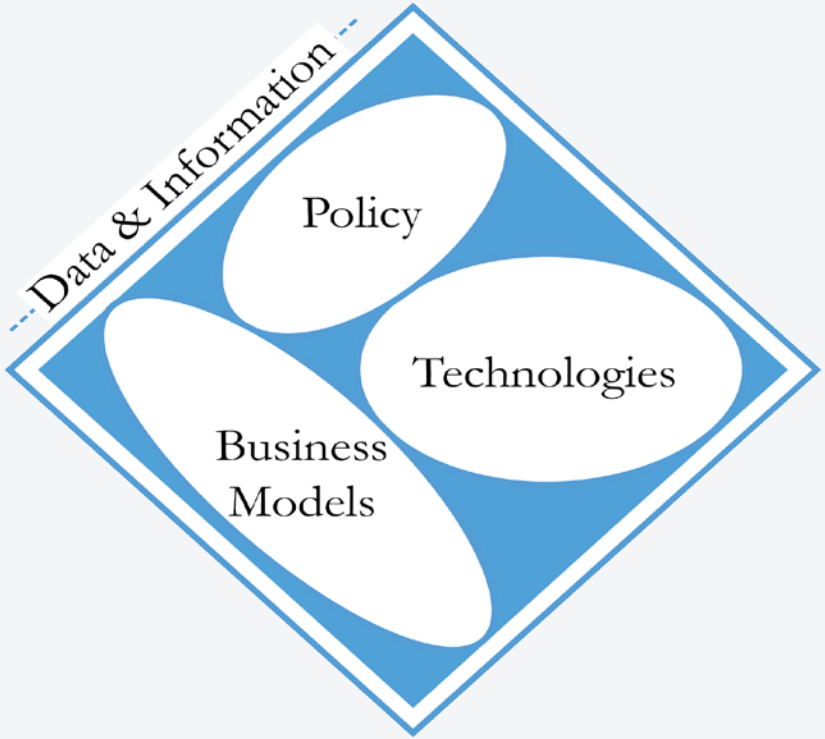
- But…progress limited by availability of actionable information
  - Fragmented data
  - Need for systems approach
  - Improved customer communication
- Need better information flows
  - Improved data integration and visibility
  - Dynamic and cross-cutting analytics



The Information Bottleneck

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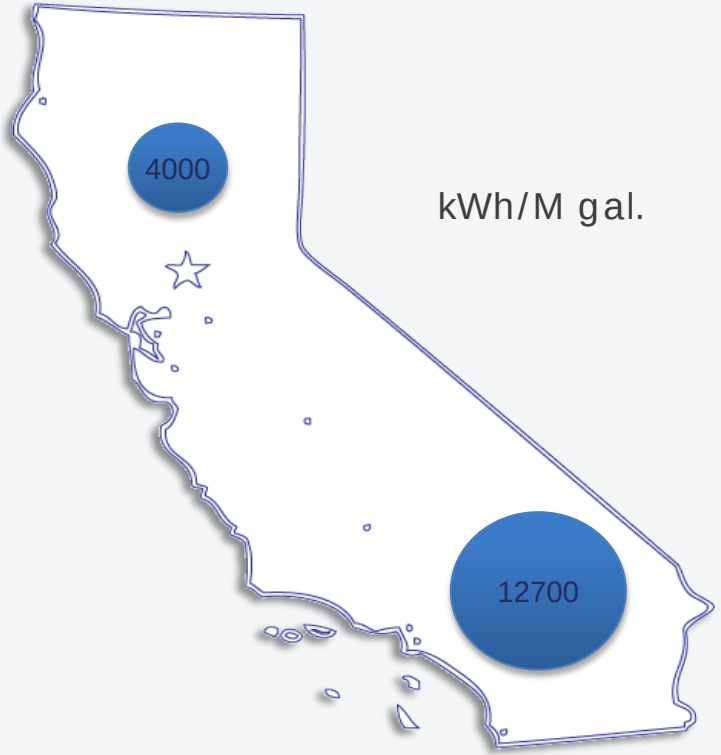
- Energy Use for Water in CA:
  - 20% of electricity (7% infrastructure)
  - 30% of natural gas
  - 2.1M bbl/yr of diesel
  - 100M t. CO2-eq.
- Motivation
  - Joint conservation of water & energy
  - DROUGHT



Energy for Water in California

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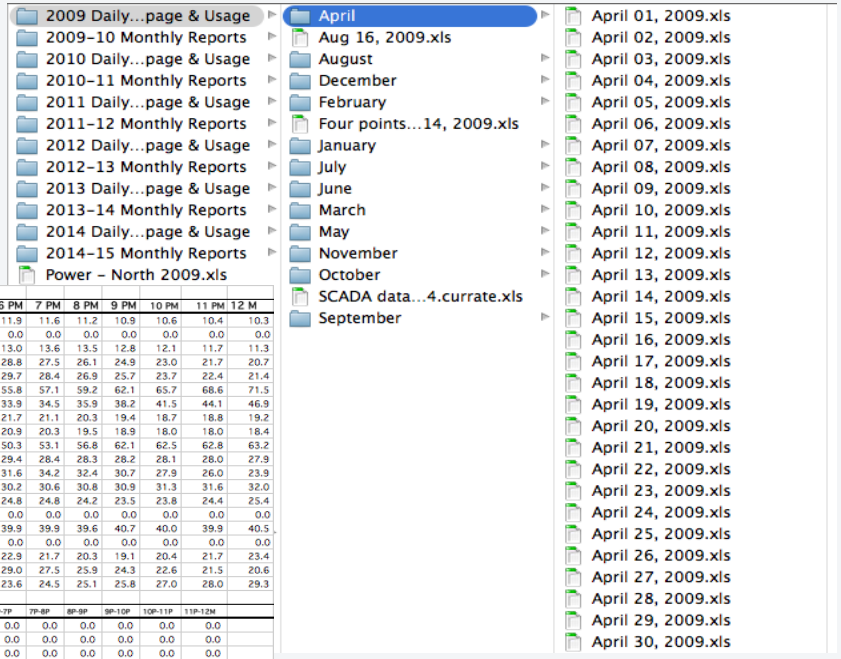
- Databases are fragmented
  - GIS, Billing, SCADA, Asset, Conservation…
- Data is also cumbersome, incomplete, and underutilized



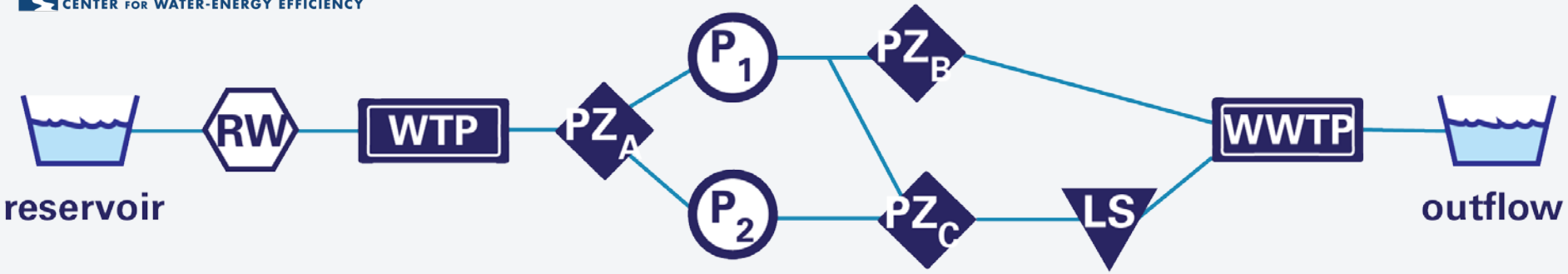
PAGE 1

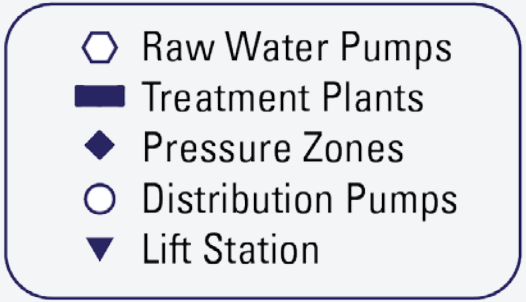
RESERVOIR LEVELS (FT.)	12 M	1 AM	2 AM	3 AM	4 AM	5 AM	6 AM	7 AM	8 AM	9 AM	10 AM	11 AM	12 N	1 PM	2 PM	3 PM	4 PM	5 PM	6 PM	7 PM	8 PM	9 PM	10 PM	11 PM	12 M
NORTH AUSTIN	9.3	9.5	9.6	9.8	9.9	10.0	10.1	10.2	10.4	10.5	10.7	10.8	10.9	11.1	11.2	11.3	11.4	11.6	11.9	11.6	11.2	10.9	10.6	10.4	10.3
EAST AUSTIN	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SPICEWOOD SPRINGS	11.7	12.4	13.0	13.9	13.6	13.4	13.1	12.1	10.5	9.9	8.6	8.4	8.3	8.6	9.8	10.4	11.3	12.2	13.0	13.6	13.5	12.8	12.1	11.7	11.3
HOWARD LANE # 1	17.9	19.4	20.7	22.4	23.7	25.0	26.1	26.2	26.3	26.5	26.7	26.9	27.2	27.4	27.8	28.1	28.3	28.5	28.8	27.5	26.1	24.9	23.0	21.7	20.7
HOWARD LANE # 2	18.5	20.0	21.4	23.0	24.5	25.8	26.9	27.0	27.1	27.3	27.5	27.7	28.0	28.3	28.6	28.9	29.2	29.4	29.7	28.4	26.9	25.7	23.7	22.4	21.4
MARTIN HILL	71.5	69.5	67.9	66.2	65.4	64.4	63.2	62.7	62.2	62.0	62.2	61.9	61.4	60.7	59.7	58.9	58.0	56.9	55.8	57.1	59.2	62.1	65.7	68.6	71.5
JOLLYVILLE	47.8	46.4	45.5	44.5	44.2	43.5	42.6	42.2	42.2	42.2	42.5	42.2	41.7	41.2	39.6	38.6	37.2	35.5	33.9	34.5	35.9	38.2	41.5	44.1	46.9
POND SPRINGS	27.0	26.8	26.7	26.6	26.2	25.1	23.5	22.0	20.1	19.7	19.4	19.6	20.1	20.2	20.8	21.1	21.3	21.6	21.7	21.1	20.3	19.4	18.7	18.8	19.2
ANDERSON MILL	26.3	26.2	26.1	25.8	25.5	24.3	22.7	21.1	19.2	18.9	18.5	18.8	19.2	19.2	19.9	20.3	20.4	20.8	20.9	20.3	19.5	18.9	18.0	18.0	18.4
FOREST RIDGE	63.4	62.4	61.5	60.3	58.7	57.1	55.7	57.0	56.5	56.0	55.6	58.2	60.5	61.0	57.5	55.8	54.0	52.0	50.3	53.1	56.8	62.1	62.5	62.8	63.2
FOUR POINTS GROUND	31.3	29.2	27.6	25.8	26.9	28.1	29.4	30.5	32.3	33.3	35.0	35.0	35.0	34.9	34.8	34.8	33.1	31.0	29.4	28.4	28.3	28.2	28.1	28.0	27.9
FOUR POINTS ELEVATED	16.6	22.8	27.9	33.1	31.4	29.3	26.7	24.2	20.8	19.4	17.3	15.8	14.5	13.3	11.4	10.0	17.4	25.3	31.6	34.2	32.4	30.7	27.9	26.0	23.9
CENTER STREET	45.5	47.5	48.6	49.8	50.7	49.2	48.0	47.2	46.1	45.8	45.1	44.7	43.3	38.9	35.1	32.8	30.9	30.5	30.2	30.6	30.8	30.9	31.3	31.6	32.0
PILOT KNOB	23.4	24.4	25.2	26.5	27.4	28.1	28.5	28.4	28.3	28.2	28.2	28.1	28.1	27.6	26.9	26.4	26.0	25.4	24.8	24.8	24.2	23.5	23.8	24.4	25.4
DAVIS LANE # 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
DAVIS LANE # 2	42.7	40.8	39.8	38.7	39.4	41.3	42.4	42.6	42.9	41.3	36.0	32.9	29.0	32.0	35.2	37.5	39.1	39.8	39.9	39.9	39.6	40.7	40.0	39.9	40.5
LEUTHAN LANE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SLAUGHTER LANE	26.2	28.7	30.5	32.4	32.0	29.6	25.1	20.6	15.8	16.2	20.7	23.3	26.3	25.6	25.0	24.6	24.3	23.8	22.9	21.7	20.3	19.1	20.4	21.7	23.4
LA CROSSE	19.8	18.1	16.4	14.1	11.3	11.4	15.4	18.2	22.5	29.9	29.5	32.6	35.0	34.0	33.0	32.1	31.3	30.2	29.0	27.5	25.9	24.3	22.6	21.5	20.6
THOMAS SPRINGS ELEVATED	31.7	30.5	29.3	27.7	26.3	24.7	22.7	21.0	18.9	18.0	16.7	16.0	15.0	16.9	18.7	20.0	21.2	22.6	23.6	24.5	25.1	25.8	27.0	28.0	29.3

GREEN WTP PUMPAGE RATE (MGD)	12M-1A	1A-2A	2A-3A	3A-4A	4A-5A	5A-6A	6A-7A	7A-8A	8A-9A	9A-10A	10A-11A	11A-12N	12N-1P	1P-2P	2P-3P	3P-4P	4P-5P	5P-6P	6P-7P	7P-8P	8P-9P	9P-10P	10P-11P	11P-12M
PUMPS 52-55	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUMPS 54	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUMPS 53-58	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
PUMPS 57	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL PUMP RATE	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

DAVIS WTP PUMPAGE RATE (MGD)	12M-1A	1A-2A	2A-3A	3A-4A	4A-5A	5A-6A	6A-7A	7A-8A	8A-9A	9A-10A	10A-11A	11A-12N	12N-1P	1P-2P	2P-3P	3P-4P	4P-5P	5P-6P	6P-7P	7P-8P	8P-9P	9P-10P	10P-11P	11P-12M
MEDIUM SERVICE PUMP 11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MEDIUM SERVICE PUMP 12	21.2	21.3	21.3	21.3	21.4	21.4	21.3	21.2	21.3	21.3	21.3	21.3	21.2	21.2	21.3	21.3	21.3	20.5	20.5	20.5	20.3	20.2	20.1	20.1
MEDIUM SERVICE PUMP 13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.6	11.6	11.4	11.5	11.4	11.4	11.4
MEDIUM SERVICE PUMP 14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MEDIUM SERVICE PUMP 15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MEDIUM SERVICE PUMP 16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MEDIUM SERVICE PUMP 17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL MED. SERV. PUMPAGE RATE	21.2	21.3	21.3	21.3	21.4	21.4	21.3	21.2	21.3	21.3	21.3	21.3	21.2	21.2	21.3	21.3	21.3	32.1	32.1	31.9	31.8	31.6	31.5	31.5

Complexity of Water Data





- Energy intensity is based on network design
- Sequencing and location matter

Sequencing Energy Flows

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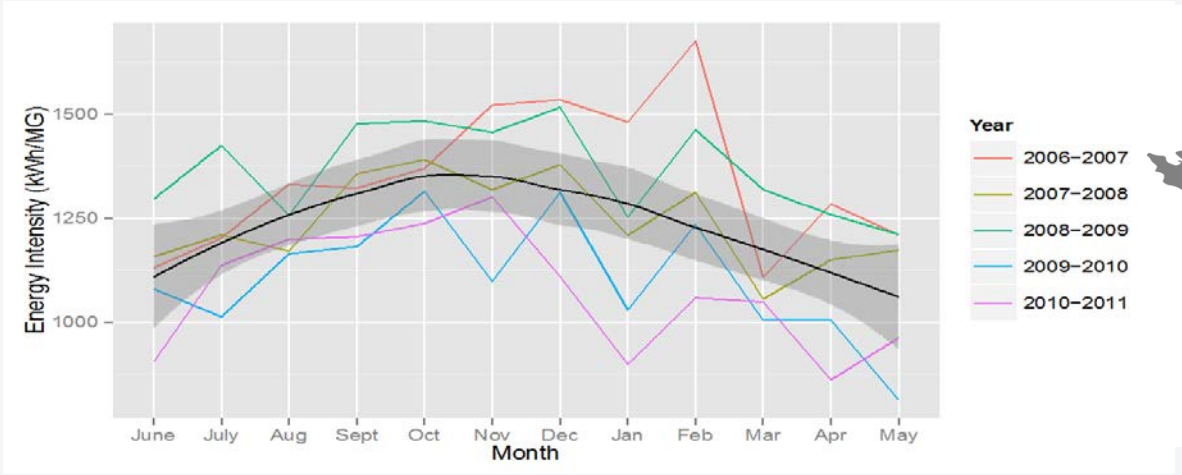
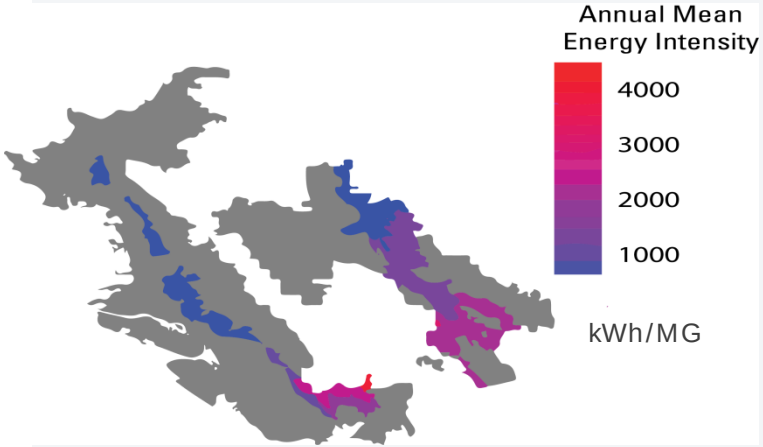
- Understanding the energy flows in high resolution
- Variability of infrastructure energy intensity:
  - Temporal: 10-12% monthly variation around the annual mean
  - Spatial: >12X difference across the distribution network

Pacific Gas and Electric Company

EBMUD





Case Study: East Bay MUD

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Select Facilities to Compare:

☑ 1004-2 ☐ 1050-1 ☑ 1090-1 ☐ 1100-1 ☐ 1200-1
☐ 1296-1 ☐ 1485-1 ☐ 1530-1 ☐ 1655-1 ☐ 711-1
☐ 803-1 ☑ 832-1 ☐ 850-2 ☐ 860-1 ☑ 870-1
☐ 944-1 ☐ 978-1 ☐ 980-2

Select All | Deselect All

Select Years:

☑ 2009 ☑ 2010 ☑ 2011 ☑ 2012 ☑ 2013 ☑ 2014

Select All | Deselect All

Select Months:

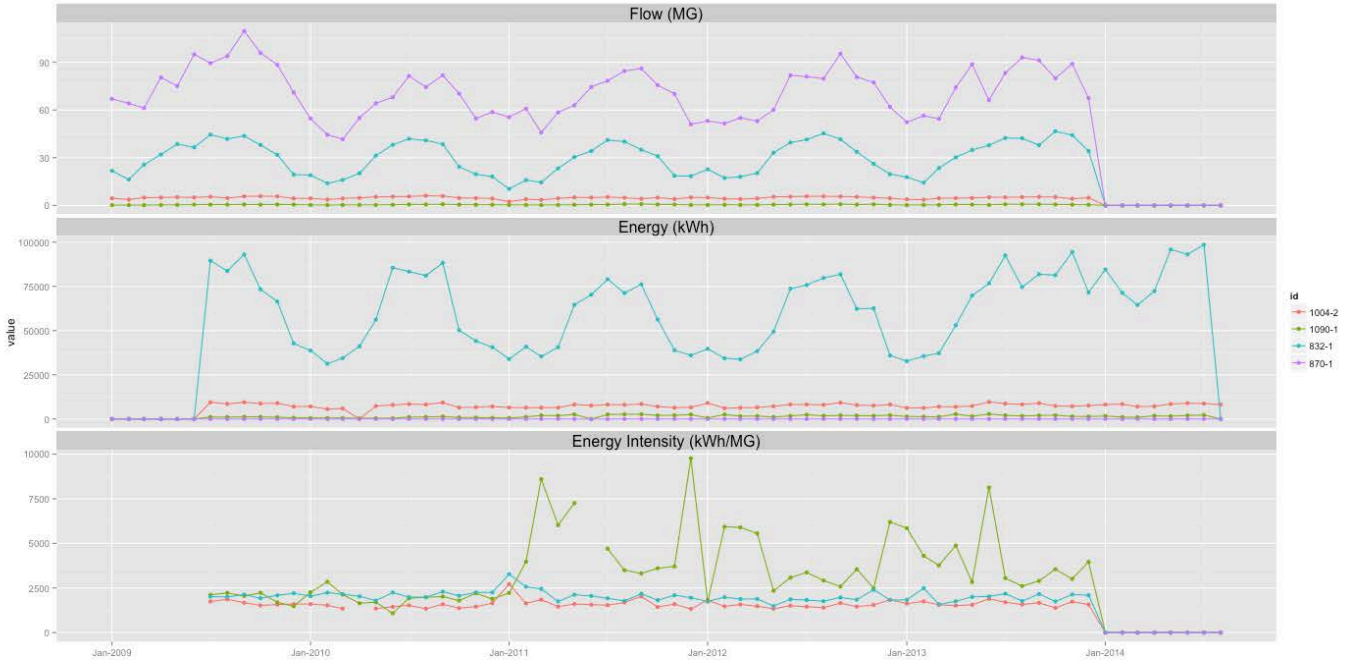
☑ Jan ☑ Feb ☑ Mar ☑ Apr ☑ May ☑ Jun ☑ Jul
☑ Aug ☑ Sep ☑ Oct ☑ Nov ☑ Dec

Select All | Deselect All

☑ Include zero on y-axis

Update View

By Hour | By Day | Heatmap | Facility | Geography



Download Data

Comparing Multiple Pumps

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Variable:
- (•) Energy Intensity (kWh/MG)
- ( ) Water Consumption (MG)
- ( ) Energy Consumption (kWh)

Select Years:
☑ 2009 ☑ 2010 ☑ 2011 ☑ 2012 ☑ 2013
Select All | Deselect All

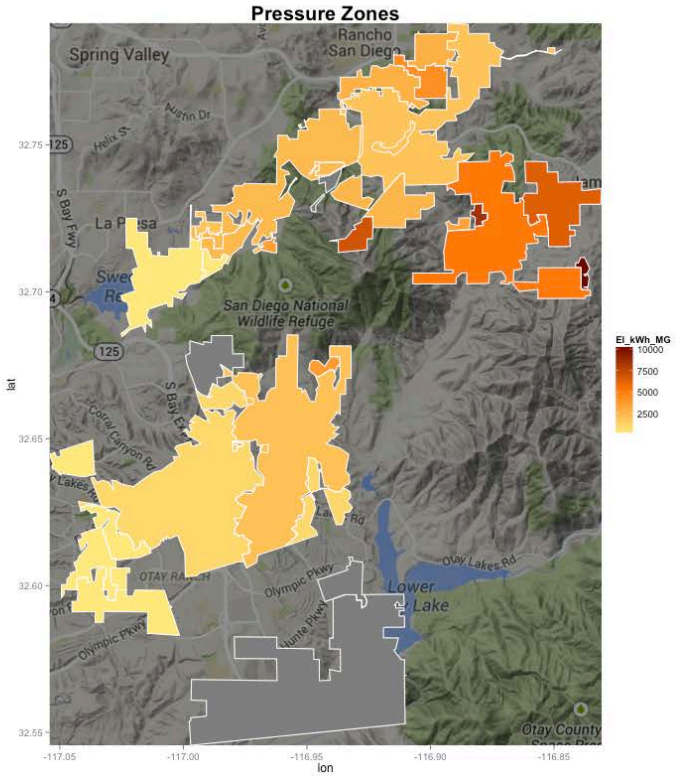
Select Months:
☑ Jan ☑ Feb ☑ Mar ☑ Apr ☑ May ☑ Jun ☑ Jul
☑ Aug ☑ Sep ☑ Oct ☑ Nov ☑ Dec
Select All | Deselect All

Transparency:
0 —— 1

Background Map Darkness:
0 —— 0.5 —— 1

Update View

By Hour | By Day | Heatmap | Facility | Geography



Energy Intensity (kWh/MG)

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Variable:
- ○ Energy Intensity (kWh/MG)
- ◉ Water Consumption (MG)
- ○ Energy Consumption (kWh)

Select Years:
☑ 2009 ☑ 2010 ☑ 2011 ☑ 2012 ☑ 2013
Select All | Deselect All

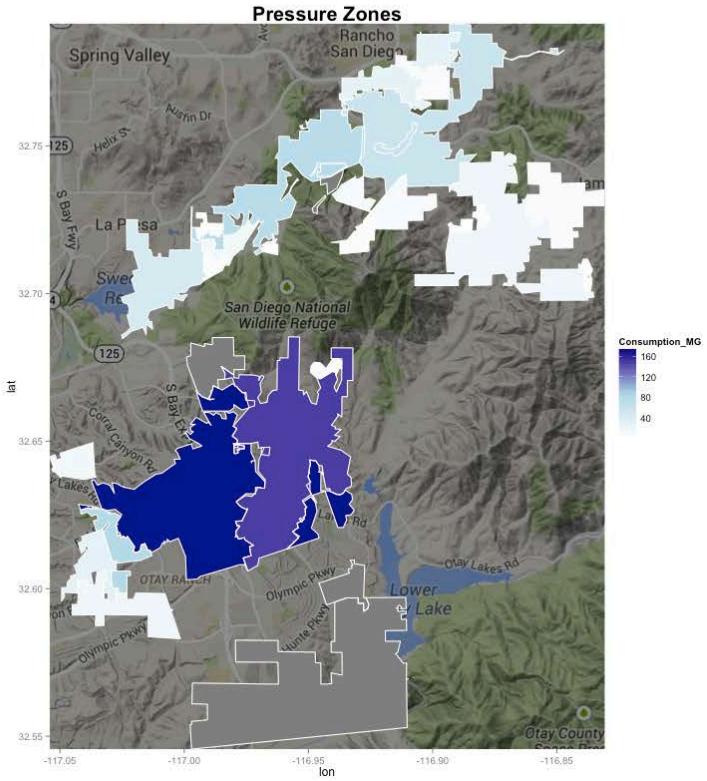
Select Months:
☑ Jan ☑ Feb ☑ Mar ☑ Apr ☑ May ☑ Jun ☑ Jul
☑ Aug ☑ Sep ☑ Oct ☑ Nov ☑ Dec
Select All | Deselect All

Transparency:
0 —— 1

Background Map Darkness:
0 —— 0.5 —— 1

Update View

By Hour | By Day | Heatmap | Facility | Geography



Water Consumption (MG)

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Variable:
- ○ Energy Intensity (kWh/MG)
- ○ Water Consumption (MG)
- ◉ Energy Consumption (kWh)

Select Years:
☑ 2009 ☑ 2010 ☑ 2011 ☑ 2012 ☑ 2013

Select All | Deselect All

Select Months:
☑ Jan ☑ Feb ☑ Mar ☑ Apr ☑ May ☑ Jun ☑ Jul
☑ Aug ☑ Sep ☑ Oct ☑ Nov ☑ Dec

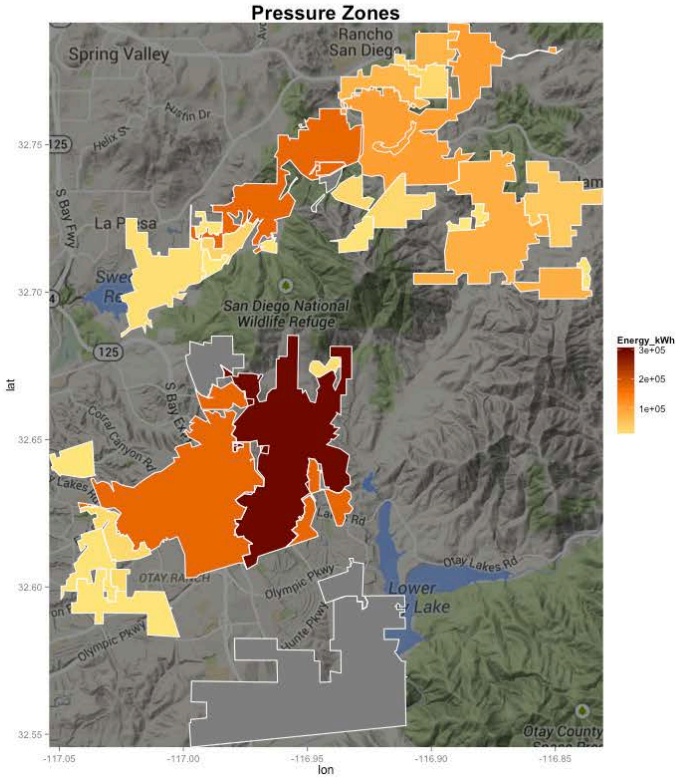
Select All | Deselect All

Transparency:

Background Map Darkness:

Update View

By Hour | By Day | Heatmap | Facility | Geography



Embedded Energy (kWh)

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Resource ID:

1004-2

Select Years:

2012 2013 2014

Select All | Deselect All

Select Months:

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Select All | Deselect All

Color By:

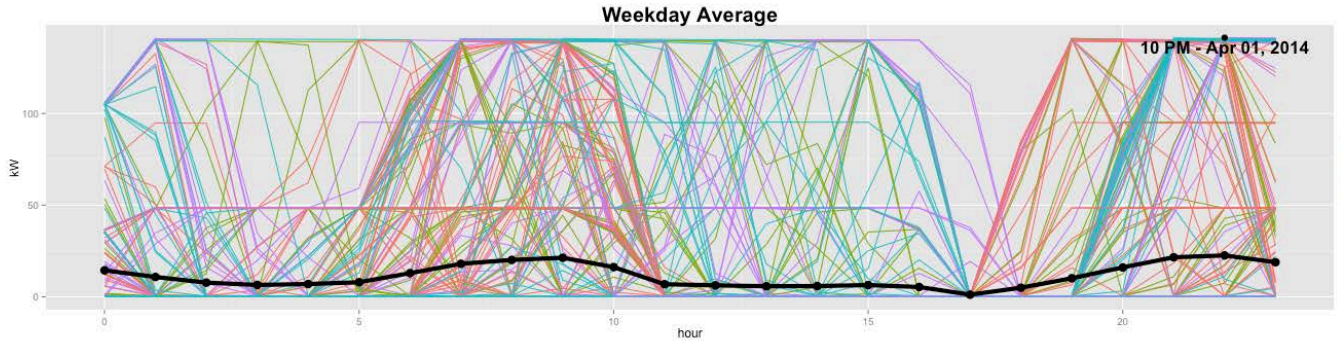
- None
- Season
- Month
- Year

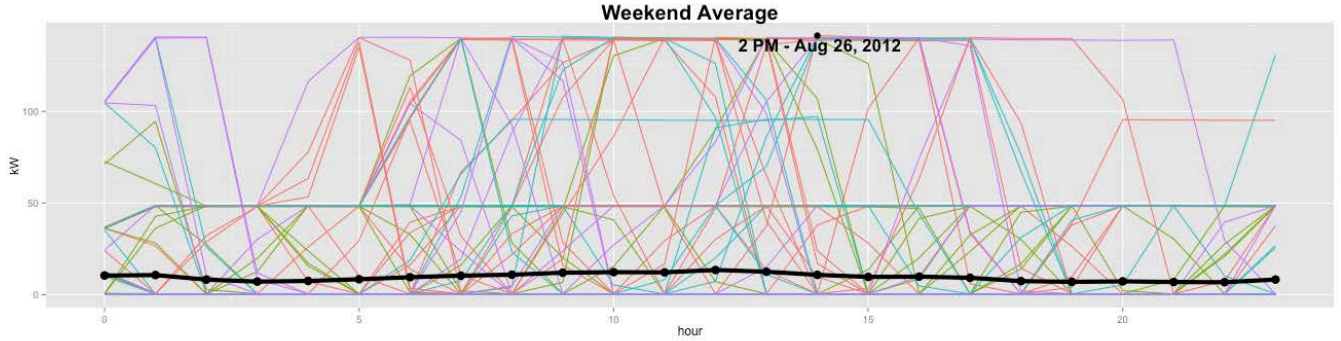
Labels:

Label Max kW

Update View

By Hour | By Day | Heatmap | Facility | Geography





Download All Data
Download Summary Data

Seasonal Load Curves for a Pump

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Resource ID:

1004-2

Select Years:

2012 2013 2014

Select All | Deselect All

Select Months:

Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec

Select All | Deselect All

Color By:

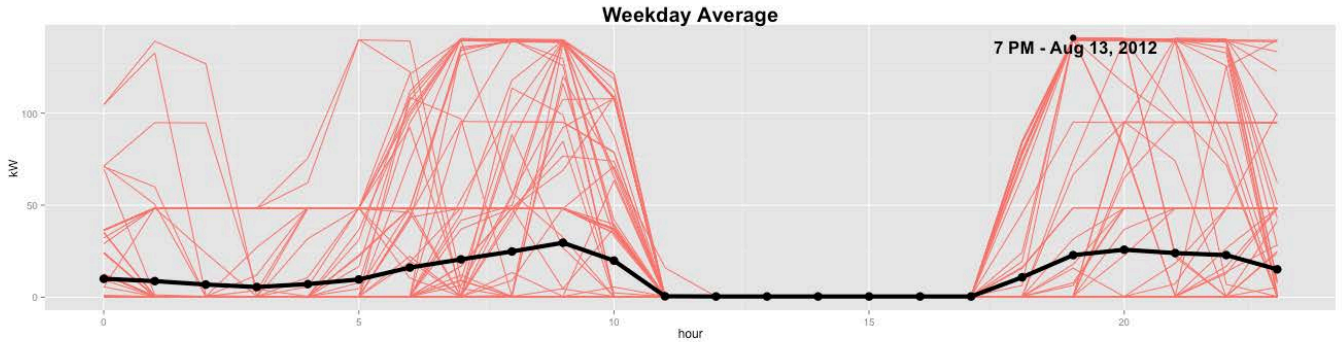
- None
- Season
- Month
- Year

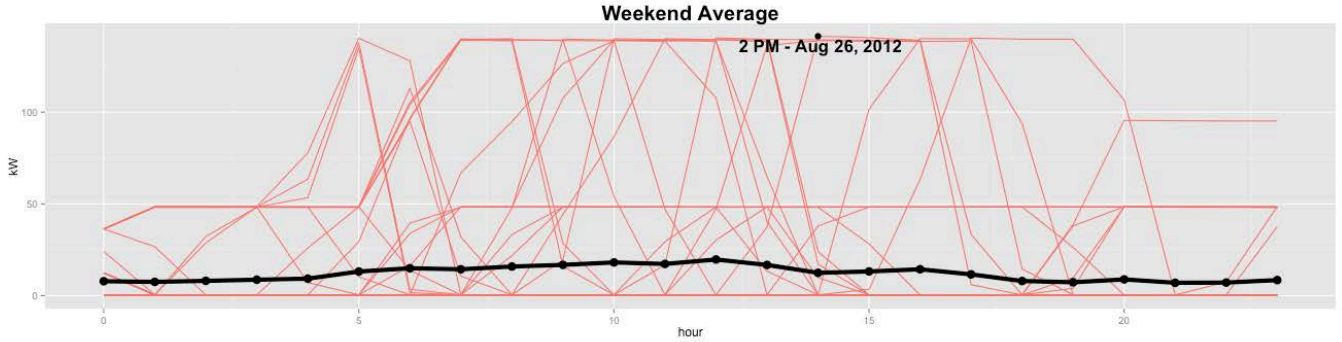
Labels:

Label Max kW

Update View

By Hour | By Day | Heatmap | Facility | Geography





Download All Data
Download Summary Data

Checking Response to Summer TOU Pricing

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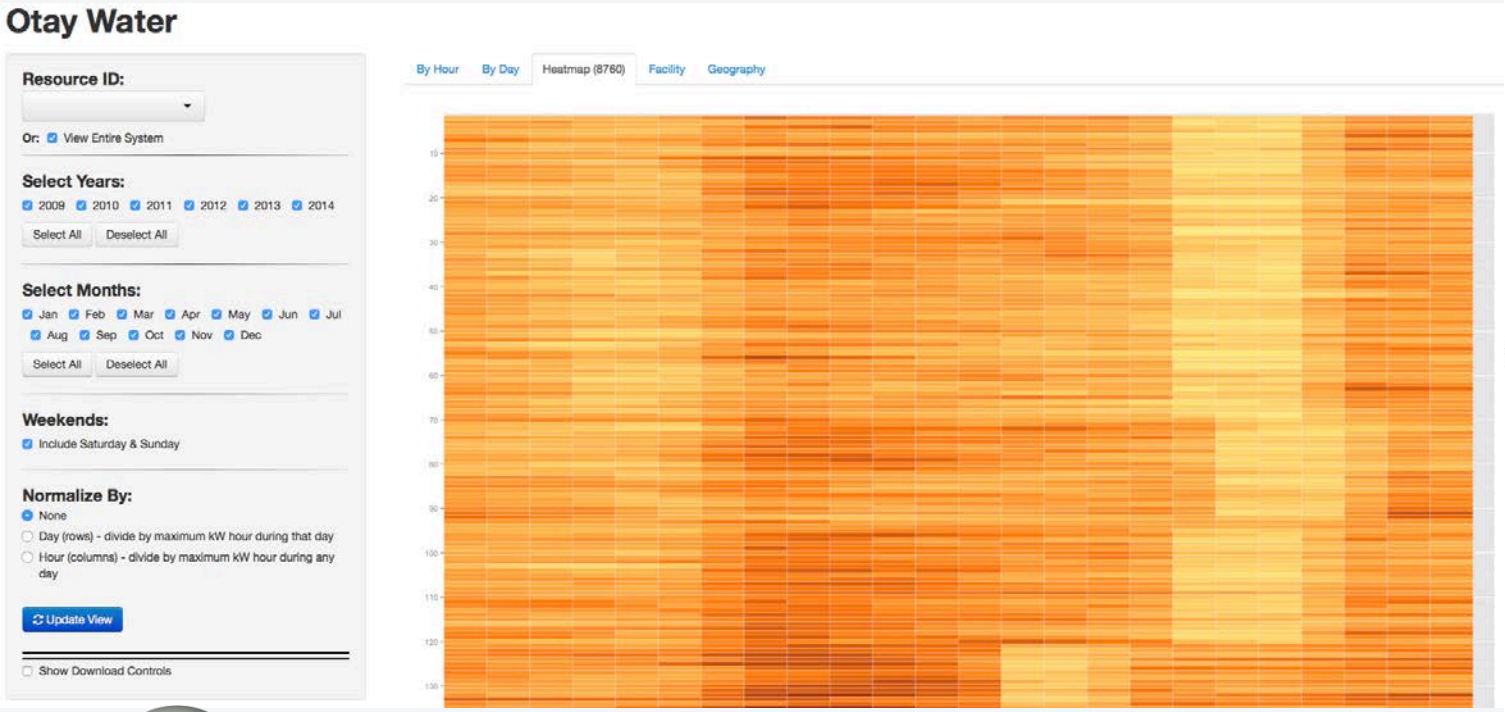
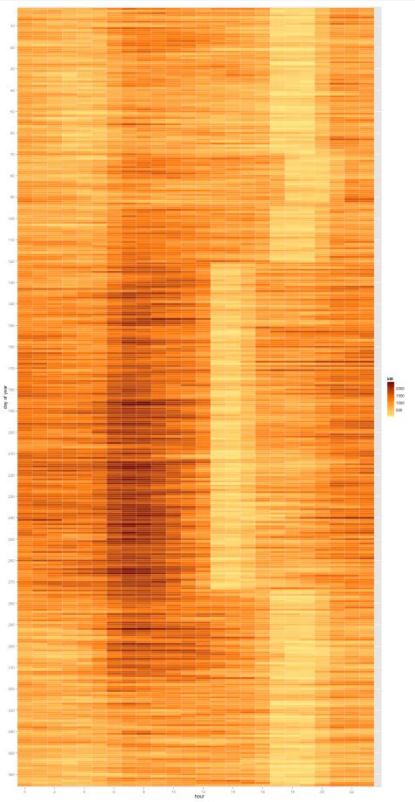
Application View



Full Year View



Hourly Energy Consumption Heat Map (8760)

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- Behavior-based hot water conservation
  - Messaging for water use savings
  - Estimation of hot water savings
  - Associated energy and GHG savings

CITY OF BURBANK Water and Power Since 1913

Southern California Gas Company

Household as Water/Energy Consumer

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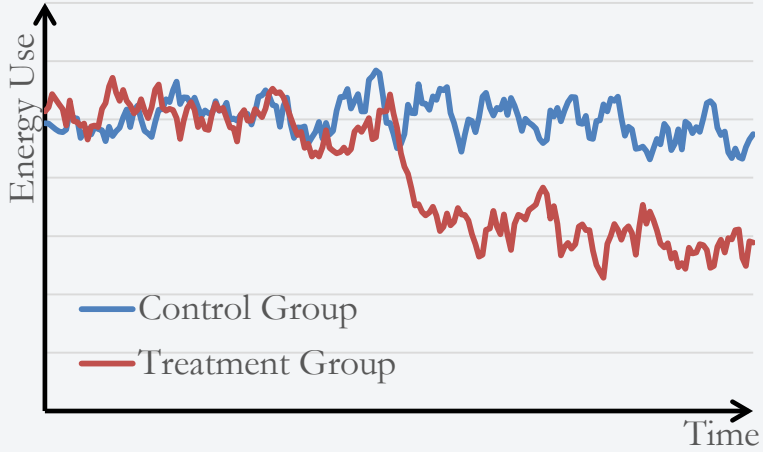
- Measuring the Impact:
  - Randomized control trial
  - High-resolution data
  - AMI data for water, gas, electricity
  - 19,000 single family homes



CITY OF BURBANK Water and Power Since 1913

Southern California Gas Company

Household as Water/Energy Consumer

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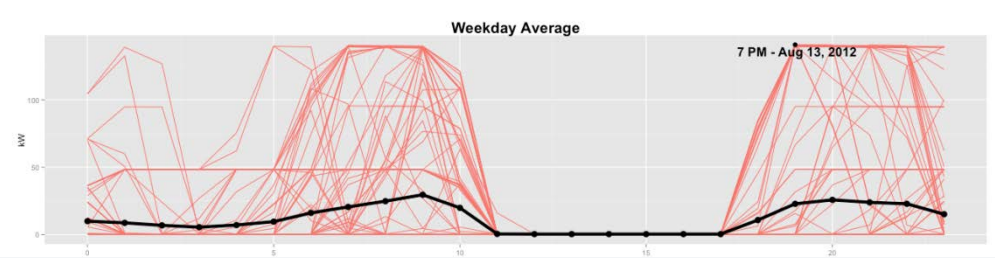
- Wexus Energy & Water Management Mobile Software Project
  - Energy Intensity Mapping
  - Peak Load Analysis
  - Predictive Irrigation
  - Ag Water-Energy Benchmarking
  - Monitoring and Verification
- Developing Pump Efficiency Modeling



Agriculture as Water/Energy Consumer

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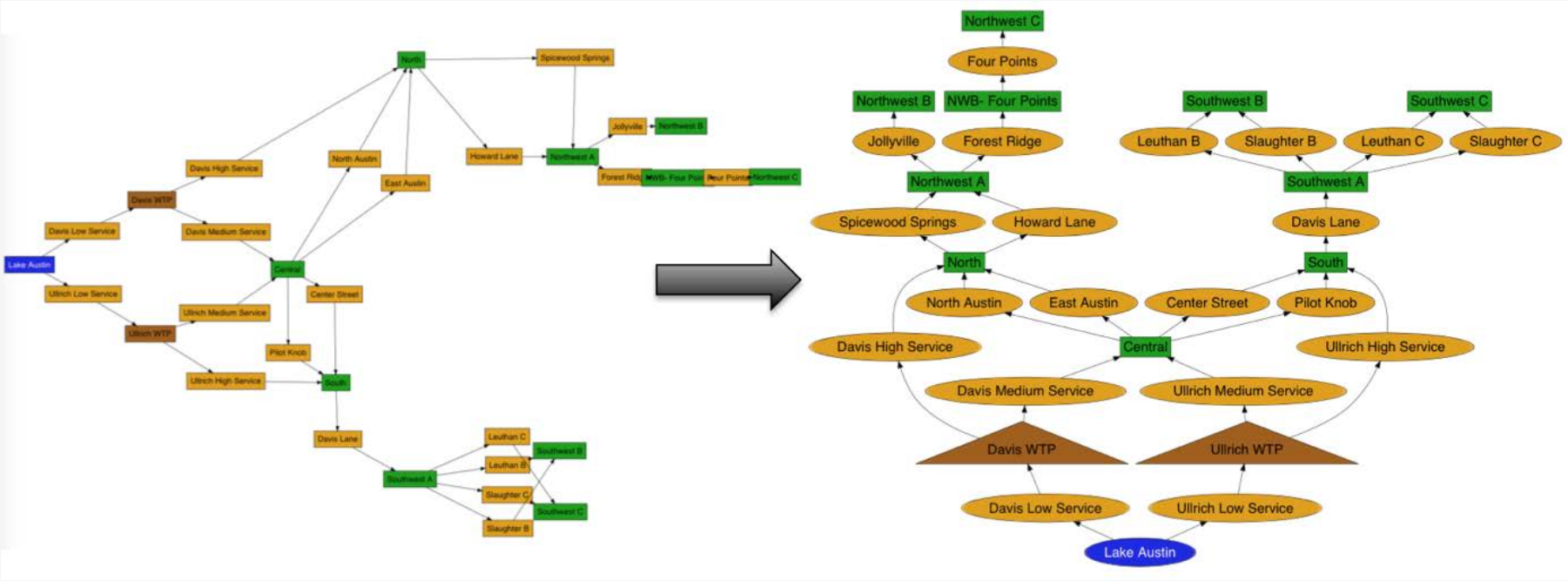

Digital Asset Framework

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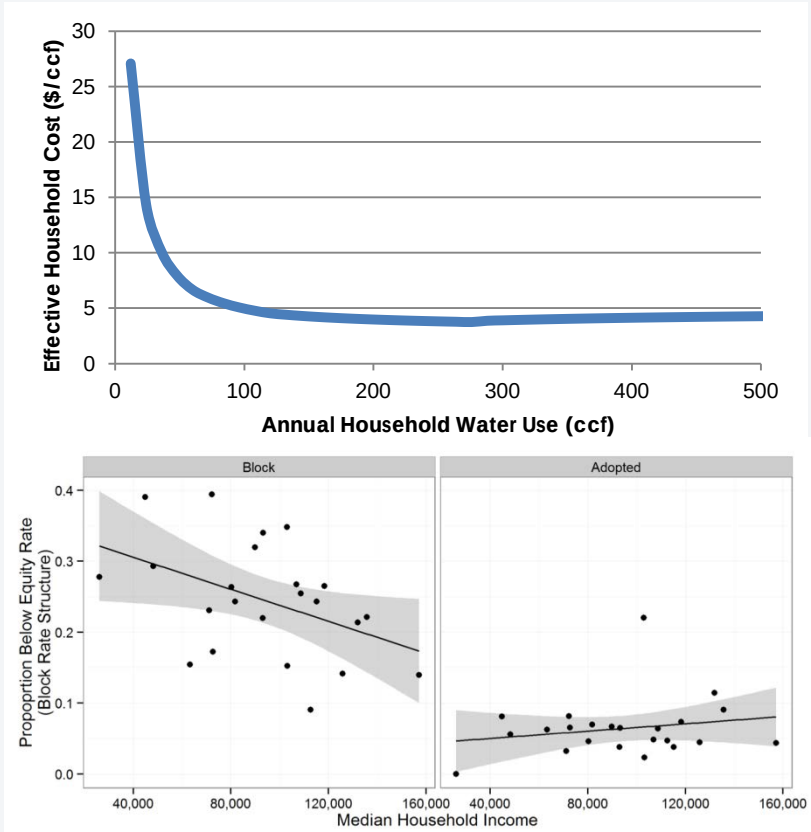
- Enterprise
  - **Billing and rate structures**
  - Capital planning
- Infrastructure
  - Network Data:
    - Network design
    - Asset attributes
  - Time series data:
    - Flow, pressure, & energy consumption
    - Water quality
- Customer
  - **Customer types and location**
  - **Water Meter Data (monthly or AMI)**
  - Energy Meter Data (gas/electric)
  - Water conservation programs



Rate Design Equity

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By Year | Rate Class

Rate Class help

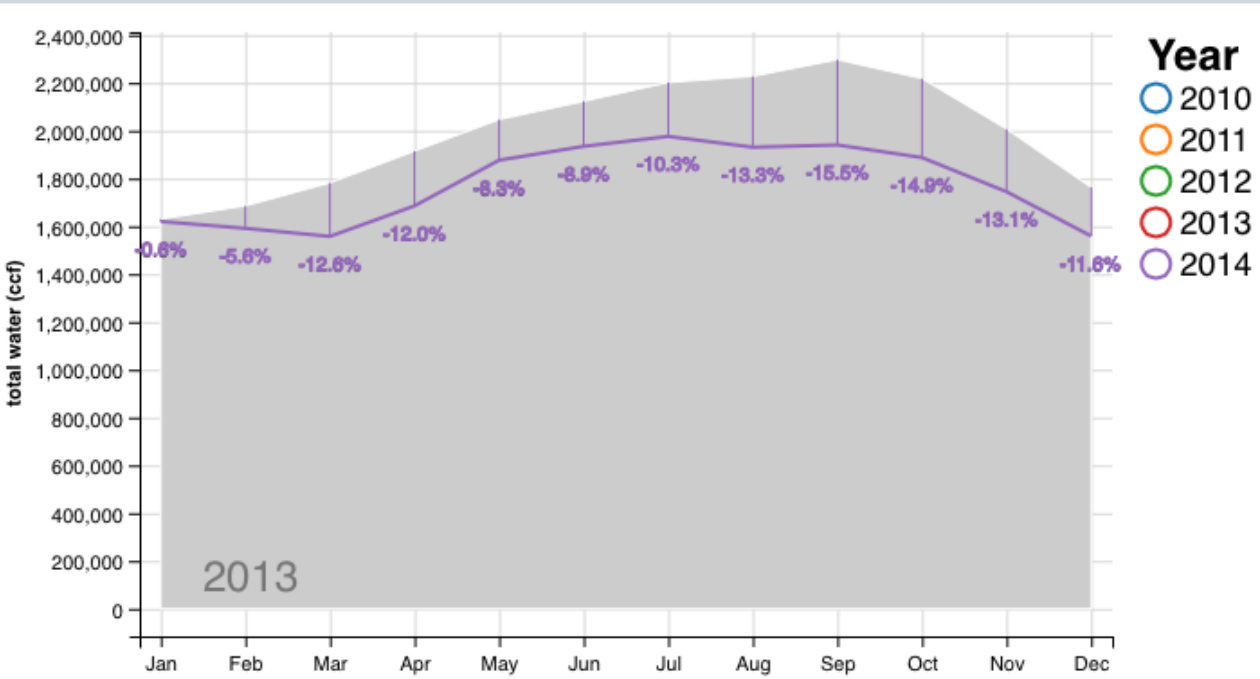
All

Base Year

2013

Compare Year

2014



Total Change (2013 to 2014) : **-10.9%**

Tracking Overall Water Use

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By Year | Rate Class

Rate Class help

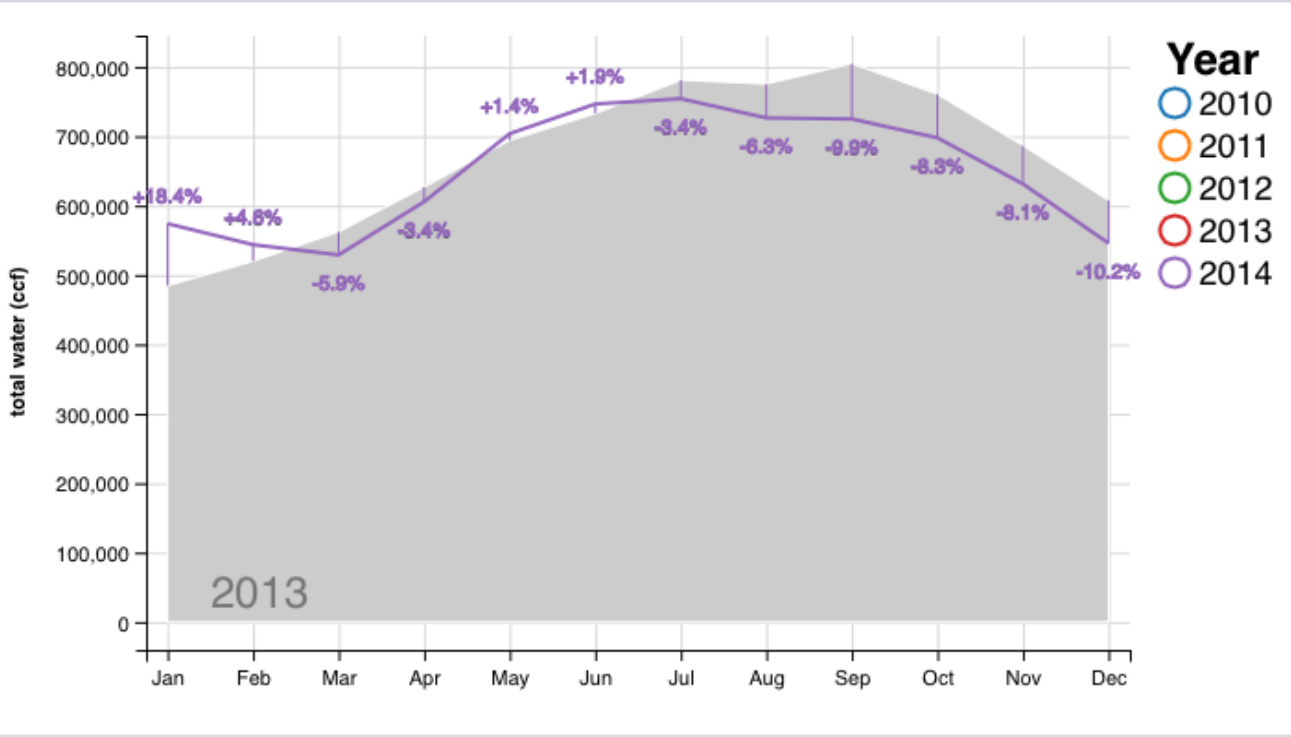
Res Single-family Detached

Base Year

2013

Compare Year

2014



Total Change (2013 to 2014) : **-3.2%**

Tracking Water Use: Customer Class

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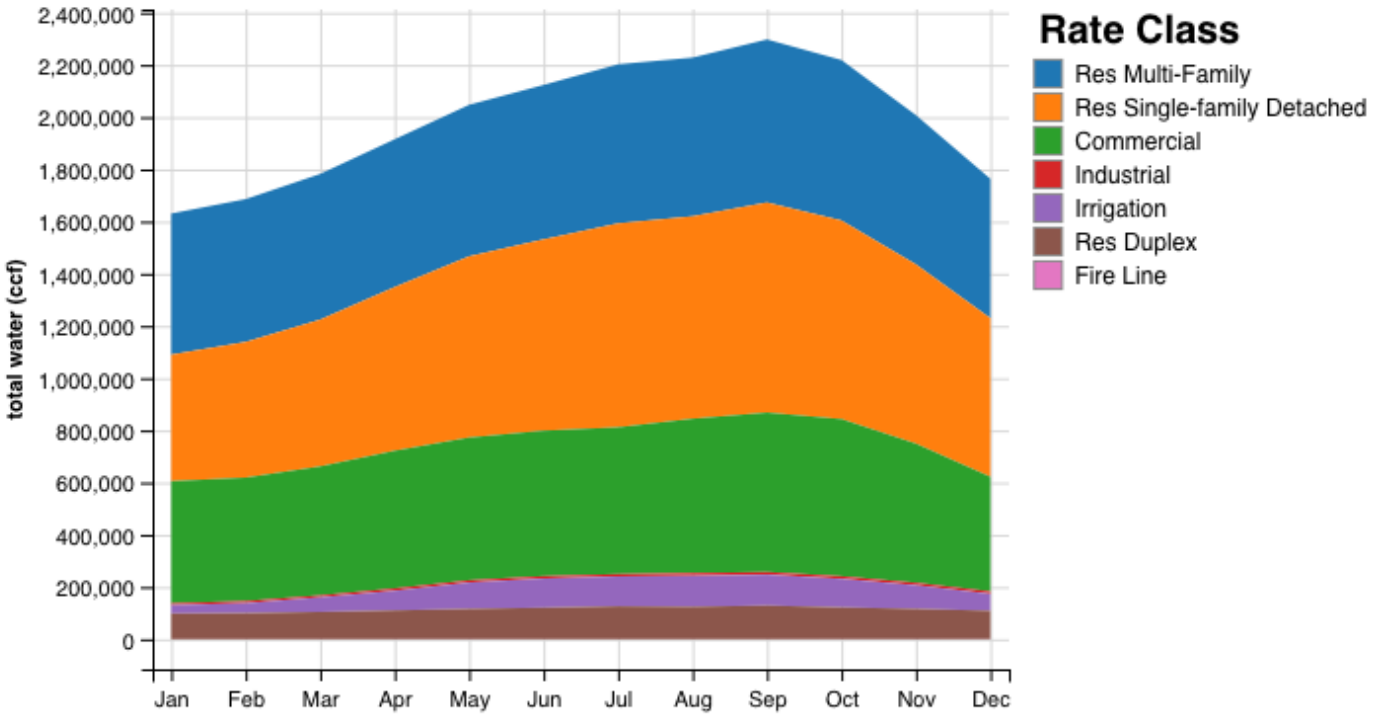
By Year | Rate Class

Year help

2013

Rate Class

- [x] Res Multi-Family
- [x] Res Single-family Detached
- [x] Commercial
- [x] Industrial
- [x] Irrigation
- [x] Res Duplex
- [x] Fire Line



Water Use: Customer Class

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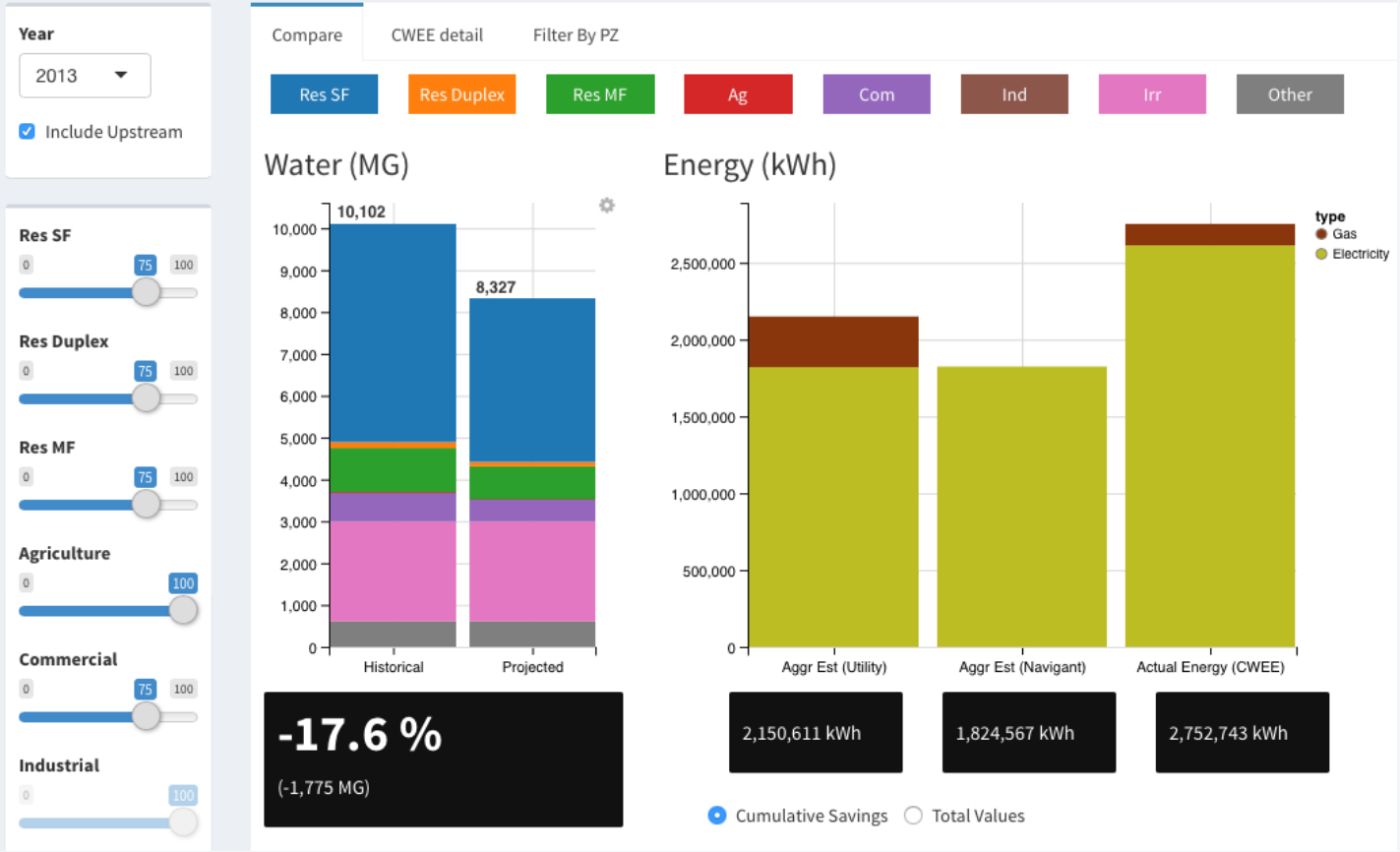

Estimating Energy Savings

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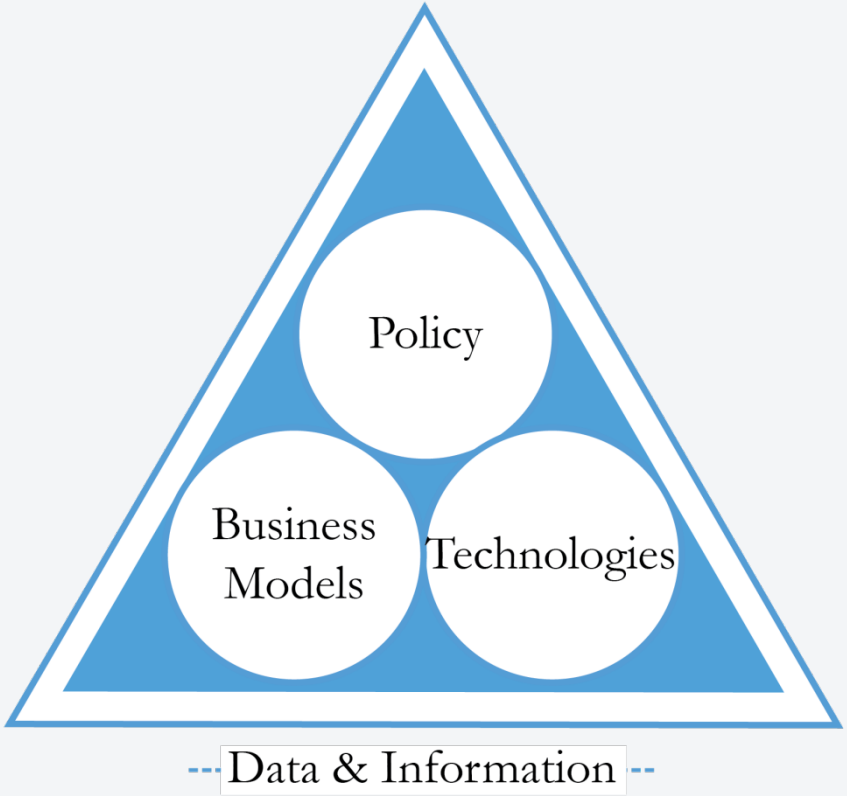
- Aligning water and energy data
  - Common data platform
  - Dynamic and accessible
  - Security and privacy provisions
  - Evolving suite of analytics
  - Diverse funding sources
  - Multiple stakeholders
- To drive innovation in policy, technology, and business models
- Engaging the fragmented, conservative water agencies.



Moving Forward

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Contact info:

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skohong@ucdavis.edu

Thank you