Applied water-energy nexus: a system integration framework

Presentation to the 2022 Emerging Water Technology Symposium

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Introduction | A story of Dave, Steve, and Bill

The railroad owners

The colleges

The 7-state energy producer

The Chamber of Commerce

The City and County mayors and councils

Dave: city planner, directing waterfront development

The project manager

Steve: civil engineer, directing city Public Works Dept.

Bill: civil engineer, directing a Muni water and energy utility

The local activists, for and against whatever

The local societies

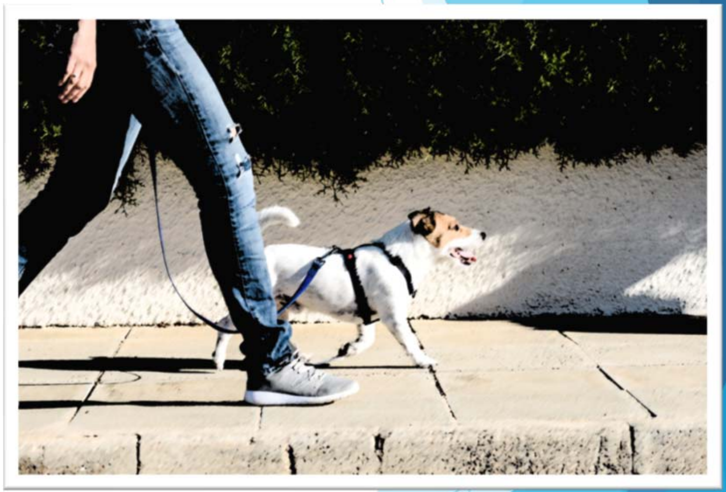
The local developers

The local businesses

The local residents

Presentation walk-through

Water-energy nexus 101 refresher	Acknowledging interdependencies
Shifting working parameters	Working with changing dynamics
How the nexus manifests in real life	Visualizing integration
The people process behind that	Exploring integration approaches
Workshopping the cornerstones	Facilitating an iterative process



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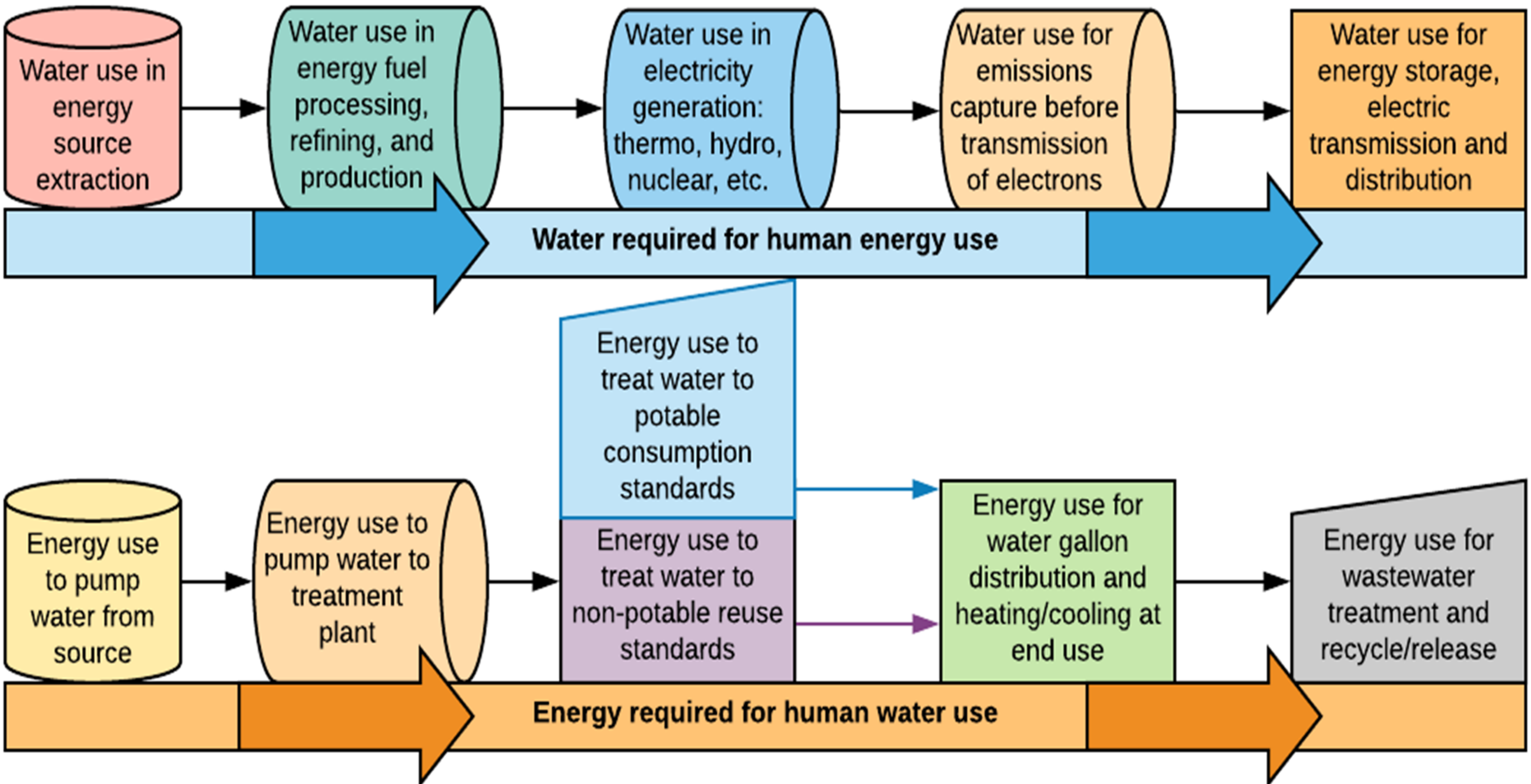
Water for energy and energy for water in urban settings



Water for energy: interdependencies, constraints, trade-offs:

Temperature Limitations

- Water use in power plants = largest share of freshwater withdrawals in the U.S.
- Water availability, flow, and temperature are critical; plant discharge hotter upon exit
- Energy plants must power down when water is too low /too hot, reducing energy to meet demand

Water Source Limitations

- Water sources can be energy intensive to access / energy sources can be water intensive to access
- Energy source access can be limited by lack of water / power can compete with communities for water
- Energy use can rise when alternative water sources are tapped or transported to users

Fuel Source Limitations

- Renewable energy and/or non-traditional energy extraction methods can have large water footprints
- Energy sources must diversify due to restricted access to fossil fuels + carbon emission regulations
- Water use can increase with growth of new fuel stock and/or fracking injection methods

Energy for water: interdependencies, constraints, trade-offs

Old Infrastructure Limitations

- Old water systems require more energy to:
  - treat unintended water entering the system
  - supply water lost in transit via leaky pipes
- High energy costs to operate older systems inhibit water utilities from making needed capital investments
- System maintenance is not covered by water rates, which don't reflect actual costs
  - Energy efficiency upgrades can help, though

Peak Time of Use Limitations

- Energy use to withdraw, move, and treat water can be between 30 and 50% of a community's energy bill
- Community peak energy use coincides with peak water use
- Water pumping schedule adjustments and renewable energy use to avoid peak energy use times and rates

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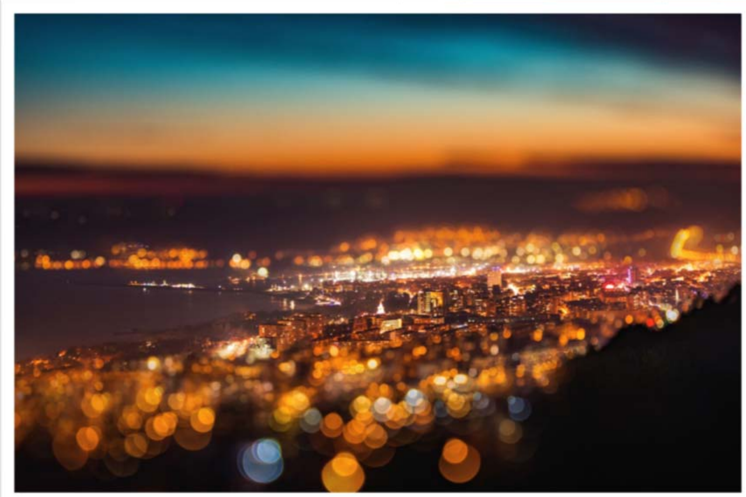
Influencers of local water-energy dynamics:

SYSTEMS	LOCAL DRIVERS
Environmental and climate conditions	Dry: cold or hot
	Wet: cold or hot
Social and economic systems	Growing populations
	Declining populations
	Affordability
Resource availability and regulatory / utility structures	Energy sources
	Water sources
	Regulation / Utility design



Water and energy impacts in a changing climate:

Climate Projection	Water Sector Impact	Energy Sector Impact
Increasing air and water temperatures	Increased water treatment to maintain adequate dissolved oxygen levels and remove bacteria	Reduced plant efficiencies and generation capacities, increased risk of regulatory violation in discharge temps
Decreasing water availability from less rain and snowpack	Increased difficulty in pressurizing water systems and meeting demand	Reduction in available generation capacity due to reduced fuel supplies
Increasing intensity of storm events, surge, and flooding	Increased risk of overflows, water contamination, loss of service, loss of life	Increased risk to the grid and to coastal and inland facilities, loss of service, loss of life

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Water and energy customer profiles:

WATER

More connected to product and view it as a human right

- Water rates are increasing
  - Up 43% over 10 yrs., water rates are rising faster than other household utility bills
- Still undervalued and taken for granted, especially by more affluent consumers
- Water utilities struggle to maintain and profit - water is viewed by many as a right:
  - **No water, no life**

ELECTRIC

Limited understanding of product and take it for granted, but do not see as a human right

- Pricing is more effective in consumption control than conservation encouragement is
- Pecan Street, a pilot electricity neighborhood in Austin, showed a 14% reduction in electricity with peak pricing
  - Consumer lives are powered by the internet of things:
    - **No power, no work**

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Utility business model transitions:

Traditional model:

Continue to invest in centralized systems "behind the meter"; maintain vertically integrated and regulatory structure

Resource provider model:

Still vertically integrated, yet beginning to offer additional resource services as part of regulated functions

Distribution model:

Let unregulated providers begin to supply resources and distributed services, focusing instead on selling access to infrastructure: networks, grids, pipelines

Integrated service model:

Provide network operation services and partner with third-party service providers to offer bundled and distributed service options to customers

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No more invisible utilities:

Both business models are slowly changing, moving from consumption-based income models to income from providing multiple services for customers

Customers have more choices, information, and control around their own consumption of water and energy – as well as who provides it

Water and energy utilities that engage with each other and their communities develop shared approaches to as they adaptively manage their systems

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Common pain points across utilities / local governments:

Providing reliable services through acute and chronic system stressors

Planning for and achieving regulatory compliance

Optimizing systems and diversifying sources to lower costs and vulnerabilities

Funding run to failure, deferred, or proactive maintenance

Changing business models, including accounting for conservation and decentralization

Responding to customer/investor climate and equity concerns

Transferring knowledge across workforce generations

Visualizing integrated systems | energy generation in water and wastewater systems:

LARGE-SCALE HYDROPOWER

BOULDER'S WATER UTILITY OPERATES 8 HYDROPOWER PLANTS

SMALL-SCALE HYDROPOWER

PORTLAND'S WATER BUREAU HAS GENERATING TURBINES IN GRAVITY-FED WATER PIPES

SOLAR PV

500 FLOATING PANELS INSTALLED BY NEW JERSEY AMERICAN WATER

INTEGRATED WIND SYSTEMS

THE JERSEY-ATLANTIC WIND FARM OPERATED BY THE ATLANTIC COUNTY UTILITIES AUTHORITY IS LOCATED ON-SITE AT THE WASTEWATER TREATMENT PLANT

WASTE TO ENERGY

DC WATER WASTEWATER TREATMENT PLANT INSTALLED THE FIRST THERMAL HYDROLYSIS PROCESS (THP) SYSTEM TO GENERATE ENERGY FROM SOLID'S STEAM AND METHANE

Visualizing integrated systems| storage and decentralized systems:

BATTERY ENERGY STORAGE

IRVINE RANCH WATER DISTRICT INSTALLED TESLA BATTERIES AT 11 DIFFERENT SITES ACROSS ORANGE COUNTY TO REDUCE GRID RELIANCE

PUMPED STORAGE

THE LUDINGTON PUMPED STORAGE PLANT OPERATED BY CONSUMERS ENERGY PROVIDES SERVICES TO OVER ONE MILLION RESIDENTIAL CUSTOMERS

DECENTRALIZED WATER AND ENERGY SYSTEMS

FT. HUNTER LIGGETT (CA) HAS DESIGNED A WATER AND ENERGY MICROGRID TO WITHSTAND A 24-HOUR POWER OUTAGE

Visualizing integrated systems: optimization and conservation

GREEN INFRASTRUCTURE AND RAINWATER HARVESTING

THE CENTER FOR NEIGHBORHOOD TECHNOLOGY ESTIMATES A 5,000 SQ. FT GREEN ROOF GENERATES OVER 100 KWH OF ELECTRICITY SAVINGS BY MITIGATING WATER TREATMENT

SMART IRRIGATION

~50 % OF LANDSCAPING WATER USE IS OVERWATERING. WEATHER-BASED IRRIGATION CONTROLLERS USE TECHNOLOGY TO SENSE RAINFALL AND EVAPOTRANSPIRATION TO SIGNAL WHEN TO WATER LANDSCAPES

USE OF NON-POTABLE WATER

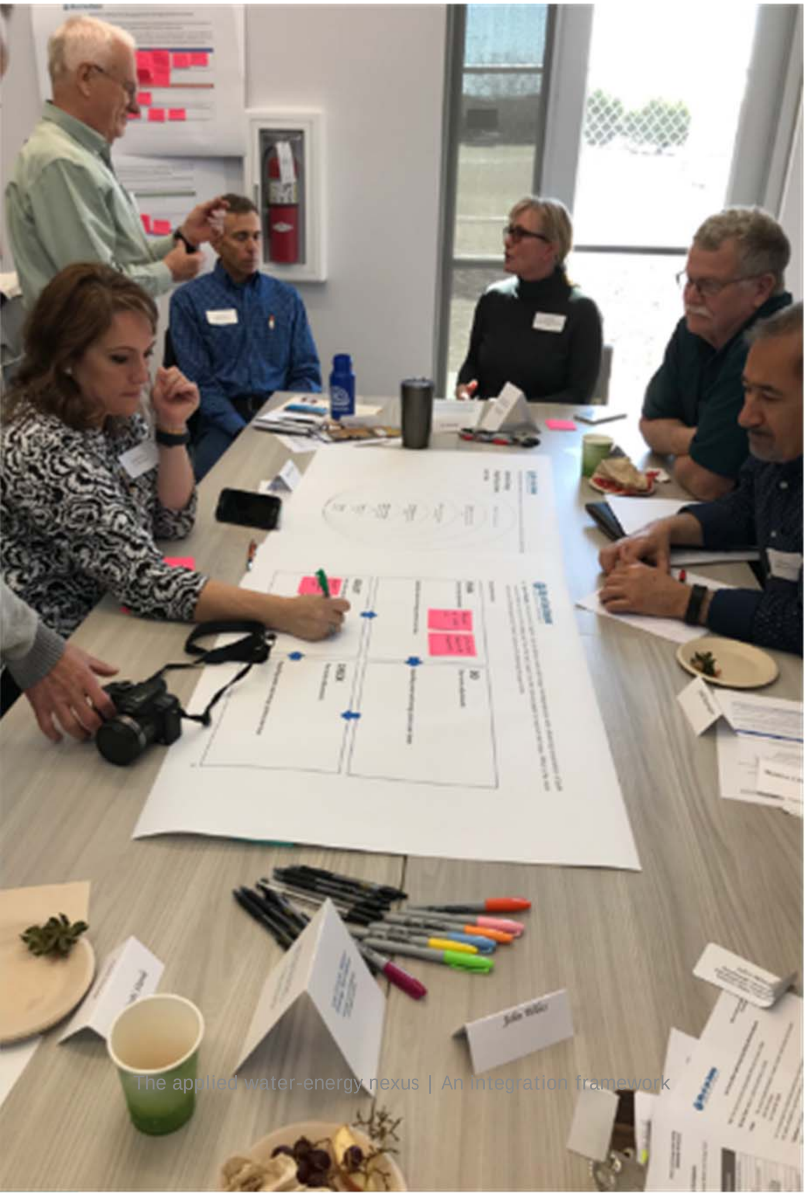
STANFORD UNIVERSITY IS EXPLORING A FORWARD OSMOSIS/REVERSE OSMOSIS SYSTEM FOR TREATMENT AND REUSE OF GREYWATER.

THE UNIVERSITY OF TEXAS AT AUSTIN CAPTURES CONDENSATE FROM AIR CONDITIONERS TO FEED COOLING TOWER BASINS

SYSTEM OPTIMIZATION

REMOVING REDUNDANCIES AND UPGRADING FACILITIES TO REDUCE WATER AND ENERGY NEEDS. THIS CAN BE INTERNAL AND EXTERNAL FACING.

SACRAMENTO MONITORED LEAKS AND PROVIDED AN ONLINE PORTAL WITH CUSTOMIZABLE NOTIFICATIONS FOR CUSTOMERS.



Integration Cornerstones:

Budget time to build trust

- Involve each other in organizational planning processes
- Train staff across systems
- Work together to provide affordable, equitable, and informed service to shared customers

Leverage shared customers

- Offer joint rebate, and/or incentive programs
- Develop shared customer-facing pilot projects
- Engage in dual community outreach

Interface with data

- Collect and share data across systems
- Approach data management, display, and assessment with the customer in mind
- Plan together for a smart network approach

Invest in connecting infrastructure

- Share metering infrastructure
- Connect water system energy generation to electrical grids
- Increase resiliency with mini/micro grids and decentralized systems

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Step 1 | Building relationships:

Local governments and utilities opportunities:

- Share planning processes
- Train staff across systems
- Provide affordable, equitable, and informed customer service

Examples:

- **California Public Service Commission** – Top-down directive mandated that investor-owned energy utilities work directly with water agencies
- **Orlando Utilities Commission** – Cross training and reporting fostered better understanding and collaboration between the water and electric departments
- **Sydney, Australia** - Diversified renewables in the water utility to add reliability and create partnership with the electric utility
    - Energy savings are realized and passed on to utility customers

Step 2 | Program coordination:

Local governments and utilities opportunities:

- Share customer-facing pilot projects
- Engage in dual community outreach
- Offer joint rebate, and/or incentive programs

Examples:

- **San Antonio, TX** – Overlapping pilot projects like joint rebates and audits expand the reach of both water and energy utilities and target high-intensity energy and water users (e.g., swimming pool owners), as well as low-income (e.g., water leak detection)
- **Medellín, Columbia** - With a growing population taxing water infrastructure, a state-owned joint water and energy utility coordinated outreach campaigns. Demand-side management and monitoring of energy and water use is reducing resource needs
- **Austin, TX** – Austin Water, Austin Energy, and Texas Gas Service partnered to provide weatherization assistance to low- and moderate-income customers

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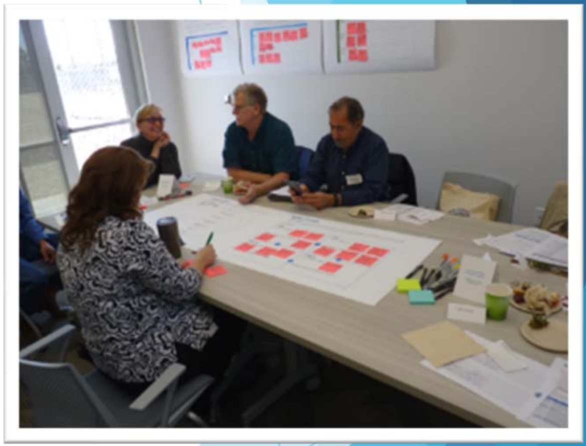
Step 3 | Data and Communications:

Local governments and utilities opportunities:

- Collect and share data across systems
- Connect data management, display, and assessment
- Jointly procure smart metering technology and service providers

Examples:

- **Ontario, Canada -** Under the Reporting of Energy Consumption and Water Use regulation, building owners need to report the property's water and energy use of buildings that are at least 50,000 square feet
- **City of Dubuque** – Worked with IBM to pilot using smart meters to connect customers with real-time water and energy use
- **Glendale, CA -** Glendale Water and Power in Los Angeles County used a Department of Energy Smart Grid Investment grant to procure single-vendor water and electric smart meters



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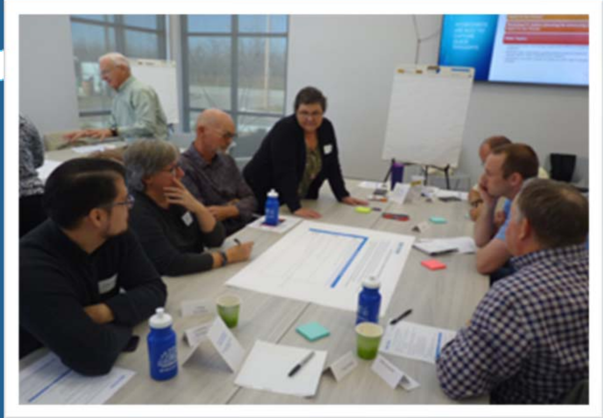
Step 4 | Physical Connections:



Local Opportunities:

- Share metering infrastructure
- Connect water system energy generation to electrical grids
- Increase resiliency through decentralization

Examples:

- **Burbank, CA -** City of Burbank Water and Power deployed over 50,000 water and electric smart meters to increase service reliability and offer more service options for customers
- **Caldwell, ID -** The Caldwell Waste Water Treatment plant installed a 896 kW solar storage system that sells additional power to the public utility
- **City of Stockholm, Sweden -** With ambitious climate goals and population stress, the City is piloting recapturing energy from wastewater to power district heating systems

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Developing the cornerstones:

Prioritize	Make the time to formalize cross-sector relationships and workflows
Talk	Embrace the dialogue, because cross-sector / community interaction isn't optional
Facilitate	Identify resources needed for each coordination point – name roles / a responsible party
Use data	Test feasibility and gauge potential benefits / drawbacks / successes
Iterate	Learn from each other and grow the relationships intentionally

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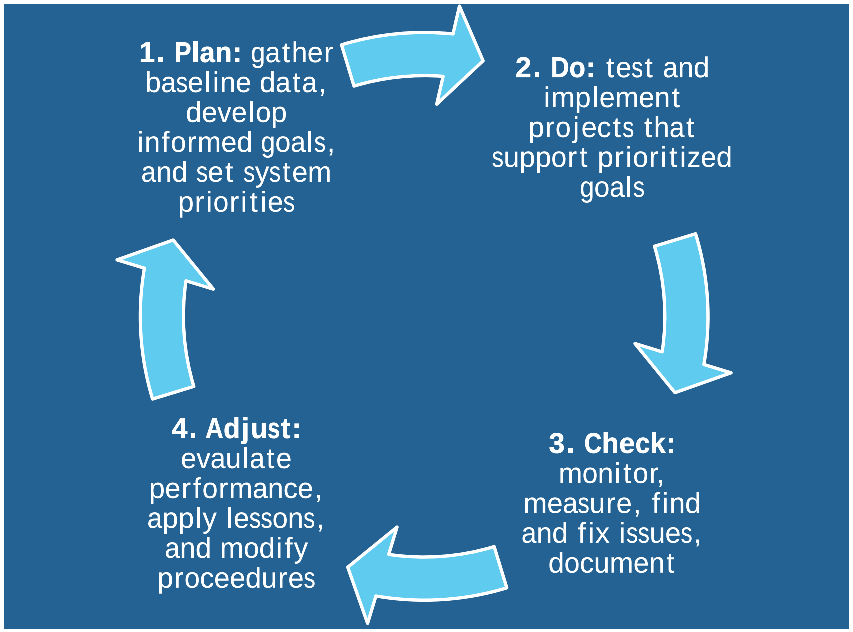
Identify the greatest areas of opportunity:

Planning Cycle



Example

- Swimming pool joint incentive program: filter and pump replacement to reduce water and energy consumption
- Roll out on-bill financing, test uptake for 1 summer season
- Adjust outreach methods/interest rates, etc. from incoming data trends
- Explore low-income leak detection: weatherization and water pipe replacement, start the cycle again

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1. Building relationships questions:

- What local government(s) and water utilities does this electric utility provide service to? Is there any shared planning, governance, or direct interaction at the staff level?
- Does this electric utility work with water utility service providers and/or local governments, either directly or indirectly?
- Are there cross-staff training opportunities or ways to jointly improve customer service, especially to low-income rate payers?
- What are the opportunities and barriers to the energy utility working with the local governments and/or water utilities more frequently and directly?

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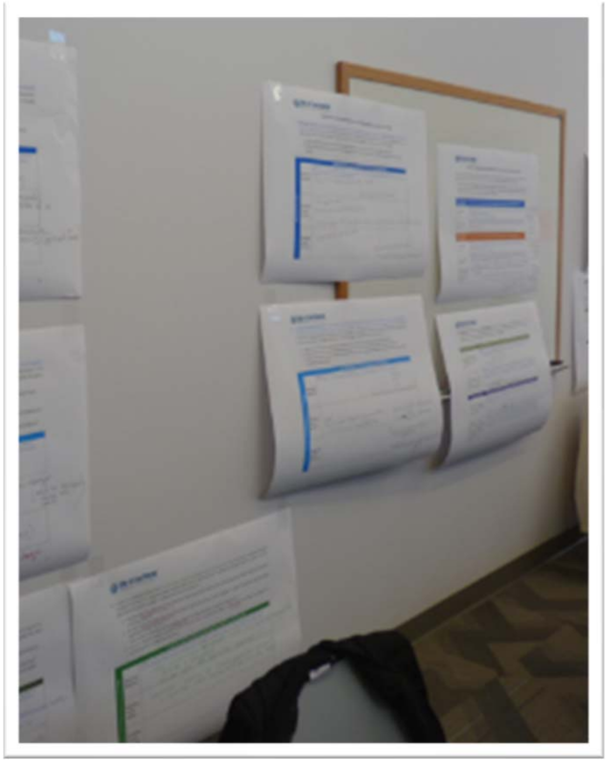
2. Program coordination questions:



Are there existing programs or partnerships with local governments and/or water utilities within this electric utility service area?

Is there an opportunity for a joint rebate or educational program to electric customers with a shared water utility?

How can local government and/or water utilities help advance this electric utility's goals and vice versa?

What are the barriers to implementing any or more joint programs with local government, water utilities, and/or electric utilities?

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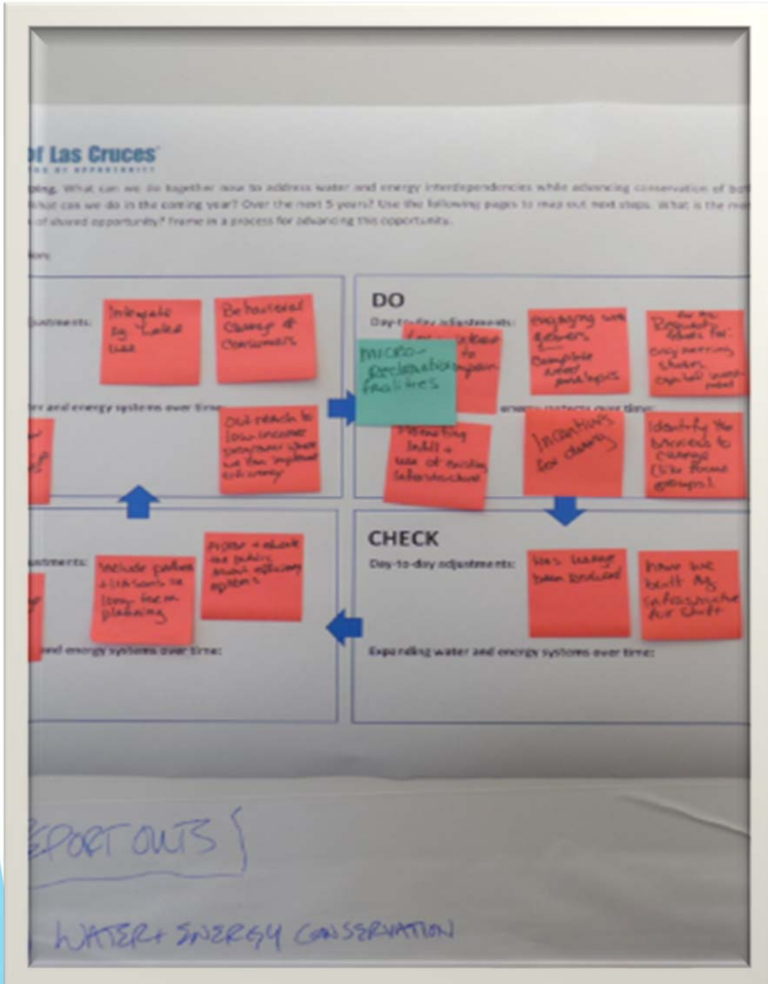

3. Data and communication questions:

- Are there data sets that local governments and/or water utilities could provide that would help this electric utility's planning?
- Are there data sets that local governments and/or water utilities could provide that would be useful to knowing how well this electric utility is meeting its goals?
- Is there an opportunity using existing or new technology to coordinate this electric utility's data collection with local government and/or water utility data collection?
- Is there an opportunity to deploy joint customer metering or develop shared customer dashboards to see water and energy consumption together?

4. Physical connections questions:

Does this energy system connect to/support the local water system at any point (e.g., the water system generates energy which is supplied to the electrical grid)?

Is there any shared water and energy metering infrastructure in this electric utility's service territory? If not, is it a possibility?

Are there any examples of mini/microgrid or building/districts scale grids in this electric utility's service territory? Is this electric utility open to any decentralized grids?

Are there any opportunities that immediately come to mind as desirable when thinking about how the water system can support this energy system?

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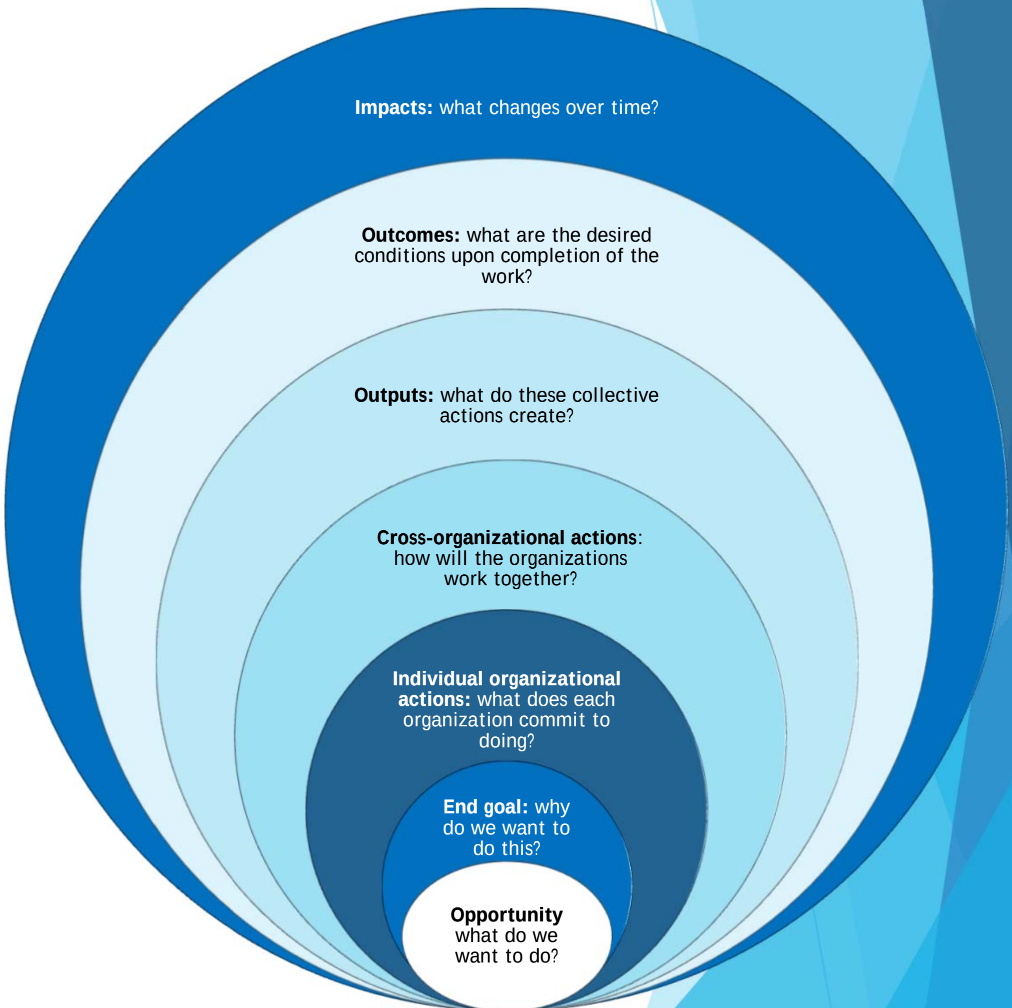
End game:

- Understand shared resources and customers
- Consider cross-sector financing and network opportunities
- Identify goal overlap and collaboration opportunities
- Find common concerns and motivators within existing utility structures
- Move from shared motivations to desired impact



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Thank you and resources:

- https://www.saenv.com/portfolio/the-applied-water-energy-nexus-a-framework-for-local-water-and-energy-system-integration/
- susanna@saenv.com

Workshop Testing PPT | A Presentation for IETC 12.20

Workshop Testing Report | Las Cruces Water-Energy Workshop Outcomes 03.20

Framework Summary | Meeting of the Minds Article 12.19

The Applied Water-Energy Nexus: Water and Energy System Integration Framework | PDF Version 09.19

Water and Energy System Integration Framework | Word Version 09.19

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