Water Conservation Showcase

MARCH 21 | SAN FRANCISCO

The Water/Energy Nexus: Lessons from Southern California

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Energy Use Effects of Water Conservation and Local Supplies in Los Angeles

Erik Porse, PhD

Office of Water Programs at Sacramento State
UCLA Institute of the Environment and Sustainability

March 21, 2019

PGE 2019 Water Conservation Showcase

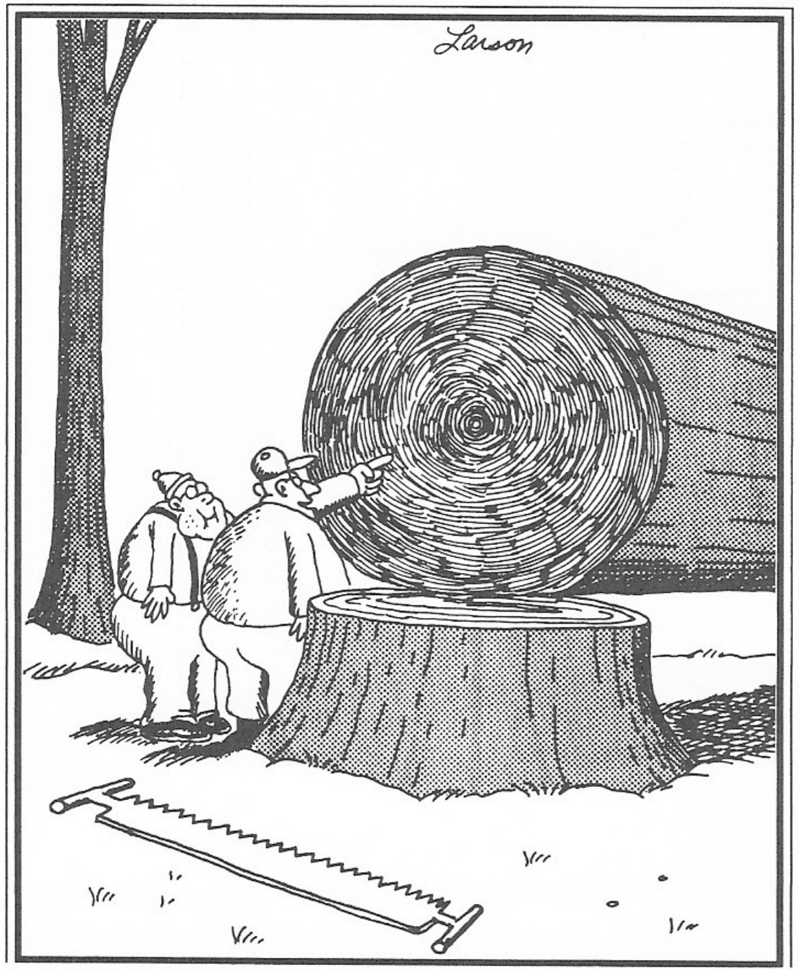
SACRAMENTO STATE
Office of Water Programs

UCLA
Institute of the Environment and Sustainability

Water-Energy Nexus

- Studying relationships between energy and water for human needs
  - Energy-for-Water
  - Water-for-Energy
- Why do we care?
  - Greenhouse gases (GHGs), cost savings, "averted" costs
- In California:
  - California Energy Commission report (2005), California Public Utilities Commission decisions & reports (2007-2016)
  - 2016: SB 1425 established a voluntary Water-Energy Nexus Registry to track GHGs

Systems Analysis: The Big Picture

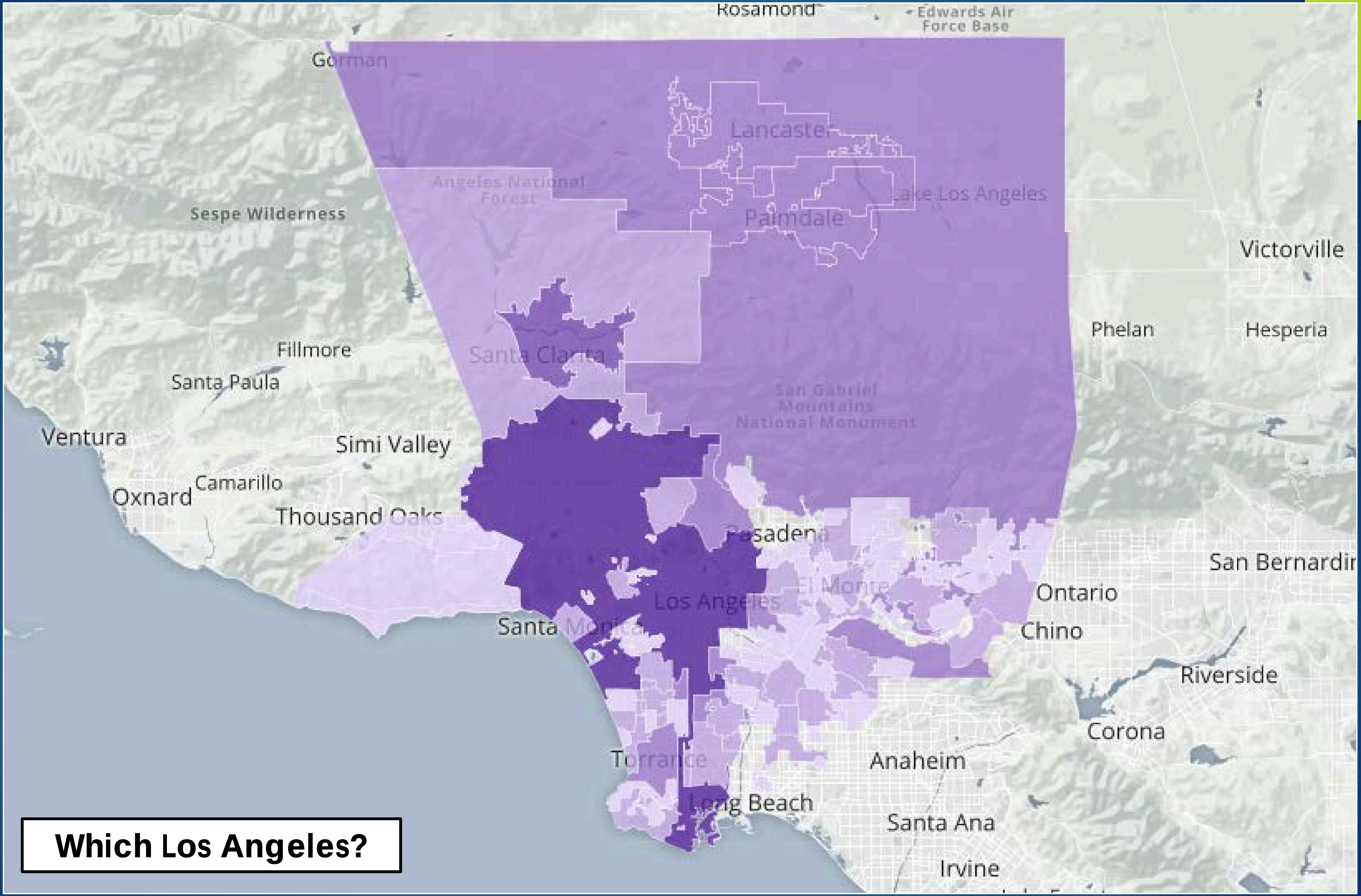


"And see this ring right here, Jimmy? . . . That's another time when the old fellow miraculously survived some big forest fire."

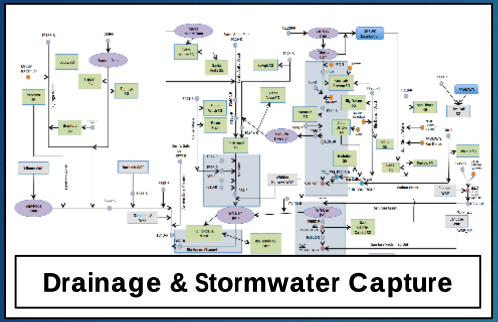
Water Conservation and Local Supply in LA: Changing a System

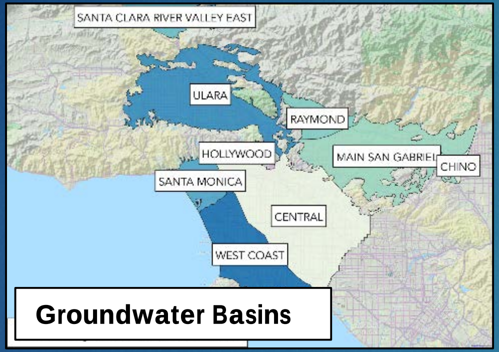
Opening of the Los Angeles Aqueduct, 1913. Source: waterandpower.org

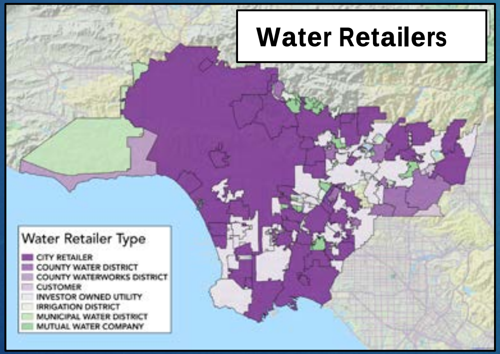
Which Los Angeles?



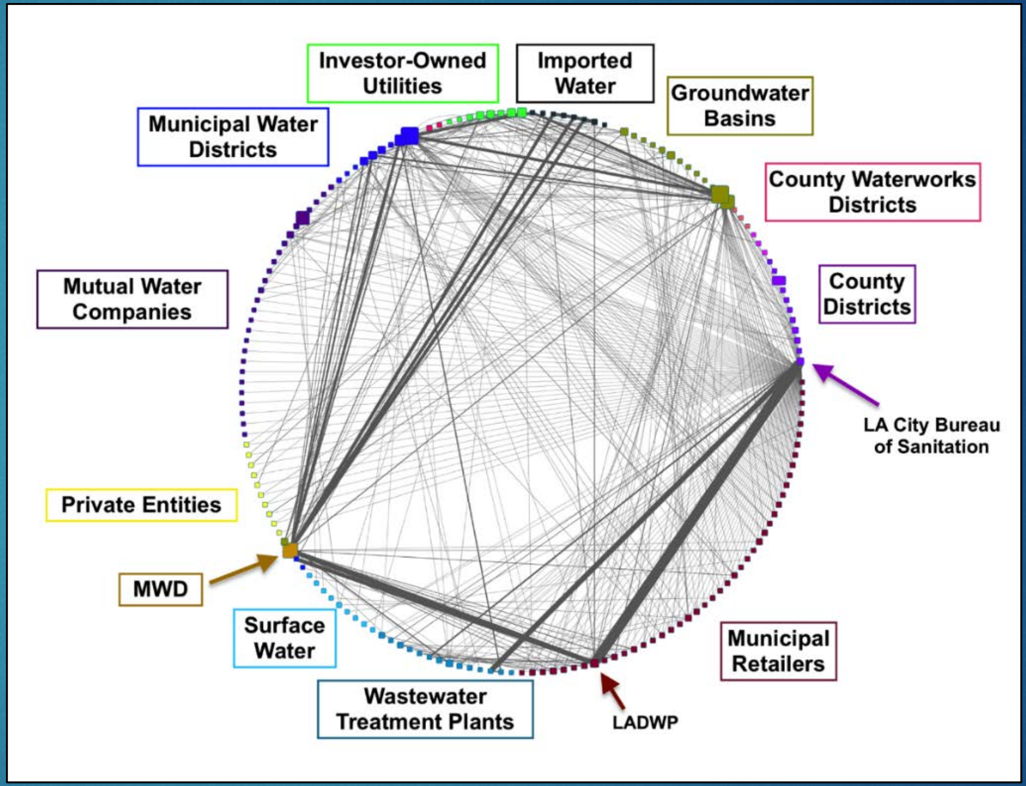
Modeling Water Management in LA







***Artes:* A Network Model for Water Management**



Flexible Objectives and Resolutions:
Maximize local supplies, Minimize costs

Porse, E., KB Mika, E Litvak., K Manago, K Naik, M Glickfeld, T Hogue, D Pataki, M Gold, & S Pincetl (2017). "Systems Analysis and Optimization of Local Water Supplies in Los Angeles." Journal of Water Resources Planning and Management, 143(9).

Artes is a Product of Many Conversations and Collaborations

UCLA

Stephanie Pincetl
Mark Gold
Katie Mika
Madelyn Glickfeld
Felicia Federico
Debbie Cheng
Dan Cheng
Claire Hirashiki
Eric Fournier
Hannah Gustafson
Kartiki Naik

Gonzalo Cortes
Brianna Pagan
Steve Margulis
Tom Gillespie
Janet Rodriguez
Sherry Jia
Nick Nobles
JR DeShazo
Greg Pierce
Henry McCann
Nick Chow
Kelsey Jessup

Peter Kareiva
Monobina Mukherjee
Marcia Hale
Paul Cleland
Bill Yeh
Vanessa Martin
Sonali Abraham
David Colgan
Dennis Lettenmaier
Cassie Rauser
Rhianna Williams
Daniel Swain

Alex Hall
Katharine Reich
Scott Gruber
Rob Cudd
Sean Kennedy
Keith Mertan

Elsewhere

Terri Hogue
Kim Manago
Katharine Radavich
Diane Pataki
Liza Litvak
Dong-ah Choi

Youn Sim
Lee Alexanderson
Daniel Bradbury
Grace Chan
Delon Kwan
Ken Manning

Jay Lund
Bill Blomquist
Fritz Raffensperger
Edith de Guzman
Annie Eby
Mike Hollis

Patrick Atwater
Alvar Escriva-Bou
Kelly Sanders
Heather Cooley
Ned Spang
Soraya Manzor

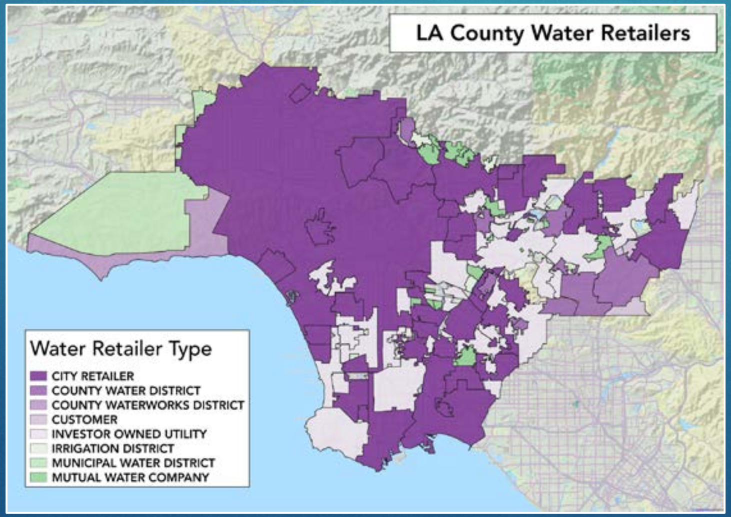
Modeling Energy-for-Water Management in LA

Estimating Energy-for-Water in LA

Utilities

- Importing
- Conveying
- Treating
- Gross vs. Net

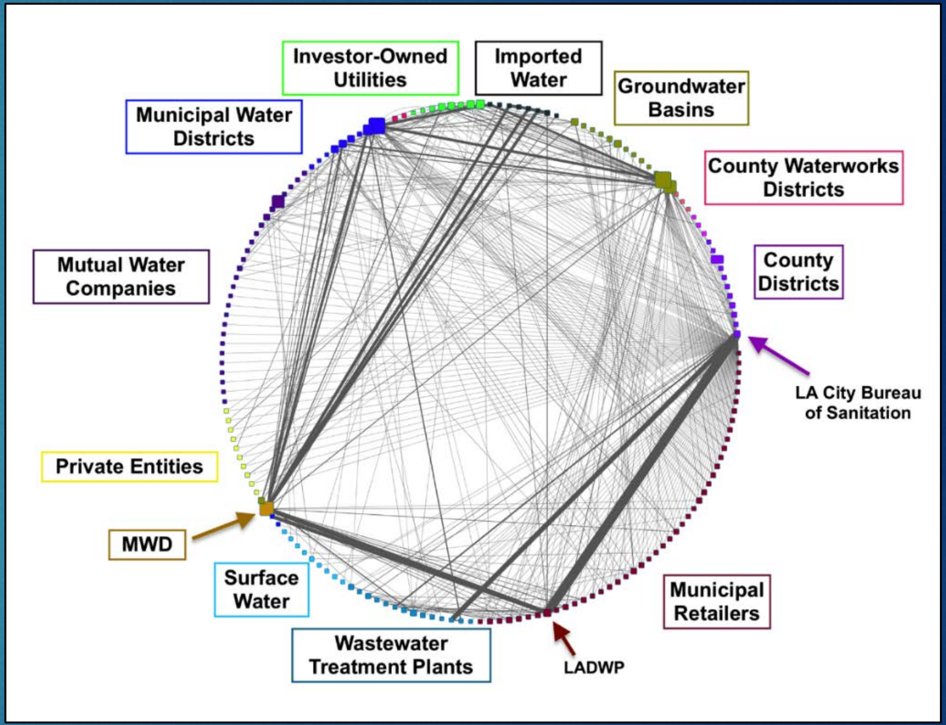
Households



Imported Sources

Calculating Results

- Apply coefficients to links throughout the network
  - Energy = flow * energy intensity
- Some Issues to consider:
  - Attribution
    - Is energy used by the wholesale or retail agency?
  - Gross vs. Net
    - Total energy use with or without offsets from produced energy
  - Total Energy Use vs. Energy Intensity



Inputs: Energy Intensity of Produced Water

Technology / Water Source	Energy Intensity (kWh/acre-foot)	
	Low	*High*
Groundwater		
Pumping	580	
Treatment		
Conventional water treatment	98	130
Membrane-based water treatment	326	489
Secondary Treatment without nutrient removal	342	456
Tertiary treatment with nutrient removal and filtration	521	635
Membrane Bioreactor (MBR)	740	2,839
Brackish water desalination	1,010	2,020
Advanced water treatment	1,059	1,303
Imported Water		
Colorado River Aqueduct imported water	2,004	2,411
State Water Project imported water*	2,581 (4,110)	3,232 (4,520)
Conveyance	varies, based on elevation and distance	
Ocean desalination	3,096	4,806

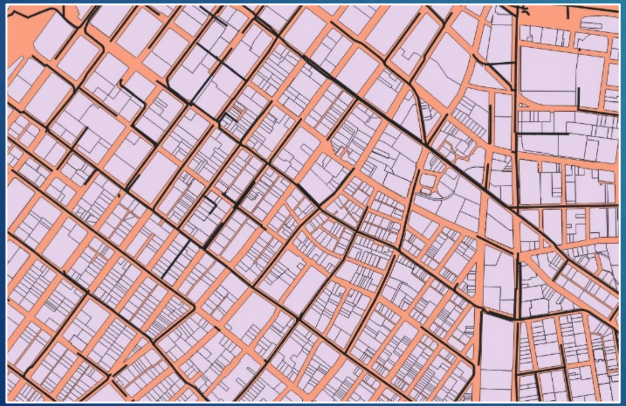
Sources: Multiple, compiled in Mika et al (2017). ***Sustainable LA Project: City Wide Overview***

* With and without system hydropower generation

Inputs: Making Assumptions

- Modeling approach to calculate retailer-specific conveyance energy
  - Bernoulli's Equation (potential, kinetic, & pressure head)
  - Translate to power and energy

Modeling approach in lieu of mapping water pipes and properties

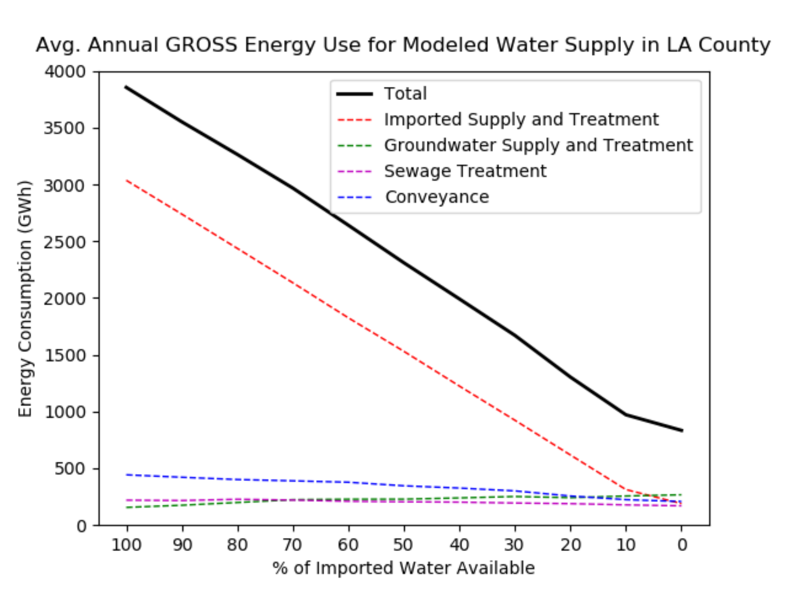


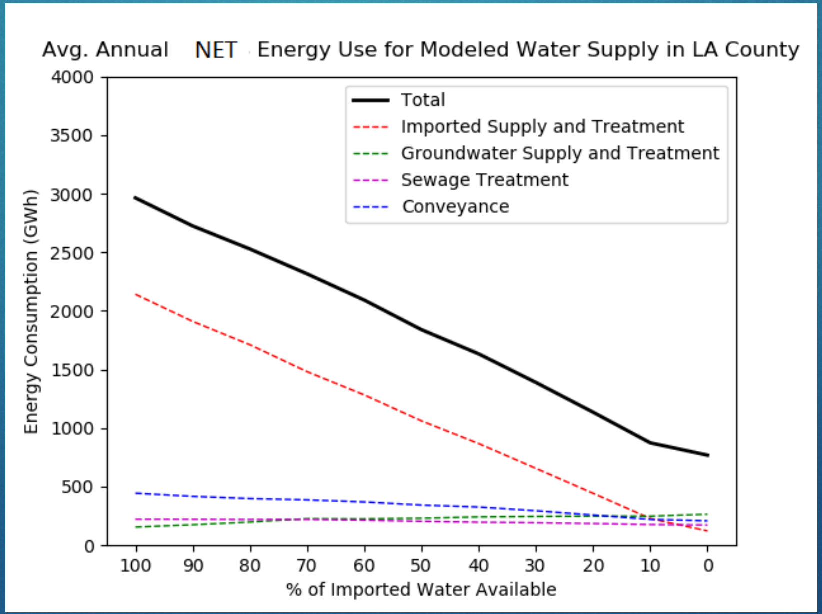
Parameter	Value
Dynamic head (kinetic)	$(K*v^2)/2g$, assume consistent across systems
K (loss coefficient)	9.95
v (pipe velocity)	Flow (Q) divided by Pipe Cross-Sectional Area (A)
Pump flow	2500 m^3/sec
Static Head (potential)	E1 – E2 (difference in elevation from source to end)
Pressure Energy	Pipe pressure = 50-60 psi, convert to head (1 psi = 2.31 ft)
Power	(Q*H*g*d)/pump efficiency
d , density of water	1000 kg/m3
Pump efficiency	.85

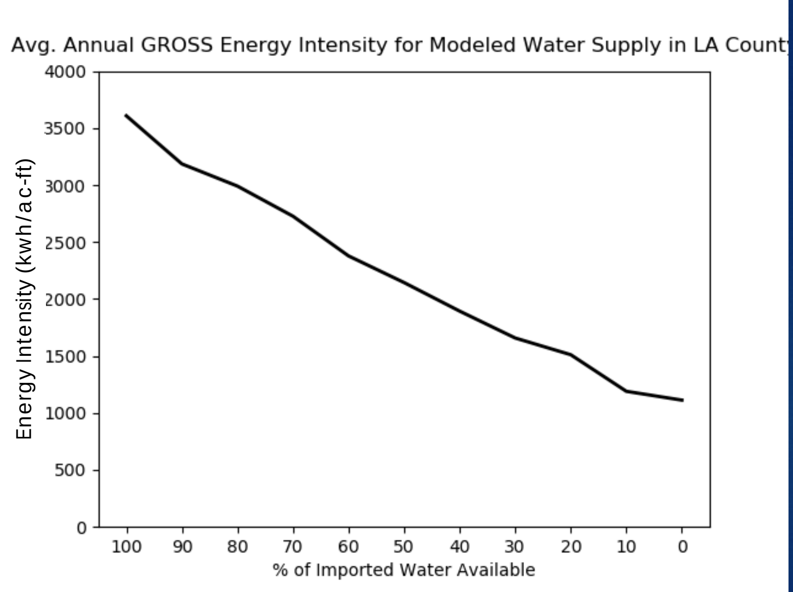
Results

Results: Utility System Energy Use, by Process

- Total Energy Use vs. Energy Intensity
- Gross vs. Net Energy Use
  - Net Energy Use accounts for energy produced in system

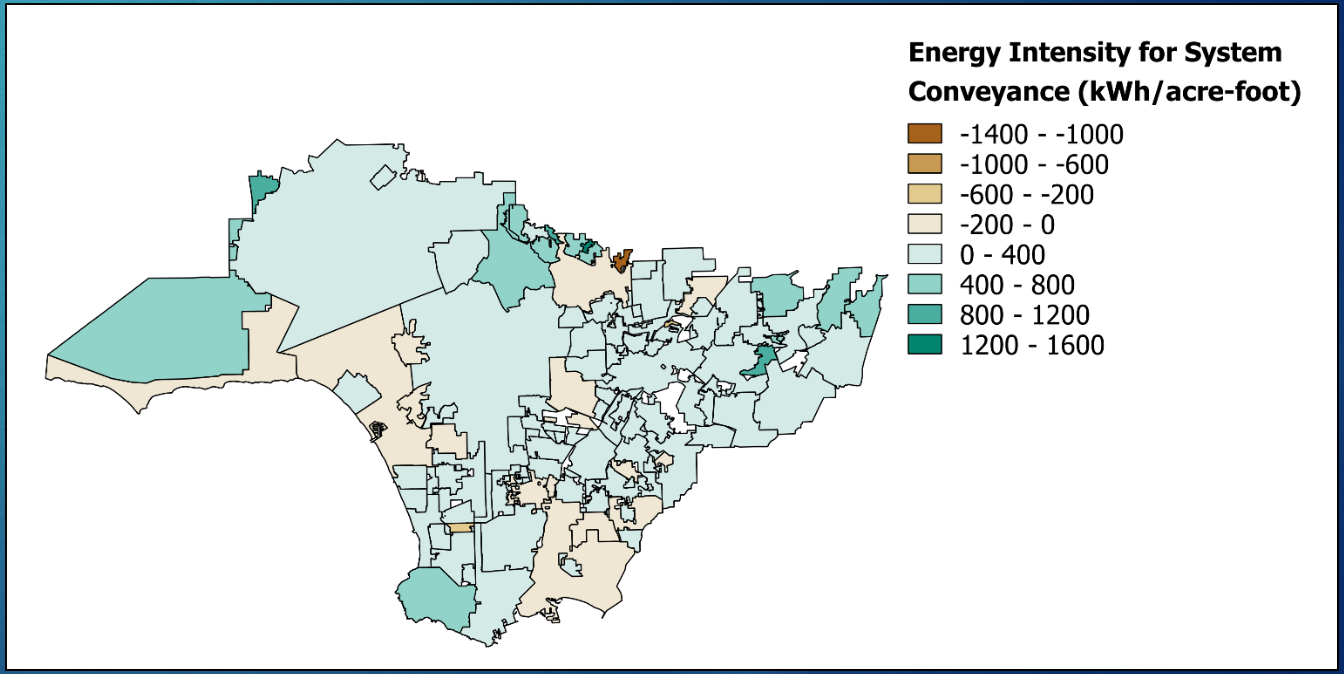






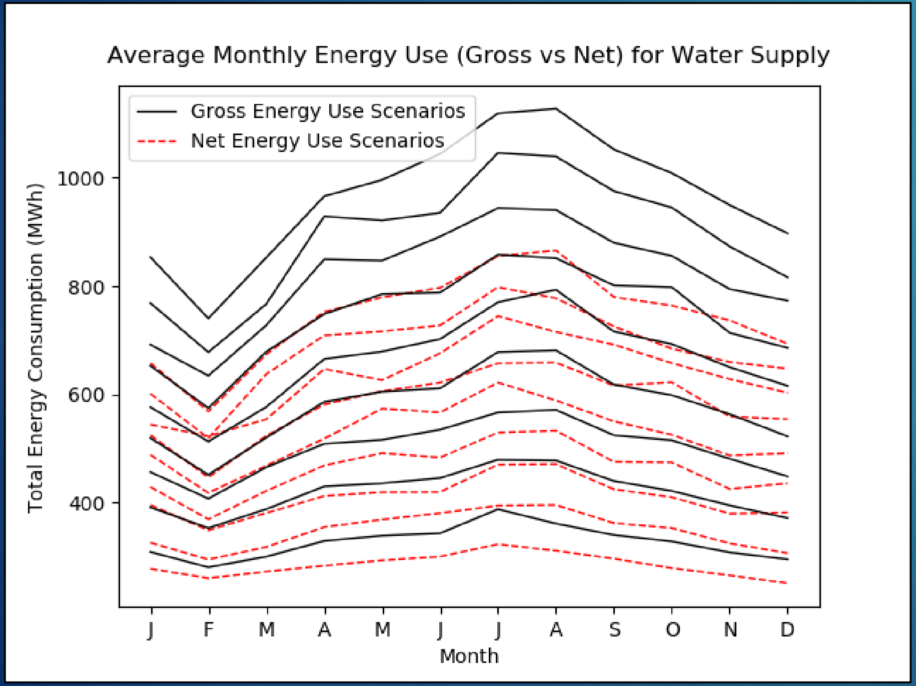
Results: Conveyance Energy, by Retailer

- Energy needed to pump water through retailer system
- Modeling approach identifies higher conveyance energy needs in retailers with hilly service territories
- Complements data-intensive assessments based on the water distribution network

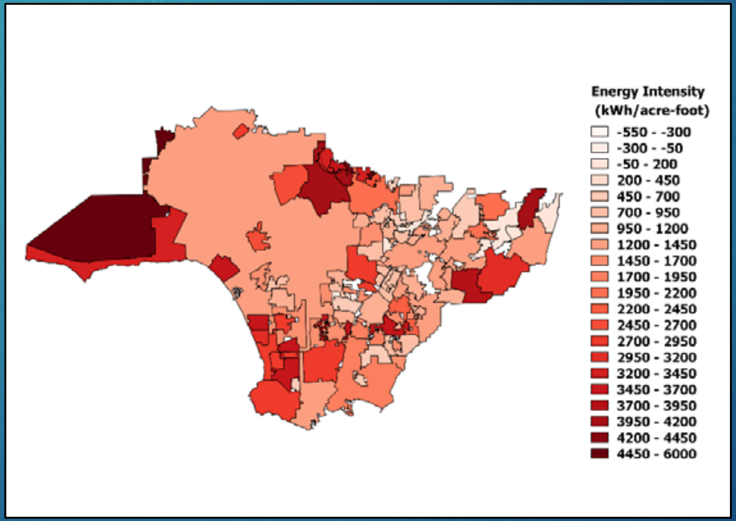


Results: Seasonal Differences in Energy Intensity

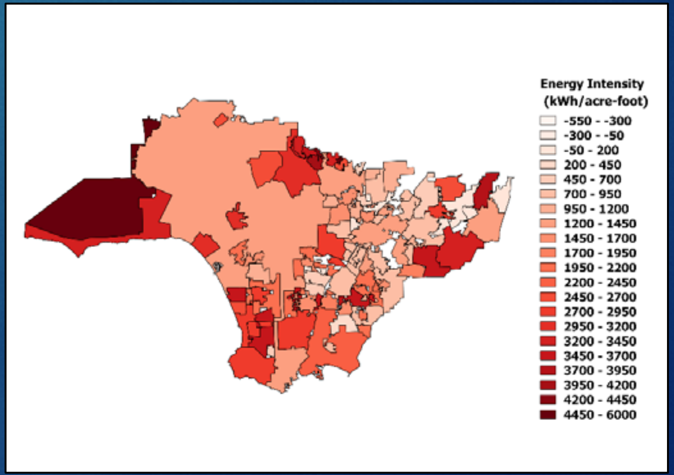
- Summer irrigation demands increase energy intensity
  - Assumes other operational parameters are constant



Gross Energy Use Intensity, 100% Imported Supplies, December



Gross Energy Use Intensity, 100% Imported Supplies, July

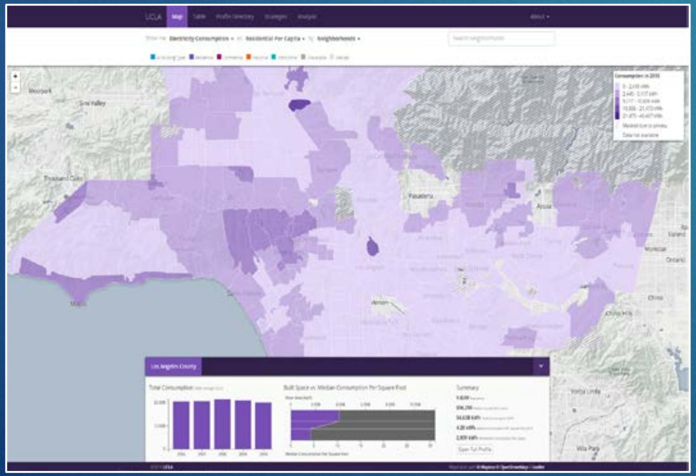


Results: Household Energy-for-Water Use

- Energy needs for hot water heating in homes
  - 3.2 million households, 2.4 million parcels
  - Indoor residential water heating = 268 Million Gallons/day using baseline indoor demands
  - Assessed via Water Heater Analysis Model (WHAM) method (natural gas)
  - Currently examining electric grid effects of electrifying water heaters

LA Energy Atlas:

Monthly, Account-level Energy Use



Total Residential Use:
~200Tr BTU/yr

Residential hot water estimate:
42.1 TrBTU/yr or 85,827 MW/month
~20% of LA County residential energy use

Sources: Escriva-Bou et al (2015); Lutz et al (1998), CCSC at UCLA

Future Water Supply Portfolio in LA City

Source	Energy Intensity (kWh/AF)	2013 Supply Volume (AF)	2013 Energy Use (GWh)	2035 Supply Volume (AF)	2035 Energy Use (GWh)
State Water Project East (MWD/DWP)	4,110	66,281	272	15,000	62
State Water Project West (MWD)	4,520	309,309	1,398	70,000	316
Colorado River Aqueduct (MWD)	2,000	66,281	133	15,000	30
Los Angeles Aqueduct (LADWP)	0	61,024	0	139,400	0
Groundwater	580	79,403	46	114100	66
Recycled Water	1,150	10,054	12	88,500	102
Stormwater	174	0	0	37,000	6
Total	**-**	**592,352**	**1,861**	**479,000**	**582**

Should consider the "full-cycles" of water supply

Source: Mika et al (2017). ***Sustainable LA Project: City Wide Overview***

Energy Use for "Full Cycles" of Urban Water?

Sources	Stages to End-Use	Cost ($/ac-ft)
Imported Water for Supply	Capture >> Conveyance >> Local Storage >> Treatment >> Delivery	$1476-$1,790
Imported Water for Recharge	Capture & Storage >> Conveyance >> Local Storage >> Conveyance >> Infiltration	$1,325-$1,639
Groundwater Pumping	Pumping >> Treatment >> Conveyance >> Delivery	$739
Existing Large Stormwater Capture	Capture >> Filtering & Sedimentation >> Spreading & Infiltration >> Pumping >> Treatment >> Delivery	$995
Proposed New Large Stormwater Capture	Capture >> Filtering & Sedimentation >> Spreading & Infiltration >> Pumping >> Treatment >> Delivery	$1,110-$2,727
Indirect Potable Reuse	Sewage Collection and Treatment >> Conveyance >> Spreading & Infiltration >> Pumping >> Treatment >> Delivery	$1,551-$2,641
Non-Potable Reuse	Sewage Collection and Treatment (tertiary and disinfection) >> Conveyance >> Delivery (irrigation, CII)	$556-$1,646
Direct Potable Reuse	Sewage Collection and Treatment >> Conveyance >> Delivery	-

Source: Porse et al (2018). "The Economic Value of Local Water Supplies in Los Angeles". *Nature Sustainability*

Some Insights

- Cutting imported water could save energy
- **In-home** energy-for-water use is much larger than **utility operations**
- Electrifying natural gas water heaters could reduce GHGs
- Need **systems thinking** to address energy-for-water planning

Links

LA Water Hub

http://waterhub.ucla.edu

Artes Source Code and Data

https://erikporse.github.io/artes/

LA Energy Atlas

http://energyatlas.ucla.edu

Contact

erik.porse@owp.csus.edu
@researchcp

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