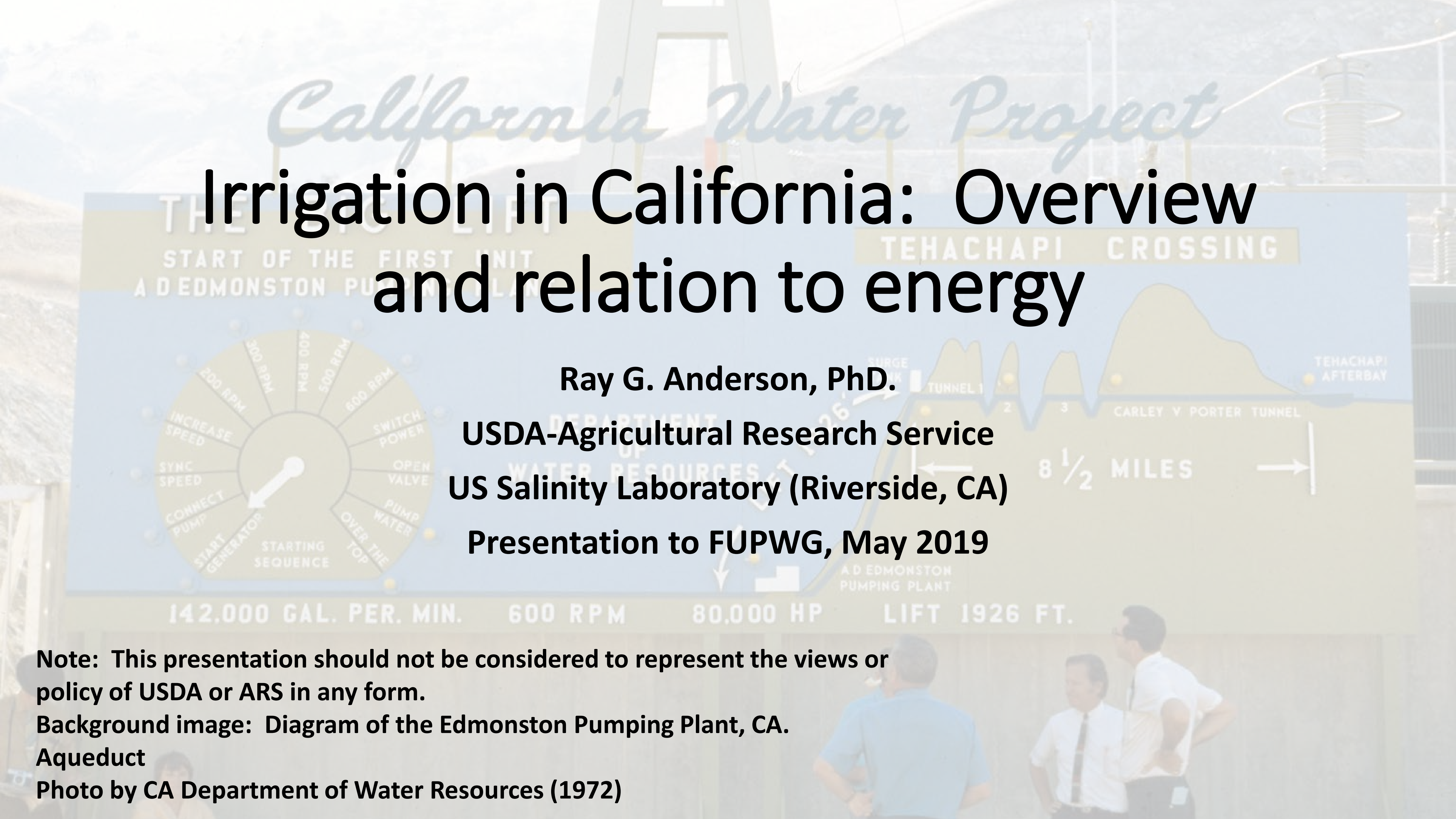

Irrigation in California: Overview and relation to energy

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Presentation to FUPWG, May 2019

Note: This presentation should not be considered to represent the views or policy of USDA or ARS in any form.
Background image: Diagram of the Edmonston Pumping Plant, CA. Aqueduct
Photo by CA Department of Water Resources (1972)

Outline

- **Overview of water resources in California and irrigation methods**
- **Energy use for irrigation and water movement**
- **Challenges with trends in irrigation and energy**
- **Potential future solutions**

Without irrigation, there is little ag in CA

- **Precipitation has a strong north to south gradient in California.**
- **Mountains have much higher precipitation than valleys suitable for agriculture.**
- **Precipitation is concentrated in winter and is offset seasonally from peak irrigation demand.**

Irrigated areas

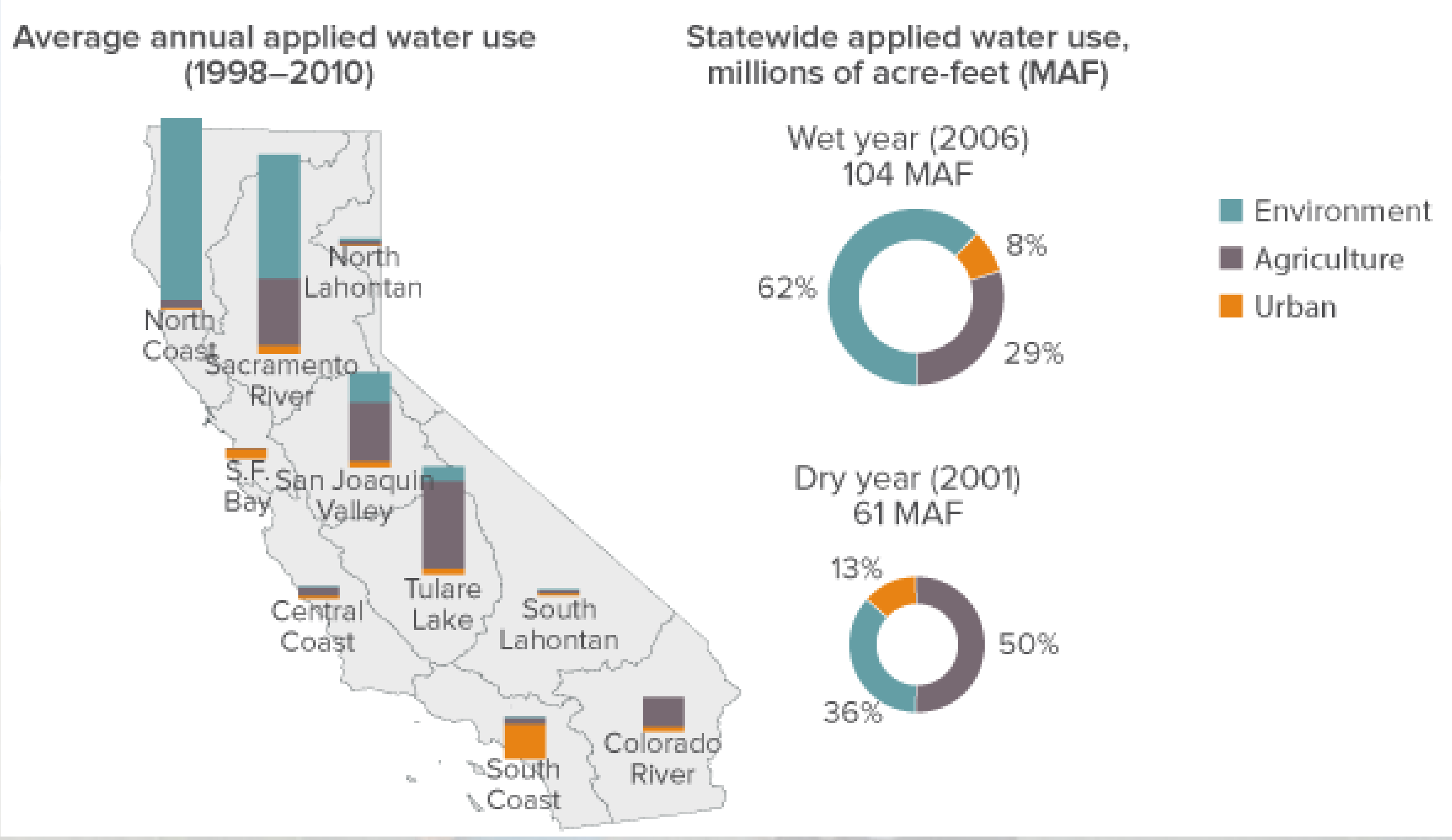
- **Largest areas for irrigation are Sacramento/San Joaquin Valleys (Central Valley), Imperial Valley, and Salinas Valley.**

- **Other coastal regions are smaller in size but often have very high value specialty crops.**

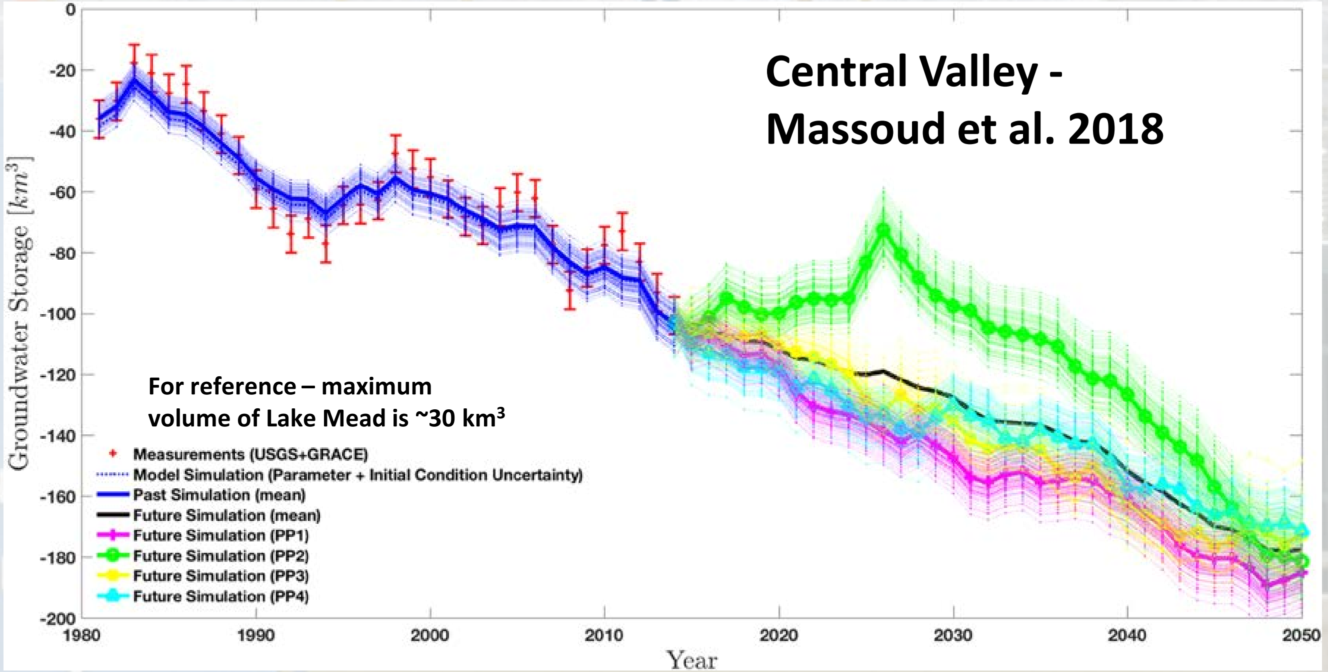
2012 MODIS assessment of irrigated lands

Overall water use

- **Irrigation consumes 30 million AF/year on average.**
- **In wet years, mostly comes from surface water.**
- **Groundwater fills gaps in dry years. Surface reservoirs much smaller than in CO River Basin.**
- **Water consumed can range from <2 ft./acre/year to >7 ft**



Groundwater: An overdrawn account



- **Farmers extensively and unsustainably pump groundwater. Damage to surface infrastructure, water quality, and increased energy use.**

- **CA state law [SGMA] mandates end to overdrafts by 2040. Likely to result in land fallowing.**

Irrigation methods

- **Gravity/flood**
  - ***Low energy, low initial cost, minimal equipment, IE highly variable***
- **Sprinkler**
  - ***Moderate/high energy; equipment intensive, low labor, IE highly variable. Least commonly used in CA***
- **Drip/Microspray**
  - ***Moderate energy, plastic intensive, moderate labor, can have highest IE***

Pictures courtesy Tom Trout – USDA-ARS

Irrigation method frequency in California

- **Gravity/flood**
  - ***Most common statewide (4.5 million acres – 2013)***
- **Sprinkler**
  - ***Least common in California (1.7 million acres)***
- **Drip/Microspray**
  - ***2.9 million acres - ~60% of all drip irrigation in the US! Increasing retrofits of flood systems to drip***
- **Other notes: ~85,000 large capacity pumps, ~60,000 of which are for groundwater**
- **Many farmers try to have access to both surface and groundwater**

Field vs. Basin Efficiency

- **Field Irrigation Efficiency – percent of water applied to a field that is used by the crop**
  - **“Wasted” water – deep percolation; runoff**
  - **Can impact water quality (nutrients, pesticides, salts)**
- **“Basin” Efficiency – generally much higher**
  - **Water is reused several times down the basin**
  - **Only evaporation/transpiration is really “lost”**
  - **Opportunities to “save” water often very small**

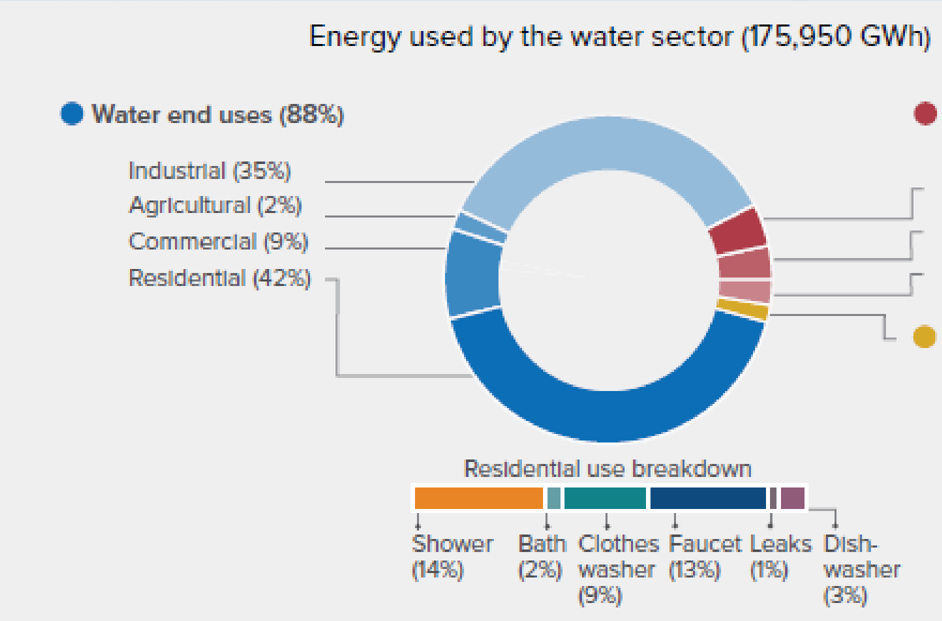
Value of Efficiency is Basin Specific

- **Example: San Joaquin Valley, CA**
  - **East Valley – lost water goes to groundwater and is pumped later in the season.**
  - **West Valley – lost water goes to saline groundwater and cannot be easily reused.**
- **Example: Colorado Water Rights**
  - **Only ET can be claimed or transferred; losses become downstream water rights.**

Energy and water in California

- **Water is a major consumer of energy in California and ag is a significant component.**
- **Groundwater pumping for agriculture has more than doubled in energy usage in the past 10 years.**
- **Increased conversion of furrow and flood irrigation requires more energy for pressurized systems.**

20% of electricity and 30% of natural gas statewide



PPIC

Pumping economics

- **Electricity/fuel (for diesel pumps) are 75-80% of lifetime costs for pumping systems.**

- **Evaluation of electric pumps in High Plains found average efficiencies of 40-50% (practical maximum of 75%).**

- **Energy costs to pump 1 acre/foot from well can average from 320 to over 1600 kWh/AF depending on depth to GW.**

Table 1: Potential energy savings from pump improvement (kWh/ac-in pumped) assuming 65 percent efficiency after improvement.

	Present pump efficiency (%)							
H	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**
50	10.5	7.7	5.6	4.1	2.9	2.0	1.2	0.5
100	21.0	15.3	11.2	8.2	5.8	3.9	2.4	1.1
150	31.5	23.0	16.9	12.3	8.7	5.9	3.6	1.6
200	42.0	30.6	22.5	16.4	11.7	7.8	4.8	2.2
250	52.5	38.3	28.1	20.5	14.6	9.8	6.0	2.7
300	63.0	45.9	33.7	24.6	17.5	11.8	7.2	3.3
350	73.5	53.6	39.4	28.7	20.4	13.8	8.4	3.8
400	84.0	61.2	45.0	32.8	23.3	15.7	9.5	4.4
450	94.5	68.9	50.6	36.9	26.2	17.7	10.7	4.9
500	105.0	76.6	56.2	41.0	29.2	19.7	11.9	5.5

TDH = Total pumping head or total dynamic head (ft).
kWh/ac-in = kilo Watt hour per acre-inch.
*To convert to metrics use the following conversion: 1 foot = 0.3048 meter.

Jose Chavez, Colorado State Univ.

Challenges between optimizing irrigation and energy – conflicts in priorities

- **Irrigation systems often set to irrigate in 12-24 hours sets historically.**
- **Drip irrigation requires pumping costs during peak energy demands. Low flow systems and frequent need for inspections.**
- **Increased conversion of furrow and flood irrigation requires more energy for pressurized systems.**
- ***System based on consistently priced and consistently available electricity.* What is the impact of the changing nature and sources for the grid?**

Regulators vote to shut down Diablo Canyon, California's last nuclear power plant

By ROB NIKOLEWSKI
JAN 11, 2018 | 1:55 PM

The Diablo Canyon nuclear plant in Avila Beach, Calif., will go offline. (Joe Johnston / San Luis Obispo Tribune)

Renewables Portfolio Standard (RPS)

Docket # 11-RPS-01, 16-RPS-01, and 16-RPS-03

Quick Links

» **RPS Online System**
» Enforcement Procedures for POUs - Amended Regulations
» RPS Eligibility Guidebook

Farmer and state approaches to energy costs

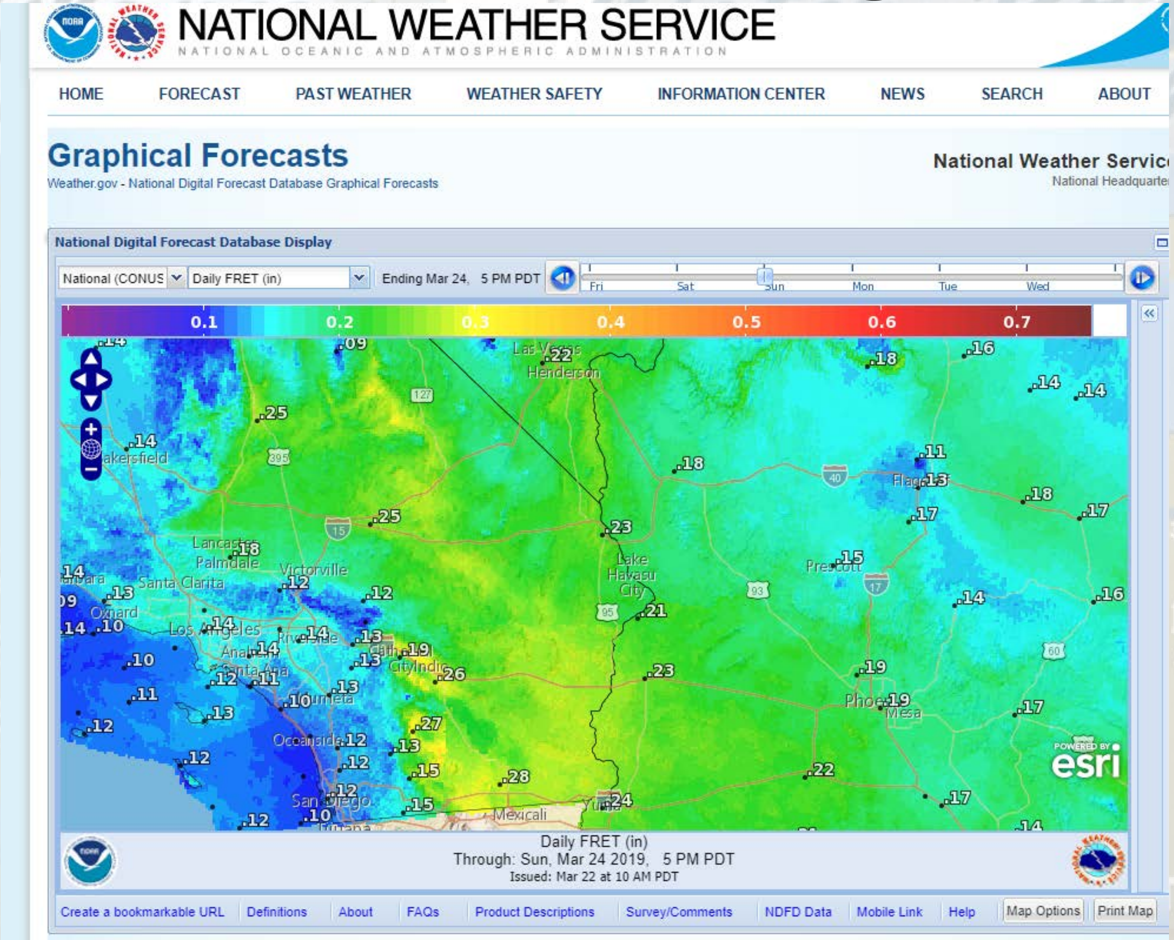
- **Off rate/Variable rate pumping (where system capacity exists).**
- **Evaluating system design to improving efficiencies.**
- **Improve field-scale IE (especially with expensive water). Better monitoring and scheduling of irrigation.**
- **State incentive programs built around these steps.**

Future opportunities – increased variable capacity

- **Increase on field capacity to apply water to match peak electrical availability.**
- **Advantages: Less grid strain and lower GHGs through increased renewable use. Storage ponds would have water resource benefits.**
- **Costs: Initial infrastructure costs (especially ponds). Operational systems would also need to detect leaks more quickly in drip.**

BTL liners

Future opportunities – better irrigation scheduling



- **Evaporative demand can be forecast up to a week in advance.**
- **Irrigations could be moved forward to fill up soil moisture profile before a heat wave stresses the grid.**

Deficit irrigation

- **Deficit irrigation is an established practice to conserve water and improve crop quality for some crops.**

- **Has not been done as an energy conservation measure.**

- **Some mechanism would be might be needed to compensate farmers**

USDA-ARS Research farm, Greeley, CO

Summary

- **Irrigation is a major consumer of energy in California and the Western US.**
- **Changes in irrigation sources and methods have increased energy consumption and reduced demand flexibility.**
- **Current approaches to reducing irrigation energy use are largely focused on efficiency.**
- **New approaches for shifting irrigation application and demand may be warranted, especially as energy grid changes.**

Questions?

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