Irrigation in California: Overview and relation to energy

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Presentation to FUPWG, May 2019

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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.
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

Efficiency: 50-75%
Pictures courtesy Tom Trout – USDA-ARS

Efficiency: 70-85%

Efficiency: 75-90%
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

Energy used by the water sector (175,950 GWh)

- Water end uses (88%)
  - Industrial (35%)
  - Agricultural (7%)
  - Commercial (9%)
  - Residential (42%)
- Other supplies, treatment, and distribution (3%)
- Groundwater pumping (3%)
- Conveyance (4%)
- Water supply, conveyance, and treatment (10%)
- Westwater treatment (2%)

Residential use breakdown

- Shower (14%)
- Dishwasher (3%)
- Clothes (13%)
- Faucet leaks (1%)
- Bath (2%)

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.
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?
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.
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 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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