Energy-Water-Food Nexus

A review of how future industrial/agricultural development may have implications for energy and water use, with resulting impacts for Kern County.

#EnergyAtKern #KernLeads

www.bakersfieldcollege.edu/energy-TTWD
Opening Comments

Stuart Witt
Owner/Founder S.O Witt & Associates Consulting
(Former CEO of Mojave Air and Space Port)

#EnergyAtKern  #KernLeads
www.bakersfieldcollege.edu/energy-TTWD
Jordan Macknick
Environmental Science Researcher
National Renewable Energy Laboratory (NREL)
Agrivoltaics and Energy-Water-Food Implications

Jordan Macknick
Energy-Water-Food Nexus: Bakersfield College
February 24, 2021
A relatively small amount of land is needed for solar
Land Use Requirements of Solar Deployment Projections

- **2030:** 2-3 million acres
- **2050:** 4-6 million acres
Agricultural Lands and Solar Development

Solar PV Power Potential is Greatest Over Croplands

Elnaz H. Adeh, Stephen P. Good, M. Calaf & Chad W. Higgins

Scientific Reports 9, Article number: 11442 (2019) | Cite this article

Farm profitability remains a challenge

American Bankers Association and the Federal Agricultural Mortgage Corporation release results of joint survey.

The next money crop for farmers: Solar panels
Rural communities can resist solar development on farms

Georgetown’s ‘green’ plan to destroy a forest for a solar farm is met with resistance

Solar projects increasingly meeting local resistance

By Kathleen Conti Globe Staff, May 5, 2013, 12:00 a.m.

He Set Up a Big Solar Farm. His Neighbors Hated It.

A push toward renewable energy is facing resistance in rural areas where conspicuous panels are affecting vistas and squeezing small farmers.
Vision: Low-Impact Solar Development provides Mutual Benefits

Photos courtesy of Rob Davis, Fresh Energy; Dennis Schroeder, NREL
Agrivoltaics = agriculture + photovoltaics

Farms That Harvest the Sun—Twice

By Eleanor Greene

*photovoltaics (PV)= renewable energy production from solar panels
What is Agrivoltaics?

Agricultural activities performed underneath and around solar arrays:
- Crop production
- Grazing
- Pollinator Habitat and Apiaries
- Controlled Environment

Source: Burton (NREL)
Example Agrivoltaic Configurations

Agriculture and Solar Energy Mutual Benefits

**Potential Benefits for Agriculture**

- Economic
  - Diversification of revenue streams
  - Maintaining land in production
  - Potential increases in yields
  - Adaptation to extreme weather
  - Premium pricing and value-added products

- Ecological
  - Reduced erosion
  - Increased nutrient retention
  - Long-term pollinator and beneficial insect habitat conservation at-scale
  - Reductions in irrigation water needs

**Potential Benefits for Solar Energy**

- Economic
  - Higher energy generation due to cooler microclimates under panels
  - Lower O&M costs than traditional solar development
  - Reduced site preparation costs and needs

- Siting
  - Expanded market opportunities
  - Reduced development barriers and permitting times
  - Greater customization of configurations
**DOE InSPIRE Research**

**Field-based research topics:**
1. Economic viability of solar-agriculture co-location configurations
2. Increasing agricultural yields in arid environments
3. Energy, water, and food security in remote, off-grid areas
4. Pollinator habitat and ecological services

**Analytical research topics:**
1. Satellite imagery analysis of current land groundcover practices
2. Cost-benefit analysis of O&M ground cover practices
3. Quantification of ecological services of groundcover options

[https://openei.org/wiki/InSPIRE](https://openei.org/wiki/InSPIRE)
What is Agrivoltaics? Crop production under and around solar panels

Crops can be grown directly underneath elevated panels or in between rows

Hand-harvested or small machine-harvested crops

Crop performance varies based on location and solar design configurations

Cost and Design Factors
• Increased panel heights (optional)
• Increased panel spacing (optional)
• Change in O&M needs (more frequent presence on-site)
• Access to water
• Agricultural revenue
Key Highlight: Energy+Water+Food Benefits of Agrivoltaics

- **Energy Benefits**
  - Summertime average cooling from vegetation underneath panels: ~9°C
  - Annual generation increase: ~2%

- **Food Benefits**
  - 3x yield for chiltepin peppers
  - 2x yield for tomatoes
  - Same yield for jalapeño pepper

- **Water Benefits**
  - Peppers need 50% less water
  - Tomatoes need 30% less water
What is Agrivoltaics? Pollinator-friendly Solar

Native and pollinator-friendly vegetation can host beneficial insects
Increased beneficial insect populations can benefit nearby farms
Ongoing research evaluating species that thrive in partial shade of solar panels

Cost and Design Factors
• Panel heights (to increase or not to increase?)
• Seed mix selection and purchase
• Reduction (usually) in O&M needs over time
• Potential stormwater management benefits
InSPIRE Holistic Research Design in Minnesota

- Vegetation and seed mix field study
- Instrumentation for validation and connecting vegetation with PV performance
- Pollinator population field study

- 3 sites with diverse soil/ecotypes and nine test seed mixes
- 9 acres of field research
- Partnerships with Enel Green Power, State of Minnesota, Minnesota Native Landscapes, University of Minnesota
Benefits of Pollinator-Friendly Solar Installations in Minnesota

Research at three utility-scale solar sites in different ecoregions in MN

- **Pollinator Habitat**: 3x increase in beneficial species from 2019-2020
- **Beneficial Insects**: 4x increase in pollinators from 2018-2020
- **Energy Production**: Cooler temps leads to higher energy output
- **O&M Costs**: Establishment of pollinator habitat leads to fewer mowing events each year
InSPIRE Research Highlight: Minnesota Pollinator-Friendly Solar

Ecosystem Service tradeoffs associated with solar land use scenarios modeled from 30 sites

Ecosystem Services

Leroy J. Walston, Yudi Li, Heidi M. Hartmann, Jordan Macknick, Aaron Hanson, Chris Nootenboom, Eric Lonsdorf, Jessica Hellmann
Key Highlight: Pollinator-Friendly Solar

Over 800,000 acres of agricultural land would benefit if existing solar facilities had pollinator-friendly vegetation.

Experiencing the Potential for Agricultural Benefits from Pollinator Habitat at Solar Facilities in the United States,
What is Agrivoltaics? Solar-Powered Honey Production

Hives can be located in or outside of project fence

Innovative branding and marketing opportunities

Ongoing work evaluating honeybee and native bee preferences

Cost and Design Factors

- Seed mix selection and purchase
- Location of hives (inside or outside fence)
- Safety precautions
What is Agrivoltaics? Solar-Integrated Grazing

Sustainable grazing practices can improve soils
Potential cost reductions from standard mowing practices
Ongoing work evaluating pastureland performance
Can be compatible with pollinator habitat

Cost and Design Factors
- Temporary fencing on-site
- Fencing considerations around site
- Water access
- Panel heights (for cattle)

https://solargrazing.org/
Solar Sheep Grazing Research Shows Promising Outcomes

- 22-acre site divided into 4 trial zones in New York state
- Utilizing sheep for site vegetation management required a total of 139 hours (including travel time), resulting in 2.5 times fewer labor hours than traditional vegetation management (mowing and string trimming) on site.

Table 2. Income statement for grazing 56 sheep on 22 acres.

<table>
<thead>
<tr>
<th>Item</th>
<th>Total</th>
<th>Per acre</th>
<th>Per head of sheep</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>$1,690</td>
<td>$77</td>
<td>$30</td>
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<tr>
<td>Grazing income</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directly contracted</td>
<td>$11,000</td>
<td>$500</td>
<td>$196</td>
</tr>
<tr>
<td>Subcontracted</td>
<td>$5,500</td>
<td>$250</td>
<td>$98</td>
</tr>
<tr>
<td>Grazing expenses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mileage</td>
<td>$2,125</td>
<td>$97</td>
<td>$38</td>
</tr>
<tr>
<td>Labor</td>
<td>$2,084</td>
<td>$95</td>
<td>$37</td>
</tr>
<tr>
<td>General liability insurance</td>
<td>$1,500</td>
<td>$68</td>
<td>$27</td>
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<tr>
<td>Directly contracted total</td>
<td>$5,709</td>
<td>$260</td>
<td>$102</td>
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<tr>
<td>Subcontracted total</td>
<td>$4,209</td>
<td>$191</td>
<td>$75</td>
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<tr>
<td>Net</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Directly contracted</td>
<td>$5,291</td>
<td>$241</td>
<td>$94</td>
</tr>
<tr>
<td>Subcontracted</td>
<td>$1,291</td>
<td>$59</td>
<td>$23</td>
</tr>
</tbody>
</table>

Figure 1. Site plan.
Figure 2. Panel dimensions.
Figure 3. Water access and Electronet®.
What is Agrivoltaics? Controlled Environment Agriculture

Opportunities for direct use of electricity generated

Tunable wavelength materials

Variations in shading

Cost and Design Factors
- Greenhouse vs. indoor vertical designs, etc.
- Solar technology material
- Light, wavelength optimization
- Electricity usage
Key Highlight: Solar-Integrated Greenhouses can Improve Yields

Chervil: *annual herb related to parsley with a delicate anise-like flavor*

Plants that received the altered light spectrum of LUMO in the late afternoon performed significantly better than chervil grown under a greenhouse with clear covering.
Key Highlight: Education through field research

Educational benefits through internships, field trips, work experience, tours
Elementary school through PhD students
State agency, academic, and professional training
Key Highlight: Broad Stakeholder Impacts

Pollinator-Friendly solar standards and scorecards
State Agency partnerships and technical assistance
Direct partnerships with solar and agricultural industry
University initiatives
Thank you

Jordan.Macknick@nrel.gov
https://openei.org/wiki/InSPIRE
Lois Henry
CEO
SJV Water

#EnergyAtKern  #KernLeads
www.bakersfieldcollege.edu/energy-TTWD
Sustainable Groundwater Management Act – SGMA

SGMA, passed in 2014, mandates critically over drafted groundwater basins - all of the San Joaquin Valley - bring aquifers into balance by 2040. That means don’t pump out more than goes back in.

In Kern County, the subbasin is over drafted by about 300,000 acre feet per year.

Newly formed Groundwater Sustainability Agencies only have 2 ways to get aquifers in balance – bring in more water or reduce pumping.

Here’s what the required amount of pumping reduction would do:

<table>
<thead>
<tr>
<th>Valley wide</th>
<th>Kern County</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 million acres of productive farmland fallowed.</td>
<td>200,000 acres fallowed</td>
</tr>
<tr>
<td>85,000 jobs lost</td>
<td>12,500 jobs lost</td>
</tr>
<tr>
<td>$7 billion lost farm revenue</td>
<td>$600 million lost farm revenue</td>
</tr>
</tbody>
</table>
### Bulletin 118 Groundwater Basins Subject to Critical conditions of Overdraft – Update based on 2018 Final Basin Boundary Modifications.

<table>
<thead>
<tr>
<th>Number</th>
<th>Basin/Subbasin Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-001</td>
<td>Santa Cruz Mid-County</td>
</tr>
<tr>
<td>3-002</td>
<td>Corralitos - Pajaro Valley</td>
</tr>
<tr>
<td>3-004.01</td>
<td>Salinas Valley - 180/400 Foot Aquifer</td>
</tr>
<tr>
<td>3-004.03</td>
<td>Salinas Valley - Paso Robles Area</td>
</tr>
<tr>
<td>3-004.05</td>
<td>Los Osos Valley - Los Osos Area</td>
</tr>
<tr>
<td>3-005</td>
<td>Cuyama Valley</td>
</tr>
<tr>
<td>4-004.02</td>
<td>Santa Clara River Valley - Oxnard</td>
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<tr>
<td>4-005</td>
<td>Pleasant Valley</td>
</tr>
<tr>
<td>5-022.03</td>
<td>San Joaquin Valley - Eastern San Joaquin</td>
</tr>
<tr>
<td>5-022.05</td>
<td>San Joaquin Valley - Merced</td>
</tr>
<tr>
<td>5-022.06</td>
<td>San Joaquin Valley - Chowchilla</td>
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<tr>
<td>5-022.07</td>
<td>San Joaquin Valley - Madera</td>
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<tr>
<td>5-022.08</td>
<td>San Joaquin Valley - Delta Mendota</td>
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<tr>
<td>5-022.09</td>
<td>San Joaquin Valley - Kings</td>
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<tr>
<td>5-022.10</td>
<td>San Joaquin Valley - Westside</td>
</tr>
<tr>
<td>5-022.11</td>
<td>San Joaquin Valley - Kaweah</td>
</tr>
<tr>
<td>5-022.12</td>
<td>San Joaquin Valley - Tulare Lake</td>
</tr>
<tr>
<td>5-022.13</td>
<td>San Joaquin Valley - Tulare</td>
</tr>
<tr>
<td>5-022.14</td>
<td>San Joaquin Valley - Kern County</td>
</tr>
<tr>
<td>5-024</td>
<td>Indian Wells Valley</td>
</tr>
<tr>
<td>5-024.01</td>
<td>Borrego Valley - Borrego Springs</td>
</tr>
</tbody>
</table>
Brian Curtis
Founder & CEO
Concentric Power Inc.
Intelligent Microgrid Infrastructure
What we do

Tech-advantaged Sustainable Infrastructure

Design-Build-Operate physical electric power generation and distribution assets

Advanced controls and automation

Forward looking and differentiated grid architecture and business models

Pre-engineered system blocks for rapid deployment and immediate impact
Concentric Power’s Mission:

To create pathways to reach zero carbon electric power for significant industries, while providing for our customers energy independence and resilience now.
State of the Power Industry for Ag in California
Ag on the Grid Edge

- We are at a once-every-couple-of-generations moment with a fundamental energy transition in California (and around the country)

- Energy for agriculture faces unique challenges at the “Grid Edge”

- It’s easy to focus on immediate power outages and headline news, but the underlying megatrends help guide solutions
California Power Demand

Demand trend

Day ahead forecast · Hour ahead forecast · Demand (5 min. avg.)
California Power Supply

Supply trend

- Renewables
- Natural gas
- Large hydro
- Imports
- Batteries
- Nuclear
- Coal
- Other
Texas Blackout: Death Toll Mounts While Food and Water Are Impacted

By Climate Nexus | Feb. 18, 2021 10:36AM EST

People wait in long lines at an H-E-B grocery store in Austin, Texas on February 17, 2021 as millions of Texans are still without water and power as winter storms continue. Montinique Monroe / Getty Images
INVESTIGATIVE

PG&E: Public Safety Power Shutoffs Likely ‘A Reality' Indefinitely

By Jaxon Van Derbeken • Published February 3, 2021 • Updated on February 3, 2021 at 7:31 pm
Calif. power outages: Outages could hit 15 counties — and PG&E "blacks out" parts of 15 counties — and looks to News could affect 15 counties.

California Power Outage Schedule: PG&E begins planned blackouts as KingFire threat nears.

BY JENN

PG&E CEO: Blackouts could last 10 years, but impact should ease

J.D. Morris | Oct. 18, 2019 | Updated: Oct. 18, 2019 9:20 p.m.

"Public Safety Power Shutoffs" or "PSPS Events" hit close to home in 2019-2020

Jan 2019: PG&E filed for Chapter 11 bankruptcy reorganization including upwards of $30 billion in liabilities for damage from wildfires.

Oct 2019: CEO Bill Johnson told state regulators Friday that his company is working to make forced power outages unnecessary — but the goal could take a decade to accomplish.

Jul 2020: PG&E emerges from bankruptcy focused on safety, compliance and reorganization... with weakened market position.
Headline News – Decarbonization

Jan 27, 2021: “President Biden set ambitious goals that will ensure America and the world can meet the urgent demands of the climate crisis, while empowering American workers and businesses to lead a clean energy revolution that achieves a carbon pollution-free power sector by 2035 and puts the United States on an irreversible path to a net-zero economy by 2050.”
California set a goal of 100% clean energy, and now other states may follow its lead

By SAMMY ROTH | STAFF WRIT

California approved goal for 100% carbon-free electricity by 2045

SB 100, signed in September 2018, increased the overall requirement from 50% to 60% by 2030.

The legislation also adopted an additional goal of 100% of all retail sales by 2045 come from renewable energy resources and zero-carbon resources.

- 20% of retail sales by December 31, 2013
- 25% of retail sales by December 31, 2016
- 33% of retail sales by December 31, 2020
- 44% of retail sales by December 31, 2024
- 52% of retail sales by December 31, 2027
- 60% of retail sales by December 31, 2030

CA laws and regulations are impacting energy procurement choices for utilities
Favorable Legislative and Regulatory Environment Supports Microgrid Development

Favorable trends in CA lay the foundation for the next 25+ years of energy project development:

- **RPS:** SB1078, SB350, SB100
- **CCA’s:** AB117
- **Microgrids and Supply Aggregation:** SB1339, FERC Order 2222
- **Local ordinances for electrification of everything**

**Implications:**
- Fundamental re-regulation is in progress
- Nuclear is being decommissioned
- No new large gas generation plants
- High penetration of renewables is impacting grid stability and need for upgrades

Concentric’s policy and regulatory strategy focuses on building real projects and engaging customers:

- We are building beneficial projects to present as live case studies for rule making in progress
- We work with key customers (private and public sector) and trade organizations such as Western Growers Association where we have close ties to ensure that the voice of the end user is the one being heard
- We leverage RPS, CCA’s and overall trends
- For 2020-2021, our focus includes engagement in SB1339 and FERC 2222 rule making and implementation
  - Independent effort, together with our customers
  - With peer group to shape industry landscape

~~Confidential~~
CA Food and Ag: Market Size and Urgency

- California's food and ag processors are a large and essential national industrial base.
- Energy density and requirements are high due largely to refrigeration and cold chain management.
- Energy cost in CA under large ag rates have increased 25% in the last 16 months to >$0.20/kWh.
- **California** (5,531 plants) has by far the most food processing plants in the country, more than double that of second place New York (2,508 plants). The State holds an important national position in several food processing industries, including fruit and vegetables, sugar, wine, and coffee, because of its favorable climate for growing a variety of crops and for its ports. California's large population results in the State having numerous dairy processing plants. Fluid milk and ice cream plants are located near major metropolitan areas primarily because of high distribution costs associated with the perishability of these products. **Source:** Manufacturing, by Stephen Martinez, USDA, Economic Research Service, August 2019

- In 2018, California's farms and ranches received almost $50 billion in cash receipts for their output. This represents a slight increase over adjusted cash receipts for 2017. California's agricultural abundance includes more than 400 commodities. Over a third of the country's vegetables and two-thirds of the country's fruits and nuts are grown in California. California is the leading US state for cash farm receipts, accounting for over 13 percent of the nation's total agricultural value. **Source:** California Dept. of Food & Ag (CDFa) website

- Cold chain logistics and cold storage are not included in the above numbers and constitute an additional large adjacent market.

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Farming, ag processing and supporting communities are at high risk of power outages and problems due to wildfire shutoffs and poor utility power quality at grid edge.
Megatrends in CA Energy – 2020 to 2045
Megatrends --- Cost of Renewables

Cost of Solar

$/watt

2008 2010 2012 2014 2016 2018
Megatrends --- Cost of Batteries

US Utility Scale BESS Install Cost Outlook 2016:40 – IHS Markit
Megatrends --- Cost of Fuel
Megatrends --- Cost of Capital

10 Year Treasury Rate - 54 Year Historical Chart

Interactive chart showing the daily 10 year treasury yield back to 1962. The 10 year treasury is the benchmark used to decide mortgage rates across the U.S. and is the most liquid and widely traded bond in the world. The current 10 year treasury yield as of January 23, 2020 is 1.74%.
Megatrends --- Cost of PG&E Power

PG&E AG5C Large Ag Electric Rates
2008-2020

9.9% Increase in 4 months
1/1/20 to 5/1/20

25% Increase in 16 months
1/1/19 to 5/1/20
Megatrends viewed together tells the story...
Concentric Power Selected Reference Projects
Typical Concentric Behind-the-Meter Ag Industrial Microgrid: Gonzales, CA

Wind: 1.85 MW

Cogen: 2.25 MW

Solar: 1.0 MW
True Leaf Farms Microgrid by Concentric, San Juan Bautista, CA
Typical Concentric Behind-the-Meter Aggregated Ranch-Scale Microgrid, King City, CA

Microgrid Distribution
to 10,000 acre ranch,
incl aggregation of 46 PG&E meters and ranch-scale Energy Storage

Solar: 5.3 MW

Energized Nov 2020

12 kV gen-tie to microgrid hub
Cogeneration provides island capability and active load management. Cogeneration ties into glycol system for cooling and product driers for heat (trigeneration).

Main goal of project is to provide outage ride thru as well as lower cost and support for expansion projects without utility timing dependence.

SYSTEM CAPACITY:
Gas Engines: 3.6 MW
Batteries: 1200 kW / 600 kWh
Solar: 120 kW-DC
Typical Concentric Ag Community Microgrid: Gonzales, CA --- 35 MW solar+storage+firm gas

Concentric Power Microgrid Serving Agricultural Industrial Business Park Phase 1 Breaking Ground 2021

10 MW Flexible Thermal Generation
10 MW / 27.5 MWh Battery Energy Storage
Advanced Microgrid Controller and NOC

14.5 MW-AC Solar
Typical Concentric Ag Community-Scale Microgrid: Gonzales, CA --- 35 MW solar+storage+firm

Concentric Power Microgrid Serving Agricultural Industrial Business Park Phase 1 Breaking Ground 2021

City of Gonzales, CA

Ag Industrial Park

14.5 MW-AC Raised Solar Co-located at existing and future Waste Water Treatment Plant
Q&A

James McCall
Distributed Energy and Environment Analyst
National Renewable Energy Laboratory (NREL)

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www.bakersfieldcollege.edu/energy-TTWD
Future Webinars - Save the Date

Energy TT&WD Webinar 4
April 28, 2021

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