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California Central Valley Farm and Water Issues

A Proposal for Distributed Energy Systems with Benefits of Reduced Pollution and Reduced Loss of Water

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ENG 300 Presentation

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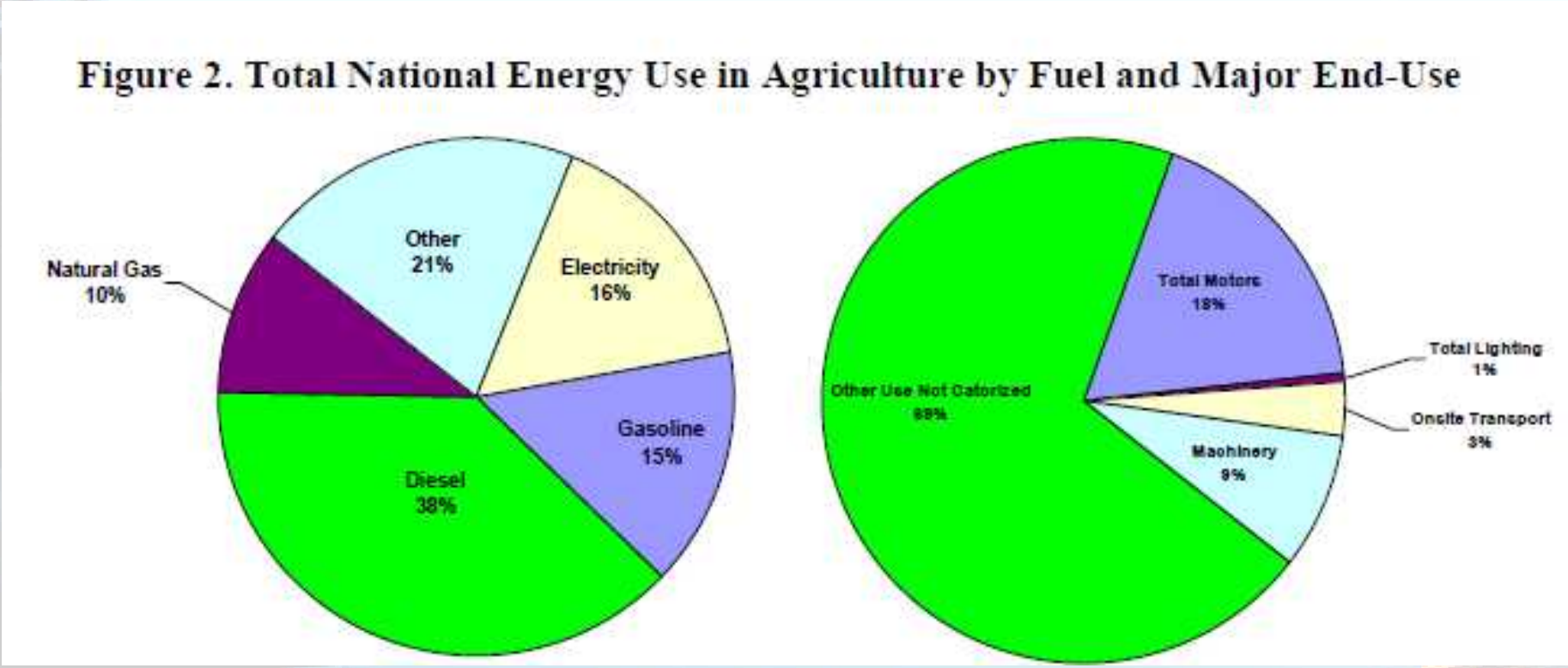
A lot of food is grown in the Central Valley

- The valley produces one quarter of the food that America eats
- between 8 - 12% of the nation's agricultural production by value

A lot of energy goes into growing that food

- 19 trillion BTUs / year in CA



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The Aqueduct makes it possible

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Some CV & aqueduct facts

- includes 2 major watersheds – Sacramento & San Joaquin
- for the most part, surrounded by mountains
- handles 7 million acre ft. per year; delivers 5 million acre ft. for agriculture – enough to irrigate 3 million acres
- 593 miles in canals as opposed to only 45 miles in pipes, tunnels, etc.
- 20 dams and reservoirs for storage along the way
- About one-sixth of the irrigated land in the U.S. is in the Central Valley

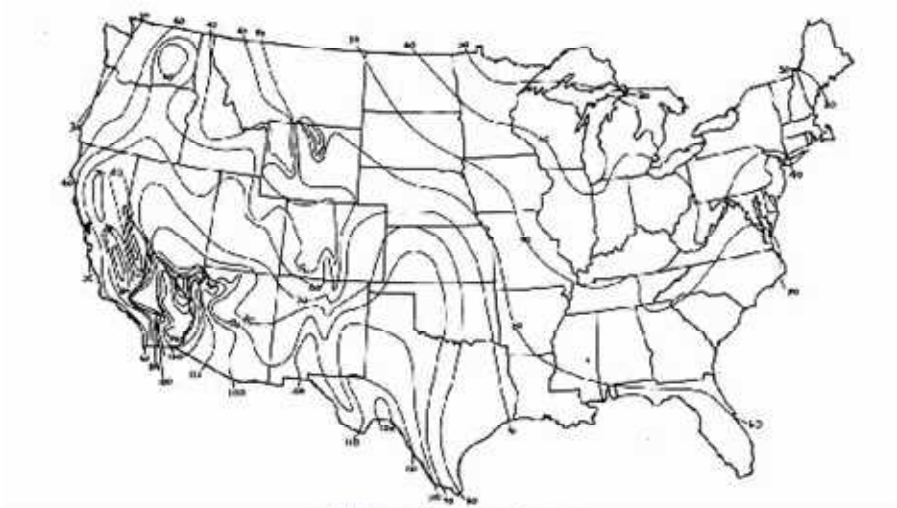
Some problems are introduced

- Water is lost to evaporation
- Increased agricultural activities leads to high levels of pollution
- Aqueduct removes water from ecosystems/fisheries where it flowed previously
- Reliance on imported energy sources creates a major exposure for food security risks
- Exposure to risk of failure from climate disruption

Evaporation is a problem

The National Weather Service uses a large water pan with a diameter of 4 feet. They measure the drop in water level in one day, fill it back to the level it was before and measure the level drop the next day. They and others do this all over the United States. Others do it throughout the world. The Weather Service reports the evaporation at each location, each day, and sum all these daily values up to obtain an annual evaporation rate in inches. All the data through the US is collected and compiled into an annual evaporation map.

Annual Class A Pan Evaporation (inches)



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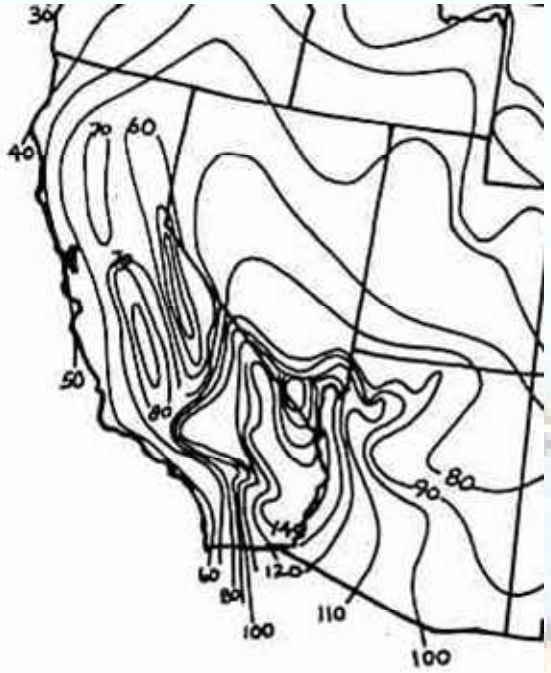
Looking at the annual evaporation map one can find the average annual evaporation rate for any location. It is roughly 100 inches for Tucson, Arizona.



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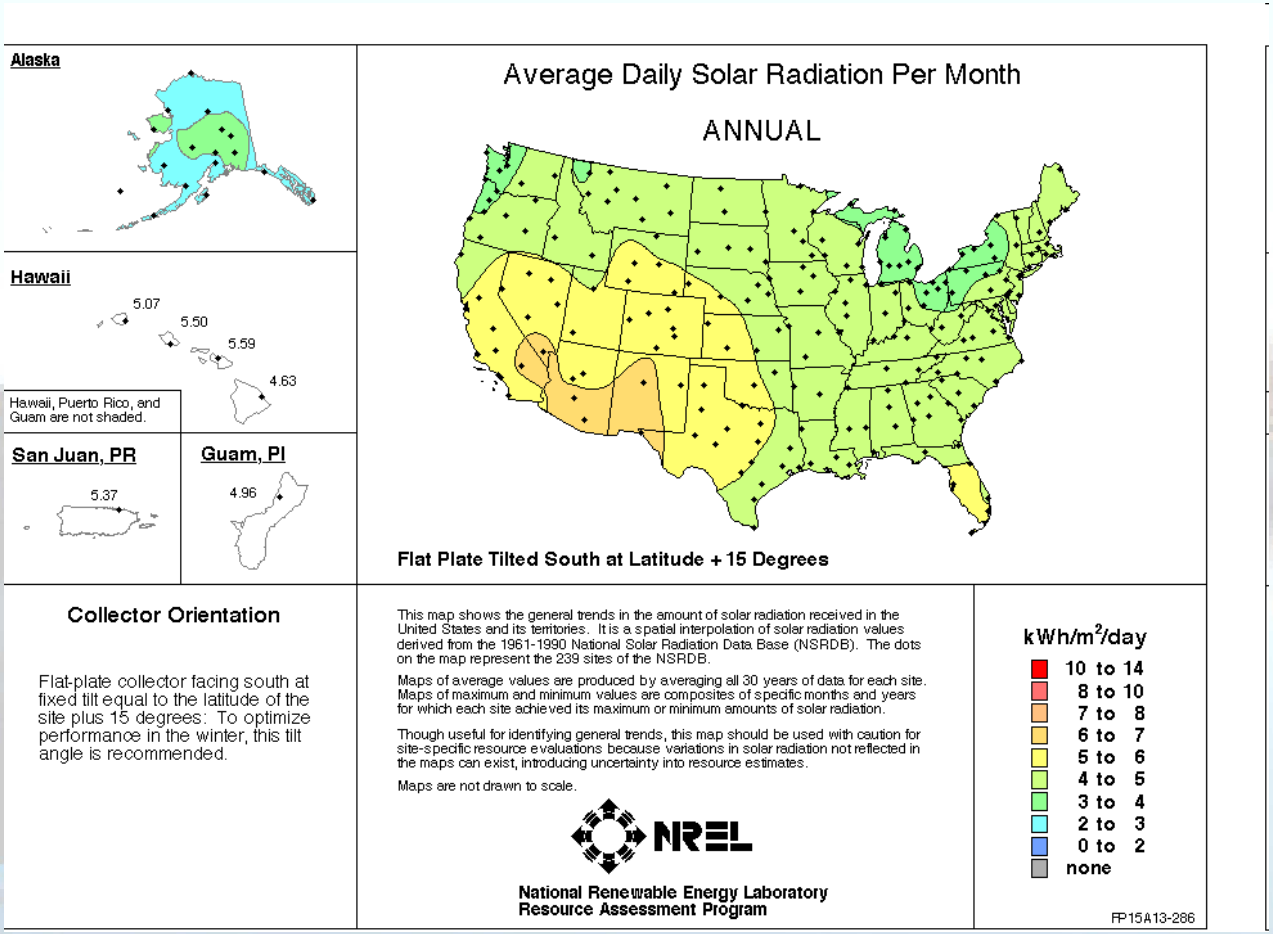
Central Valley gets a lot of sunshine

- Annual solar insolation for CV, ~ 5 kWh/m^2/day



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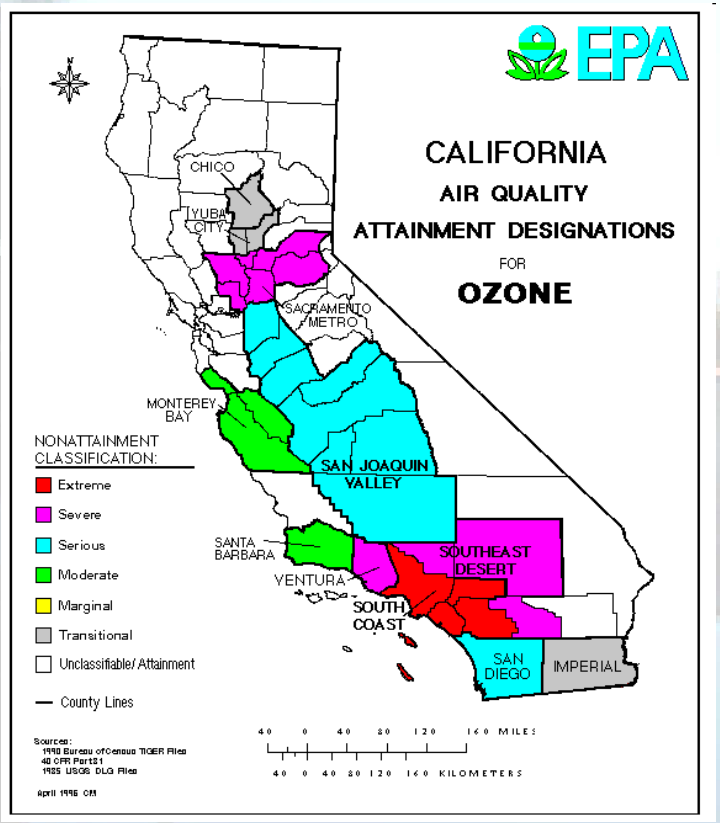
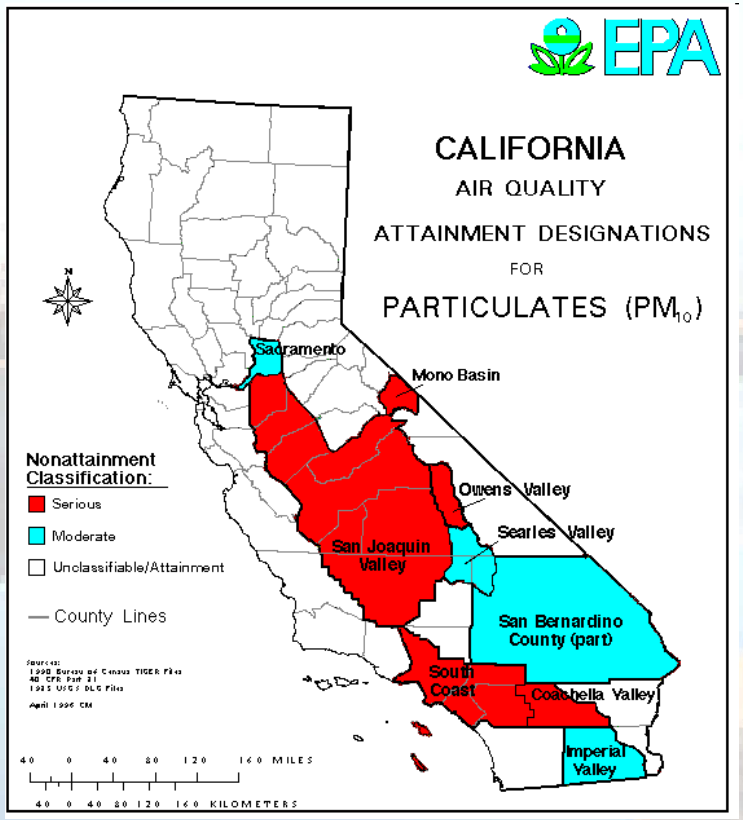
Air quality in Central Valley is poor

- Many agricultural activities have been exempt from Clean Air and Clean Water Acts





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Water must be shared with fisheries

- Closure of salmon season for second year in a row is blamed by many on water diversion to aqueduct – entire CA salmon fleet is out of a job this year, again
- Salmon season closing costs: $255 m to commercial fisheries, $1.5 b from recreational fisheries retail value -- thousands of jobs
- Farmers who haven't gotten expected allotments of water are left with unplanted fields; contributing to unemployment, among other things – they blame water diverted to fisheries, wetlands
- Loss from farmland out of production between $440 m and $644 m; 16,200 – 23,700 jobs lost and expected rise of food costs nationwide
- $260 m of federal stimulus money pledged to addressing the CA water crisis

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Reliance on imported energy sources

Table A-2. End-Use Energy Use by Farm-Type and Fuel-Type in California (in trillion Btus)

	Total Motors	Total Lighting	Onsite Transportation	Machinery	Other Not Categorized	Total
Total — All Farm—Types						
Gasoline	1	—	1	0.1	10	12
Diesel	4	—	3	3	17	26
Natural Gas	0.383	—	—	—	10	11
Other	0.001	0.023	—	0.05	7.7	8
Electricity	4	2	—	—	13	19
Total Petroleum	5	0.02	4	3	44	56
Total Energy	9	2	4	3	58	75

- Total energy use in California per year (2000 data) ~ 75 trillion BTU's/year
- Largest energy use in crop farming is for pumping water
- In California 95% of crop land is irrigated
- California is highly reliant on petroleum products for food production

Photo source for attribution: Ted Holzem, Mintier & Associates.

Fruit and Nut Farming in the CV is energy intensive

Table 4. Summary End-Use Energy Use in California[2] (in trillion Btus)

	Total Motors	Total Lighting	Onsite Transportation	Machinery	Other Not Categorized	Total
Dairy — Total Energy	2	0.1	0.1	1	0.22	3
Greenhouse/Nursery — Total Energy	3	0.2	0.2	1	1.00	6
Cattle Feedlots — Total Energy	1	0.1	0.1	0.4	0.01	1
Oilseed and Grain Farming — Total Energy	0.5	0.0	0.3	0.3	0.04	1
Fruit and Tree — Total Energy	5	0.4	1.7	3	0.36	11

- Energy use by type of farm in California
- Fruit and nut farming is most energy intensive farm type listed and is large part of Central Valley farming.

Photo source for attribution: Ted Holzem, Mintier & Associates.

A proposed approach

- Build structures over the aqueduct that would simultaneously reduce evaporation and produce energy for agricultural uses
- Benefits would include:
  - increase water flow thru canals thus allowing more to be released for fisheries and wildlife uses :: increase abundance of fish and quality of natural watersheds, provide ecosystem services
  - provide clean energy alternatives to polluting diesel, etc. :: reduce air pollution in the Central Valley
  - distribute the energy sources, reducing dependence on imported energy :: create some food security
  - make use of real estate that is already publicly owned for energy projects; no need to take any agricultural land out of production :: foil common obstacle to renewables development

How much could we increase flow?

- The amount of water lost to evaporation from the canals:
  - 0.7 inches/day X 400 miles X 30 ft = 3.7x10E6 ft3 or 27x10E6 gallons / day (27,000,000 gallons a day)
  - that's about 83 acre ft. a day, 30,000+ acre ft. a year
  - enough for 82,000 households
  - at $1/1000 gallons, about $10 million a year

Solar Panels used as Parking Shade

Oroville, California (Butte County, Sacramento Valley) 2004

Solar Panels

Oroville Wastewater Treatment Plant, (Butte County, Sacramento Valley) 2004

Photo source for attribution: Ted Holzem, Mintier & Associates.

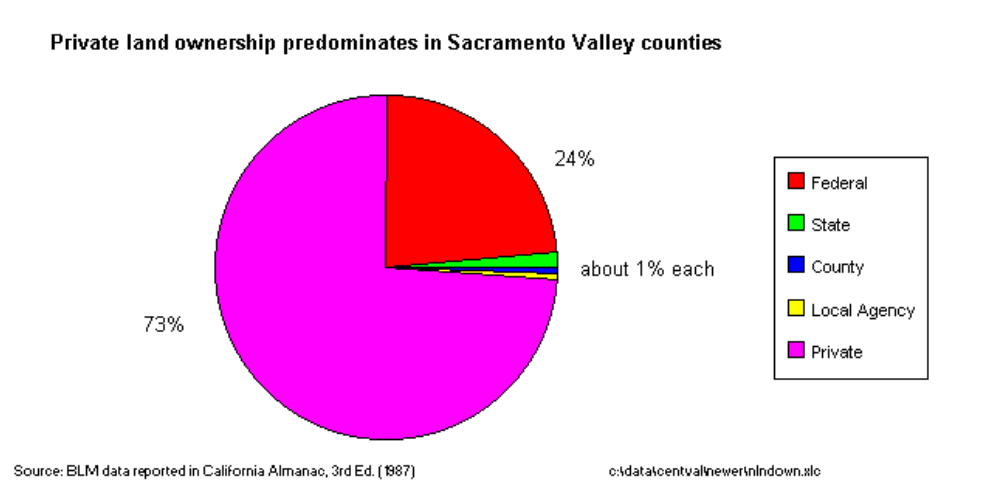
Going to cleaner energy

- many agricultural uses of energy could be switched to renewable and/or less polluting sources
- pumps and and machinery that move irrigation water tend to be diesel fueled
- tractors tend to be replaced infrequently and are often highly polluting
- tractors in the CV use about 500 million gallons fuel/year

Photo source for attribution: Ted Holzem, Mintier & Associates.

Real Estate Issues

- most of the land in the CV is privately owned
- the public lands are mostly the mountainous edges, and the water projects
- many alternative energy projects have been held up because of land issues
- the water projects have a history & precedent of multiple use – there are already hydroelectric projects incorporated



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What fraction of Central Valley farm energy use could be provided by solar panels covering the canals?

- From annual insolation map, assuming fixed, tilted panel arrays, 5 kWh/m^2/day, and half of 400 mile, 30 ft wide, canal covered with solar panels -> 5.4 billion kWh per year
- Total California farm energy use / year is about 75 trillion BTU's or 22 billion kWh / year. (http://www.aceee.org/pubs/ie052full.pdf)
- 7 million acres of irrigated land in the Central Valley (http://ucce.ucdavis.edu/freeform/waterquality/documents/Ag_Discharge_Waiver_Information5922.pdf)
- About 9 million acres of irrigated land in CA. (http://www.waterplan.water.ca.gov/docs/meeting_materials/plenary/09.18-19.08/day2/irrigated_land_area_charts.pdf)
- Assume about 75% of energy use in California farming is used in Central valley (fruit and nut crops are more energy intensive than most other farming operations).
- Central Valley energy use about 17 billion kWh / year. So $\frac{1}{2}$ of Central Valley Canal system covered with solar panels could provide about a third of energy used on the farms.

Summary - food security

- agriculture in CV relies on significant imports; namely energy and water
- anything that we can do to reduce this reliance increases food security in California and in the nation
- if we can do this well, we can also receive less tangible benefits such as:
  - reduction of pollution-caused illness
  - reduced habitat loss and degradation
  - halted ecosystem collapse
  - greater benefit from ecosystem services
  - higher employment in relatively poor counties (green jobs)
  - release from dependence on foreign energy imports
  - reduced dependence on carbon based fuels – reduced contribution to global climate disruption

Required information….

- Why the topic was selected:
  - tight tie between water and energy issues is becoming increasingly evident and increasingly an issue
  - relevant to everyone, but especially to Californians
- How the this topic relates to ENG300
  - taking a systems approach to problems with energy and water in the Central Valley
- How could Sandia help?
  - finding solar (or other) energy generating solution that makes economic sense
  - alternative to diesel for tractors and irrigation pumps (biodiesel, fuel cell, etc)
  - examine possibilities for cogeneration and for increased efficiencies relating to distribution of production

Photo source for attribution: Ted Holzem, Mintier & Associates.

References

- links to sources can be accessed at:
  http://delicious.com/accipiter/eng300
- other photo credits:
  - Ted Holzem, Mintier & Associates

"When the well's dry, we know the worth of water"

- Benjamin Franklin

Photo source for attribution: Ted Holzem, Mintier & Associates.

Tractor calculations

- assume farmed area of central valley is 1% of US farmed area, or 9.2 million acres
- assume one 'medium' sized tractor per 50 acres. This gives about 184,000 tractors in Central Valley.
- medium sized tractor (200 hp) uses about 9 gals/hr. Tractor statistics assume 300 hours / year for each tractor. Total fuel use estimate is then 184,000 x 300 x 9 ~ 500 million gallons fuel / year.
- Btu/US gallon for diesel fuel = 138,700 (http://en.wikipedia.org/wiki/Fuel_efficiency)
- total BTU used = 6.9e13 BTU = 0.07 Quad BTU = 20 billion kWh. Compare this to 26.6 Quad (10^{15}) BTU energy used in US in 2000 (March 31, 2009 ENG300 presentation by M. Hightower).
- cost of fuel, assuming $3/gallon, is $1.5 billion/year. Over 25 years (assuming fuel cost doesn't change), cost of fuel would be $45 billion.

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Solar Panel Calculations

- Assume 200 W panels in 2 ft x 3 ft size. ~30 W/ft^2.
- Assume half of 400 miles is covered with panels. 200 miles x 30 ft ~ 30 million ft^2 or about 3 million m^2.
- From annual insolation map, assuming fixed, tilted panel arrays, 5 kWh/m^2/day -> 5.4 billion kWh per year, or about ¼ that used by farm equipment.
- If we use same ratio of diesel fuel to electrical use as shown on California Energy use pie chart slide, electricity is about 40% of diesel fuel use, or about 8 billion kWh. The solar panels would cover about 68% of the farm electrical cost.
- Assume cost of $400/MWh produced. Assuming 5.4 billion kWh/yr over 25 years the system would generate about 135 million MWh. Backing out the initial cost from this, system cost would be about $54 billion.
- Assuming average price of $0.15/kWh average over 25 year life, value of electricity generated by PV is only $20 billion….