Thoughts on Energy/Water Nexus – Energy Technologies, California Case

Terry Surles, Executive VP for R&D
Desert Research Institute
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The New Paradigm: We Can No Longer Ignore the Inter-Relationships

- **Energy Security**
  - Secure supply
  - Reliability

- **Environmental Impact**
  - Carbon mitigation
  - Water availability and quality

- **Economic Productivity**
  - Global financial issues
  - Energy and resource prices

Vulnerability or Opportunity
There remains a critical need to make the best use possible of indigenous national resources:
- Water in the Southwest
- Energy resources in the region and nation

International energy resource competition will require effective development and use of national resources:
- Geothermal, solar, wind, coal, uranium

Changing climate can produce “winners” as well as “losers” - requires an understanding of past climate events and the impact on cultures:
- Northern countries may benefit: Canada, Russia
- Temperate countries may suffer due to loss of cropland and increase of tropical diseases and exotic pests
- Winners and losers will also be driven by water (or lack thereof) – more severe storms, more persistent droughts, and wildfire

Exacerbate international tensions – Particularly issues of water availability: China, Middle East
Increase in Drought and Aridity Is Already Occurring

Mainly decrease in rain over land in tropics and subtropics, but enhanced by increased atmospheric demand with warming.
Principal Reservoir: Sierra Snow Pack Is Shrinking AND Runoff Will Start Too Early in the Year

Warmer Winters Have:

- Reduced snow pack
- Produced earlier snow melt
- Decreased Spring runoff by 10%
- Had major effects on water supply, Cal Fed and Delta

Sacramento River Runoff (1906-2001) April to July as a Percent of Total Runoff

Source: California Protection Agency, Environmental Protection Indicators for California, 2001
Under drought conditions, all 45 state water managers who responded to the GAO predicted water shortages that could be "accompanied by severe economic, environmental and social impacts."

Water managers in 36 states surveyed by the GAO said they anticipate water shortages in the next 10 years under "average water conditions."
Water/Energy Nexus: Need to Address Demand from Both Directions

- Reduce energy required for water development, transportation, treatment, consumer delivery, processing and recycling gray water, climate-appropriate landscaping, drip irrigation, etc.

- Develop technologies for decreasing water needs for energy development and generation: fossil fuels, biomass, and solar (CSP) technologies

- Reduce industrial, agricultural, and water process energy costs through improved load management and metering technologies.
Energy and Water are Inextricably Linked

Energy production and generation require water.

Water pumping, treatment, and distribution require energy.
Water Management is an Energy Intensive Industry (California Data)

- Water (Irrigation & Pumping): 17,652 million kWh
- Petroleum Refining: 6,230 million kWh
- Electrical & Electronics: 5,521 million kWh
- Food Products: 5,131 million kWh
- Chemical & Allied Products: 3,910 million kWh
- Oil & Gas Extraction: 3,846 million kWh

High Priority
Priority Only In Collaboration
System-Wide Energy Use In Water and Wastewater Treatment

1. Pumps to Plant = 100 kWh/MG
2. Water Treatment Plant = 250 kWh/MG
3. Pumps to Distribution System = 1150 kWh/MG
4. Pumps to Plant = 150 kWh/MG
5. Wastewater Treatment Plant = 1050 kWh/MG

Accumulating Total: 100 kWh/MG, 350 kWh/MG, 1500 kWh/MG, 1650 kWh/MG, 2700 kWh/MG
As Much Freshwater Is Used For Producing Electricity As For Irrigation

Estimated Freshwater Withdrawals by Sector, 2000

- Thermoelectric: 39%
- Irrigation: 39%
- Public Supply: 14%
- Industrial: 6%
- Livestock: 2%

Source: USGS Circular 1268, March, 2004
Energy Efficiency: The Most Cost Effective Approach
Power Plant Water Withdrawal Requirements

*with and without CO₂ capture*

| Source: Coal and Performance Baseline for Fossil Energy Power Plants, Volume 1: Bituminous Coal and Natural Gas to Electricity; NETL, May 2007 |
Life Cycle Emissions: Well-to-Wheels Analysis – Biofuel System

- Solar Energy
- CO₂ - FIBREVehicle
- Harvesting
- Bio-Energy Facility Combines CO₂ into Ethanol, Electricity & CO₂
- Distribution
- Use as Fuel
- Cars Burn Ethanol to Release CO₂, Which is Recycled
Massive Development of Biomass Technology is Not Without Issues

- **Water Use**
  - Irrigation requires energy
  - Water rights will be at issue

- **Fertilizer**
  - Many are produced with natural gas feedstocks
  - Run-off causes considerable pollution, ocean dead zones

- **Competition for Food**

- **Land Availability**
  - Use of marginal lands can make erosion problems worse

- **Contribution to Global Warming**
  - Destruction of tropical forests

- **Conversion Technologies**
  - Problems with developing cost-effective cellulosic conversion systems
California: Electricity Generation from Renewable Resources Is Increasing

Percentage Change in Source of Generated Energy: California in 2001 and 2008

- **2001**
  - Coal: 16%
  - Natural Gas: 47%
  - Hydro: 16%
  - Nuclear: 13%
  - Renewable: 9%

- **2008**
  - Coal: 16%
  - Natural Gas: 47%
  - Hydro: 10%
  - Nuclear: 15%
  - Renewable: 14%
“Whiskey’s for drinking, water’s for fighting over.”

– Mark Twain
California Energy Crisis: An Imperfect Storm

- Flawed 1996 approach to deregulation allowed for significant manipulation of electricity prices
  - Original premise was to create a price cap that allowed IOUs to recover costs on stranded assets
  - SDG&E recovered costs first, with the cap removed (and the assumption that prices would go down), resource costs skyrocketed in summer of 2000
  - California legislative response was to force SDG&E to rescind price increases
- Low hydro year in the Pacific Northwest
- El Paso natural gas pipeline put out of service
Water and Energy in the California Energy Crisis: An Avenue for Litigation

- Flawed 1996 approach to deregulation
  - Last “bid in” created market price for all suppliers for that time period
  - As a result, Enron and others took advantage of market imperfections to “game” the system

- One unanticipated result was that Powerex received ~$1B during 2001
  - CA Attorney General Lockyer sued to recover $850M
  - Lawsuit was dismissed
  - Final denouement was Powerex’s agreement to settle a separate FERC lawsuit for $1.3M
Water/Energy: CPUC Pilot Efforts

- ECONorthwest funded by CPUC to evaluate water pilot programs in which foci were:
  - Conserve water
  - Use less energy-intensive water
  - Make delivery and treatment systems more efficient

- Results from the pilots were mixed at best
  - Audits, leak detection, large customer pilots resulted in reduced water and, therefore, reduced electricity use

- Where linkages were attempted between utilities, results were not good
  - SCADA improvements were ineffective due to lack of cross-training between water and electricity utilities
Success of Tamarisks in Invasive Environment Leads to Lessons Learned Beneficial to Native Habitat
Creating Opportunities From Scarcity: Link R&D, Public Policy to Commercialization Process

Basic Research & Development

Collaborative Technology Development Integration Application

Technology Commercialization

National Laboratories

Universities

Institutional Issues Regulations Incentives

Government

Industry R&D

Suppliers

Vendors

End Users
Driving to a Sustainable Future:
The “E”s are Linked

- Environment
- Energy
- Economics
  - Replicability
  - Scalability
  - Expandability
- Equity
- Education