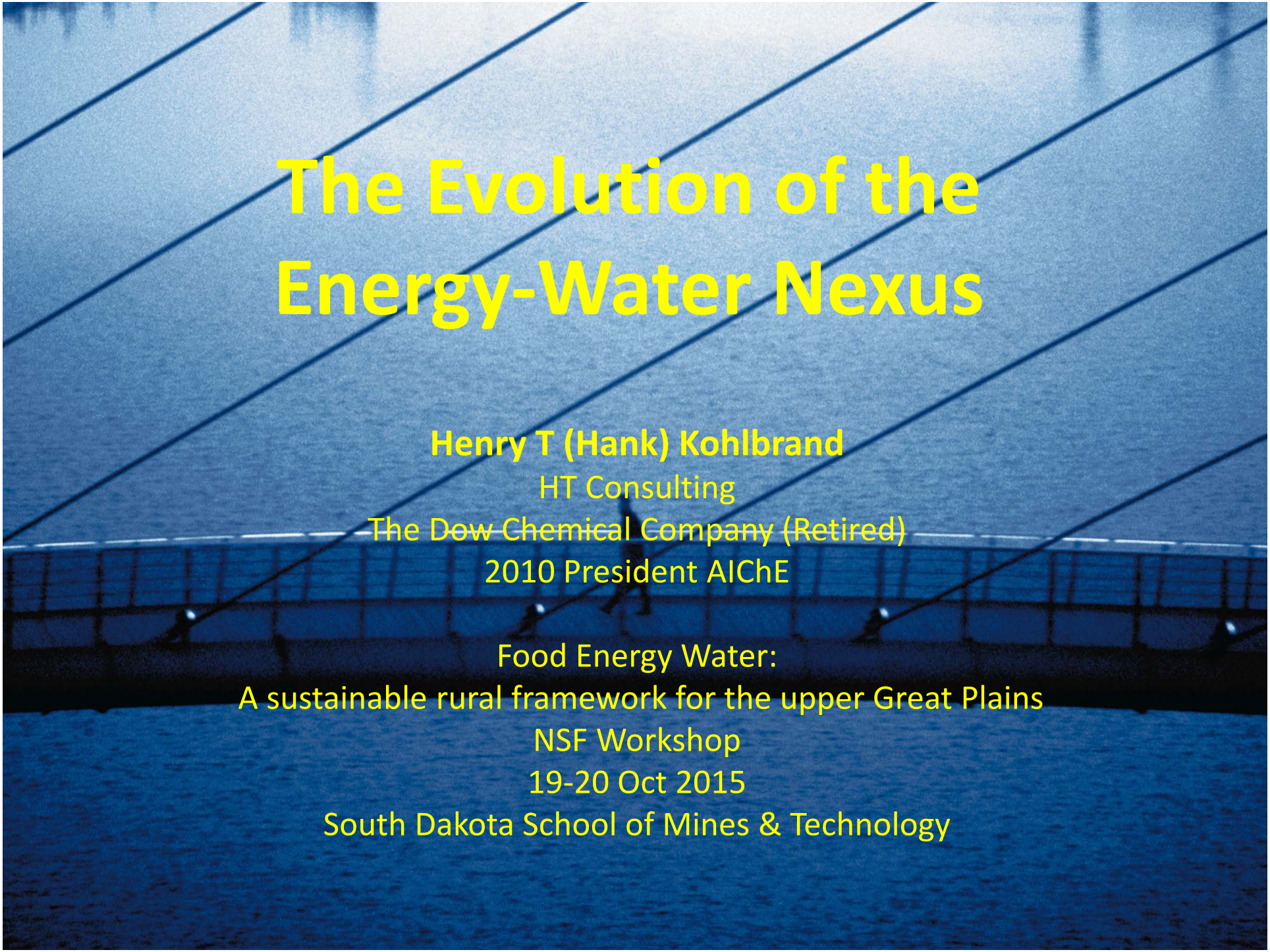
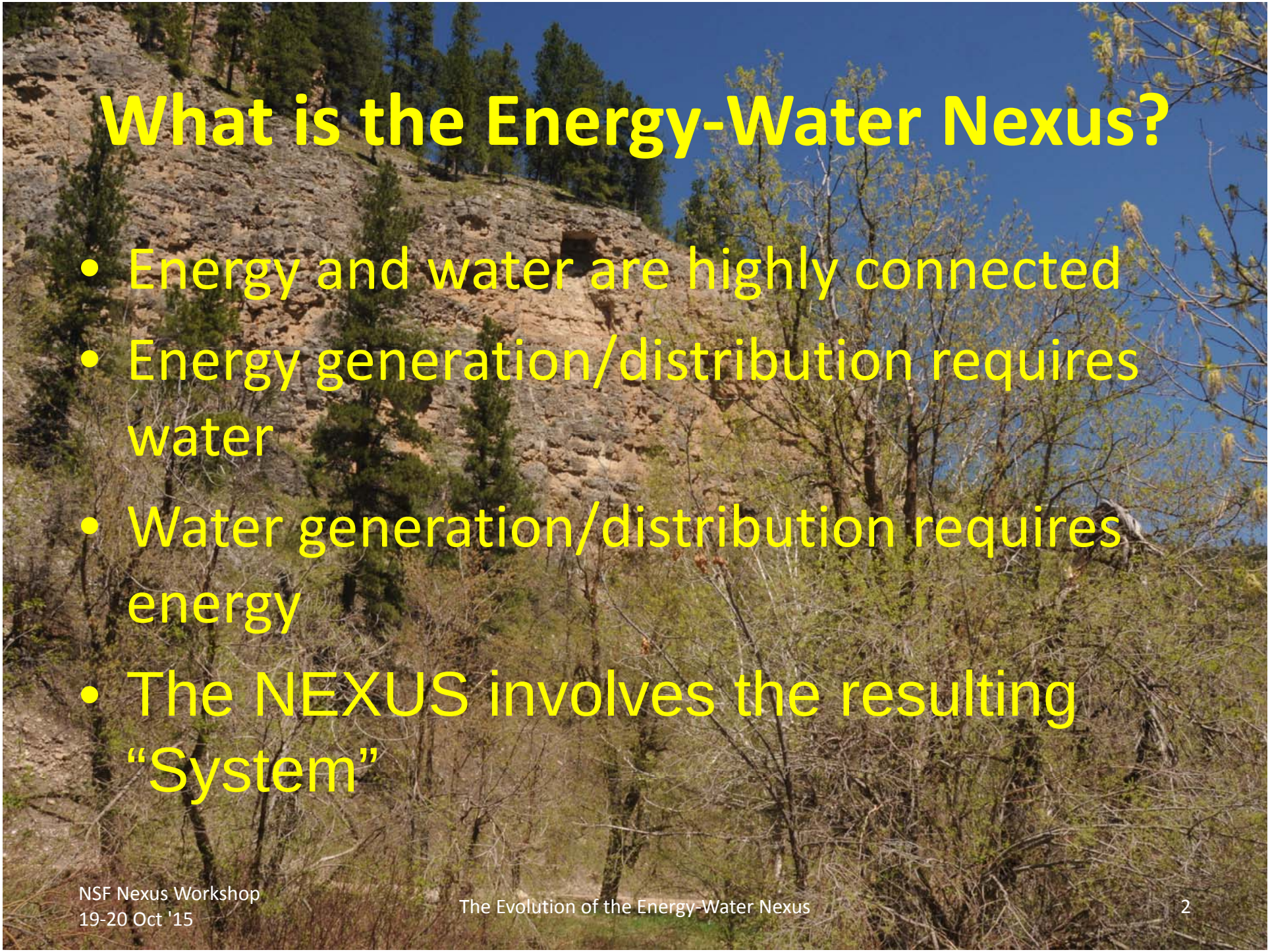


# The Evolution of the Energy-Water Nexus

**Henry T (Hank) Kohlbrand**
HT Consulting
~~The Dow Chemical Company (Retired)~~
2010 President AIChE

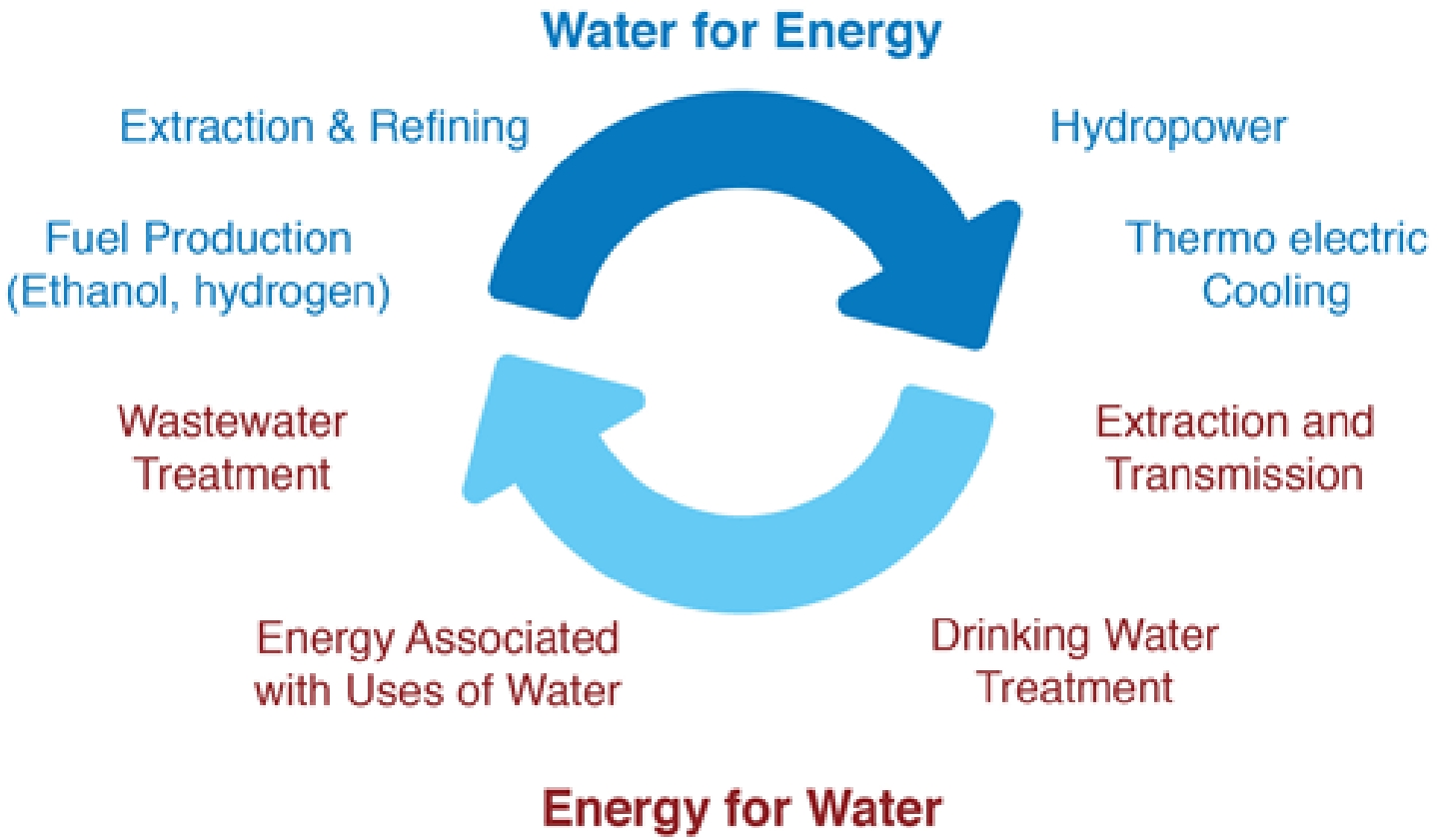
Food Energy Water:
A sustainable rural framework for the upper Great Plains
NSF Workshop
19-20 Oct 2015
South Dakota School of Mines & Technology



# What is the Energy-Water Nexus?

- Energy and water are highly connected
- Energy generation/distribution requires water
- Water generation/distribution requires energy
- The NEXUS involves the resulting "System"

# Energy Requires Water & Water Requires Energy



# The Water-Energy Nexus

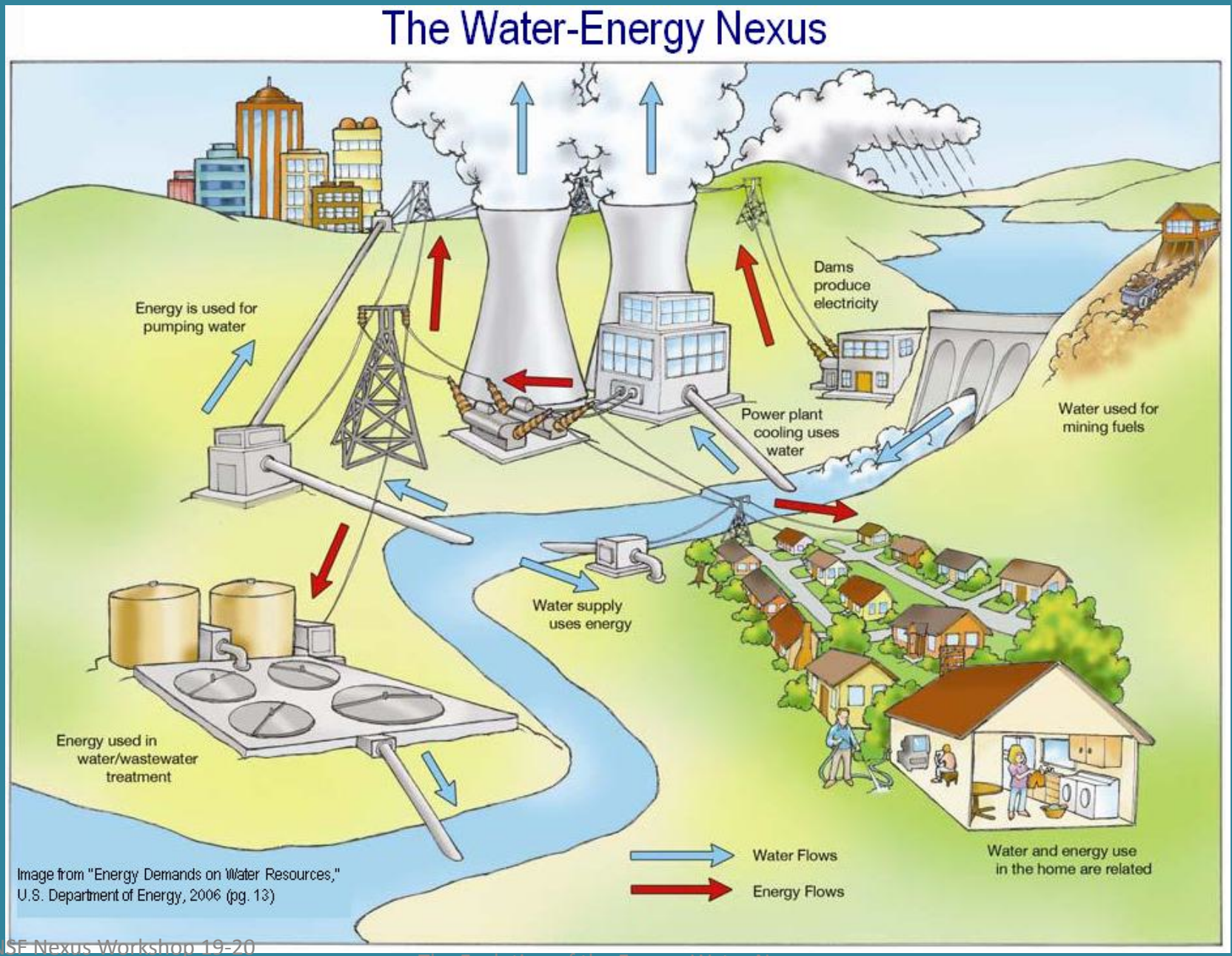



Image from "Energy Demands on Water Resources," U.S. Department of Energy, 2006 (pg. 13)

# California's Water-Related Energy Use

30% of all Natural Gas

Enough to supply 60% of CA home's gas needs:

7.2 million homes

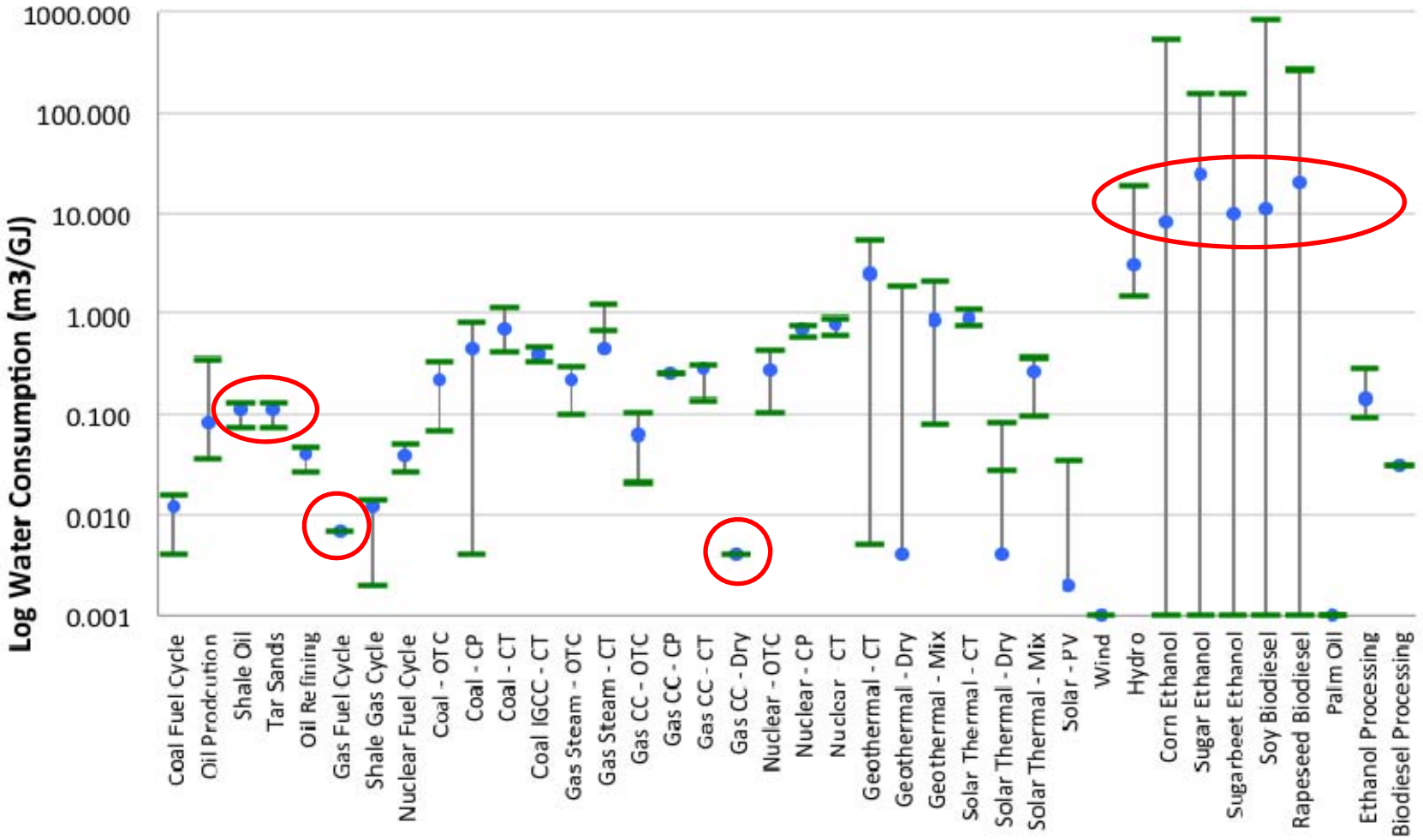
20% of all Electricity

Enough to supply entire state's electricity needs:

Oregon or Mass

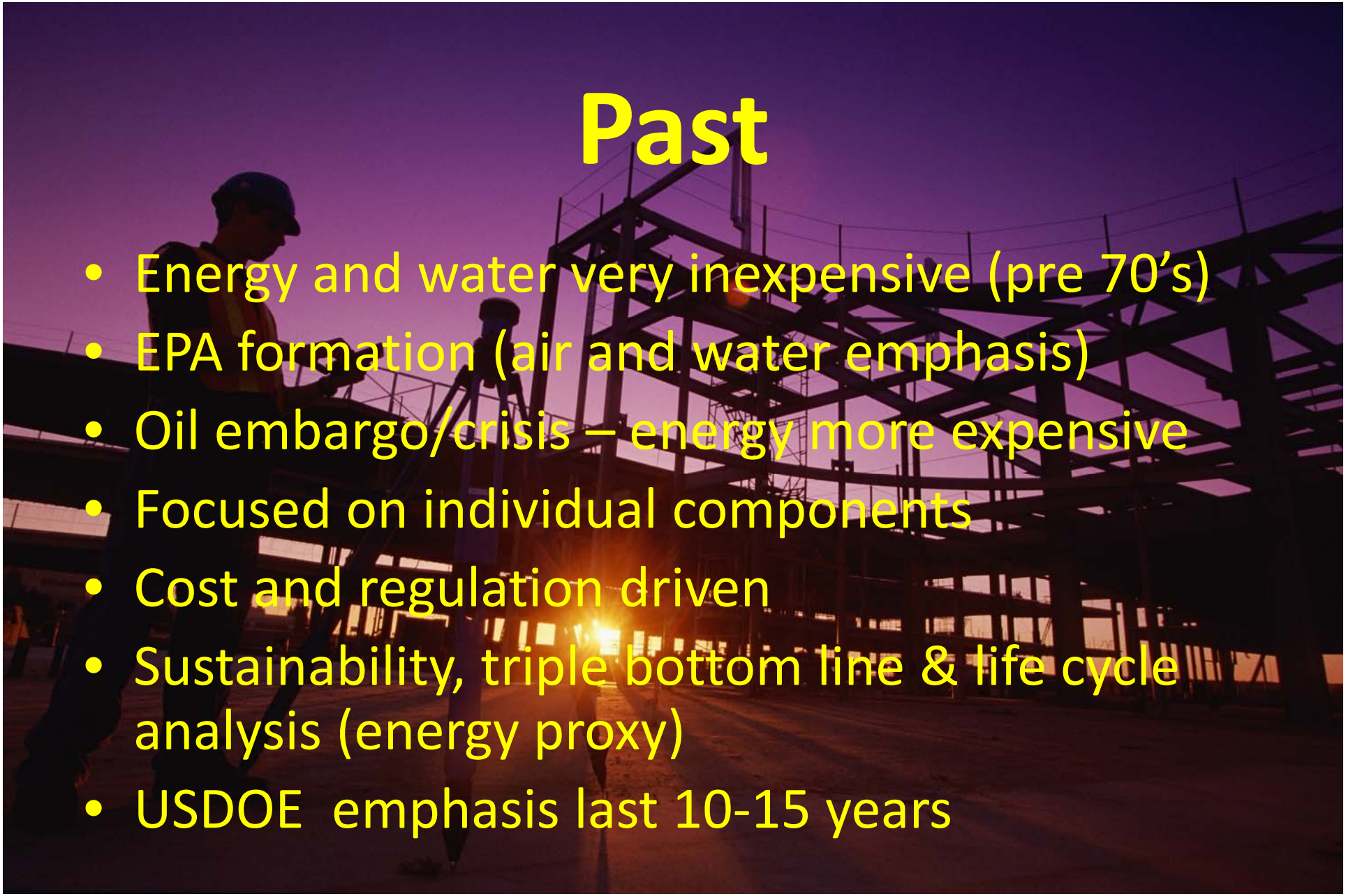
# Water for energy production

Water consumption coefficients for energy technologies




***Dr. Edward Spang, CWEE, University of California, Davis***

***A thirst for power: A global analysis of water consumption for energy production, 2012***



# Past

- Energy and water very inexpensive (pre 70's)
- EPA formation (air and water emphasis)
- Oil embargo/crisis – energy more expensive
- Focused on individual components
- Cost and regulation driven
- Sustainability, triple bottom line & life cycle analysis (energy proxy)
- USDOE emphasis last 10-15 years

# Challenges for the next generation of change


Energy


Climate Change


Water


Health & Nutrition


Transportation & Infrastructure

- Sustainable solutions to these challenges will provide many opportunities for current and future engineers and scientists
- An eye on product development as well as process will provide additional opportunities
- Sustainability will provide a strong driver for innovation

# Food Considerations

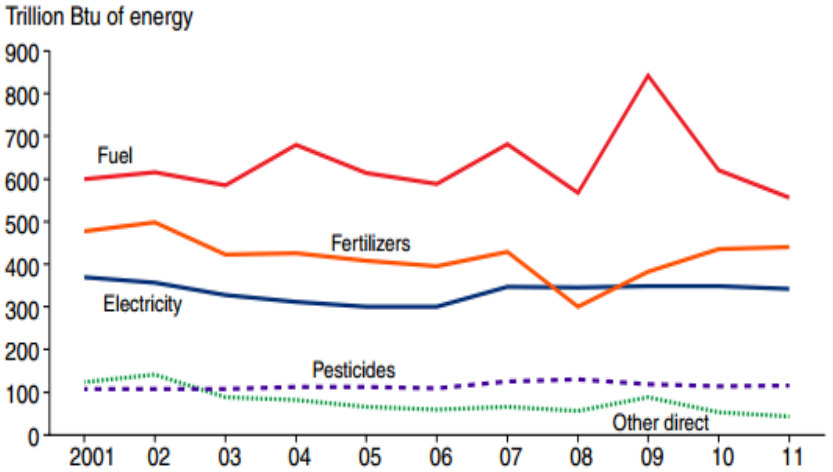
- Analysis of land use components of energy-water nexus pointed out need to consider food
- Agriculture uses 70% of fresh water withdrawals
- Energy production uses 15% of fresh water withdrawal
- Water production/distribution consumes 30-40% of energy
- Food production/supply chain accounts for 30% of total energy production


http://www.unwater.org/statistics_use.html

# ENERGY FOR FOOD

Food production and supply chain is responsible for around 30% of total global energy demand

**Energy inputs consumed on U.S. farms, by component, 2001-11**




Note: "Other direct" represents liquid petroleum and natural gas. Energy consumed is calculated by taking the total yearly expenses, divided by the average yearly price, and multiplying this amount by the energy conversion ratio. Btu = British thermal units.

Source: Miranowski (2005) and USDA, Economic Research Service calculations.

***Also must take into account transport, storage, processing and other energy costs for food.***

***Courtesy Kate Scow***

# Observations

- Social complexity playing larger role
- Timescales
  - Sustainability – long
  - Political <4 years
  - Business 1-5 years
- Systems approaches – SCIENCE & TECHNOLOGY SOL.
- Embedding life cycle thinking cradle to grave
- Footprints that look at multiple elements
- Solutions involving wider social, environmental, economic, regulatory, political, and ethical framework
- Regional ramifications for our area
- Asymmetric economics (each element on different basis)

# Wicked Problems

- Difficult or impossible to "solve"
  - incomplete requirements
  - Contradictory requirements
  - changing requirements
  - difficult to recognize
- Complex interdependencies
  - Solve one problem
  - Create or reveal other problems

# Examples

- CLIMATE CHANGE – NO AGREEMENT ON PROBLEM
- ENERGY GENERATION
- WATER RESOURCE MANAGEMENT
- GENETICALLY MODIFIED ORGANISMS
- URBAN PLANNING, WASTE DISPOSAL
- NUCLEAR WASTE
- BIODIVERSITY LOSS

Image courtesy of the World Resources Institute

# Are we approaching "Planetary Boundaries"? What is the "*Safe Operating Space for Humanity*"?

- Climate change
- Biodiversity loss
- Nitrogen loading
- Phosphorous loading
- Ozone depletion
- Ocean acidification
- Freshwater use
- Land use change
- Atmospheric aerosols
- Chemical pollution

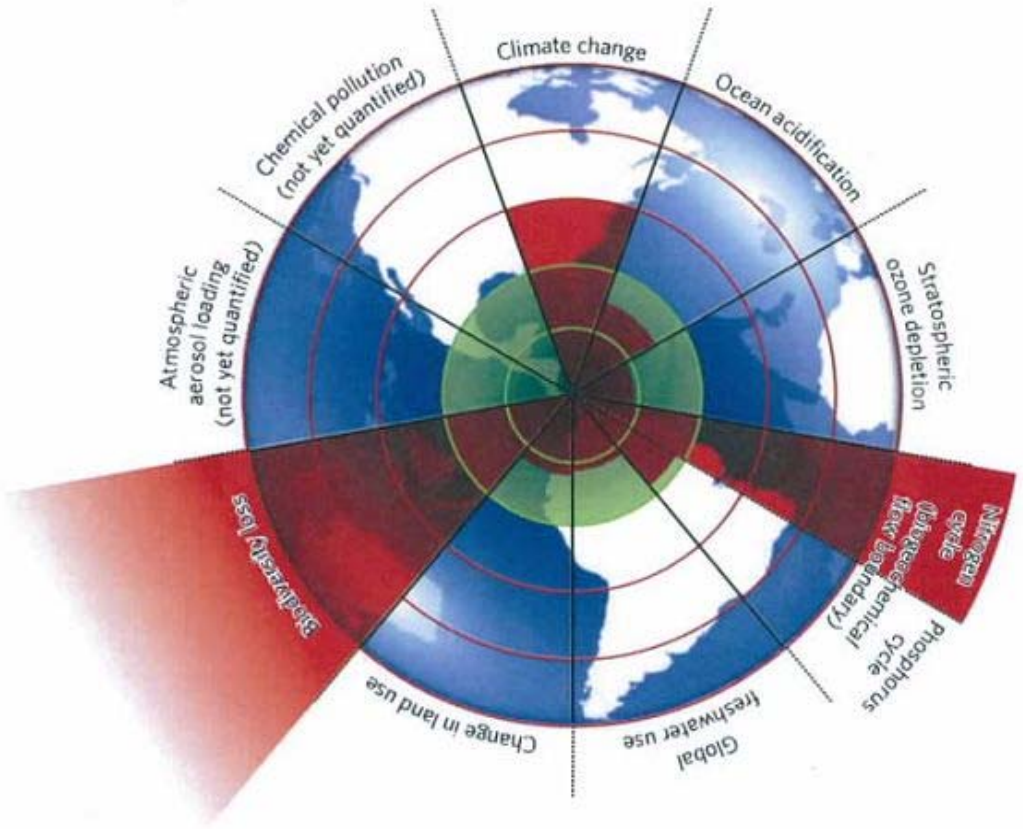
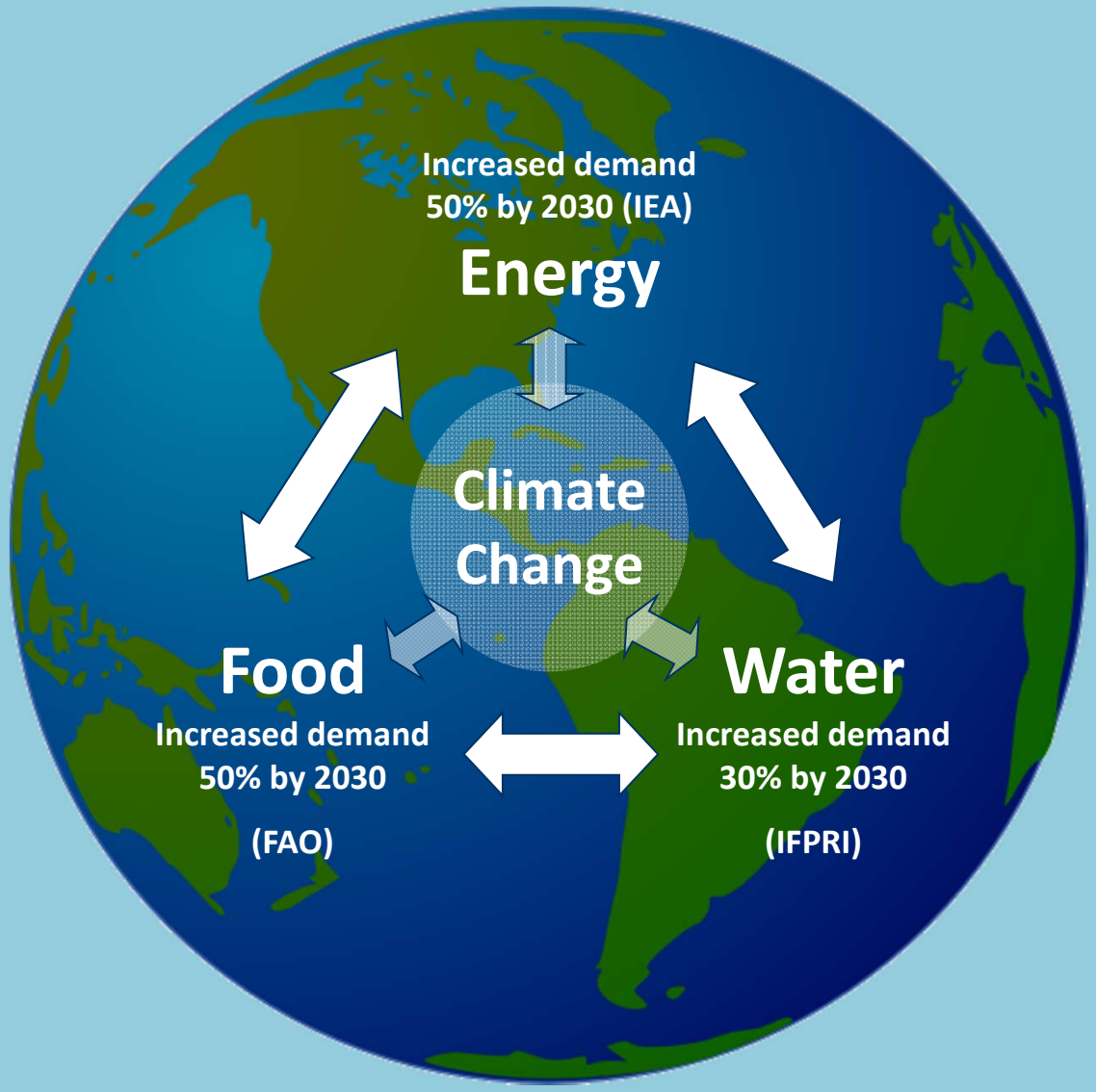



**Figure 1 | Beyond the boundary.** The inner green shading represents the proposed safe operating space for nine planetary systems. The red wedges represent an estimate of the current position for each variable. The boundaries in three systems (rate of biodiversity loss, climate change and human interference with the nitrogen cycle), have already been exceeded.

J Rockstrom, et al.
*Ecology and Society* 14(2) 2009
*Nature* 2009

# The Nexus – The Perfect Storm?

1. Increasing population
2. Increasing levels of urbanisation
3. The rightful goal to alleviate poverty
4. Climate Change




***The Food-Energy-Water Nexus: AIChE – IChemE Collaboration With WCEC***

Courtesy Des King

# Thank You