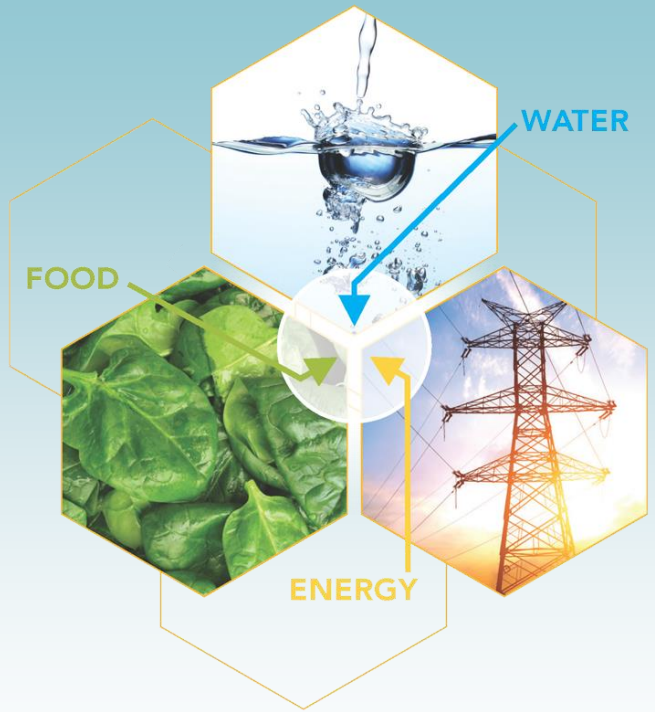


ENABLING RESILIENCY IN ENERGY, WATER, AND FOOD SYSTEMS FOR SOCIETY

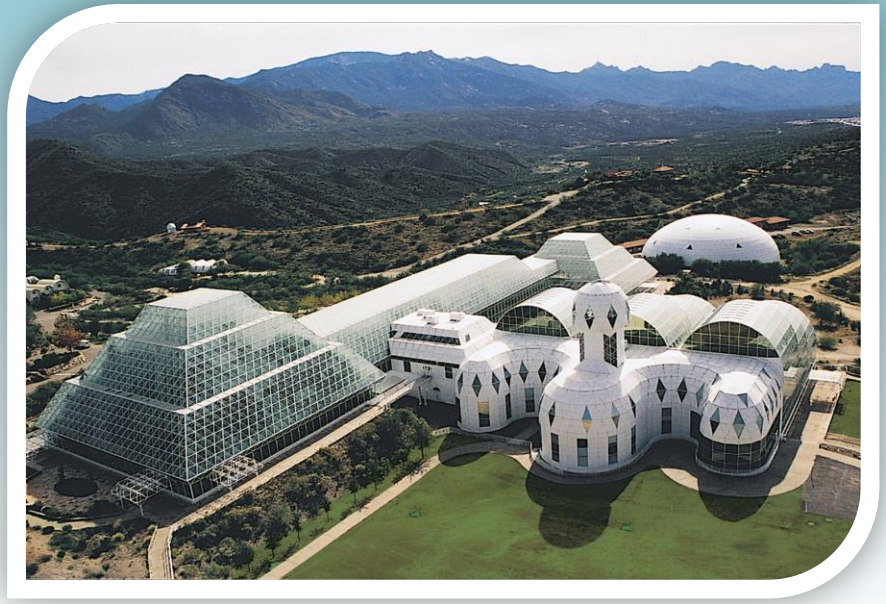
April 15 - 17, 2015 | Biosphere 2

REN
Renewable Energy Network

THE UNIVERSITY OF ARIZONA

Research
Office for Research & Discovery

Iconic, Inspirational, Uniquely Enabling

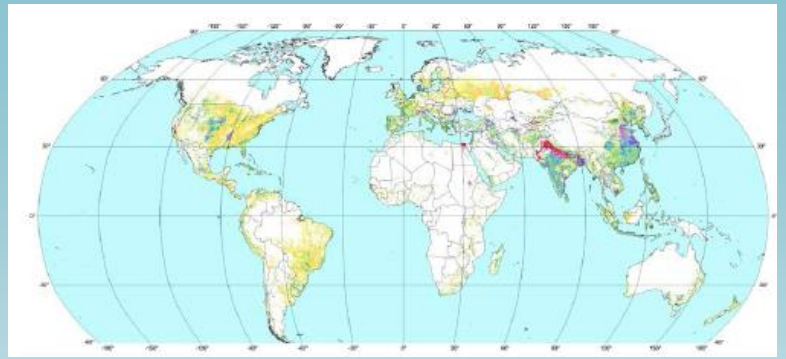


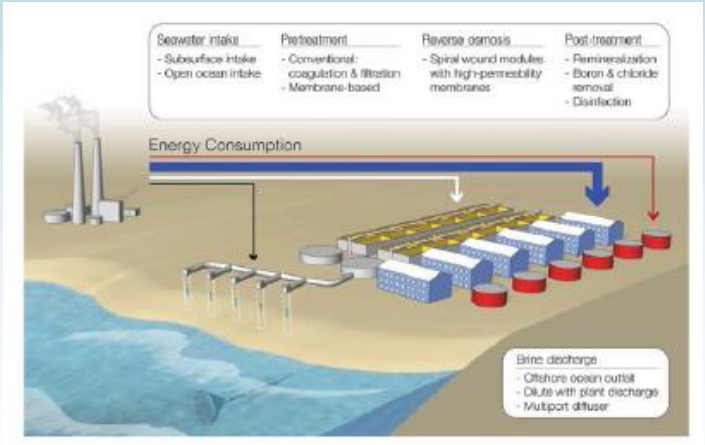
Biosphere 2

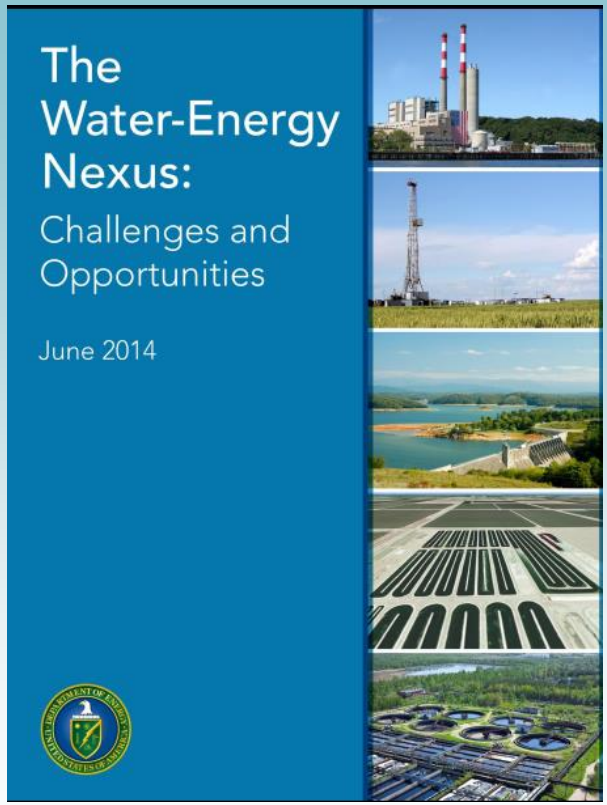
What is the problem?

- Energy, water and food systems tightly intertwined and increasingly interdependent – and at some risk
- Growing population – increased demand for all 3
- New science, technologies and policies which are easily integrated into the EWF Nexus are not evolving fast enough
- Increased climate variability has raised the stakes, and makes it incumbent upon us to create solutions, seize opportunities, respond to "surprises"

Guidance: NSF and DOE June 2014 Workshops







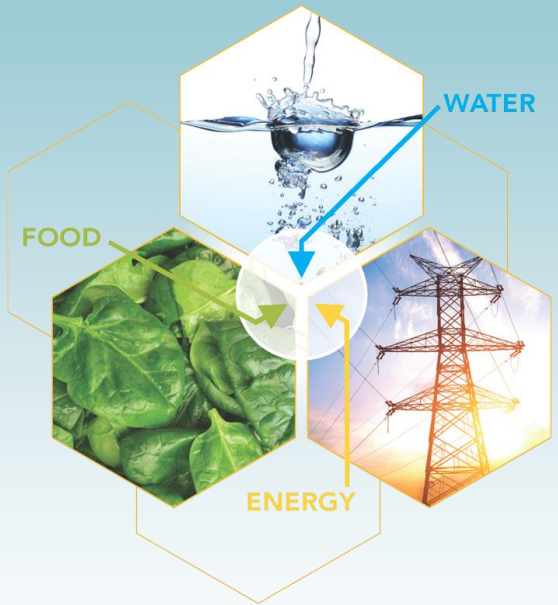
EXPECTED OUTCOMES

- White papers to workshop attendees and NSF, DOE, EPA, USDA, DOD, National Research Council.

- Journal articles and publications
  Chemical Engineering Progress (*CEP Magazine* Engineers), *Science and Public Policy*

- Briefings to interested NSF/DOE leaders (e.g. Cordova, Knotek, etc.)

- Dedicated website

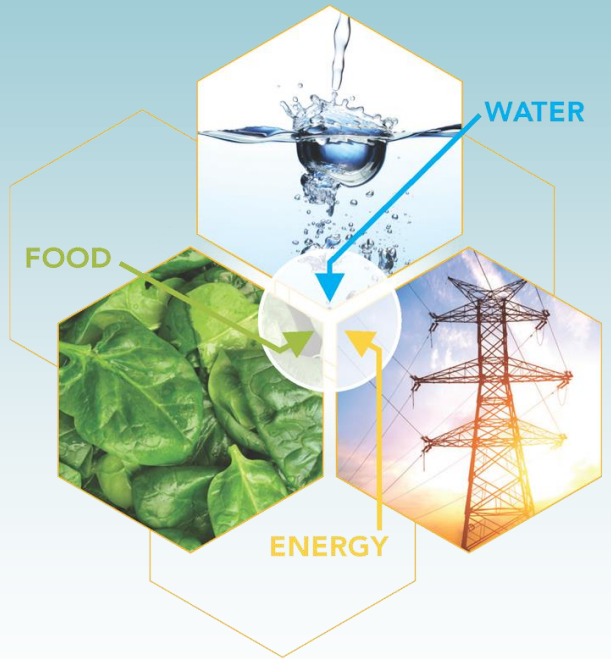


Format

- Three general topics determined – systems, food productivity, molecular/unit operations level
- Four 10 minute presentations to introduce topic with questions – 1 hour
- Facilitated Breakout – 1.5 hours
  - Questions determined in advanced
  - Tables of 10 – with 2 facilitators per table (facilitator + note taker, training in advance)
  - Participants pre assigned questions to work on (mix of science, engineer, etc)
  - Report out – 1 hour
- Break for meal with keynote speaker and start again.

Session 1

- Systems Level – Energy, Water, Food



Speakers

Dan Schwartz, Ph.D. – Social aspects for rural solutions, fuel cell

Director, Clean Energy Institute; Boeing-Sutter Professor of Chemical Engineering, University of Washington

Stanley Reynolds, Ph.D. – Energy markets, integration of renewables

Eller Professor of Economics,
University of Arizona

Michael Sheehan – water supply and grid issues when switching from coal to natural gas, siting near cities

Director, Resource Planning
Tucson Electric Power Co.

Susan Butler – perspective of integrated water management systems, scenario based systems, net zero

Strategic Planning and Environmental Resources Specialist,
CH2M

Session 1 - Outcomes

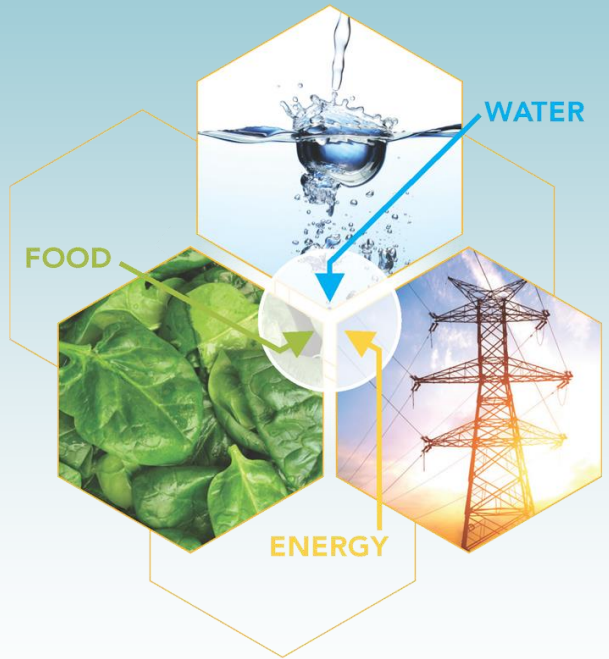
- Waste heat – how best to use, low temp catalysts
- Batch processing efficiency – water, solar
- Co-location strategies – test bed sites
- Mass balances – especially recycling and reuse of water
- Integrated models of different water sectors
- Involve the public
- Learn from each other – integrated systems at power plants
- Centralized vs decentralized systems
- Dilute resources (instead of waste) to recover metals, compounds – may not be correct time economically – waste to energy/products
- Right sizing and scaling
- Not one solution for every area – regional solutions
- New metrics – cost of water
- Researchers across disciplines – better communication

Colby A. Foss, Ph.D.

Program Director, Division of Chemistry,
Mathematical & Physical Sciences Directorate,
National Science Foundation

Session 2

Food Systems and Productivity



Speakers

Gene Giacomelli – controlled environments, growth in city centers, energy & water efficiency challenges

Director, Controlled Environment Agriculture Center,
University of Arizona

Brent Massmann – precision agriculture, water management, pest control, complex planning process required by farmers, data analysis, waste reduction

Senior Manufacturing Technologist,
Monsanto, Inc.

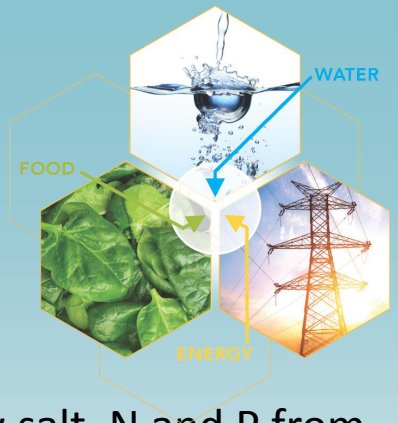
Alan Stephens – climate and risk, rural network minimize transportation

State Director, Rural Development,
USDA

Michael Hanemann, Ph.D. – weather data, predicting extreme events, temperature and crop yields, climate

Director, Center for Environmental Economics and Sustainability Policy, W.P. Carey School of Business, Arizona State University

Session 2 - Outcomes



- Sensors and control
- Data – field, monitoring, availability, who owns
- Nutrient availability, efficient water strategies
- Irrigation, area specific application and type of water required (low salt, N and P from wastewater, pathogens)
- Pumping strategies, efficiency
- Should you grow crops everywhere – repurposing land
- Infrastructure – where to produce food, distribution, storage
- Food safety and packaging, reduce food waste
- Climate and food production – mitigation (green houses/precision agriculture)
- CO2 sequestration
- Policy and Economics

Michael Hoffmann

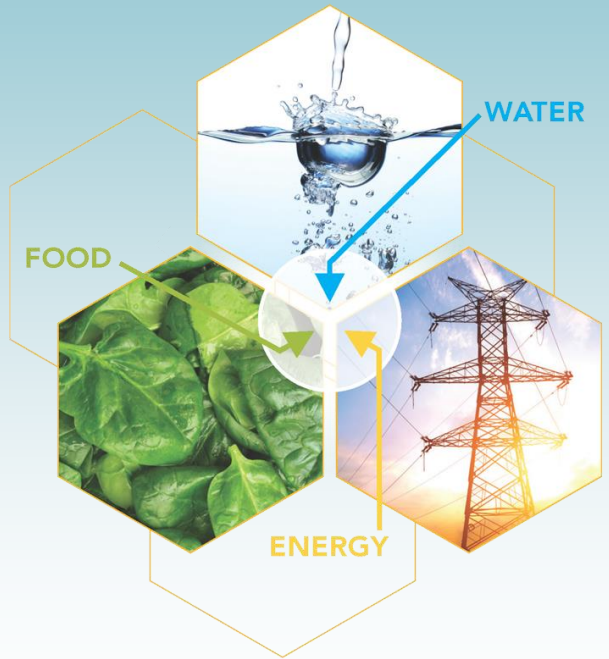
Professor of Environmental Chemistry,
California Institute of Technology

Tracy Young

Global Application Development Leader, Dow Water and Process Solutions
Dow Chemical Company

Session 3

Integrating Basic Science and Energy, Water, Food Systems



Speakers

Shane Snyder, Ph.D. – water reuse (policy and energy), trace contaminants, pathogens, cellular bioassays, advanced oxidation, real-time sensors

Environmental Engineering; Co-Director, Water & Energy Sustainable Technology Center
University of Arizona

Peter Crozier, Ph.D. – microscopic techniques, catalysis

Professor, School for Engineering of Matter, Transport and Energy,
Arizona State University

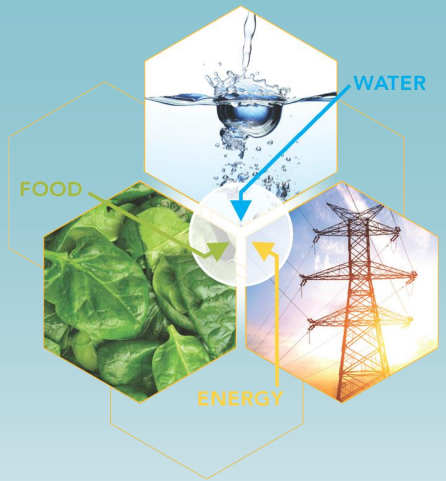
Fernando Temprano-Posada, Ph.D. – integration of water and energy, planning, model systems

Director, Technology Center,
Repsol, S.A

Nathan R. Neale, Ph.D. – cooling water and power, nitrogen cycle – solar, unit operations, chemistry

Senior Scientist, Energy Sciences,
National Renewable Energy Laboratory

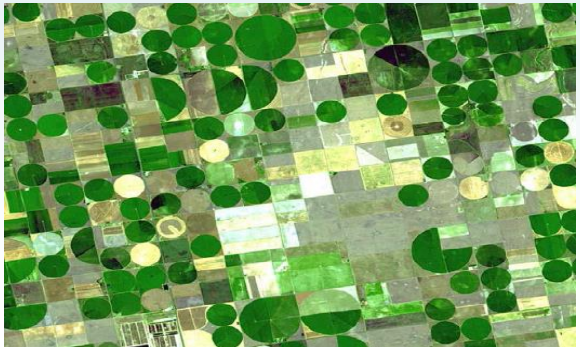
Session 3 – Outcomes



- Membranes - multifunctional, scaling, fouling, recycling – evolutionary gains – new ideas (integrated catalysis)
- Capture and reuse of valuable components – biological, adsorption, specificity – novel separation strategies
- Work across scales
- Communication chemists to chemical engineers, work on correct problems (nitrogen cycle)
- Low energy unit operations – order of operations to produce fit for use water
- Integration of solar to help with water purification
- Combined reactor/separator technologies
- Real time sensors and control – drones, pathogens

Overall Conclusions

- Ensuring a Sustainable Water Supply for Agriculture
- Closing the Loop - for Nutrient Life Cycles
- Crop Protection
- Innovations to Prevent Waste of Food and Energy
- Sensors for Food Security and Safety
- Maximizing Biomass Conversion to Fuels, Chemicals, Food, and Materials



Overarching Themes - Situational scarcity

- Localized regions and periods of time – water in CA/SC
- Amplified as a result of increasing climate variability
- Inadequate management of local and regional water, energy and food supplies, expanding populations, and a
- Lack of coherently developed, deployed and integrated technology and policy solutions.
- Research initiatives at molecule-, material- or system-scale, with a clear evaluation of their anticipated economic and societal impacts;

Overarching Themes - New Materials, New Technologies and Unit Operations

- Energy-efficient water re-use and purification for municipal, agricultural, mining, industrial and energy production sectors;
- Economical, distributed energy sources and energy storage platforms:
- Widely dispersed, multi-analyte, sensor platforms.
- Atomic and molecular scale understanding of separations, molecular recognition, and charge transfer and catalysis
- Balance energy requirements, cost and water quality – fit for purpose water

Overarching Themes - Smart Data and Decision-Making

- Measurement, analysis and optimization (control), of chemical and physical parameters on heretofore-unrealized scales;
- Generation of massive data sets requiring new modes of data transmission and stable data archival in partially analyzed formats,
- Real-time access by a wide range of researchers, decision makers, policy experts and the public

Overarching Themes - Policy

- Bottom-up integration of new science and technologies with policy development, decision-making, workforce training, human resource development and outreach.
- Development of policies that transform the regulatory and market environment
- Revitalization of local communities
- Social equity

Common Themes - Next Steps

- Working across scales
- Data for decision making
- Multi-disciplinary work required – social science, law, etc

- Collaborations to attack problems that require multiple institutions
- Webinar and distilling ideas for Report/Publication

SPONSORED BY

This material is based upon work supported by the National Science Foundation under Grant No. CHE-1539597. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

ADDITIONAL SPONSORS

The University of Arizona, Tucson
IMR
Lowell Institute for Mineral Resources

ARIZONA
Eller

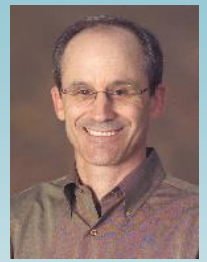
TEP
Tucson Electric Power

ORGANIZING COMMITTEE














Attendees

Tom Acker, Northern Arizona University
Michael Baldea, University of Texas
Sandra Begay-Campbell, Sandia National Lab
Eric Betterton – University of Arizona
Paul Brierly – Yuma Desert Agriculture
RD Castillo – Tech Launch Arizona
Zachary Celement – DOE
Andrea Corral – University of New Mexico
Alex Dely – Raytheon
Meghan Downes – New Mexico State University
Elizabeth Eide – National Research Council
Claudi Estrada Gasca – Renewable Energy Institute, Mexico
John Finley – Louisiana State University
Jesus Gonzalez Hernandez – CONACYT
Shannon Heuberger – Federal Legislative Affairs
Rebeca Hernandez – UC Berkeley
Gerardo Hiriart le Bert – National University of Mexico
Kerry Howe – University of New Mexico
Keith Hutchenson - DuPont
Jani Ingram – Northern Arizona University
Dale Keairns – Booz Allen Hamilton
Carey King – University of Texas
Ron S. Lee – Office of US Representative Kirkpatrick
Bob Lotts – Arizona Public Service
Jordan Macknick – National Renewable Energy Lab
Casey McKeon- Resolution Copper
Len Nedefer – Carnegie Mellon University
Deborah Newby – Idaho National Laboratory
Asia Philbin – Town of Marana
Benjamin Ruddell – Arizona State University
Valentin Ruiz Santa Quiteria – REPSOL
Gary Rumbles – National Renewable Energy Laboratory
Phil Sadler – Salder Machine Company
Clinton Sadle – Cornell University
Robert Webber – Pacific Northwest Laboratories
Richard Wiener – Research Corporation
Derrick Wu – AIChE
Douglas Young – EPA
Clair Zucker – Pima Association of Governments