



Energy-Food-Water Nexus Dialogue: Competitiveness Challenges & Opportunities

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Letter from the Co-hosts

On behalf of University of California, Davis (UC Davis) and the Council on Competitiveness, we are pleased to share with you the findings from a major conversation held on October 28-30, 2012 at the UC Davis campus in Davis, California—the “Energy-Food-Water Dialogue: Competitiveness Challenges & Opportunities.”

Pressures from global population and economic growth are boosting demand for an increasingly interdependent set of resources—energy, food and water. And this is, at the same time, generating a series of new global challenges, as well as potential opportunities—from new products and services, to expanded industrial capacity and job creation—for regions and nations that respond in innovative ways.

We believe the United States is primed to address both the urgent challenges and opportunities surrounding this complex convergence of resource needs. With this report, we invite you to take a look at the pre-report that created a baseline for our two-day conversation and the post-report that presents the results from this dialogue. More than 50 senior leaders from across industry, academia, labor and government participated in this dialogue via moderated talks and explorations, as well as: a keynote by the Secretary of the California Department of Food and Agriculture, Ms. Karen Ross; and, a special presentation by Apple co-founder Steve Wozniak.¹

Going forward, we would like to encourage you to join the Council on Competitiveness in critical discussions to lay the groundwork for a potential, new initiative to position the United States to transform scarcity into abundance by adopting strategies that consider how resources shape profitability, growth opportunities and technological discontinuities.

Sincerely,

Dr. Linda P.B. Katehi

Chancellor
University of California, Davis

The Honorable Deborah L. Wince-Smith

President & CEO
Council on Competitiveness

Dr. Harold H. Schmitz

Chief Science Officer
Mars, Incorporated, and
Executive Director for the Mars Center for Cocoa
Health Science

ENERGY-FOOD-WATER NEXUS DIALOGUE

Participants

CO-HOSTS

Dr. Linda P.B. Katehi
Chancellor
University of California, Davis

Dr. Harold H. Schmitz
Chief Science Officer
Mars, Incorporated and
Executive Director of the Mars Center for Cocoa
Health Science

The Honorable Deborah L. Wince-Smith
President and CEO
Council on Competitiveness

PARTICIPANTS

Dr. Barbara Allen-Diaz
Vice President for Agriculture and Natural
Resources
University of California, Davis

Ms. Victoria Bradshaw
Principal
California Strategies, LLC

Dr. Jeffrey Collmann
Professor of Microbiology & Immunology
Georgetown University

Ms. Dona Crawford
Associate Director for Computation
Lawrence Livermore National Laboratory

Dr. Steven C. Currall
Dean, Graduate School of Management
University of California, Davis

Dr. Jeannie Darby
Professor, Department of Civil and Environmental
Engineering
University of California, Davis

Dr. Mary Delany
Interim Dean, College of Agriculture and
Environmental Sciences
University of California, Davis

Dr. Tomás Díaz de la Rubia
President
YDS International Consulting

Dr. Gary Dirks
Director, LightWorks
Arizona State University

Dr. Paul Dodd
Associate Vice Chancellor for Interdisciplinary
Research and Strategic Initiatives
University of California, Davis

Dr. Georgia Drakakaki
Assistant Professor, Department of Plant Sciences
University of California, Davis

Mr. Anthony Eggert
Executive Director, Policy Institute for Energy,
Environment and the Economy
University of California, Davis

Mr. Karl M. Engelbach
Associate Chancellor
University of California, Davis

Mr. Chad Evans
Senior Vice President
Council on Competitiveness

Dr. John Evans
Vice President, Technology
Lockheed Martin Corporation

Dr. Graham Fogg
Professor, Department of Land, Air
and Water Resources
University of California, Davis

Mr. Mark Friedman
President
Fulcrum Property

Dr. Robin Graham
Deputy Associate Laboratory Director,
Computing, Environment, and Life Sciences
Argonne National Laboratory

Dr. Ronnie Green
Vice President and Vice Chancellor
of Agriculture and Natural Resources
University of Nebraska

Dr. Andrew Hargadon
Charles J. Soderquist Chair in Entrepreneurship
and Professor of Technology Management
University of California, Davis

Dr. Ralph J. Hexter
Provost and Executive Vice Chancellor
University of California, Davis

Dr. Jan W. Hopmans
Associate Dean, College of Agricultural
and Environmental Sciences
University of California, Davis

Mr. Robert Hutchinson
Managing Director, Research & Collaboration
Rocky Mountain Institute

Dr. Louise Jackson
Professor, Department of Land, Air and Water
Resources
University of California, Davis

Dr. Lovell (Tu) Jarvis
Professor; Special Assistant to the Dean, College
of Agricultural and Environmental Sciences
University of California, Davis

Dr. Bryan Jenkins
Director, Energy Institute
University of California, Davis

Dr. Thomas Johnson
Associate Vice President and Chief
of Strategic Initiatives
Webster University

Dr. Martha Krebs
Executive Director, Energy Institute
University of California, Davis

Dr. Enrique Laverna
Dean, College of Engineering
University of California, Davis

Ms. Karen Law
Senior Manager, Transportation &
Energy Systems
TIAX LLC

Dr. Harris Lewin
Vice Chancellor for Research
University of California, Davis

Dr. Frank Loge
Associate Director, Energy Efficiency Center;
Director, Center for Water-Energy Efficiency
(CWEE); and Professor, Civil & Environmental
Engineering
University of California, Davis

Dr. Subhash Mahajan
Distinguished Professor of Chemical Engineering
and Materials Science; and Special Advisor to the
Chancellor
University of California, Davis

Dr. Michael McCarthy
Professor and Chair, Food Science and Technology
University of California, Davis

Dr. Debbie Niemeier
Professor, Civil and Environmental Engineering
University of California, Davis

Dr. Anita Oberbauer
Professor and Chair, Department of
Animal Science
University of California, Davis

Dr. Dushyant Pathak
Associate Vice Chancellor for Technology
Management and Corporate Relations
University of California, Davis

Dr. Raul Piedrahita
Professor and Chair, Department of Biological and
Agricultural Engineering
University of California, Davis

Dr. Brad W. Pietras
Director, Advanced Research and Development
Lockheed Martin Corporation

Ms. Karen Ross
Secretary
California Department of Food and Agriculture

Dr. Douglas Rotman
Program Director for Energy and
Environmental Security
Lawrence Livermore National Laboratory

Dr. Kate M. Scow
Professor, Department of Land, Air & Water
Resources
University of California, Davis

Dr. Ken Shackel
Professor and Pomologist, Department of Plant
Sciences
University of California, Davis

Dr. Cindy Stewart
Senior Director of Advanced Research
Corporate R&D
PepsiCo Inc.

Dr. Scott Tinker
Director, Bureau of Economic Geology
The University of Texas at Austin

Dr. Tom Tomich
WK Kellogg Endowed Chair in Sustainable Food
Systems;
Professor, Environmental Science & Policy; and
Director, Agricultural Sustainability Institute
University of California, Davis

Dr. Spyros Tseregounis
Faculty Coordinator in the Office of Corporate
Relations, Office of Research
University of California, Davis

ENERGY-FOOD-WATER NEXUS DIALOGUE

Agenda

Sunday, October 28

EVENING

6:00 Reception

Vanderhoef Studio Theatre
Robert and Margrit Mondavi Center
for the Performing Arts

Welcoming Remarks

Dr. Ralph J. Hexter
Provost and Executive Vice Chancellor
University of California, Davis

Dr. Subhash Mahajan
Distinguished Professor of Chemical Engineering
and Materials Science and Special Advisor to the
Chancellor
University of California, Davis

7:00 Dinner

8:30 Conclude

Monday, October 29

MORNING

8:30 Registration and Continental Breakfast UC Davis Conference Center

Ballrooms B and C

9:00 Introductions and Opening Remarks

The Honorable Deborah L. Wince-Smith
President and CEO
Council on Competitiveness

Dr. Linda P.B. Katehi
Chancellor
University of California, Davis

Dr. Harold H. Schmitz
Chief Science Officer
Mars, Incorporated and
Executive Director of the Mars Center for Cocoa
Health Science

9:30 The Energy-Food-Water Nexus and the Competitiveness Landscape: Transforming Scarcity into Abundance

Moderator

Dr. Frank Loge
Associate Director, Energy Efficiency Center,
Director, Center for Water-Energy Efficiency (CWEE)
and Professor, Civil & Environmental Engineering
University of California, Davis

Kick-Off Discussants

Dr. Tomás Díaz de la Rubia
President
YDS International Consulting

Dr. Martha Krebs
Executive Director, Energy Institute
University of California, Davis

Key Questions

1. What are the implications of the energy-food-water nexus on U.S. competitiveness?
2. What are the challenges involved in managing the trade-offs imposed by the energy-food-water nexus? How are they connected? What is the nature of these challenges (engineering, political, financial, cultural, etc.)?
3. How can nations leverage the pressures of global population trends, economic growth, and climate change—all at the core of the energy-food-water nexus—to expand industrial capacity, open up investment opportunities, develop new products and services, and create jobs?

4. How can the U.S. leverage its technical leadership and institutional knowledge of agriculture?
5. What are the competitiveness implications of the recent natural gas boom?

10:30 Break

10:45 Innovating at the Nexus: Meeting Future Demand Through Science and Technology

Moderator

Dr. Subhash Mahajan

Distinguished Professor of Chemical Engineering and Materials Science and Special Advisor to the Chancellor

University of California, Davis

Kick-Off Discussants

Dr. John Evans

Vice President, Technology
Lockheed Martin Corporation

Dr. Ronnie Green

Vice President and Vice Chancellor of Agriculture and Natural Resources
University of Nebraska

Dr. Cindy Stewart

Senior Director of Advanced Research
Corporate R&D
PepsiCo Inc.

Key Questions

1. Are there potential, disruptive innovations that can boost resource supply and productivity while leveraging the energy-food-water nexus? How will these affect the competitiveness equation?
2. Do energy, water, and food technologies face unique and/or critical barriers to development and deployment? If so, how can we innovate around these barriers?
3. Do we have successful (or failed) models, projects, or solutions to garner lessons-learned to be shared across organizations and institutions?

11:45 Keynote Lunch

Interactions Between Energy, Food and Water: A Perspective from California

UC Davis Conference Center

Introduction

Dr. Linda P.B. Katehi

Chancellor

University of California, Davis

Keynote

Ms. Karen Ross

Secretary

California Department of Food and Agriculture

AFTERNOON

1:00 Policy Implications: Supporting the Energy-Food-Water Nexus

Moderator

Dr. Harold H. Schmitz

Chief Science Officer

Mars, Incorporated and

Executive Director of the Mars Center for Cocoa Health Science

Kick-Off Discussants

Dr. Gary Dirks

Director, LightWorks

Arizona State University

Mr. Anthony Eggert

Executive Director, Policy Institute for Energy, Environment and the Economy
University of California, Davis

Key Questions

1. How can public policies and regulations—such as irrigation, energy, and crop subsidies—alleviate or exacerbate the energy-food-water nexus?
2. Are there best practices (trade policy, energy policy, etc.) in the United States or elsewhere that point the way to a balancing of supply and

demand of critical resources while enhancing U.S. competitiveness?

3. What federal, state, and local government agencies/departments/committees need to be engaged in the energy-food-water nexus conversation? And what steps can we take to promote a more coherent policy approach to resource management?
4. What role, if any, should government play in the provision or encouragement of capital investment in developed and developing countries?

2:00 Networking Break

2:30 Building Partnerships: A Vision for Effective Collaboration

Moderator

Dr. Paul Dodd

Associate Vice Chancellor for Interdisciplinary Research and Strategic Initiatives
University of California, Davis

Kick-Off Discussants

Dr. Douglas Rotman

Program Director for Energy and Environmental Security
Lawrence Livermore National Laboratory

Dr. Robin Graham

Deputy Associate Laboratory Director, Computing, Environment, and Life Sciences
Argonne National Laboratory

Dr. Harris Lewin

Vice Chancellor for Research
University of California, Davis

Key Questions

1. How can industry, universities, national laboratories and governments build strategic partnerships that leverage the energy-food-water nexus? What ought to be priority areas?
2. Who are the stakeholders, nationally and

internationally, and what level of global engagement by the U.S. is appropriate?

3. What are the elements needed for this new paradigm and are there inhibitors to public-private collaboration?
4. What is the best way to engage the new Administration and Congress in prioritizing the energy-food-water nexus and resource management?
5. How can we ensure long-term, bipartisan support of major research, policies, and regulations needed to address the energy-food-water nexus?

3:30 Wrap-up & Next Steps

Mr. Chad Evans

Senior Vice President

Council on Competitiveness

3:45 Closing Remarks

The Honorable Deborah L. Wince-Smith

President and CEO

Council on Competitiveness

Dr. Harold H. Schmitz

Chief Science Officer

Mars, Incorporated and

Executive Director of the Mars Center for Cocoa Health Science

Dr. Linda P.B. Katehi

Chancellor

University of California, Davis

4:00 Conclude

4:30 Tour of the Robert Mondavi Institute for Wine and Food Science

Monday, October 29**EVENING****5:30 Reception**

Dean's Board Room
Gallagher Hall

6:00 Dinner**7:30 Dinner Concludes****Monday, October 29****MORNING****8:00 In Conversation with Steve Wozniak**

Moderator
Dean Enrique Lavernia
UC Davis College of Engineering
Jackson Hall, Robert and Margrit Mondavi Center

9:30 Wozniak Event Concludes**Tuesday, October 30****MORNING****8:00 Continental Breakfast**

UC Davis Conference Center
Conference Room B

8:30 Tour of West Village

Mr. John Meyer
Vice Chancellor for Administration and Resource
Management
University of California, Davis

Mr. Robert Segar
Assistant Vice Chancellor for Campus Planning and
Community Resources
University of California, Davis

9:45 Return to Conference Center and Break**10:00 Beer versus Wine**

Dr. Charles W. Bamforth
Anheuser-Busch Endowed Professor of Malting and
Brewing Sciences
University of California, Davis

Dr. Andrew L. Waterhouse
Professor of Enology
University of California, Davis

**11:00 Transportation in a world powered
entirely by wind, water, and solar energy**

Dr. Mark A. Delucchi
Research Scientist
Institute of Transportation Studies
University of California, Davis

AFTERNOON**12:00 Lunch****1:00 Conclude**

Part 1:
Energy-Food-Water
Nexus Dialogue
Pre-Report

PART 1: ENERGY-FOOD-WATER NEXUS DIALOGUE PRE-REPORT

Connecting the Dots

Extreme heat and lack of rainfall have gripped the United States in the worse drought since the 1950s—with far-extending implications

- As fields dry out, irrigation pumps strain to keep crops hydrated to little avail; corn damage alone is expected to cost the United States billions in losses.²
- U.S. governors—prompted by growing fears of a global food shortage and rising gasoline prices—have asked the Obama administration to waive temporarily the law requiring conversion of a percentage of corn yields into biofuels.³
- In Kansas, oil companies engaged in water-intensive hydraulic fracturing have run out of water and are paying local farmers for their reserves, when they can be spared, or trucking in water from neighboring states.⁴
- To combat heat, households are running air conditioners around the clock while power plants struggle to obtain enough cooling water to keep up with energy demands.⁵

The worst drought in a half-century makes it easy to forget 2011's record levels of rainfall and spring snowmelt that pushed the Mississippi River over its banks and into surrounding towns and cities. The 2011 flooding was the worst in almost 100 years, made evident by the dozens of counties that were declared federal disaster areas along the Mississippi River.

In slightly more than one year, the United States has suffered wild swings between extreme weather events—from severe flooding to oppressive drought—that, combined, are expected to cost the country billions in economic losses while imposing uncertainties that hinder businesses' ability to function efficiently.

International markets provide little reprieve. In concert with the United States, Russia and Australia—two of the largest global food producers—are suffering from simultaneous droughts.⁶ In China and India, water shortages are hampering growth and pitting U.S. foreign affiliates against local farmers and governments. The most challenging cases involve multinational firms facing fines for “serious depletion” of shared water supplies.⁷

Environmental pressures, economic expansion, and population growth have tightened energy, food and water markets, while increasing price volatility.

Given these realities, competing in the 21st century will require a national strategy, bridging the public and private sectors, that recognizes the implications of the energy-food-water nexus, and optimizes the nation's resilience, sustainability and innovation capacity.

PART 1: ENERGY-FOOD-WATER NEXUS DIALOGUE PRE-REPORT

Changing Innovation Landscape: The Resource Revolution

Nations today are collectively facing a new, defining challenge. The concurrent pressures of global population and economic growth are boosting demand for an increasingly interdependent set of resources: energy, food and water. At the same time, this challenge has created a perfect storm for innovation, new products and services, expanded industrial capacity, and job creation.

The Council on Competitiveness recognizes the United States is better positioned than perhaps any other country to transform scarcity into abundance by adopting strategies that consider how resources shape profitability, growth opportunities and technological discontinuities. Economic, environmental, geopolitical and technological forces—together with the impending 2012 national elections—have converged to create a sense of urgency in the public and private sectors to act on this issue.

The United States must take action to: (1) manage existing resources in a way that proves prosperous for Americans and American institutions, and (2) make the national innovation investments necessary to optimize and expand the U.S. resource base. These actions require collaboration across government, academia and private sector stakeholders to cultivate the innovative operational models, public policies, strategies and technologies that will deepen and expand U.S. leadership in the resource revolution.

The purpose of the UC Davis-Council on Competitiveness Energy-Food-Water Nexus Dialogue is to bring together thought leaders from all stakeholder groups to reflect on the energy-food-water nexus and lay the groundwork for a comprehensive roadmap that will best position the United States to realize the potential opportunities of this new competitive landscape.

PART 1: ENERGY-FOOD-WATER NEXUS DIALOGUE PRE-REPORT

Background: The Energy-Food-Water Nexus

Truncated supply growth and increasing demand in the energy, food and water markets have resulted in a tightening of these markets—as well as higher prices for these resources (see Figures 1 and 2).

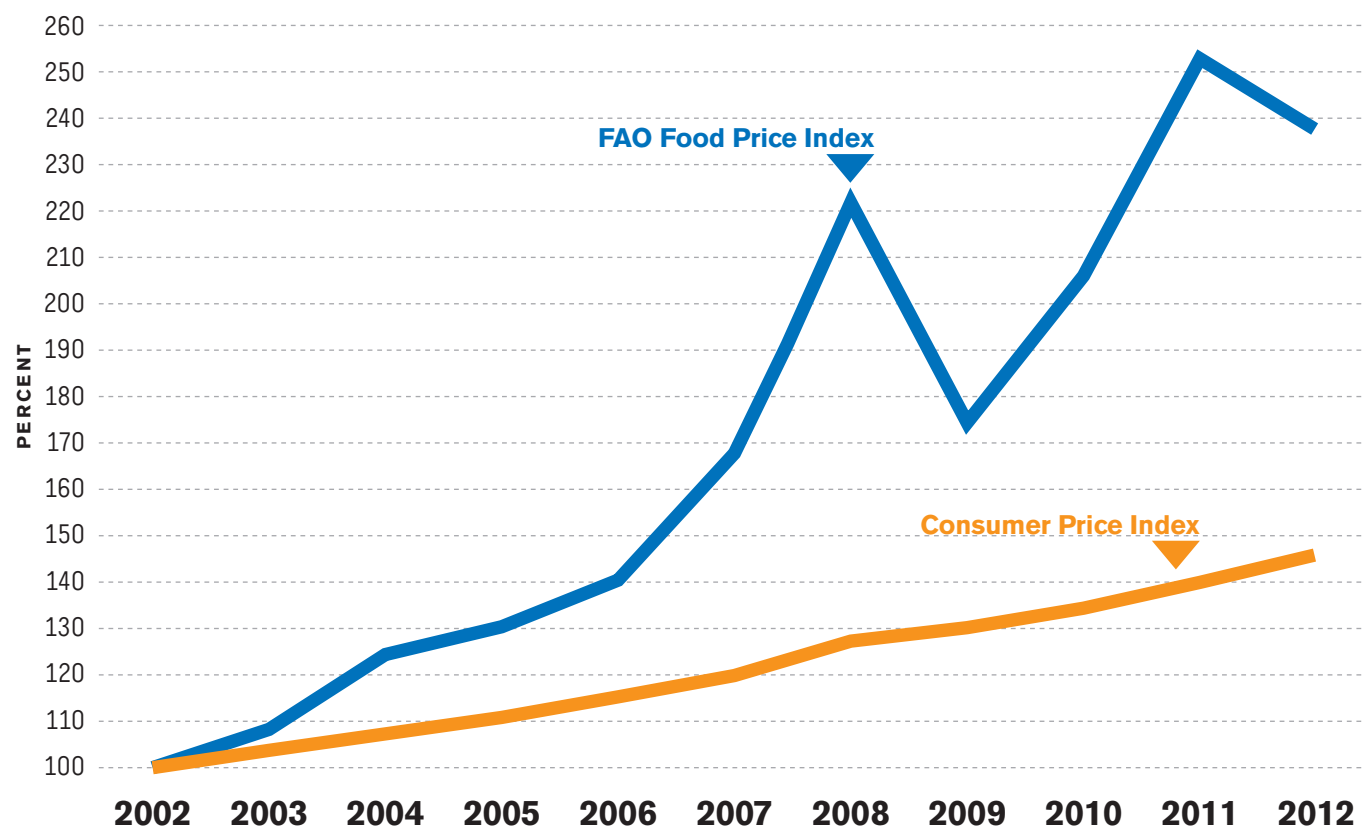
As many observers have noted, “food production requires water and energy, water extraction and distribution requires energy, and energy production requires water (see Figure 3).”⁸ Consequently, a constraint on one resource quickly translates into a restriction on another.

Biofuel cultivation and shale gas extraction are two recent developments highlighting the energy-food-water nexus. For example, many consider biofuels as an avenue to energy independence and carbon emission reduction. This has contributed, in part, to an eight-fold increase in U.S. ethanol production between 2000 and 2011.⁹ Though ethanol has numerous benefits, it also has several trade-offs. With respect to the environment, ethanol reduces both carbon monoxide and carbon dioxide automobile emissions relative to gasoline.¹⁰ On the

Figure 1. Rise of Global Food Prices vs. Inflation

2002=100, deviation from 100 reflects percent change

Source: Economist Intelligence Unit and Food and Agriculture Organization



other hand, ethanol production uses more water per gallon of fuel than traditional gasoline production at a time when many regions in the United States are expecting to experience water shortages.¹¹ With respect to the economy, ethanol production has created jobs both directly and indirectly.¹² Conversely, increases in land allocated for corn have displaced soybean production, which could have been used for food, feed, exports or other domestic uses.¹³ Additionally, the increased demand for corn has driven up food prices, which benefits producers while simultaneously hurting consumers.¹⁴

The expansion of shale production faces similar trade-offs, as it is very energy- and water-intensive, as well as dangerous to the environment if mismanaged. However, the nation must balance these risks with the huge economic potential and national security benefits associated with U.S. shale gas production. Decisions on how to optimize resources cannot be made in a vacuum, and the energy-food-water nexus embodies the systems-level approach required to overcome the nation's grand challenges. That is, the best solution will be determined when the problem is considered as a whole, not by optimizing the various parts of the system separately.

Figure 2. Percent Change in Average Retail Price of Electricity

Indexed to 2001 as Zero Percent

Source: U.S. Energy Information Administration

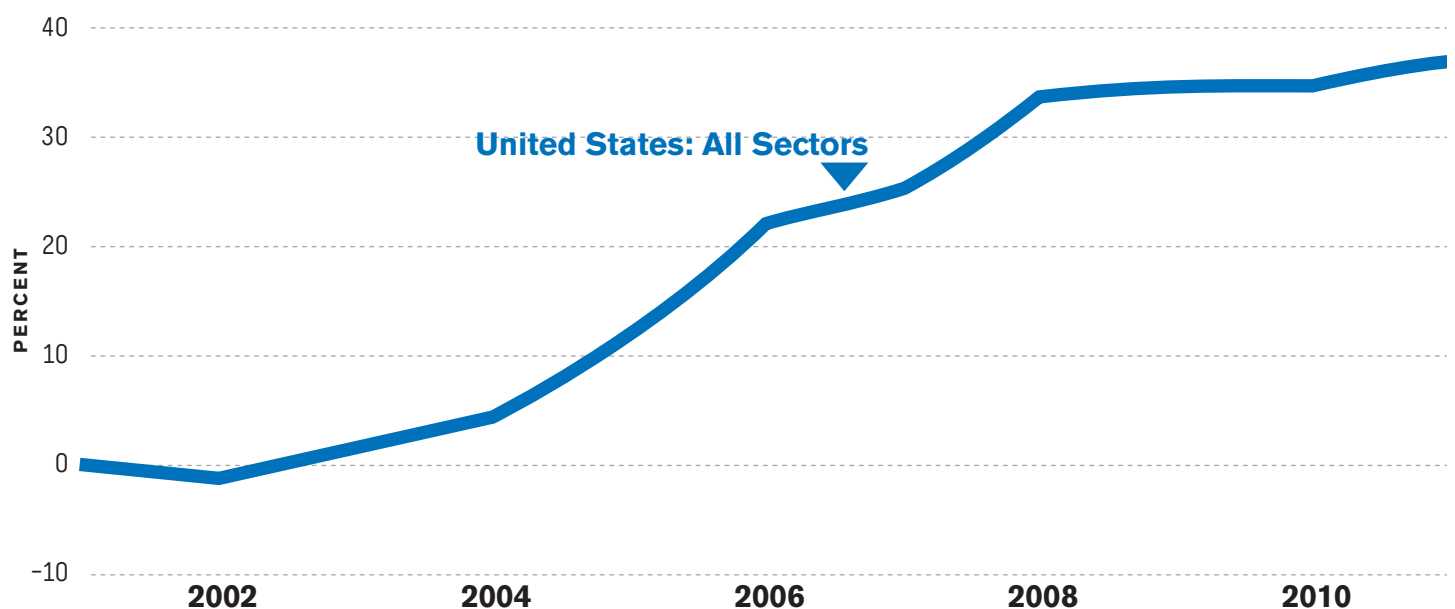
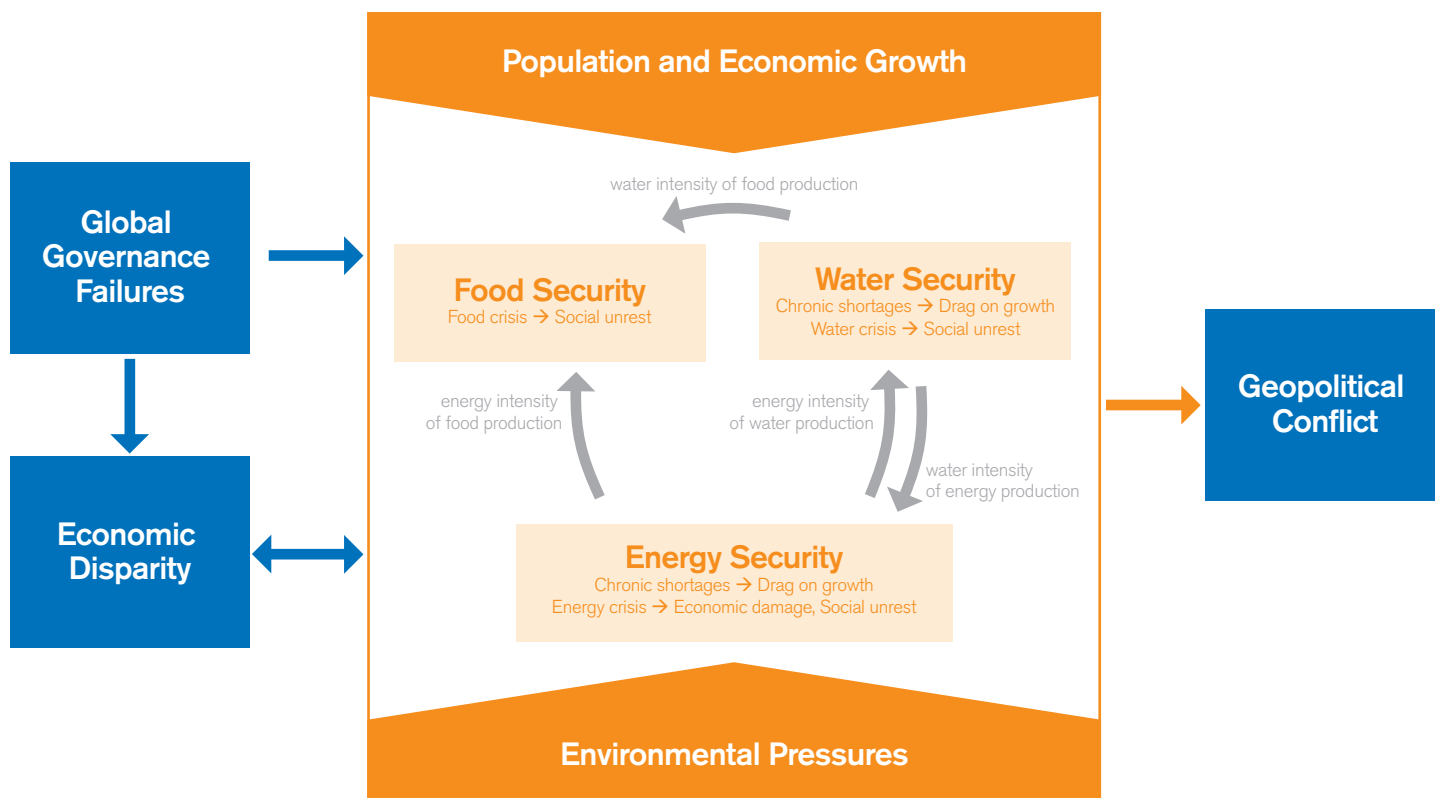


Figure 3. Energy-Food-Water Nexus

Source: World Economic Forum



PART 1: ENERGY-FOOD-WATER NEXUS DIALOGUE PRE-REPORT

Considerations for a National Strategy

Firms, universities, national laboratories and governments will face obstacles along the path to success. Tomorrow's winners must innovate around engineering and technological barriers. The nation will also need financial mechanisms, an enabling regulatory and policy regime, and new cultural norms to compete successfully. Such solutions will require a collaborative framework to match the cross-institutional nature of the energy-food-water nexus. To facilitate a generative and progressive dialogue, this paper includes a non-exhaustive list of potential challenges for firms, universities, national laboratories and governments facing energy, food and water constraints.

Supply Expansion

By the close of this decade, global population will increase by almost one billion people.¹⁵ At the same time, the growing global middle class is transitioning to more energy-intensive diets and demanding better living conditions. By 2030, global demand for water will grow by 30 percent, and food supplies must increase by 50 percent to keep pace with population growth.¹⁶

During the same period of time, energy demand will rise by more than 53 percent—with most of the growth accounted for by non-OECD nations (see Figure 4). One avenue for meeting this particular demand is to expand the supply of traditional energy sources using established extraction and distribution methods. This, however, is becoming increasingly difficult and expensive. Moreover, increasing pressure on the energy ecosystem without a paradigm shift would have a negative impact on the

environment and face capital, infrastructure and geopolitical challenges. Mitigating these challenges is the considerable progress in the generation of relatively new sources of energy, such as shale gas, though this comes with its own unique set of risks.

Increasing Resource Productivity

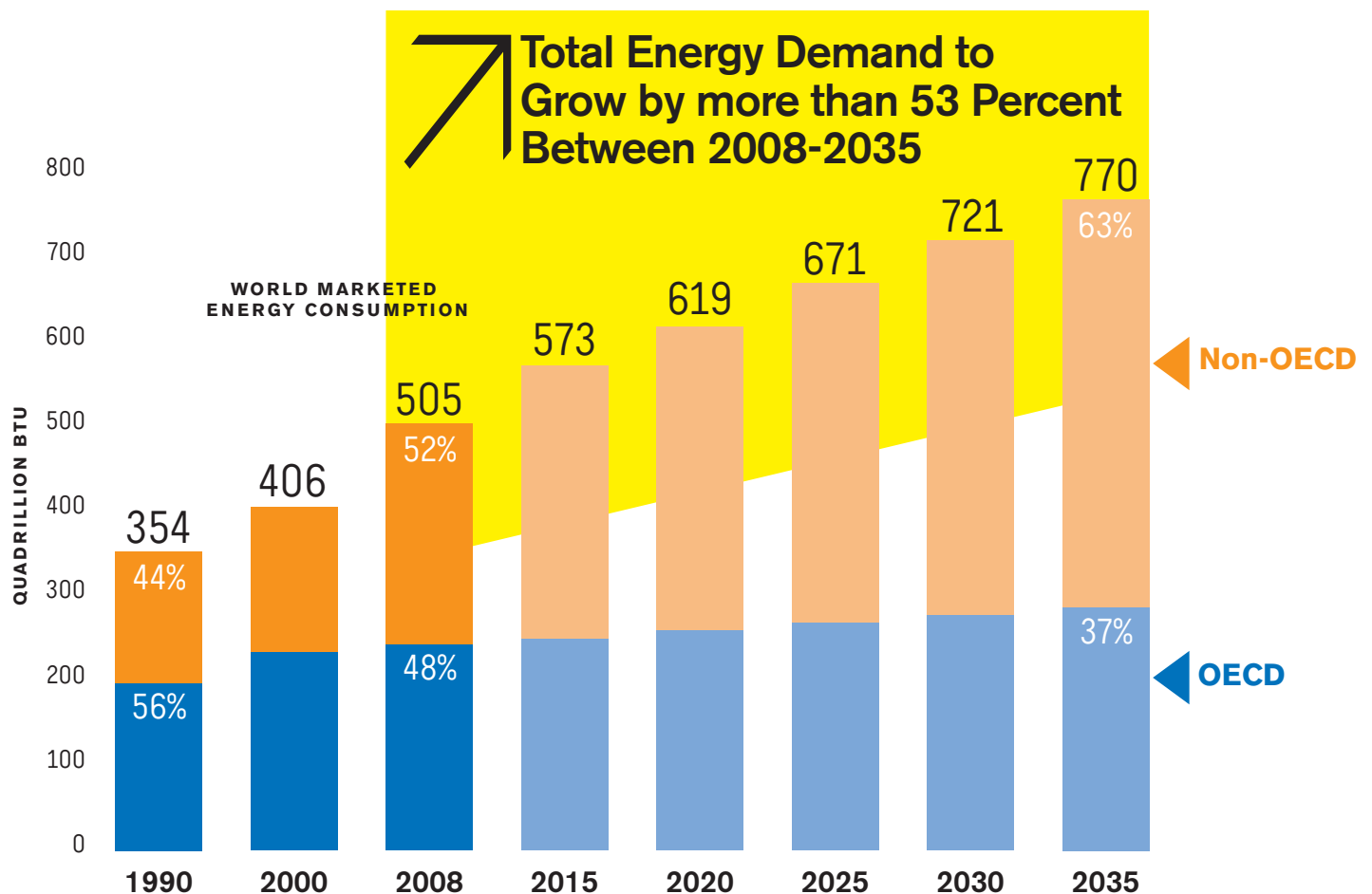
Productivity increases have historically been a mechanism for lifting national prosperity and creating competitive advantage. These productivity gains, however, have generally been accounted for by gains in labor and capital—and, to a large extent during the past couple of decades, by innovation.

But resource productivity can also be a proven source of differentiation and competitive advantage. Using the water systems as an example, roughly 5 percent of U.S. energy consumption is used to heat, treat and move water. In places like California, where access to fresh water is more difficult, that number can be closer to 20 percent.¹⁷ In addition to using energy in water systems, water is used in energy systems. In the United States, for example, the single largest use of water is in the thermoelectric power sector.¹⁸ There are several water-related opportunities to improve productivity, including a reduction in municipal water leakage, improving irrigation techniques, and increasing power plant efficiencies.

Resource productivity enhancing activities are available in all sectors of the economy. However, they tend to be very capital intensive (even higher than resource expansion) and suffer from failures of institutional and managerial shortcomings.¹⁹

Figure 4: Growing Energy Demand

Source: Energy Information Administration



Access to Capital in Developing Countries

The McKinsey Global Institute estimates that up to 85 percent of opportunities to boost resource productivity are in developing countries.²⁰ However, access to capital is necessary to finance the resource revolution and is a challenge for the emerging economies of the world that lack a robust financial system.

On the other hand, successful investments in these projects have the potential to produce high returns. As an example, McKinsey has also reported that investments in technologies that ease the water deficit in China are expected to reap \$19 billion in profit each year.²¹

Policies & Regulation

Subsidies for irrigation, energy and crops dampen market signals and can lead to a wasteful use of resources. In addition, production externalities (i.e. the cost of production that is paid by someone other than the producer — such as costs associated with the effects of pollution or the depletion of natural resources that are a result of a production process) can exacerbate tensions in the energy-food-water nexus. The global value of these subsidies approaches \$1 trillion per year.²² And this amount does not include the opportunity cost of foregone investment. Moreover, relative to the manufacturing sector, agriculture has much higher levels of trade protection. Average agricultural tariffs are 64 percent, while manufactured goods have average tariffs of 4 percent.²³

Compounding all this is fragmented U.S. policy, funding mechanisms and oversight are oftentimes separated, and there are many agencies, committees and departments involved, but no clear authority.

Insufficient Information

Data across resources and geographic regions is sparse, disparate, error-prone and inconsistent.²⁴ This prevents investors and managers from having the intelligence on demand, supply and risks to make informed decisions.

Enabling Innovation

Energy and water technology development during the past century has largely been focused on the supply side.²⁵ Part of the success of agriculture research and development during the last 50 years has been due to the attention given to operational and technological advancement over the entire food lifecycle. Though the tide has already begun to shift, next generation energy and water technology development strategies should include a demand-side approach that focuses on efficiency of use. As the United States has experienced with other crosscutting initiatives, an energy-food-water innovation roadmap will require state and federal agencies currently managing these issues independently to collaborate not only with each other, but also with private sector stakeholders and academia, in order to understand the complexities of the problem and develop an effective path forward. Of course, all such activities must be considered in the context of fiscal restraint and the perennial challenge of commercializing new technologies, especially those with a weak market pull such as energy.

PART 1: ENERGY-FOOD-WATER NEXUS DIALOGUE PRE-REPORT

Looking Forward

The pressures of the energy-food-water nexus have the potential to trigger an innovation wave, similar to the innovation waves associated with the creation of steam power and information technologies. Catching this wave, however, will require the engagement of industry—small and large—universities, labor unions and government stakeholders. The Council exists at the intersection of these institutional actors and, thus, is singularly positioned to generate and capture insights informing the national and global discourse. Resource scarcity also has a unique technological component that plays well to the Council's strengths as a champion of innovation and an advocate for investment in research and development.

The United States cannot afford to miss the coming resource revolution. An open and continuous dialogue engaging key actors with an interest in the energy-food-water nexus will maximize collective efforts for the improvement of national and global welfare.

PART 1: ENERGY-FOOD-WATER NEXUS DIALOGUE PRE-REPORT

Key Questions for the Dialogue

- Bridging the gap between demand and supply—whether in energy, food and/or water—is not solely a question of advancements in technology. However, are there potential disruptive innovations that can boost resource supply and productivity while leveraging the energy-food-water nexus?
- How can industry, universities and government build strategic partnerships that leverage the energy-food-water nexus in a way that creates competitive asymmetries, boosts productivity and increases standards of living?
- How can the United States leverage its technological leadership and institutional knowledge of agriculture?
- What are the competitiveness implications of the recent natural gas boom?

Part 2: Findings from the Energy-Food-Water Nexus Dialogue

PART 2: FINDINGS FROM THE ENERGY-FOOD-WATER NEXUS DIALOGUE

Opening Remarks

This initial dialogue can best be described as foundational. Though the discussion was rich with pragmatic technical, organizational and policy insights—the result of a participant group with abundant formal and experiential training—the fruit of this discussion was the acknowledgment that defining both the problem and the desired outcomes should be the first and potentially most important step. As was noted several times throughout the day, how the problem is defined will determine the scale and scope of a future energy-food-water nexus initiative as well as the actors, institutions and resources that will be made available. Moreover, the desired outcomes will determine the tools deployed in pursuit of end goals or milestones. These early discussions will lay the groundwork for the nexus of energy, food and water and, thus, their importance cannot be overstated.

Dr. Linda P.B. Katehi
Chancellor
University of California, Davis



Since the inception of the University of California, Davis in 1959, agriculture has been one of the pillars, if not the largest, that has created the foundation, the strength and the identity of this institution. We have done a lot of work over many years in the areas of energy, food and water—as well as in the intersections of these three systems. At UC Davis, our faculty, staff and students who are involved in these discussions and concerns have thought about them as very interconnected. The work here is important because it can lead to many policies that are appropriate today and in the future for the United States—not just for the State of California. There is also tremendous opportunity here in the United States to develop an agricultural-based economy that can make the nation very competitive at a time when food, energy and water are so critical.

The Honorable Deborah L. Wince-Smith
President & CEO
Council on Competitiveness



The Council on Competitiveness believes that the pressures and the opportunities circling the energy-food-water nexus have the potential to trigger a new eve of innovation, productivity and prosperity in the United States—one similar in scale and scope to those that catalyzed the creation

of steam power and the emergence of information technologies and the Internet.

However, to capitalize on and catch this wave, America needs new collaboration between industries large and small, universities, labor unions, government stakeholders and the financial community—from angel and venture capitalists to large-scale institutional investors—who can, together, deploy at scale these opportunities. The United States will not be able create the products and services on the scale we need to compete in a world characterized by turbulence, transition and transformation if this is pursued through national strategies focused solely upon startups and equity investments alone. America will need large-scale infrastructure financing for these opportunities.

The Council on Competitiveness—because of our multi-stakeholder membership and partnership network—is distinctly positioned as a platform for the development of the new-to-the-world business models and policies to underpin this future competitiveness opportunity. I am confident this dialogue will be productive in setting the framework for where we head as a nation.

Dr. Harold H. Schmitz
Chief Science Officer
Mars, Incorporated and
Executive Director
Mars Center for Cocoa Health Science



In the food and agriculture sector, innovation often is thought to equal research and development.

And that is disastrous.

Innovation actually can, of course, only happen when all the players and all the sectors are sitting around the table. We are not going

to have much impact in changing the food and agriculture footprint in the world if we just talk about it within the food and agriculture sector.

As we go forward in this effort with the Council on Competitiveness, all of the different disciplines and sectors need to sit around the table, so that innovation can happen.

PART 2: FINDINGS FROM THE ENERGY-FOOD-WATER NEXUS DIALOGUE

Energy-Food-Water Nexus and the Competitiveness Landscape: Transforming Scarcity into Abundance

Economic, environmental, geopolitical and technological forces have motivated global competitors to engage in the energy-food-water nexus discourse. As previous shifts in the competitiveness landscape have proven, institutions that fail to recognize and adapt to the ever-changing topography of competition risk falling behind in the race to innovate. As such, this opening panel maps out a new competitiveness landscape—one that includes the energy-food-water nexus. To facilitate this process, the following framing questions were posed to the kick-off discussants and participants:

- What are the implications of the energy-food-water nexus on U.S. competitiveness?
- What are the challenges involved in managing the trade-offs imposed by the energy-food-water nexus? How are they connected? What is the nature of the challenges (technological, political, financial, cultural, etc.)?
- How can nations leverage the pressures of global population trends, economic growth and climate change—all at the core of the energy-food-water nexus—to expand industrial capacity, open up investment opportunities, develop new products and services, and create jobs?
- How can the United States leverage its technical leadership and institutional knowledge of agriculture?
- What are the competitiveness implications of the recent natural gas boom?

Pervasive throughout the discussion was the sense that the United States is at a potentially serious competitive disadvantage by not addressing the challenges presented by the energy-food-water nexus—and that other nations and their public and private sectors are focusing more intently in this space. This solutions-focused group, however, moved quickly into visualizing solutions and the obstacles the nation will likely face along the way. As such, the session's two framing questions receiving the most attention were those related to how best to leverage national and strategic assets, and understanding the trade-offs inherent in the energy-food-water nexus.

Moderator**Dr. Frank Loge**

Associate Director, Energy Efficiency Center;
Director, Center for Water-Energy Efficiency
(CWEE); and Professor, Civil & Environmental
Engineering
University of California, Davis



The lens of competitiveness provides a new dimension to the energy-food-water nexus by introducing a different set of stakeholders to a dialogue in which many participants in today's discussion have been involved for decades. And with new stakeholders come new ideas to enhance the

already robust intellectual community around the energy-food-water nexus and to increase the sense of urgency felt by those in a position to catalyze change. To get this point, however, we need to explore the implications of food, energy and water on the future of U.S. and global competitiveness.

Kick-Off Discussant**Dr. Tomás Díaz de la Rubia**

President
YDS International Consulting



The issue of unconventional natural gas resources is changing the energy landscape, and in turn, the competitiveness landscape in the United States. There is a very serious discussion about an industrial renaissance at a scale that has not been talked about for 50 years. For the first time

in decades, big, private sector companies are talking about building new chemical factories to manufacture everything from plastics to fertilizers, or re-light-

ing steel furnaces in the industrial Midwest because natural gas costs are three or four dollars per million BTUs. This relaxation in the energy side of the energy-food-water nexus has the potential to dramatically increase U.S. economic competitiveness.

This is by no means a panacea. These new plants will not likely replace all the U.S. manufacturing jobs lost over the last couple of decades. Moreover, in keeping with the theme of this dialogue, extracting natural gas from shale formations is very water and energy intensive—and there remain many environmental concerns with natural gas production. Thus, meeting the energy demands of the future cannot depend on increasing the availability of natural gas alone.

How then do we address these concerns? The answer is through innovative, transformative technologies, and new forms of energy sources such as nuclear and biofuels. The implications for competitiveness are enormous as we continue thinking about new technologies that can meet resource requirements in a sustainable way. That is where the tremendous opportunity lies for the future.

Kick-Off Discussant**Dr. Martha Krebs**

Executive Director, Energy Institute
University of California, Davis



The California water system is the largest energy user in the state. In 2005, it used 33 percent of California's natural gas and 20 percent of its electricity—compared to a 6 percent national average. Because of California's unique irrigation needs, the majority of this energy was used in pumping groundwater

from municipal systems for use on farms.

These facts illuminate the energy-food-water nexus—and why the nexus is so vivid in California. More important, California is an example of how food and water challenges can simultaneously be thought through to create a powerful agricultural sector. For

the last 40 years California has been supporting research and policy experiments to make our energy systems cleaner, our agricultural practices more sustainable, and our water systems safe for humans and the environment. But only in the last decade has California really begun to grapple with the interconnections. While there are lessons to be learned from our experience, what applies to California does not necessarily apply to rest of the country.

It is also important this dialogue moves beyond supply-side solutions—such as renewable energy—and address demand side issues. For example, a recent study supported by the U.S. Department of Agriculture (USDA) explored energy usage at each step in the food supply chain between 1997 and 2007. The most striking result was that the largest increase in food-related energy use was in food processing and food services industries. In essence, Americans are outsourcing their food preparation. This means that we also need to be thinking about interactions and opportunities at the social and cultural levels, as well as the economic and technical levels.

Open Discussion

The general consensus of the dialogue participants emphasized that the United States is not facing a shortage of assets to address problems in the energy-food-water nexus—our university system, industrial research complex, and America's system of national laboratories are world-class by any standard. The need to raise awareness of the issues surrounding the energy-food-water nexus among these institutions to a point that motivates them to develop an actionable, explicit strategy was a common thread woven throughout the conversation. Also clear from the conversation was that the method American leaders use to define the problem matters. This will determine the amount of resources that public, private, and academic institutions are willing to devote to the issue.

What's our sound bite for energy, water and food? What's the sound bite that would mobilize a national effort to infuse resources in this very complex environment?

Dr. Barbara Allen-Diaz

Vice President for Agriculture and Natural Resources
University of California, Davis

According to some dialogue participants, the United States needs a “Sputnik moment” to mobilize stakeholders and institutional actors—particularly the public—to prompt a government response. Several participants highlighted the geopolitical tensions the energy-food-water nexus is likely to create in the coming years and proposed framing the ensuing challenges and opportunities as a national security concern. Regardless of the chosen framework, many actors—like the national laboratories—work best when there is a clear national goal and very clear line of mission management in Washington, DC. Thus, the nation must define the mission with a clear owner and chain of command. If this occurs, key actors, like the national laboratories, fall into place. Dialogue participants also raised the implementation process as a concern. Even with the right framing of the challenges and opportunities inherent in the intersection of energy, food and water interests, sourcing and implementing solutions will be difficult. The federal government, for example, is comprised of decentralized actors and agencies with oversight in these arenas. Intra-agency collaboration is quite difficult, let alone interagency collaboration. And the resources themselves—energy, food and water—are managed by a range of stakeholders (e.g., local governments manage water).

In addition to the drive to compete, the private sector may still need incentives to act in this diverse, broad space. The food and the agricultural sectors, as well

as energy, are big and relatively slow moving when it comes to change. Business strategies in these sectors have worked for decades without a fundamental change. Thus, there is less incentive for businesses to reorient their views toward resource management. Providing incentives to industry to embrace the full set of opportunities that could emerge from a more strategic, comprehensive approach to the energy-food-water nexus may require new metrics by which industry could judge the opportunity and success.

Thinking about the interaction of government, private sector and universities is also important. After all, dealing with the energy-food-water nexus is a systems issue. Many, perhaps most, of the technologies the United States needs for a better integrated, more productive energy-food-water system already exist. Making this happen is really an issue of deploying these technologies into the market—and one not just about the technologies, but also the scientists and engineers who think in a multidisciplinary way. The national laboratories and university system need to develop leaders with skills across engineering, business, economics, and social sciences who can leverage these skills both in the private and public sectors.

Optimizing the energy-food-water nexus will likely imply tradeoffs. Dialogue participants acknowledged determining those tradeoffs and the concomitant challenges would require considerable attention. Specifically, the discussion tended toward public policy and systems analysis. Interestingly, it became clear that the tradeoffs were not just between energy, food and water.

If we want to emphasize competitiveness, we have to be able to persuade producers that their main interest is in improving competitiveness—which largely comes through technical change as opposed to manipulating federal or state policies.

Dr. Lovell Jarvis

Professor and Special Assistant to the Dean, College of Agricultural and Environmental Sciences
University of California, Davis

For some dialogue participants, a proposed method to determine the appropriate balance of energy and water use was not to make a decision at all. If resources were priced to reflect their true value, economic markets could be relied on to determine the most efficient allocation of resources. However, irrigation, energy and crop subsidies—as well as production externalities—in the United States and around the world dampen market signals and enable resource waste.

Others around the table argued the solution was not so straightforward. So many variables are involved in the energy-food-water nexus that the only way to simplify the complex interaction between policy, research, technology, and industry is through experiments in regional ecosystems. This is a systems

“A hurdle moving forward is that the energy, food, and water sectors are not well coordinated—there is not an existing systems-based approach to solving problems and implementing solutions even within the sectors. What we really need is a systems-based or network approach across those three sectors if we want to get to the nexus of how we concurrently optimize decisions for the sustainability and economic development of energy, food and water.”

Dr. Cindy Stewart

Senior Director of Advanced Research, Corporate R&D
PepsiCo

problem and solutions should be determined by systems analysis. For example, Lawrence Berkley National Laboratory is currently studying the effects of new water security policies in the State of Qatar. This—and other efforts similar to the policy experiments in California, as discussed by Ms. Karen Ross—can offer valuable insight.

Addressing the energy-food-water nexus will also require setting national priorities, which—in this era of fiscal restraint—will likely require trade-offs. Unfortunately, national public investment in agricultural research has already suffered a downturn as has investment in water transmission infrastructure, where huge, potential economic returns exist from reducing water leakage in the existing network of pumps and pipes. These are not science and technology grand challenges. Nonetheless, finding the public funding for these types of projects can be just as difficult as solving the grand challenges.

PART 2: FINDINGS FROM THE ENERGY-FOOD-WATER NEXUS DIALOGUE

Innovating at the Nexus: Meeting Future Demand Through Science & Technology

As was discussed in the previous panel, the United States has at its disposal a world-class innovation system. In this second panel, the discussants and dialogue participants explored how this innovation system can be applied to the energy-food-water nexus to create opportunities for stakeholders while overcoming barriers to progress. The discussion was framed with the following questions:

- Are there potential, disruptive innovations that could boost resource supply and productivity while leveraging the energy-food-water nexus? How will these affect the competitiveness equation?
- Do energy, water and food technologies face unique and/or critical barriers to development and deployment? If so, how can we innovate around these barriers?
- Do we have successful (or failed) models, projects, or solutions to garner lessons learned for organizations and institutions?

It was clear from the discussion that all levels of science and technology—research, development, and deployment—have unique cultural, technical, political, and economic barriers. Regardless, several promising examples of both existing and developing technologies were raised for discussion as well as organizational models to most effectively advance and deploy such technologies. Specifically, the right model should have the scale, scope, and multi-stakeholder attributes of the energy-food-water nexus. Several examples of existing models were discussed that could inform a national energy-food-water nexus initiative.

Moderator

Dr. Subhash Mahajan

Distinguished Professor

Chemical Engineering and Materials Science and
Special Advisor to the Chancellor

University of California, Davis



What is the interplay between science and technology? In practice, we find that science and technology interact in two unique ways.

First, there are cases when engineers are faced with a problem, and that problem requires a technological solution. However, the sci-

ence does not yet exist to support the necessary technology. This scenario describes the development of the transistor in the late 1930s. Early telephone switches used vacuum tubes, which were prone to overheating. AT&T's switching systems, for example, would get so hot that technicians would open up the switching station doors and use large fans to cool the telephone switches. Marvin Kelly, the president of AT&T Bell Labs at that time, posed a question, "How can we develop a solid state device to solve the heating problem?" The rest, as we all know, is history. William Shockley, John Bardeen and Walter Brattain would go on to invent the transistor in 1947. That is one example of the interplay between science and technology.

Second, scientific history shows us examples of solutions looking for problems—that is, a scientific principle is developed and explored without a technological application in sight. This situation describes the development of lasers. Charles Hard Townes

developed the laser at Columbia University in the 1950s-1960s, but there were no available applications at the time. Nonetheless with time the applications have come along, such as CO₂ lasers used for microsurgery.

These examples reveal there are two ways to implement solutions. In this process, the most important thing is how the question is posed. A thoughtful question is fundamental and very important—as the degree of thoughtfulness can yield very beneficial results. My feeling is that human beings are bright enough to find solutions to global grand challenges—including those associated with the complex interplay of energy, food and water—if we are posing the right questions.

Kick-Off Discussant

Dr. Ronnie Green

Vice President and Vice Chancellor of Agriculture and Natural Resources
University of Nebraska



Up to this point in today's discussion, we have heard that one of the biggest challenges in addressing the energy-food-water nexus is the dispersion of resources. This can be viewed, if you will, as two levels. The first level of dispersion is among the producers that hold and manage agriculture and en-

ergy resources. In Nebraska alone, we have 47,700 producers. The next level of dispersion is among the science, technology, and innovation resources that reside in industry laboratories, national laboratories,

academia, and around the world. Institutions have yet to create a framework around energy, food, and water that truly reflects the nature of the challenge.

If we continue on this path—addressing this challenge in a dispersed way—then 25 years will likely pass with little progress toward more efficient and productive use of our resources. For example, we have underutilized existing technologies that—if deployed—could boost crop and animal protein yields all over the globe. Moreover, we have yet to find the disruptive technologies needed to boost nutrient-use and water-use efficiency. Toward this effort, the University of Nebraska organized the Daugherty Water for Food Institute, a trans-disciplinary and multi-institution global initiative, to directly address this issue of dispersion as it relates to food and water as a new approach to these major issues.

Dealing with the global dispersion of resources—a critical barrier to this nexus problem—is really an issue of scale. This requires a very different level of thinking than what we have done in the past, which is provincial at the federal level largely within USDA (in partnership with the states through the land-grant university system) with some investment by National Institutes of Health (NIH), Department of Energy and National Science Foundation (NSF). Until we recognize that this institutional model is antiquated and vastly under-resourced for the magnitude of the challenges ahead, we will continue to lose ground to others who are making significant investments in this arena (e.g. Brazil and China). One idea that this forum should consider is the creation of a new approach to our federal investments either through new resources at NSF or even more radically through the creation of a new federal agency. The question is whether or not the energy-food-water nexus is of that stature. I personally think that it is.

Kick-Off Discussant

Dr. Cindy Stewart

Senior Director, Beverage Processing, PepsiCo Advanced Research, Corporate R&D
PepsiCo Inc.



What the food and agriculture industries have accomplished over the last 50 years—in terms of safety, supply, preservation, manufacturing, transportation, etc. to ensure a safe, nutritious and abundant food supply globally—is nothing short of phenomenal. These advancements are due in large

part to the application of science and technology.

Our products have a deep connection to culture, emotion, and the well-being of our families, our friends and ourselves. However, consumers have become disconnected from the food supply chain and the advancements that allow us to have the food supply we have today. This disconnect contributes to a fundamental barrier to technology deployment in the food industry that does not exist in many other sectors. There are a number of fantastic food safety and technology tools for specific applications that are either not being used by the food industry or are under fire in the press for their use.

Why are we not using these scientifically proven tools? Despite sound scientific data and approval by regulatory and other scientific organizations, people are afraid of the use of some technologies in food production. Nongovernmental organizations (NGOs) have played a large part in perpetuating this fear—of the broader application of science and technology in the food sector—and they have been effective. The food industry is currently facing a negative emotional response from consumers, even for use of technologies that are proven to be safe.

Besides the impact on specific technologies, this negative response has many damaging effects. Two directly related to this panel discussion are the impact on scientists entering the field and the public and private spending on research and development (R&D). Food science and technology is not viewed as an important science—at least in a relative sense—and not enough people are entering the field. The flagging reputation of food science is also reflected in R&D budgets, particularly in federal funding. For example, at the federal level, little more than one percent of the budget is allocated to the USDA for food-related R&D. This shows up in industry as well; compared to the automotive or pharmaceutical industries, the food industry spends a fraction of what the automotive or pharmaceutical companies spend on R&D, as a percentage of their revenue.

Open Discussion

The open discussion followed the topic of Dr. Green's opening remarks—institutional models, and specifically, the topic of the appropriate level of government involvement. In response to Dr. Green's suggestion for a new federal agency, participants suggested a range of alternative measures that tended toward less government leadership. For instance, a federal initiative may be more appropriate than the creation of an agency. National Aeronautics and Space Administration (NASA), for example, addresses an issue that will never go away. But the Nation's interest in NASA has flagged recently, and the agency is suffering, because an agency cannot be dismantled easily. An initiative may be more appropriate, as initiatives can come and go. Moreover, an initiative, as opposed to an agency, also precludes the formation of government-led programs. There was a consensus that the chosen model—whatever form it takes—should be a public-private partnership. Taking this a step further, it may be appropriate to have the government play a supporting role to the

“What is the coalition of uncommon collaborators that's going to make that happen?”

**Energy-Food-Water Nexus Dialogue Participant,
October 2012**

private sector. That is, partnerships should be led by industry, academia and nonprofit organizations/ NGOs that would help direct government resources as needed.

The organizational model must be suited to create—or at a minimum accommodate—technology creation and diffusion. The United States has many existing technologies to deploy in meeting the demands inherent to the energy-food-water nexus—for example, drip irrigation, low-volume irrigation, and techniques to schedule water and nutrients. However, there is no incentive for a grower to adapt new technologies if it is not going to change the grower's bottom line. There may also be some perverse incentives built into the way the system works right now. Dialogue participants encouraged more thought on incentives, such as water rights in California. The dialogue participants also highlighted the need to look at best practices in advanced innovation to bring disruptive technologies to market. The trick is going to be marrying advanced research and advanced innovation. The participants also suggested a closer look at the success of Lockheed Martin; the ultimate goal at Lockheed Martin is to protect national security - and this goal pushes employees through the pain involved in advancing innovation. In comparison to Lockheed Martin's successes in innovation, the current economics of the food and agricultural sector do not push the need for advanced innovation.

Existing Organizations that Advance and Deploy Technologies

The Intergovernmental Panel on Climate Change (IPCC) and the Millennium Ecosystem Assessment (MA) are two organizations developed in the last decade that synthesize findings of existing research and publish views on advancing and deploying technologies while overcoming public perception challenges similar to those faced by the food sector. The public perception challenges are in large part addressed by the broad consensus view expressed by respected scientists and thinkers embraced by both organizations.

PART 2: FINDINGS FROM THE ENERGY-FOOD-WATER NEXUS DIALOGUE

Interactions Between Energy, Food and Water: A Perspective from California

The Honorable Karen Ross

Secretary

California Department of Food and Agriculture



Always with high praise for the California agricultural community, Secretary Ross was happy to share her insights on the energy-food-water nexus as it relates to her experiences in California. Specifically, she discussed the interactions between regions and resources at the core of the energy-

food-water nexus, stressing the importance of R&D performed at the state's university laboratories, and highlighted what she feels is the appropriate role of government in multi-stakeholder initiatives to solve grand challenges.

Environmental pressures, economic expansion, and population growth have tightened energy, food, and water markets—this dynamic is at the core of the energy-food-water nexus. Secretary Ross provided two examples that highlight the interconnectedness of these resources: the 2012 drought and land use policies. The 2012 drought, Secretary Ross explained, has been a game changer in a lot of different ways, such as the profound impact on the livestock sector. In California and on the West Coast, the dairy and poultry industry have relied on importing subsidized feed grains from the Midwest using cheap energy. The drought highlighted the connection and dependency on these feeds—and indirectly energy—from the Midwest. Moreover, California is seeing the cumulative impacts of changing land use. One example of this is the loss of agricultural land

from continued urban growth and public infrastructure development, including large-scale wind and solar projects to help meet state standards for utilities to source renewable energy. At the same time, the agricultural landscape has changed significantly as markets evolve, the value of land and the cost of water have transformed more and more acres from annual low-value crops to plantings of vineyards and fruit and nut orchards. This hardens the demand for water to maintain the significant capital investment in these crops which have a life of twenty-five years or more. These examples highlight an era where food, water, and energy planning can no longer occur independently.

Nonetheless, California's agriculture sector is one of the most diverse and resilient in the world. One of the challenges to sustain these attributes is examining how to maintain a robust university research system and bring the new knowledge and technologies generated in laboratories into the hands of farmers and ranchers. For example, Secretary Ross discussed water quality—a significant issue for California, with involvement from the Department of Food and Agriculture through its Fertilizer Research and Education Program. In the California Central Valley, water quality is an issue of nitrates, which is a more recent development, and salinity. By exploiting all the capabilities of plants, we will be able to maximize our productivity and solve some of California's environmental problems at the same time. For example, it may be possible to have cover crops or feed stock for energy that can actually absorb salt and nitrogen from groundwater. This is an approach that truly resides at the nexus of energy, food, and water. At the end of the day, it is new ideas and science that will unlock a game changing solution. Not only do

our universities help solve practical challenges and create opportunities around food, energy, and water, university research provides indispensable input to policy decisions.

There are several big policies that are driving change in California such as AB32, legislation that requires reductions in greenhouse gas emissions and providing a cap and trade program to help achieve those reductions. What makes this program—and others like it—a reality is that they were developed using sound scientific principles as well as input from stakeholders—not only the impacted regulated community, but also health and conservation NGOs and environmental justice community representatives. Though the government is the ultimate vehicle for this program, the real leadership for making it work comes from innovators in the private sector.

Any public policy discussion should start with an understanding of the appropriate partnerships needed to translate policy ideas into real change. Engaging all of the stakeholders in a collaborative process will result in richer, longer-lasting solutions. It can be tedious and messy but if we fail with upfront collaboration we are in jeopardy of enabling those left out of the process to become critics. These critics can derail progress on the policy actions that must be a part of any initiative to manage and capitalize on the energy-food-water nexus.

PART 2: FINDINGS FROM THE ENERGY-FOOD-WATER NEXUS DIALOGUE

Policy Implications: Supporting the Energy-Food-Water Nexus

Like the energy-food-water nexus, the topics of this dialogue overlap and intersect. As such, the previous panel discussions have precluded relevant public policy aspects of energy, food, and water. This panel is intended to directly address the role that government policies—local, state, or federal—can play in creating opportunities around the energy-food-water nexus and/or overcoming barriers to intelligent stewardship of these resources. To this end, the following questions were posed to the group:

- How can public policies and regulations—such as those for irrigation, energy and crops—alleviate or exacerbate the energy-food-water nexus challenges?
- Are there best practices (in trade policy, energy policy, etc.) in the United States or elsewhere that point the way to a balancing of supply and demand of critical resources while enhancing U.S. competitiveness?
- What federal, state and local government agencies/departments/committees need to be engaged in the energy-food-water conversation? And what steps can we take to promote a more coherent policy approach to resource management?
- What role, if any, should government play in the provision or encouragement of capital investment in developed and emerging economies?

The first panel briefly touched on the importance of framing the issue in regards to motivating stakeholders to act. This panel has continued—and built on—the theme of framing as it relates to policy. Specifically, how we define the problem directly impacts the structure of the solutions. Moreover, defining the

metrics of success—what does a solution look like—also shapes the policy debate. The conversation took deeper dives into structuring an energy-food-water nexus initiative and what specific policy tools may be of use.

Moderator

Dr. Harold H. Schmitz

Chief Science Officer
Mars, Incorporated, and
Executive Director for the Mars Center for Cocoa
Health Science



I presented recently at the World Wildlife Fund Presidents Council and I asked people three questions: Do we have a moral responsibility to feed all of the people in the world? Do we have a moral responsibility to protect the environment—the biodiversity—so the future generations can have the

wonderment that we have had with it? And, do we have the moral responsibility to use the best science available to us to secure a sustainable future? The answer to these questions was yes. Recent and persistent climate distractions, and the acknowledgment of our moral responsibility on these matters, mandate that we commit to supporting a healthy and ongoing R&D and innovation pipeline.

Kick-Off Discussant**Dr. Gary Dirks**Director, LightWorks
Arizona State University

I would like to begin by discussing climate change, or perhaps a better term—climate disruption. I believe it is one of the great unmanaged risks of our time. Climate disruption is a global issue and, fortunately, I believe that the major economies of the world—the United States, European Union and

China—are behind the idea that we are at a tipping point. Europe, despite its fiscal challenges, is still very concerned about managing carbon and China is acutely aware of the vulnerability in its water system. The American public understands the nature of this problem as well. It may be slow, but it would appear that key global players are in a position to make progress.

It is important to think about shale gas in this context. There are tremendous competitive benefits to developing shale gas and the United States should capitalize on this opportunity. However, it is important that we capture these benefits in a way that takes into account the broader environmental consequences. Hydraulic fracturing is very water-intensive and presents some environmental challenges. Nonetheless, with smart regulations all of these things are manageable. The broader concern is ensuring that we do not get locked into a high-carbon future. Though a relatively clean fossil fuel, switching our energy systems to run on natural gas alone can-

not reduce carbon emissions enough to reach the IPCC target. On the policy side, we should be promoting co-development of gas generation with wind and solar.

Conservation is another very important approach to resource management. As Mr. Eggert mentions below, a key policy tool in this area is codes and standards. Building codes, for example, are a way to deploy technologies that can result in significant long-term energy savings. One last point on conservation, we can also promote change in ways that do not require policy action. Nonprofit organizations in southwestern Arizona have developed solar ambassador programs in partnership with local governments to promote the use of solar technologies. These programs have directly resulted in a high penetration rates of solar photovoltaics in communities in metropolitan Phoenix.

Kick-Off Discussant**Mr. Anthony Eggert**Executive Director, Policy Institute for Energy,
Environment and the Economy
University of California, Davis

As an engineer raised by a professor of economics, I like numbers. I want to introduce a few numbers from the energy sector into the discussion. In California, we expend a little more than \$130 billion annually on energy of different forms. In the United States, that number is more than \$1 trillion annually. I

highlight these numbers because they provide an idea of the economic scale of the topics and issues

we are discussing today—particularly as it relates to the amount of investment needed to realize meaningful change.

A recent report from the International Energy Agency (IEA) provides an illuminating example. IEA estimates that providing a low-carbon energy sector for a growing global economy that is consistent with stabilizing the average global surface temperature to an increase of no more than 2°C from the average pre-industrial temperature requires total investments of USD \$140 trillion from today to 2050. This is approximately USD \$36 trillion more than is currently projected for a business-as-usual investment scenario where controlling carbon emissions is not a priority. The good news is this low-carbon investment strategy is projected to reduce fuel costs by USD \$100 trillion during the same period, more than offsetting the increased investment. However, this scenario will not happen without policies that shape the type and trajectory of investments, both public and private, away from fossil-fuels and toward clean energy and energy efficiency.

There are three categories of policies that I feel will make a difference with respect to the energy-food-water nexus. First, we need to ensure the pipeline of sustainable energy-food-water technologies and strategies ready for deployment stays healthy by supporting R&D: basic, applied, and demonstration. Second, we should be using codes and standards to define the performance goals we wish to achieve and let market forces drive clean energy and efficiency gains. For example, California, has done this to great effect with appliance, vehicle and building codes and can boast a more energy efficient economy and 10's of billions of dollars in energy savings for California consumers. And, lastly, we can use fiscal and tax policies to create financial incentives for the private sector to pursue investments and deploy new technologies that will help us meet our energy-food-water demands in more cost-effective and sustainable ways.

“We are constantly undergoing change, and we don’t know where it’s headed—because of population growth, changes in land use, and climate change. If there’s any theme here, it’s resilience. We will need to understand potential outcomes and ensure system stability for any approach taken. The policies to be developed will have to deal with resilience at different scales.”

Dr. Louise Jackson

Professor, Department of Land, Air and Water Resources
University of California, Davis

Open Discussion

Setting policy—as it relates to energy, food, and water—is driven by how success is measured and how the problem is defined. During this discussion, energy security was defined in terms of availability, affordability, reliability, and sustainability. It is often very hard to find the right balance of these factors, as was learned in the first panel discussion on trade-offs. For example, corn-derived ethanol—when viewed through the lens of reducing U.S. dependence on oil—has been a great success. The United States has displaced 10 percent of gasoline through the use of ethanol that the United States would otherwise have imported. However, from a sustainability perspective—if it is a measure of pure energy in and pure energy out—the benefits of corn-derived ethanol are reduced. This is an example how defining goals determines the success or failure of the policy. Another example is shale gas. Shale gas has a high

“We should be setting up parameters by which we judge our energy choices, and then let good old markets compete...Once you push the lobbyist aside and put the engineers to work, amazing things can happen with the right signals.”

Dr. Scott Tinker

Director, Bureau of Economic Geology
The University of Texas at Austin

degree of availability and will remain affordable in the United States for years to come. However, is a carbon-based energy source a permanent solution acceptable to all stakeholders?

For the purpose of defining a solution, the idea of “Sputnik moment” was re-visited. The launching of Sputnik motivated the United States to put a man on the moon. This was a discrete and achievable end. Thus, this might be the wrong approach to defining the energy-food-water nexus, which is much more complex and enduring. It is a chronic issue of achieving milestones, but never arriving at a final solution. To be a bit more specific, this lack of a resolution matters in areas such as R&D budgets because it requires a long-term commitment. Moreover, unlike the moon shot, the targets will undoubtedly move. In every circumstance where there has been an agricultural leap, nature has caught up and found a way to render it less effective. It was suggested, that this forum should have a mandate that R&D and innovation around energy, food, and water continues indefinitely.

The participants also took a closer look at how governments can or should organize around energy, food, and water. At the core of the challenge is the issue of scale: the energy-food-water nexus spans across many levels of government, sectors in the economy, disciplines in science and engineering, and market actors. The organization around

the energy-food-water nexus should reflect this dispersion. Currently, policy making related to the nexus is fragmented and there is no venue at the federal level for discussion of the problems. A multi-stakeholder venue is needed to convene experts for policy discussions at the federal level. A venue that brings together experts across government, industry, and academia—similar to the President’s Council of Advisors on Science and Technology—is essential to fostering a forum for policy recommendations. In addition to developing policy, these types of venues can be foundational to the formation of collaborative partnerships between the public and private sectors ensuring the appropriate scale of investments, and vital to the implementation of new policies. Solutions depend upon interdisciplinary research and policies designed to encourage collaboration across agencies and between the public and private sectors. This must be reflected in the organization structure of an initiative.

The most specific policy tool that was explored was the use of standards, which are a derivative of the idea of letting the solution define the policy. For example, stakeholders can determine the desired outcome—such as reduced consumption or lower emissions—and codify this outcome into a standard. After which, industry should be given the freedom to innovate toward a solution, thereby driving innovation. California has one very famous example of standards being used to meet a desired outcome. At the formation of the California Energy Commission in the 1970s, the Commission proposed standards for refrigerators. It is also worth noting industry stridently opposed these standards, claiming it was going to destroy the industry. Today, despite the fact that refrigerators are larger and have more amenities, they use one quarter the amount of energy that they did 40 years ago and they cost 50 percent less on a real-cost basis. This type of success can be replicated throughout the economy and have a great impact on the energy-food-water nexus.

PART 2: FINDINGS FROM THE ENERGY-FOOD-WATER NEXUS DIALOGUE

Building Partnerships: A Vision for Effective Collaboration

The previous roundtable conversations touched on some of the institutionalized challenges in the United States when establishing inter-agency collaborations on issues such as the nexus of energy, food, and water—namely the mission-driven and decentralized nature of the federal agencies. This panel collected valuable experiential knowledge of the dialogue participants and dove deeper into the attributes that create effective collaboration. The group considered the following questions in preparation for the discussion:

- How can industry, universities, national laboratories and governments build strategic partnerships that leverage the energy-food-water nexus? What ought to be priority areas?
- Who are the stakeholders, nationally and internationally, and what level of global engagement by the United States is appropriate?
- What are the elements needed for this new paradigm, and are there inhibitors to public-private collaboration?
- What is the best way to engage the new administration and Congress in prioritizing the energy-food-water nexus and resource management?
- How can we ensure long-term, bipartisan support of major research, policies, and regulations needed to address the energy-food-water nexus?

In response, the participants focused on identifying the stakeholders and exploring their potential roles in partnerships. They also explored the elements essential for success in previous collaborations as well as lessons learned that could be applied to an energy-food-water nexus initiative. Last, group members proposed some energy-food-water priority areas around which potential partnerships could be formed.

Moderator

Dr. Paul Dodd

Associate Vice Chancellor for Interdisciplinary Research and Strategic Initiatives
University of California, Davis

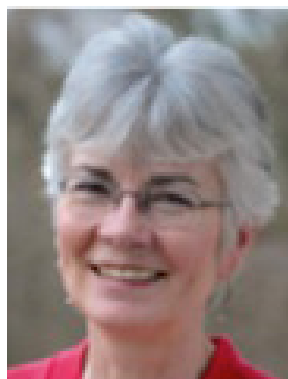


The nexus of energy, food, and water is a very challenging and powerful systems paradigm that will require new and unique partnerships across government, industry and academia. This becomes even more of a necessity as we harness the predictive power of advanced information technology tools through modeling and simulation.

Kick-Off Discussant

Dr. Robin Graham

Deputy Associate Laboratory Director, Computing, Environment, and Life Sciences
Argonne National Laboratory



There are two constraints to moving forward. One is, as Dr. Green mentioned, the dispersion of stakeholders and the other is the huge regional variation in water laws, environmental regulations and local perspectives.

Identifying stakeholders is a challenge because there are so many of them and they are widely disbursed, especially the food producers—in California alone there are 87,000 producers. In addition, one has to consider processors, shippers, and distributors.

“Utilization of a revitalized university extension system is an interesting concept to further explore—translating research on the energy-food-water nexus to driving immediate impact at the local level in California represents a tremendous opportunity in my opinion.”

Dr. Paul Dodd

Associate Vice Chancellor for Interdisciplinary Research and Strategic Initiatives
University of California, Davis

Stakeholders in the water sector include big agencies such as TVA and Bonneville that are concerned with both water and energy in addition to thousands of municipal water departments. Another type of water stakeholder is the environmental groups—many of the laws that actually control water use consumption are driven by environmental concerns, such as the need to maintain stable habitats. Human health should also be included in the discussion in terms of drinking water and water-borne diseases. As we develop this initiative, it is important to include all of the stakeholders. Regarding regional variations, living in Tennessee is not like living in California, especially from a legislative perspective. So when we think of national issues, we really have to recognize the regional cultural and political differences.

I would like to mention two action items we could tackle immediately that could help build partnerships and ensure long-term support:

First, we should promote the development of a national-scale integrated database of relevant information (land use, population, water demand, rivers, etc.) embedded or at least linked to a geographic information system. Output from climate models should be an element of the database. Such a database will make evident the gaps in our knowledge—especially the lack of good spatially explicit water quality and land use information (i.e. how crops are being grown in different locations). It will also force integration of understanding and could be a tool for education at many levels. It will be very important to engage industry in the development of this information and to develop the data in the context of the questions we need to answer. We will also need to recognize that such a database or knowledge system is a long-term project.

Second, I think we need a thorough review of the models and modeling capabilities around the energy-food-water nexus. It is my experience that there are two types of models for water—those developed by the civil engineering community and those developed by the hydrological/ecological community. The former are very useful in urban settings, are very local, and are focused on water quantity and flow. The latter, for example the widely-used Soil & Water Assessment Tool model, focus on the role of vegetation and land use, tend to be fairly mechanistic, may be used at large scales (e.g. river watersheds) and are concerned with water quality as well as flow. I do not think there are any models that handle urban, agricultural and forest settings simultaneously. I think pulling together models—thinking in context of the energy-food-water nexus—might give some direction as to where we want to go.

Kick-Off Discussant**Dr. Harris Lewin**Vice Chancellor for Research
University of California, Davis

There are four critical points in terms of building partnerships that I think will help us to advance this agenda at the nexus of energy, food, and water.

First, without defining the problem at this time, I think the problem needs to be mission oriented. The pro-

grams that drive strategic partnerships need to be directed at solving a problem. We need to have three or four grand challenges that can be put forward to attract the necessary investments. The second thing is putting together programs of sufficient scale and resources to draw the best talent to this initiative. Long-term resources should be committed to solving these problems to create the kind of magnet that we need to draw creative and innovative research investigators from universities and national laboratories to these complex challenges. The third point, and one which is not well appreciated by the agricultural community, is co-location. To solve a problem, or a series of closely related problems, requires graduate students, investigators, and postdoctoral students working, living, and interacting together on a daily basis. The fourth essential component of success for these collaborations is coordination of management. These projects need a very high level of coordination and management, including providing space for their corporate partners to execute on the joint mission.

Another important issue to tackle for our national competitiveness strategy in agriculture is developing a different model for technology transfer. Agriculture research does not create widgets that a researcher invents, discloses, patents, and licenses. A different model for technology transfer needs to be created with input from all types of stakeholders in the field—in particular, industry partners will need to embrace a new way of working together.

Kick-Off Discussant**Dr. Douglas Rotman**Program Director for Energy
and Environmental Security
Lawrence Livermore National Laboratory

The government has a very important role as the institution to define the problem, identify the gaps that we need to bridge, and lay out the goals. Once this has been achieved, the public and private actors can begin to organize around solutions and accumulate the right

science and technology to solve the problem.

There are priority areas where the government can identify a goal or a metric that would bring together the force to achieve these goals. Water and energy conservation and efficiency should be a top priority of an energy-food-water nexus initiative. Water management, including storage, should be driven by predictions calculated on time-scales ranging from seasonal to decadal. Coupling predictions with situational awareness of water resources—using remote sensing and in-situ sensors to know how

“We must create an ongoing problem solving mindset in a group of people who don’t normally work together.”

Dr. Tom Tomich

WK Kellogg Endowed Chair in Sustainable Food Systems;
Professor, Environmental Science & Policy; and Director,
Agricultural Sustainability Institute
University of California, Davis

much water is in a snow pack, rivers, and reservoir at any given time—can provide a full-scale view of water resources and availability to meet the needs of agriculture, energy generation, and other water use communities. Other priority areas should include increasing the efficiency and bringing down the cost of desalinization, reducing the water intensity of both food and energy, and, lastly, harnessing simulation and information technology to innovate solutions to all these water and energy challenges.

Open Discussion

A distinct challenge of the energy-food-water nexus is the overwhelming number of stakeholders widely dispersed across all levels of government, public institutions, academia and industry. Further complicating the challenge are regional variations in laws, regulations, and perspectives of stakeholders that can inhibit the development of partnerships. It therefore becomes imperative to recognize that all actors

will have regional, cultural, and political differences. The sheer volume of various players and the involvement from different levels of government leads to a disjointed approach to addressing issues related to the energy-food-water nexus. In order to build more effective strategic partnerships among stakeholders in the future, a “systems approach” should be developed.

The energy-food-water nexus is a problem that cannot be solved by one institution or group. It necessitates partnerships between government, national laboratories, academia, and industry. There are several critical factors in creating effective partnerships. First, once large-scale problems are identified, mission-driven approaches must be developed. Second, the existing programs that drive strategic partnerships must be directed at solving the problems of scale. A successful collaboration should secure guaranteed long-term funding to attract partners and interdisciplinary talent. Third, an effective partnership will have a high level of oversight and management. A high degree of onsite management is needed to coordinate efforts and ensure the effective use of resources.

Industry, universities, national laboratories, and government can build strategic partnerships that leverage the energy-food-water nexus in areas that either enhance the current systems in place or develop new paradigm shifts through grand challenges. One priority area within the current systems to be addressed are extension services, such as the agricultural extension services.²⁶ It is as necessary now as it has ever been, and due to the impending massive employee retirements, there is a historic opportunity to bring in a new talent pool with the skills needed to

address problems related to the energy-food-water nexus. Strategic partnerships are also needed to create new paradigms to solve these grand challenges. One example is the development of an integrated database that supports and makes available a continuum of data related to the energy, food and water sectors. Such a database would allow stakeholders to better manage resources, conduct research, and inform policy decisions. Modeling would enable stakeholders to predict how the energy, food and water sectors are affected by proposed changes—such as environmental or policy changes—and develop recommendations to better implement new policies. Supercomputers are an untapped resource capable of better modeling through a complex systems approach. The use of supercomputers for modeling enables the integration of big data across disciplines into a single eco-system creating a competitive advantage for the United States.

“The capabilities and the potential for supercomputers to solve complex problems at the systems level are untapped because they are used almost exclusively to solve problems in the physical sciences. We need to bring together expertise in economics, the social sciences, and the physical sciences into a systems-level approach that can help us develop predictive models on how the entire ecosystem surrounding and including the energy-food-water nexus responds to different stressors.”

Dr. Tomás Díaz de la Rubia

President, YDS International Consulting

PART 2: FINDINGS FROM THE ENERGY-FOOD-WATER NEXUS DIALOGUE

Conclusion



Participants in the Energy-Food-Water Nexus Dialogue.

The “Energy-Food-Water Dialogue: Competitiveness Challenges & Opportunities” at UC Davis was the first in a series of progressive dialogues. Moving forward, the Council on Competitiveness will continue to convene thought leaders across industry, universities, and labor develop a larger initiative to elevate the energy-food-water nexus to national and global prominence through the lens of competitiveness, productivity, and prosperity.

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