Water-Energy Nexus: Challenges and Opportunities

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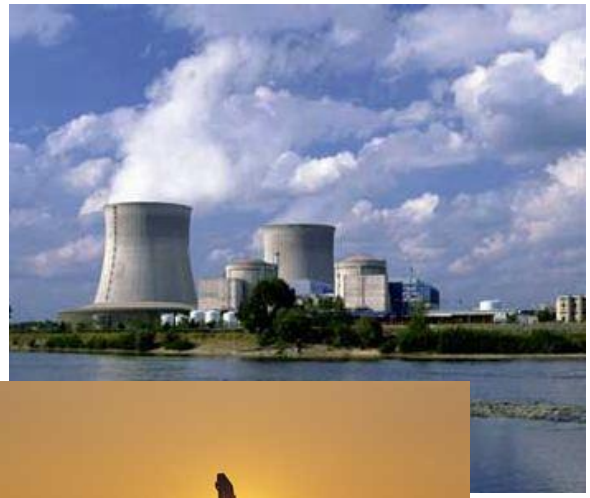
Water-Energy Nexus: Critical National Needs

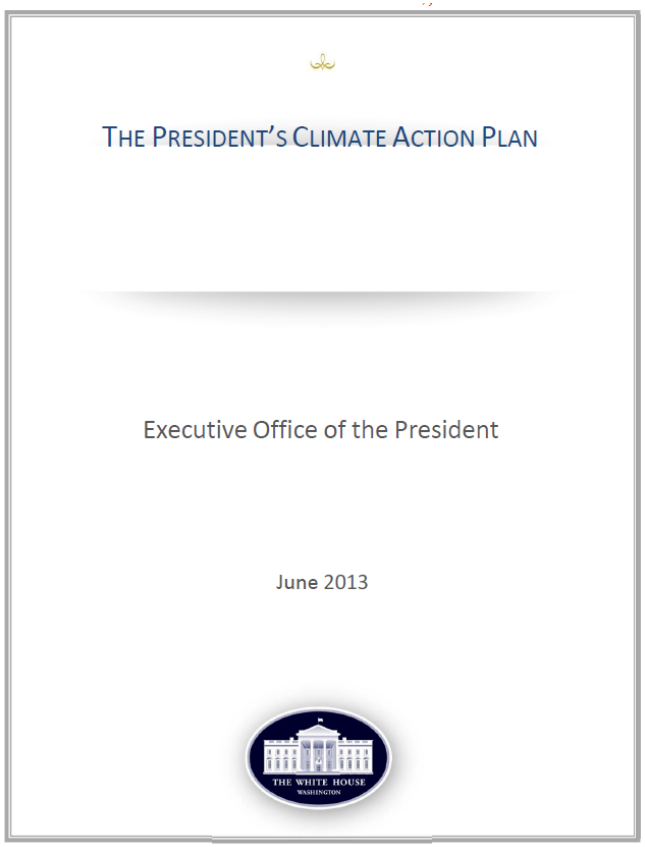
- Energy and water are interdependent.
- Water scarcity, variability, and uncertainty are becoming more prominent.
  - This is leading to vulnerabilities in the U.S. energy system.
- We cannot assume the future is like the past in terms of climate, technology, and the evolving decision landscape.
- Replacing aging infrastructure brings an opportunity to make some changes.
- Energy and water issues are gaining international prominence.



Water-Energy Nexus: U.S. Government Priorities

Administration:

- President's Climate Action Plan
- Quadrennial Energy Review
- Quadrennial Technology Review
- Science and Technology Priorities for the FY2016 Budget
- President's Executive Order on Climate Change
- Build America initiative
- Executive Order on Combined Heat and Power



Congressional:

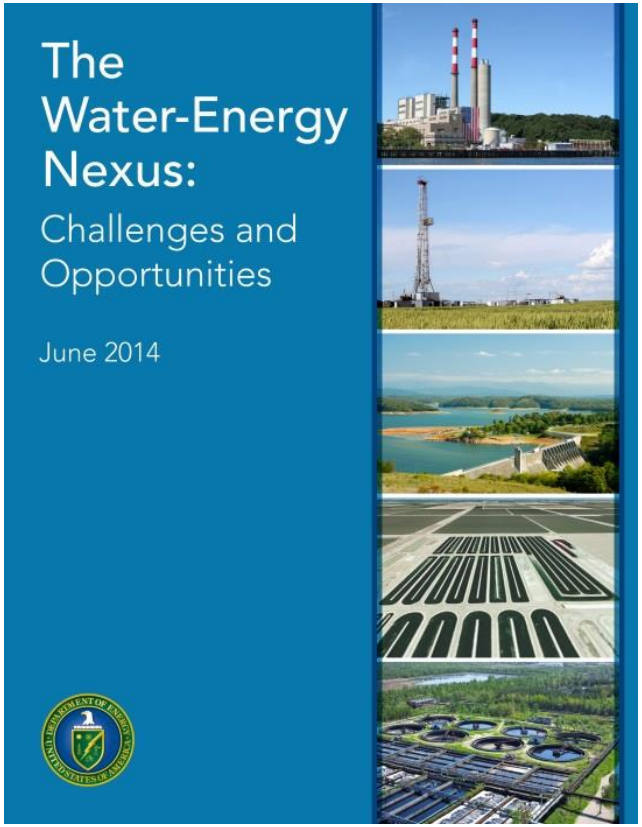
- Senate Energy and Natural Resources
- House Science Committee

Water-Energy Nexus: DOE's Role

- DOE has strong expertise in technology, modeling, analysis, and data and can contribute to understanding the issues and pursuing solutions across the entire nexus.

- Our work has broad and deep implications
  - User-driven analytic tools for national decision-making supporting energy resilience with initial focus on the water-energy nexus
  - Solutions through technology RDD&D, policy analysis, and stakeholder engagement

- We can approach the diffuse water area strongly from the energy side
  - Focus on our technical strengths and mission
  - Leverage strategic interagency connections

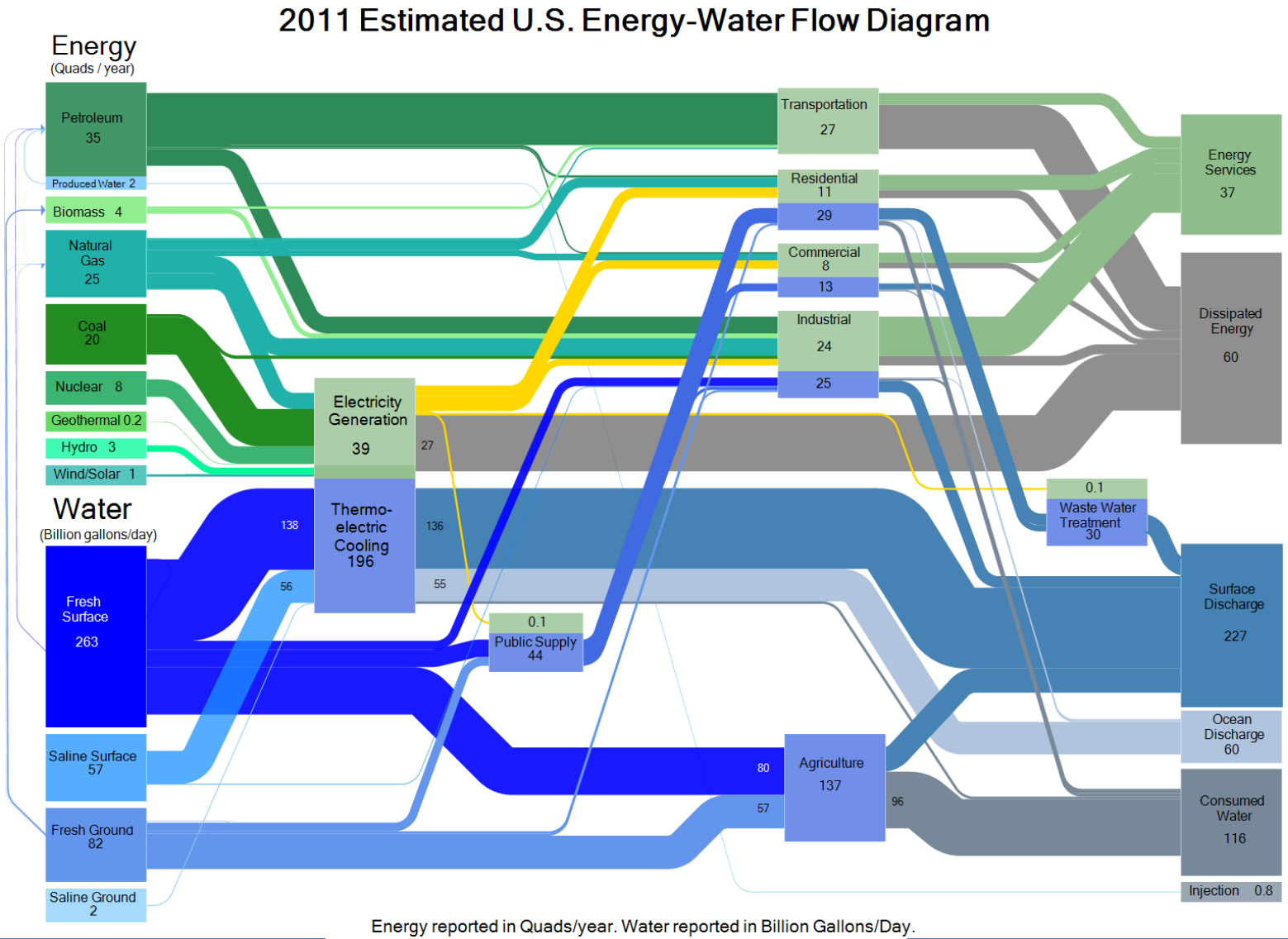


Download the full report at energy.gov

Strategic Pillars

- Optimize the freshwater efficiency of energy production, electricity generation, and end use systems
- Optimize the energy efficiency of water management, treatment, distribution, and end use systems
- Enhance the reliability and resilience of energy and water systems
- Increase safe and productive use of nontraditional water sources
- Promote responsible energy operations with respect to water quality, ecosystem, and seismic impacts
- Exploit productive synergies among water and energy systems

Interconnected Energy and Water Systems



Energy reported in Quads/year. Water reported in Billion Gallons/Day.

Responding to Challenges in the Energy-Water System

Energy Technology Pathways

Forces on System

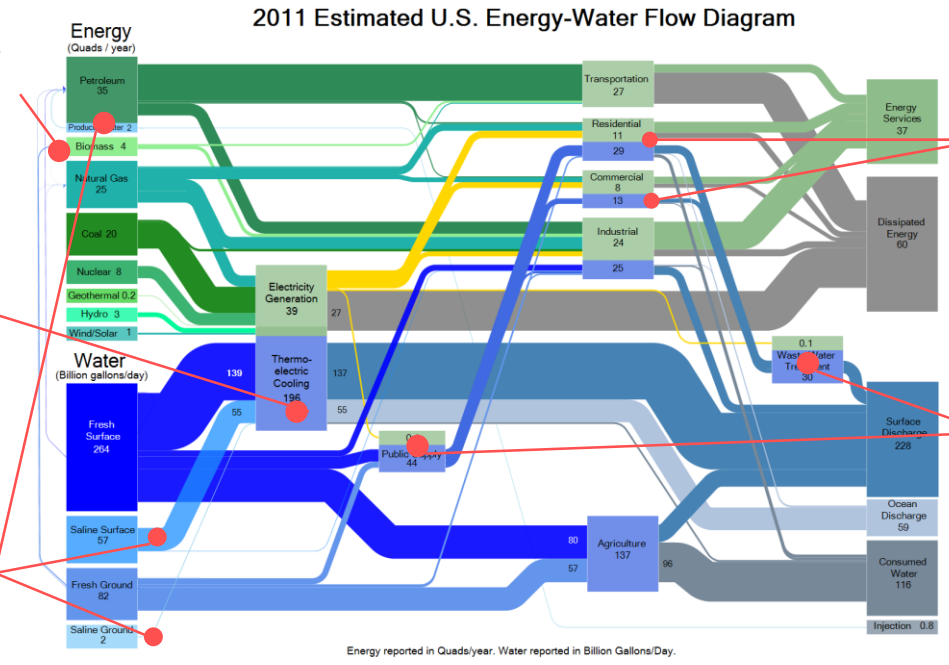
Climate Change (Mitigation and Adaptation)

Technology Solutions

Improved Water Efficiency in Bioenergy Systems

Water-Efficient Cooling for Electricity Generation

Treatment, Management, and Beneficial Use of Nontraditional Waters



Coupled Water and Energy Efficiency

Sustainable Water Utilities

Policy and Institutional Changes

Land Use & Land Cover Change

Stakeholder and Consumer Preferences

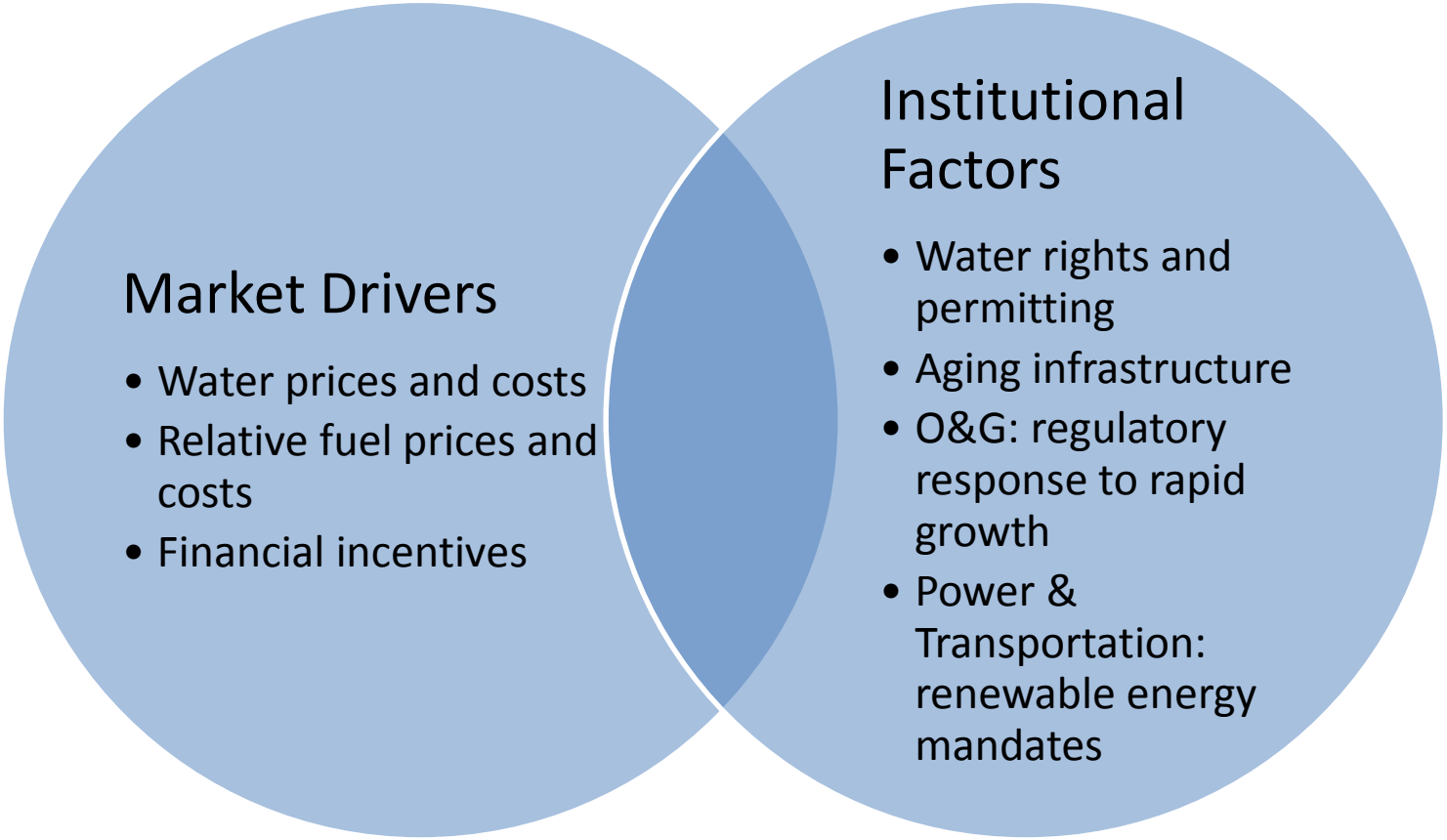
Population/ Migration

Urbanization & Infrastructure Dynamics

Regional Economic Development

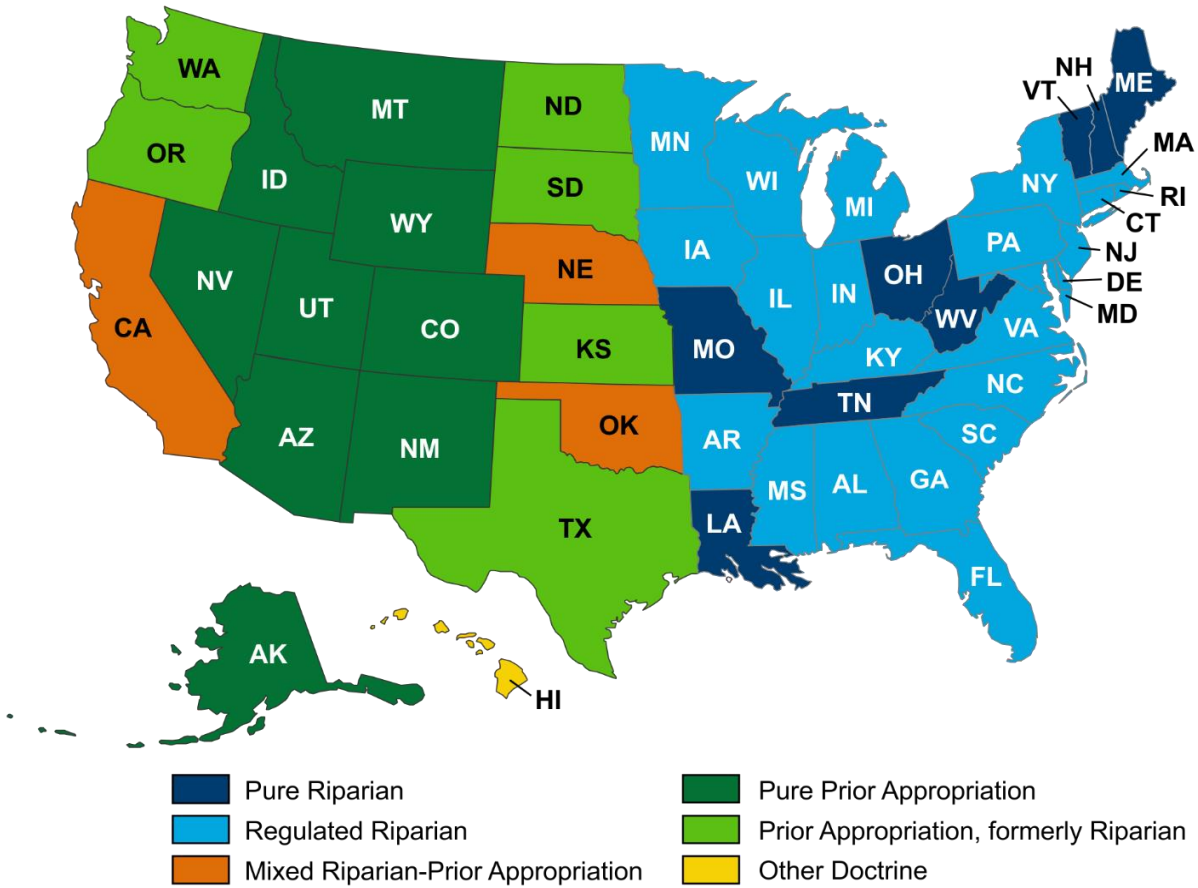
Complex Decision-Making Landscape

The water-energy decision-making landscape is characterized by market and institutional factors varying by region and sector.



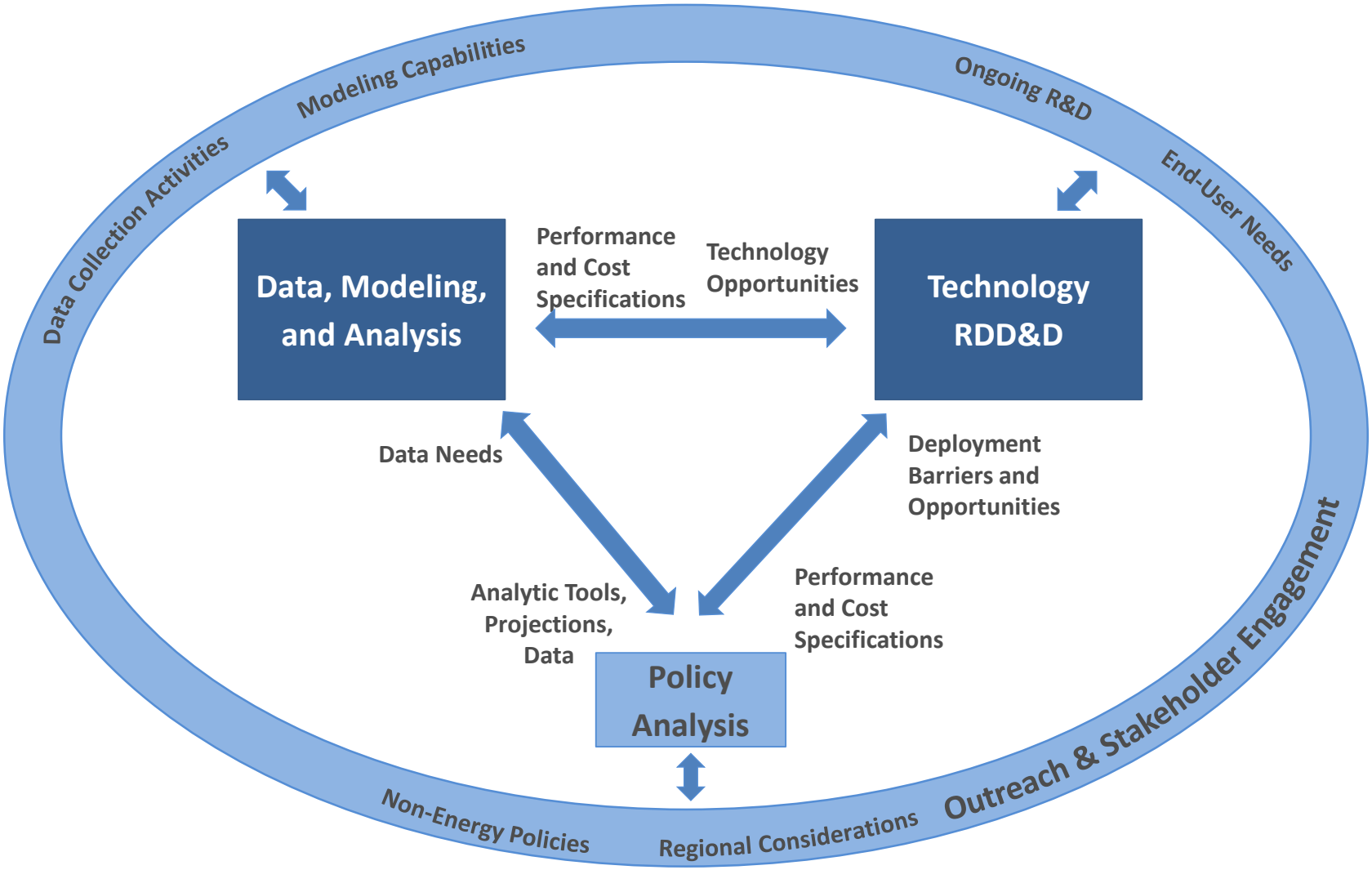
Regional Variation in Water Policy Regimes

Eastern states tend to operate under riparian water policies, while the western states typically uses prior appropriation



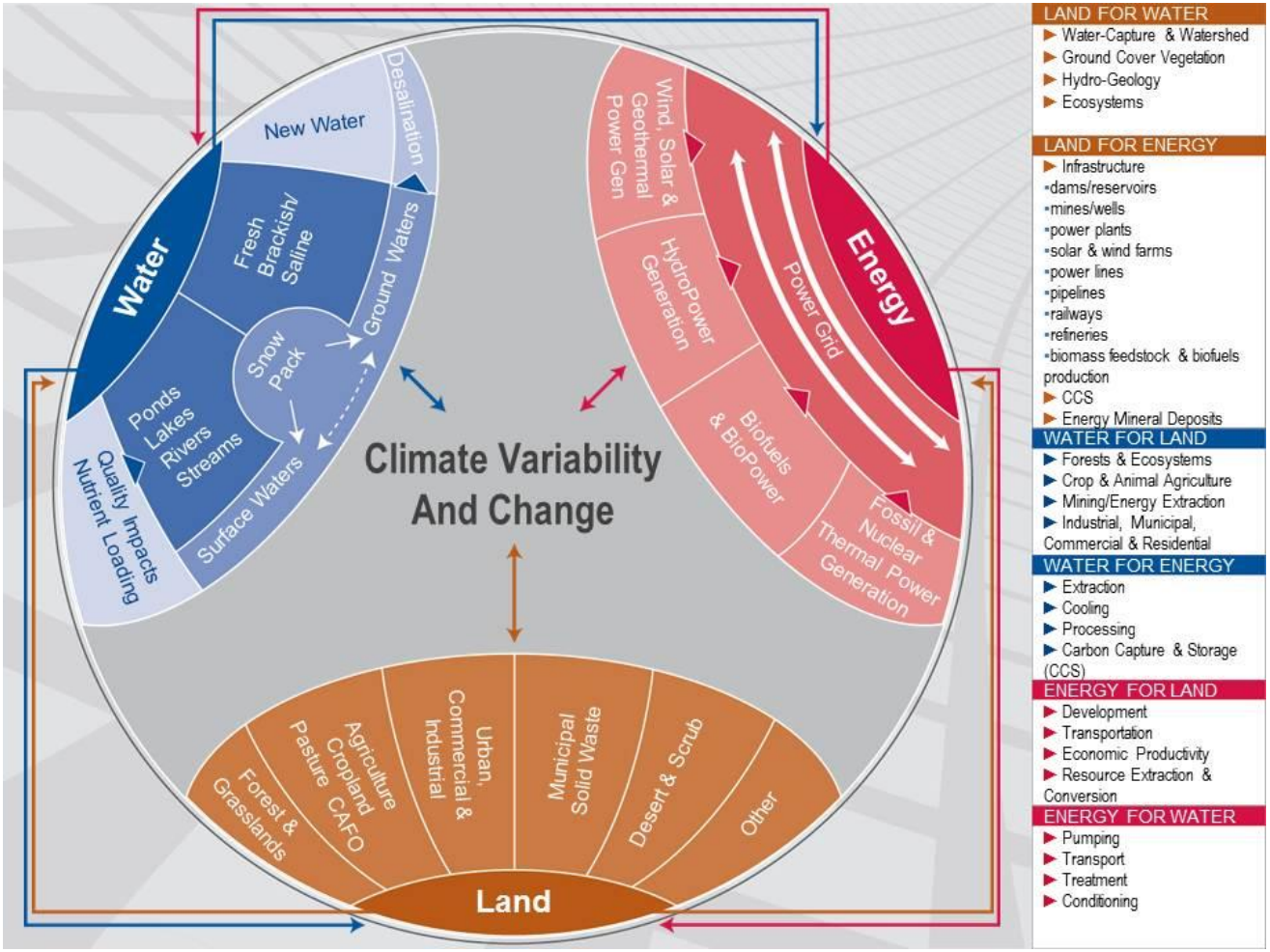
Data source: Gleick and Christian-Smith (2012)

An Integrated Approach to Energy-Water Systems of the Future



Interconnections for Data, Modeling, and Analysis

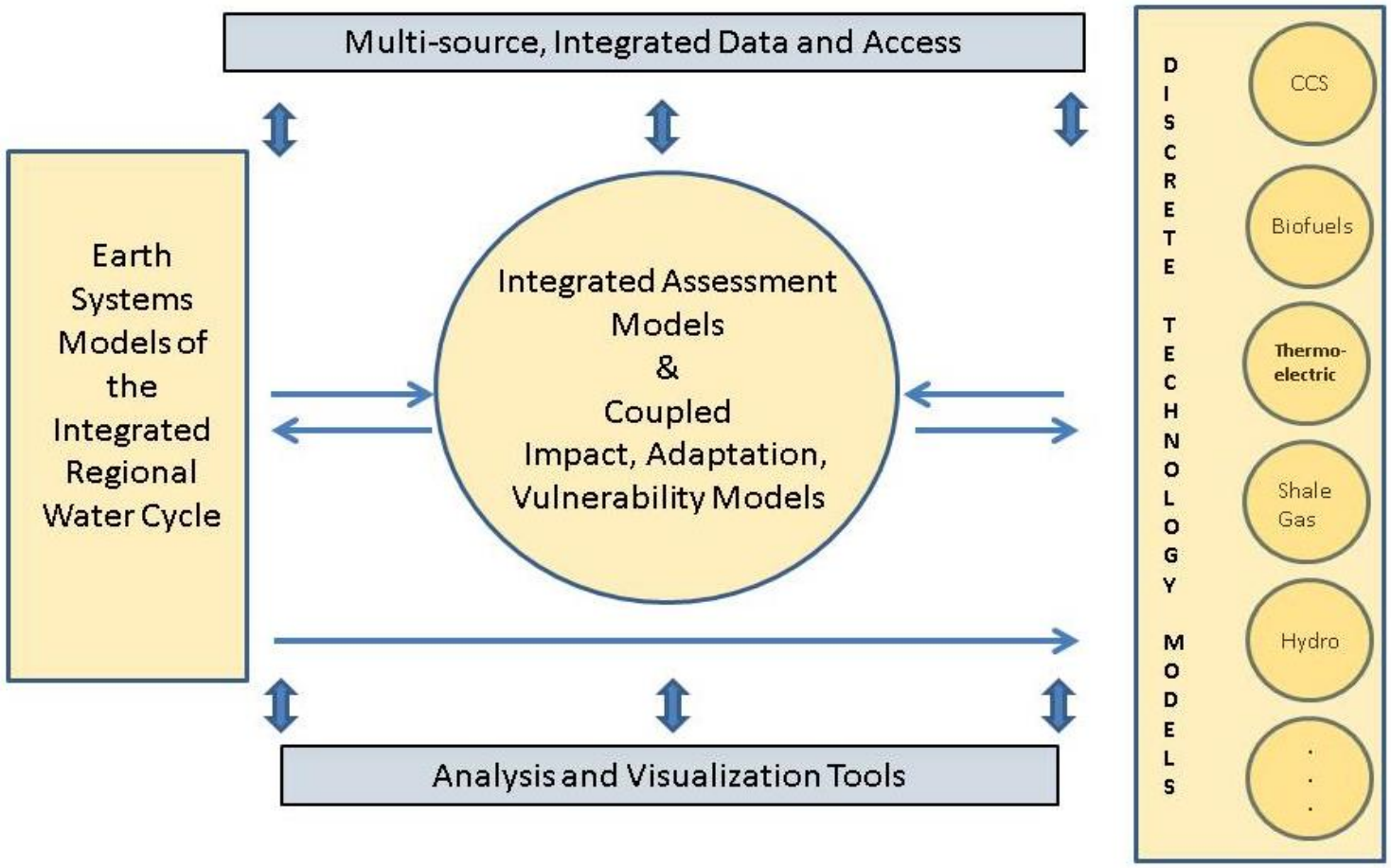
Land is an important consideration for integrative modeling and analysis



Source:
Skaggs et al. (2012)

Data, Modeling, and Analysis: An Integrated Model

A unifying framework can integrate and synthesize across model, data, and analytic components



Needs and Priorities in Data, Modeling, and Analysis

User/Societal Needs

- National and regional-scale assessments
- Sustainable development planning
- Investment and siting decisions
- Adaption strategies
- Technology analysis and R&D insights

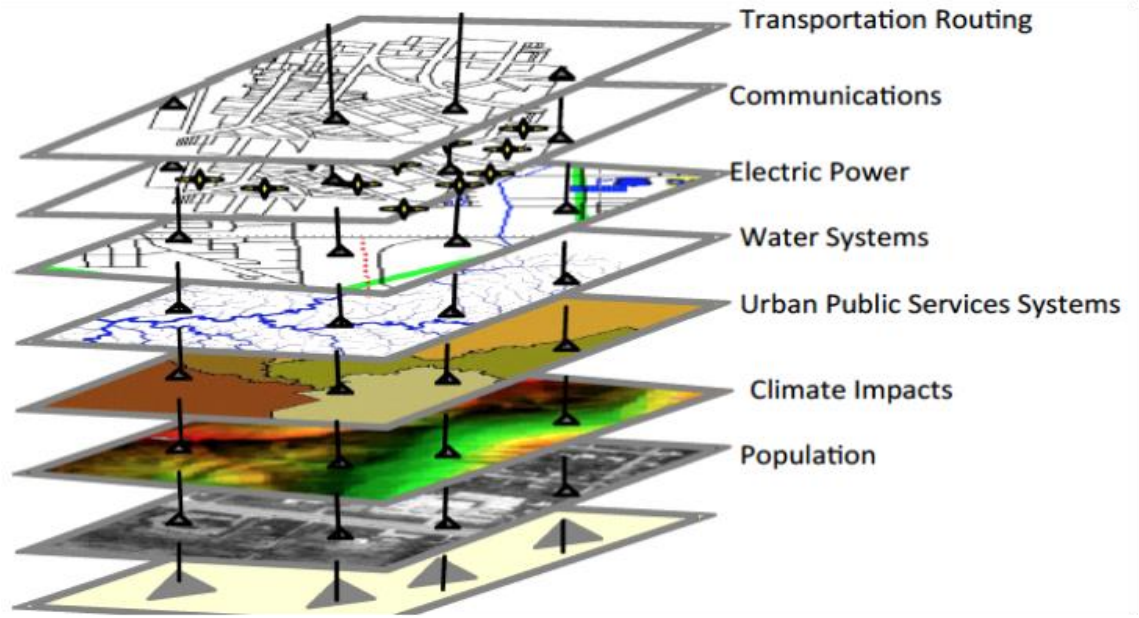
Current Capabilities

- Integrated modeling of human and Earth systems
- Modeling and analysis of human systems
- Modeling and analysis of Earth systems
- Crosscutting modeling & analysis methodologies
- Data, computation, software, observations and the user interface

Priorities for Data, Modeling, and Analysis

- Robust projections, analyses, and scenarios at decision-relevant scales
- Characterization of uncertainty and risks
- Modeling and analysis of extreme events
- Interoperable modeling, data, and analysis platforms
- Confronting models with observations and using observations to improve projections

Tools for National and Regional Scale Assessments



Connected Infrastructure Dynamic Models

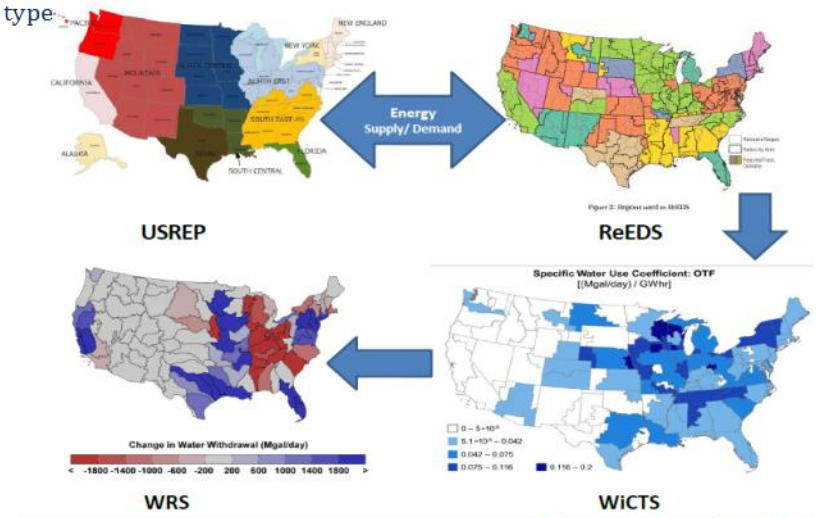
- Can be used for Impacts, Adaptation, and Vulnerability Analysis to illuminate
  - Indirect effects
  - Potential for cascading failures

Source: Wilbanks and Fernandez 2014

Tools to Inform Planning

The U.S. Regional Economic Policy (USREP) model estimates energy demand by fuel type

The Regional Energy Deployment System (ReEDS) model produces electricity by fuel type and cooling type (once through and recycle)



The Water Resource Systems (WRS) model allocates water across sectors

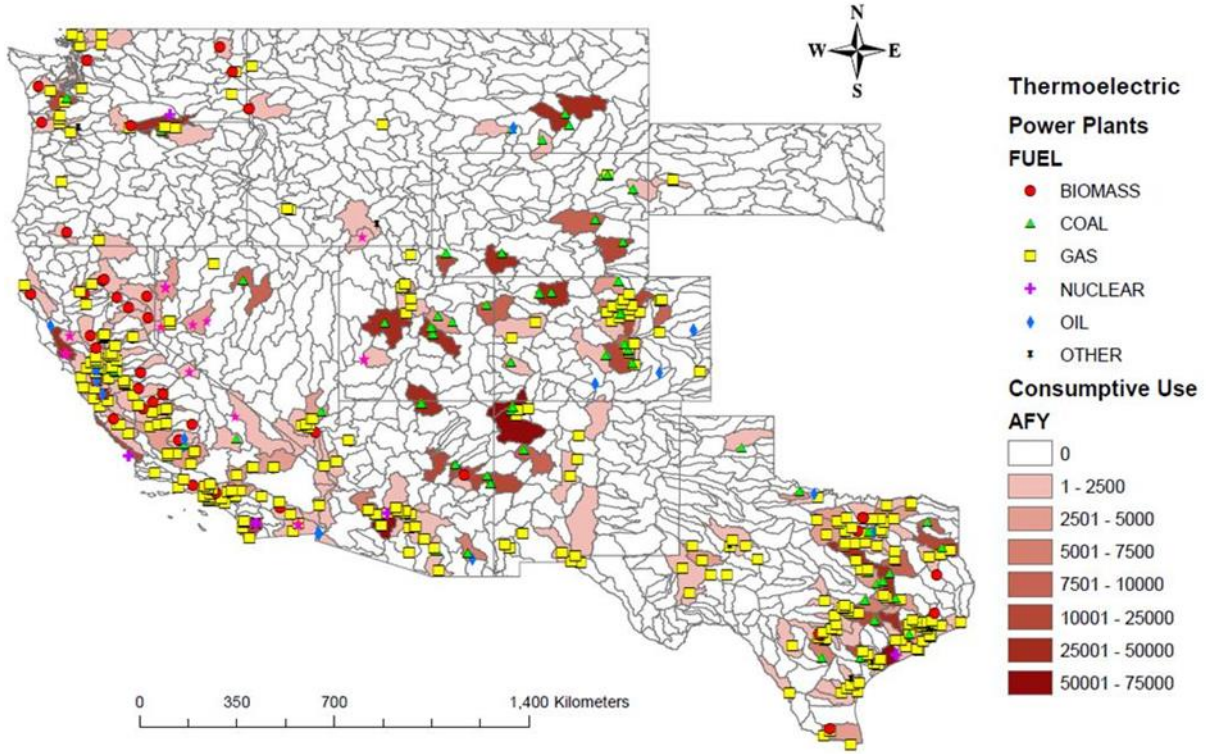
The WIthdrawal and Consumption for Thermoelectric Systems (WICTS) model estimates water withdrawal and consumption

Multidisciplinary analysis can lead to insights into changes in water stress due to alternate energy pathways that can inform planning

Source: Gunturu and Schlosser 2012; Strzepek et al. 2013

Tools to Inform Siting Decisions

Thermoelectric consumptive water use by energy type for Western regions

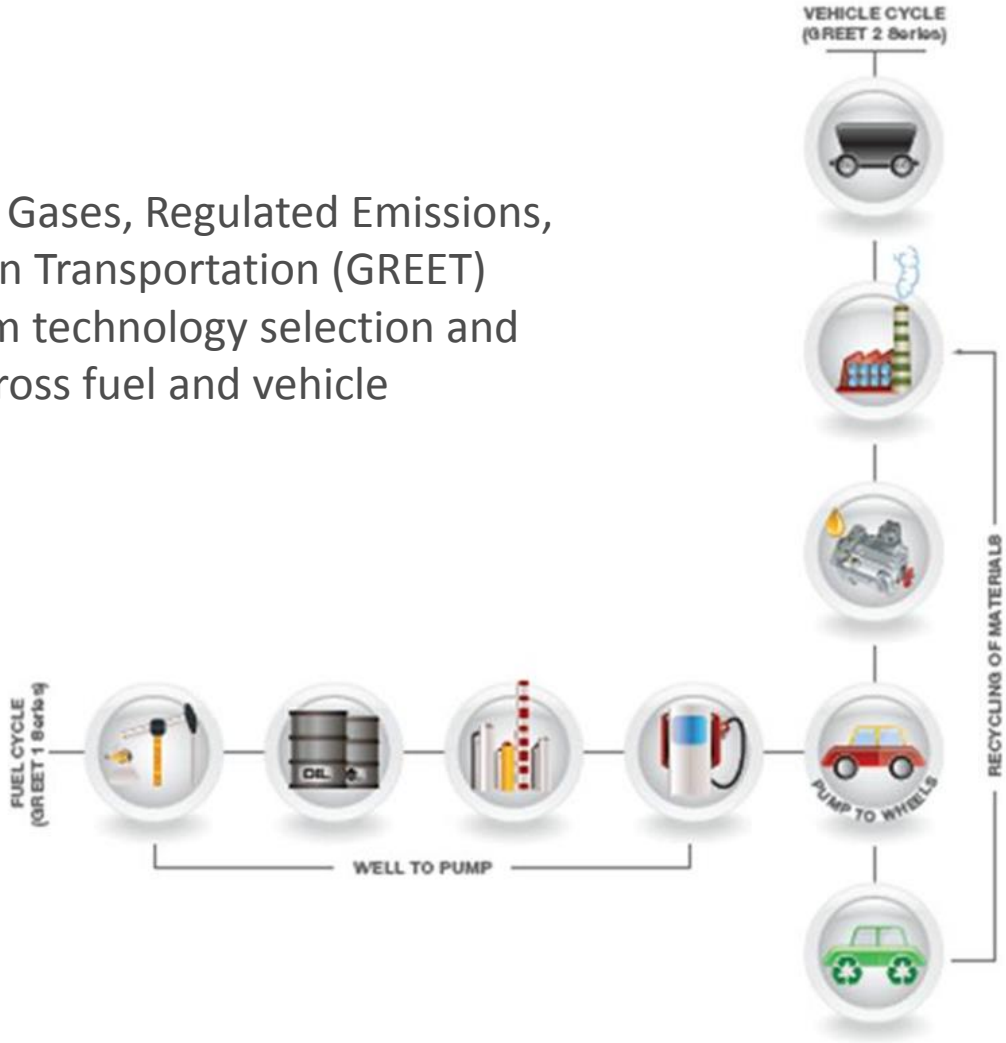


Energy planners and water managers can be informed by geospatial water availability and use data

Source: Sandia National Laboratory

Tools to Inform Technology Decisionmaking

The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model can inform technology selection and improvement across fuel and vehicle lifecycles.



Source: Argonne National Laboratory 2013

Next Steps for DOE

- Pursue technology R&D; provide technical assistance; develop in-depth technology roadmaps
  - Water-efficient cooling
  - Treatment, management, and beneficial use of nontraditional waters
  - Net positive energy water utilities
  - Improved water efficiency in bioenergy systems
  - Coupled water and energy efficiency in buildings
- Fill data gaps and improve data accessibility
- Analyze connections between policy developments and technology opportunity
- Pursue fundamental advances to enable models to inform regional decision-making
- Collaborate domestically and internationally