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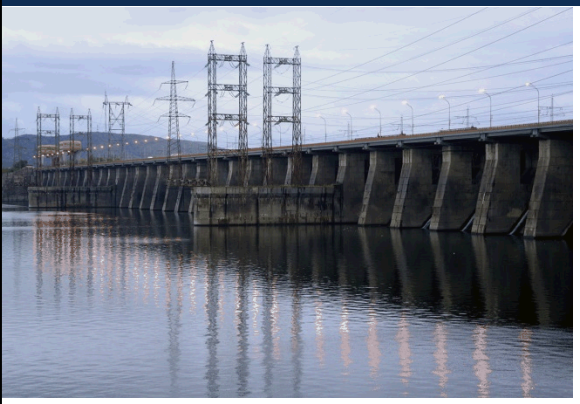

Ensuring a Secure and Sustainable Energy Future

Earth Systems Strategy

Marianne Walck, Director, Climate and Environment Program Area

July 1, 2014

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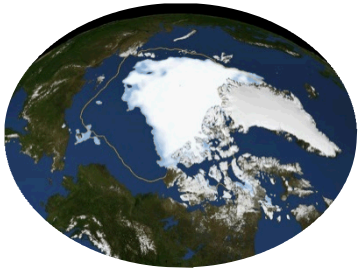
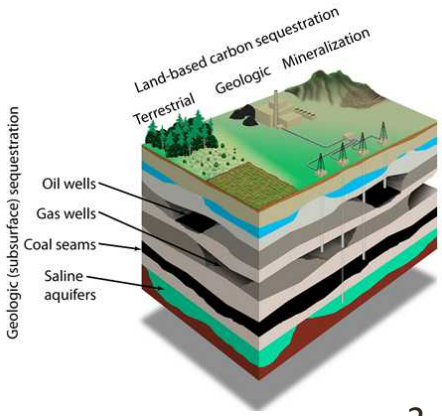
Outline

- The Earth System and the Energy Future – Context
- Measurements and Modeling
- Water/Energy Nexus
- Sustainable Subsurface Energy Development
- Crosscutting Issues with Stationary Power and Transportation





Energy Future Strategic Framework

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SNL FOCUS AREAS

STATIONARY POWER

DOE Quadrennial Technology Review

Deploy Clean Electricity

Modernize the Grid

Increase Building and Industrial Efficiency

RENEWABLE

GRID

NUCLEAR

EARTH SYSTEM

Climate Action Plan

Cut Carbon Pollution in the US

Prepare the US for Impacts of Climate Change

Lead International Efforts to Combat Global Climate Change and Prepare for its Impacts

MEASUREMENTS & MODELING

ENVIRONMENT

CARBON MGMT.

WATER

TRANSPORTATION ENERGY

DOE Quadrennial Technology Review

Deploy Alternative Hydrocarbon Fuels

Increase Vehicle Efficiency

Electrify the Vehicle Fleet

INTERNAL COMBUSTION ENGINE EFFICIENCY

ALTERNATIVE FUELS

CO-DEVELOPMENT OF FUELS/BATTERIES & POWERTRAINS

VEHICLE SYSTEM PERFORMANCE

ENERGY & CLIMATE RESEARCH

Operating Assumptions Summary – Climate/Earth Systems

1. Global Climate Change – it is happening

2. US Focus on Climate Change – President's Climate Action Plan

3. US Focus on the Arctic Region –

- Arctic is the "canary in the coal mine"
- Arctic important for both Energy and National Security – intense international interest

4. Climate Change Affects the US Energy System

5. The US Energy System Affects Future Climate Change and the Earth System

- Fossil fuels: > 80% of supply and will dominate for decades to come, requiring sustainable production, but contribute carbon to atmosphere
- The rate of adoption of low-carbon energy technologies affects greenhouse gas concentrations over time
- Stationary and Transportation energy systems impact land use, agriculture, biodiversity, and public health and the environment.

Climate/Earth Systems

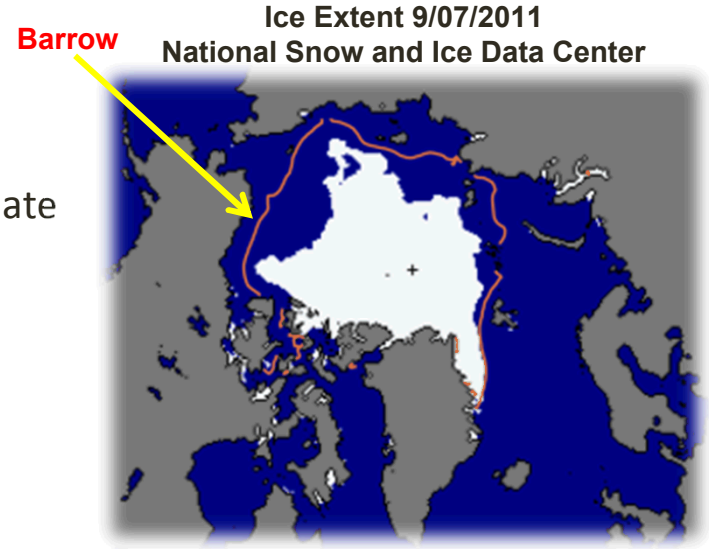
Three focus areas:

1. Climate Measurement and Modeling: focus on Arctic
2. Water/Energy Nexus
3. Sustainable Subsurface Energy Development

These align with three of the eight DOE Big Ideas (March, 2014)

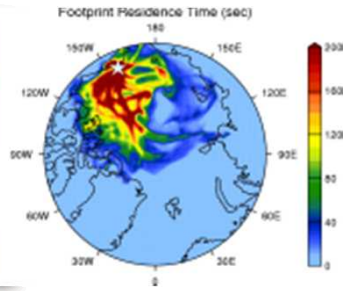
Measurements and Modeling: Focus on Arctic

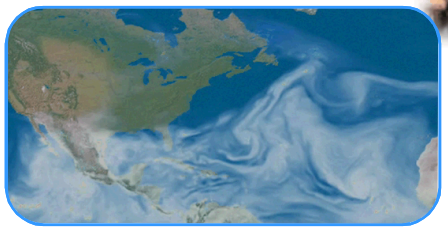
- **Goals**
  - Develop and implement frontier diagnostics and measurements using UAS on the North Slope (ARM)
  - Integrate capabilities in diagnostics, computational climate models and infrastructure impacts modeling
- **Differentiating Capabilities**
  - Arctic measurement logistics
  - Instrument development/deployment
  - Measurement technique and analysis development
  - Sandia led the multi-lab effort to develop the Community Earth System Model's petascale-ready atmospheric dynamical core
  - Systems models of climate impact on human systems e.g. water, agriculture and economics



Mobile Lab

Transport model





Instrument development

Measurements and Modeling: Technical Challenges

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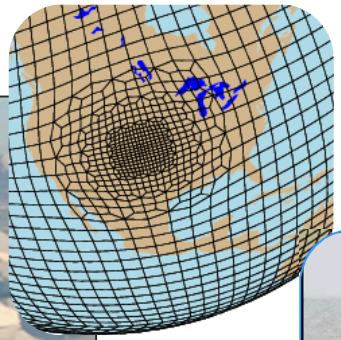
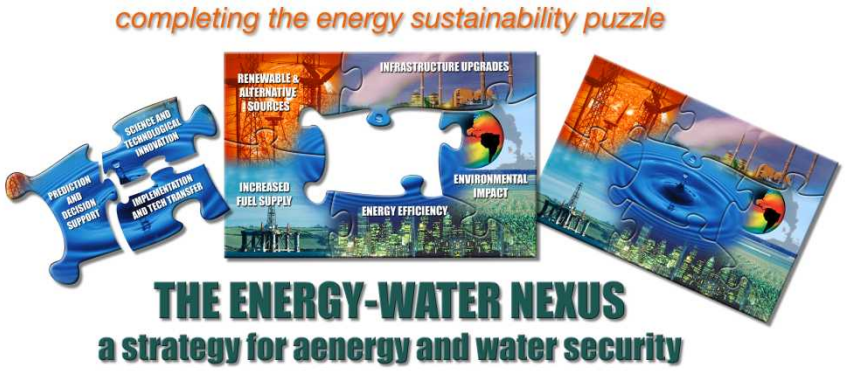
1. Collection of climate data at realistic model-sized scales for model validation.
2. Collection of climate data in dangerous and extreme environments.
3. Development of climate models with variable resolution useful for decision makers to predict regional climate impacts.



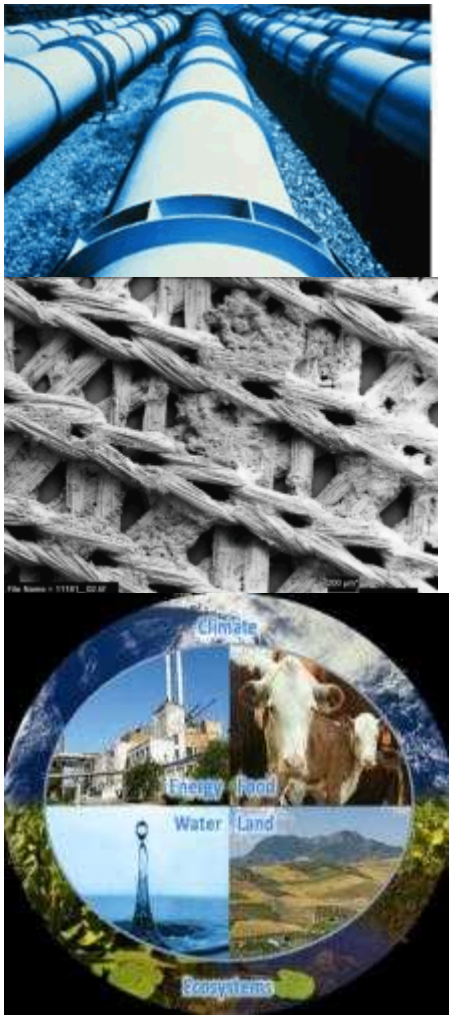
Energy/Water: Goals

- Provide technical solutions and leadership to enable policy makers to manage water and energy resources and improve human, social, and ecosystem health and resiliency.
- Develop water treatment technologies and modeling tools to address the energy-water nexus challenges due to climate change.
- Assess climate impacts on regional water basins as it affects water related infrastructure through integrated natural resource modeling.



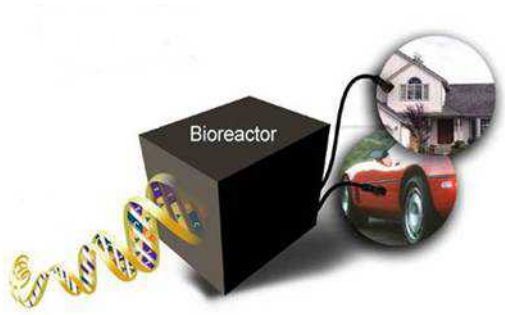
Energy and Water: Differentiating Capabilities

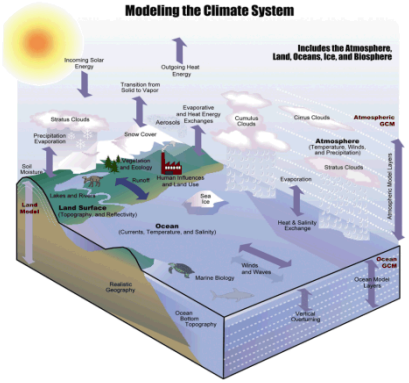
- **Water Infrastructure Security (R&D 100 award)**
  - Pathogen Interactions
  - Lab Testing and Model Validation
  - Numerical Algorithms
  - Computational Fluid Dynamics
- **Water Treatment Technologies (R&D 100 award/DOE FLC Tech Transfer Award)**
  - Coalbed methane produced water
  - Nanofiltration treatment of cooling tower water
  - Low energy desalination technologies
  - Bio-inspired membrane development
  - Mitigation of inorganic and biological fouling on membrane surfaces
  - Development and implementation of novel treatment technologies for contaminant removal (Fukushima and Hanford)
- **Water, Energy and Natural Resource Systems**
  - Energy-Water Nexus: First to bring water and energy managers together for integrated planning at the scale of the Western U.S. (WSWC, WGA, WECC and ERCOT)
  - Strong role in the establishment of the DOE Water Energy Tech Team
  - Dynamic simulation tools to build system-level decision Models
  - DHS S&T Drinking Water Resilience Project



Energy/Water: Technical Challenges

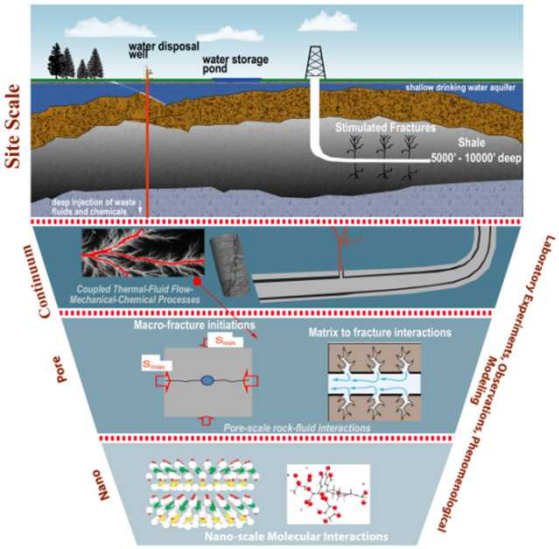
1. **Reduced water resources for energy production:** electric power, hydraulic fracturing, and fresh water for fuels (biofuels, irrigation)
2. **Improving regional climate models** for long term water planning and assessment of climate change impacts
3. **Desalination of brackish waters and other innovative treatment technologies** to allow more cycles of concentration in cooling towers, to extend use of water in hydraulic fracturing, to generate clean sources of water from energy production

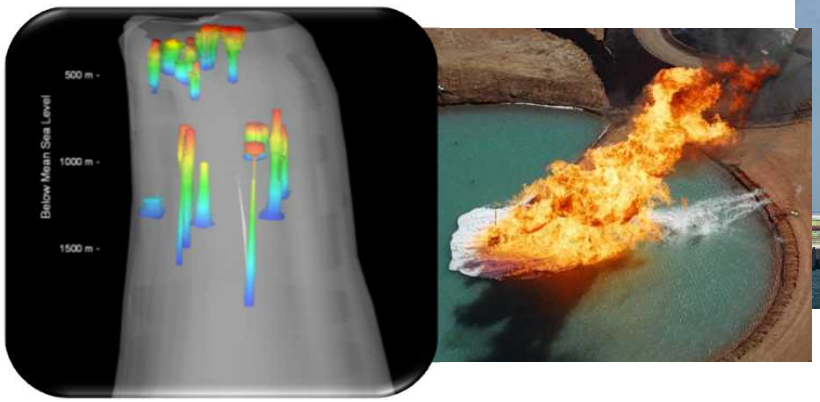




Sustainable Subsurface Energy Development (SSED): Goals

- **Develop new technologies, based on foundational science, to access, develop, and store energy in the subsurface by:**
  - Focusing on fractures and fluid flow.
  - Implementing key partnerships with universities and industry.
- **Ensure safety of energy storage and facilities through advanced technologies, tests, and analyses (e.g. LNG safety, Strategic Petroleum Reserve, and subsurface storage).**





SSED: Differentiating Foundational Capabilities - Combining Science and Engineering

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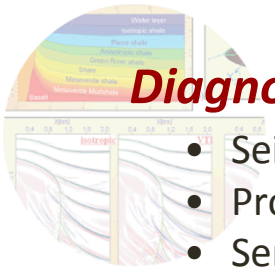
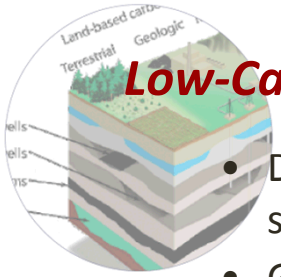
Strategic Petroleum Reserve

- Salt Cavern Technology and Mechanics
- Modeling of Long-Term Behavior



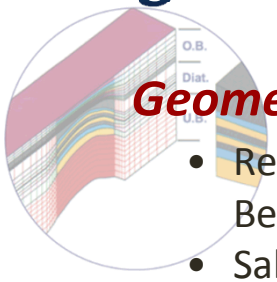
Diagnostics & Imaging

- Seismic and EM Imaging
- Production Diagnostics
- Sensor Development



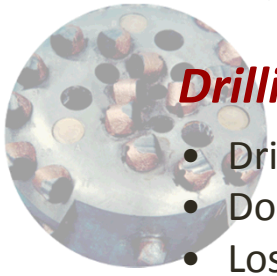
Low-Carbon Strategies

- Developing hybrid membranes to selectively trap CO^2
- Geologic characterization for CO^2 sequestration



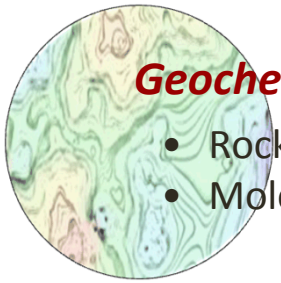
Geomechanics

- Reservoir Geology and Behavior
- Salt Mechanics
- Computational Modeling
- Distinguishing Experimental Capabilities



Drilling

- Drillbit technology (PDC)
- Downhole Telemetry
- Lost Circulation
- Downhole instrumentation – extreme environments



Geochemistry

- Rock fluid interfaces
- Molecular Modeling

SSED: Non-traditional Differentiating Capabilities

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Non-Traditional Tech Areas

- Information Technology
- Numerical & Physical Simulation
- Hardened Electronics
- Batteries
- Sensors
- Material Sciences
- Pulsed Power Physics
- Robotics
- Explosives
- Fire Science
- Telemetry

Potential Applications

- Complex database management and mining
- Simulation of large & complex production and engineering problems
- Downhole electronics for control and diagnostics
- Micro-sensors in autonomous arrays
- Proppant design
- Fracking without Water
- Borehole application of explosives
- Instrumentation packages for extreme borehole conditions
- LNG transportation Safety
- High baud rate and broad bandwidth borehole telemetry

SSED: Technical Challenges

- **Adaptive control of subsurface fluid flow and fractures (DOE Big Idea)**
  - Stress state determination away from the borehole
  - Subsurface Data collection
  - Modeling and simulation – coupled multiscale, multiphysics
  - Data inversion for relevant parameters
  - Drilling and Control Technologies
- **Shale science**
  - Geomechanics, geochemistry, geology
    - Applications to characterization, production, EOR, induced seismicity
- **Fugitive emissions from fossil fuel production**
  - Measurement, attribution

Crosscutting Issues with Stationary and Transportation

- **Stationary**
  - Improved understanding of subsurface for nuclear waste disposal
  - Water availability and treatment for low carbon energy production (cooling towers for nuclear energy)
  - Geothermal energy for low carbon energy production
  - Natural gas for electricity production
- **Transportation**
  - Water availability and treatment for production of advanced, low carbon fuels (biofuels)
  - Natural gas for transportation (LNG, CNG), including safety and risk issues

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Thank you!