

Capabilities Supporting a Clean and Secure Energy Future

LLNL's Role in a Multi-Lab Strategy for the QER

Presented to: Secretary of Energy
Advisory Board (SEAB)

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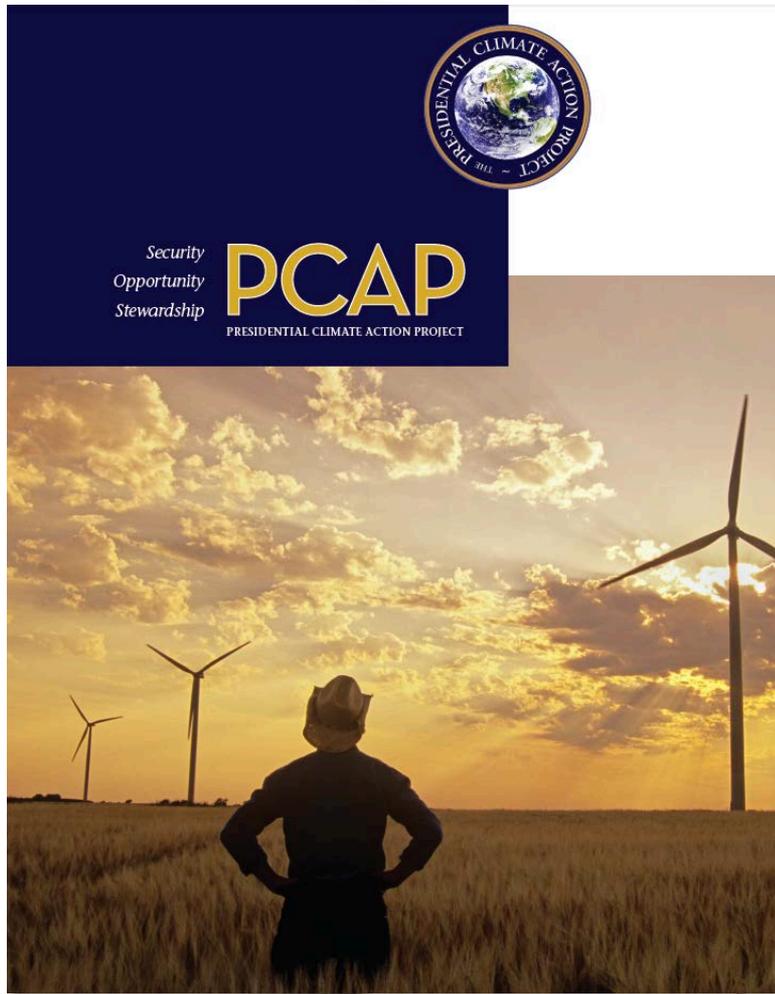
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The President's Climate Action Plan calls for a multi-agency QER led by DOE



... Innovation and new sources of domestic energy supply are transforming the nation's energy marketplace, creating economic opportunities at the same time they raise environmental challenges. To ensure that federal energy policy meets our economic, environmental, and security goals in this changing landscape, the Administration will conduct a **Quadrennial Energy Review** which will be led by the White House Domestic Policy Council and Office of Science and Technology Policy, supported by a Secretariat established at the Department of Energy, and involving the robust engagement of federal agencies and outside stakeholders. This first-ever review will **focus on infrastructure challenges**, and will identify the threats, risks, and opportunities for U.S. energy and climate security, enabling the federal government to translate policy goals into a set of analytically based, clearly articulated, sequenced and integrated actions, and proposed investments over a four-year planning horizon.

Excellence in Earth sciences and systems engineering is fundamental to Livermore's weapons mission

Containment: Geoscience

This panel illustrates geoscience in the context of nuclear containment. On the left, an aerial photograph shows a large, dark, circular crater, likely the result of a nuclear test. On the right, a photograph shows a massive nuclear mushroom cloud rising from a desert landscape under a clear blue sky.

Nuclear Winter: Climate Science

This diagram illustrates the climate science of nuclear winter. It shows a cross-section of the atmosphere with various effects of a nuclear war. Key elements include:

- Injection of 150 to 250 Tg of smoke:** A large orange arrow points to a thick layer of smoke and dust in the upper atmosphere.
- Lofted dust:** Blue arrows show dust particles being carried high into the atmosphere.
- Injection of nitrogen oxides:** Blue arrows show nitrogen oxides being injected into the stratosphere.
- Reduction of ozone layer:** A blue arrow points to a thinning of the ozone layer.
- Increase in ultraviolet flux at 0.30 μm:** An orange arrow points to an increase in UV radiation reaching the surface.
- Upper tropospheric warming by 30 to 50°C:** An orange arrow points to warming in the upper atmosphere.
- Radionuclides:** Blue arrows show radioactive particles falling from the atmosphere to the ground.
- Average dose of 20 rem:** A label indicates the radiation dose received on the ground.
- Increased land-sea temperature contrast may increase storminess:** A label indicates that the temperature difference between land and sea could lead to more storms.
- Lower tropospheric cooling:** A label indicates cooling in the lower atmosphere.
- buffered via heat supplied by oceans:** A small note at the bottom right explains that oceanic heat helps buffer the cooling.

Fallout : Atmospheric Science

This panel shows atmospheric science related to nuclear fallout. On the left is a black and white photograph of the 'Fat Man' tower at the Trinity Site. On the right is a map of the region around the Trinity Site, showing fallout contours in roentgens. The map includes labels for Los Alamos, Santa Fe, Albuquerque, Santa Rosa, Roswell, Alamogordo, and Rio Grande. A legend indicates fallout levels:

- <0.01
- 0.01-0.05
- 0.05-1
- 0.1-0.5
- 0.5-1.0
- 1.0-5.0
- 5.0-10.0
- >10.0

 A scale bar shows 100 miles, and a compass rose indicates North, South, East, and West.

Weapon Design: Systems Engineering

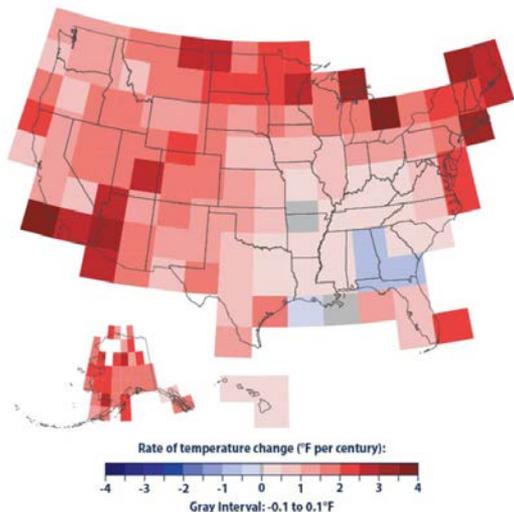
This panel illustrates systems engineering in weapon design. The image shows several technicians in hard hats and safety gear working on a large, complex, cylindrical component of a nuclear weapon. The component is supported by a structure of four large, conical legs. The scene is set in a large industrial or laboratory facility.

The Labs have are working together and providing substantive input to the QER Team

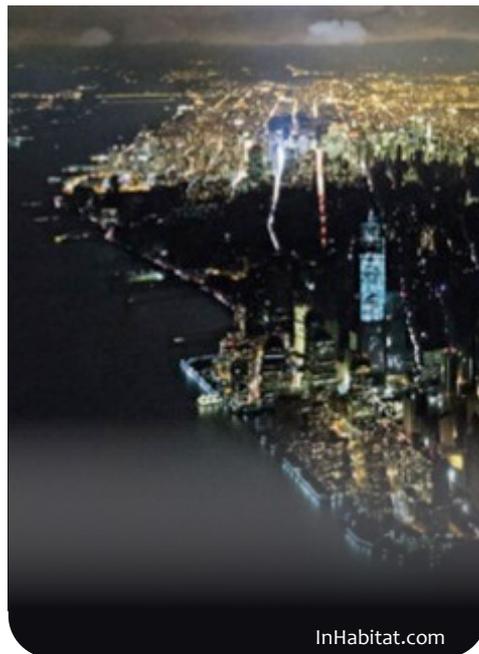


Climate variability will impact infrastructure on multiple spatial and temporal scales

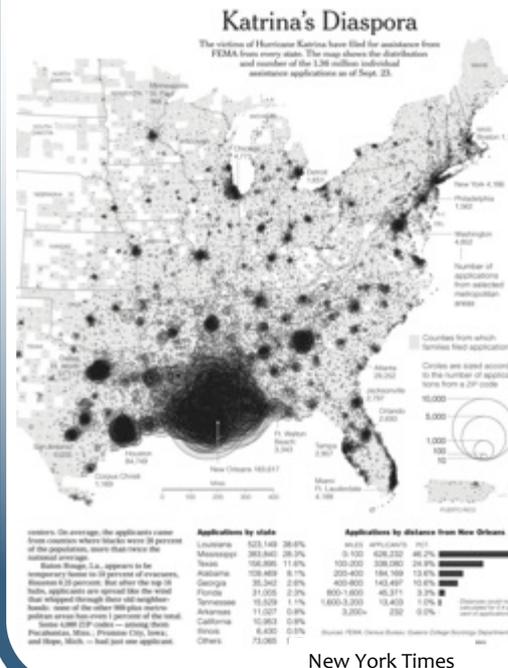
Long-Term Demand Changes



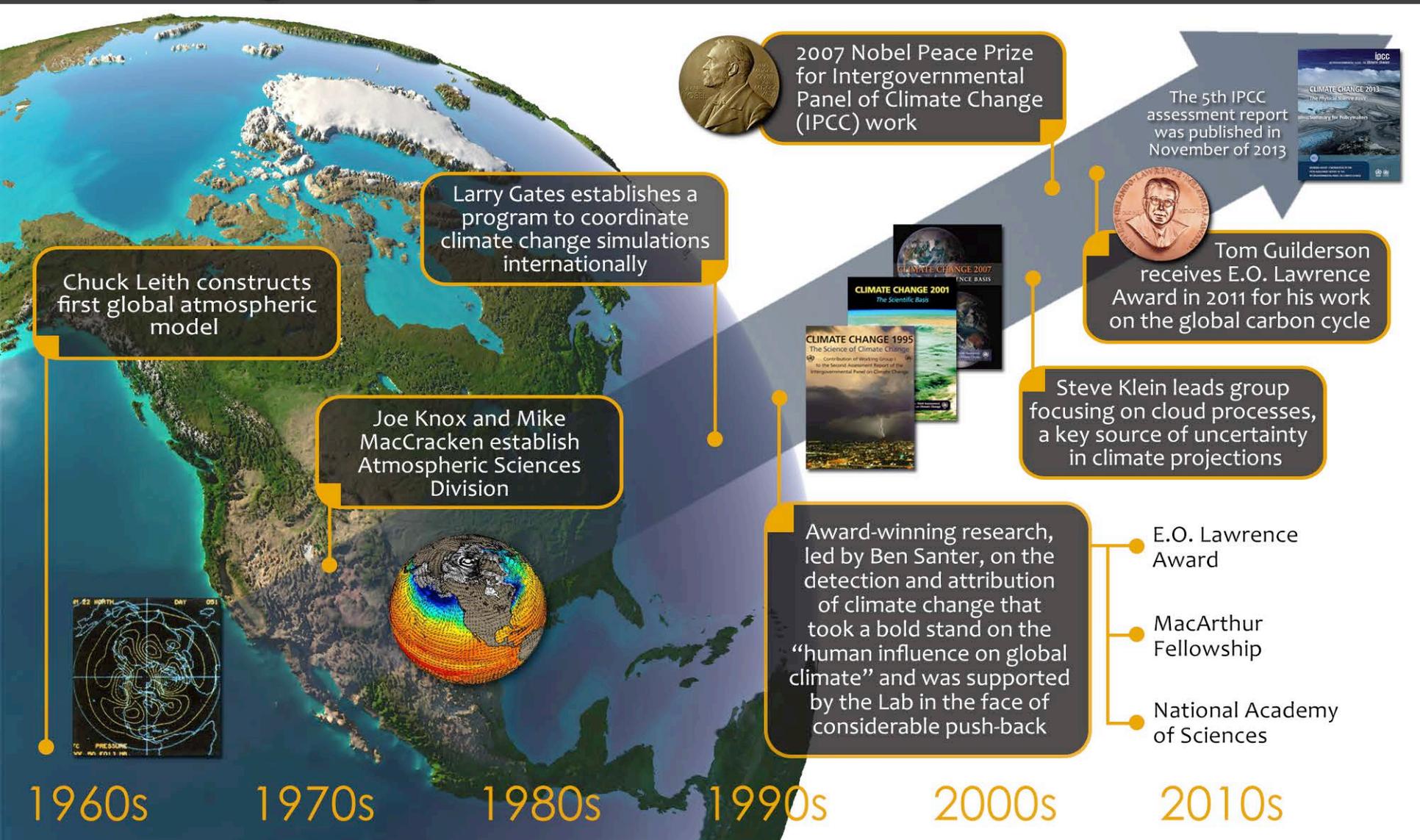
Severe Weather Impacts



Demographics Effects



LLNL was at the forefront of climate science from the beginning and remains a leader in the field



Chuck Leith constructs first global atmospheric model

Larry Gates establishes a program to coordinate climate change simulations internationally

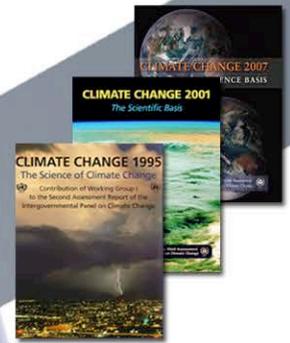
Joe Knox and Mike MacCracken establish Atmospheric Sciences Division



2007 Nobel Peace Prize for Intergovernmental Panel of Climate Change (IPCC) work



Tom Guilderson receives E.O. Lawrence Award in 2011 for his work on the global carbon cycle



Steve Klein leads group focusing on cloud processes, a key source of uncertainty in climate projections

Award-winning research, led by Ben Santer, on the detection and attribution of climate change that took a bold stand on the "human influence on global climate" and was supported by the Lab in the face of considerable push-back

- E.O. Lawrence Award
- MacArthur Fellowship
- National Academy of Sciences



The 5th IPCC assessment report was published in November of 2013

1960s

1970s

1980s

1990s

2000s

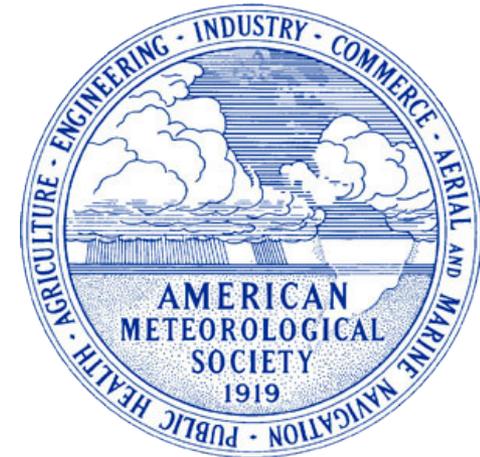
2010s

Program for Climate Model Intercomparison and Diagnosis (PCMDI) has transformed the science of climate analysis



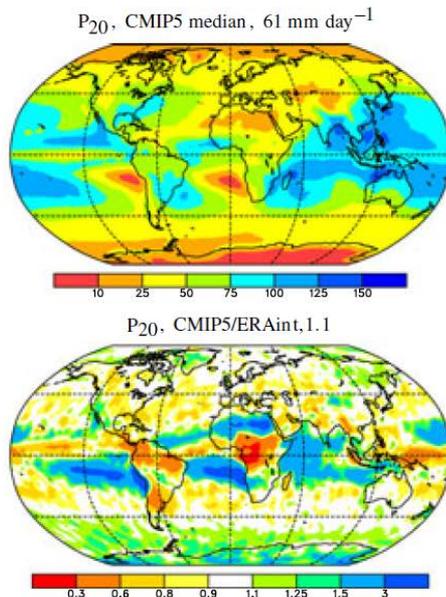
*Program for Climate Model
Diagnosis and Intercomparison*

- Special group award from the American Meteorological Society (AMS)
 - “for leadership in implementing, maintaining, and facilitating access to the CMIP-3 multi-model dataset archive, which led to a new era in climate system analysis and understanding.”
- AMS President Tom Karl stated in his congratulatory email “you have really changed the way we do business in climate science.”

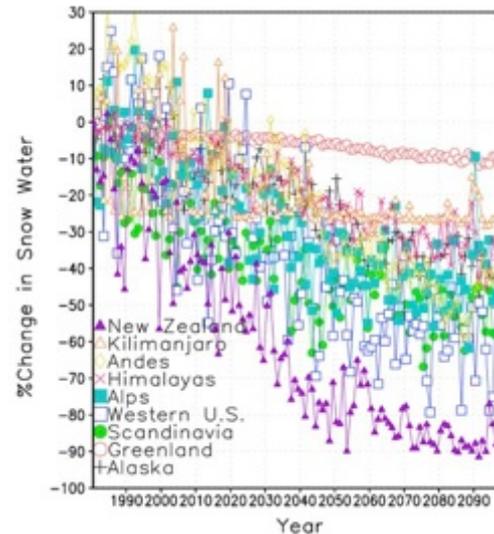


PCMDI is a key component of the capabilities that exist across the National Lab Complex

Climate Model Development, Analysis, and Diagnosis



Climate Model Regional Downscaling



Infrastructure Inventories and Operational Modeling

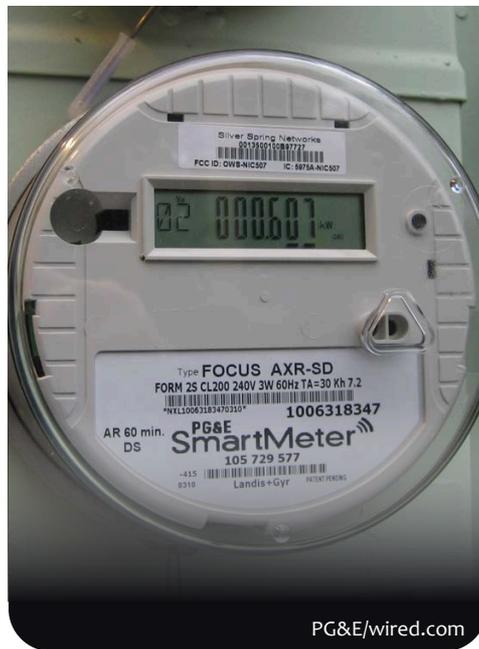


Extensive penetration by Distributed Energy Resources (DER) demands new infrastructure and markets

Variable Solar/PV



Demand Response



Energy Storage



LLNL's security mission has led to innovation in atmospheric science and weather prediction



March 28, 1979: DOE calls on LLNL to respond to Three Mile Island accident. NARAC becomes operational on April 1.

Kuwait: NARAC's first responses utilizing regional forecast models outside the U.S.

Fukushima: NARAC operated on a 24/7 base for almost 4 weeks and remained on alert through the end of May.

Siemens Wind Energy CRADA

1970s

DOE queries LLNL on computer-based system to estimate radiation exposure anywhere in U.S.

1980s

Chernobyl: NARAC estimated activity released, modeled the transport of radioactive materials and calculated dose.

1990s

NARAC monitors Tracy Dump Fire smoke and detects cesium release in Algeciras, Spain.

2000s

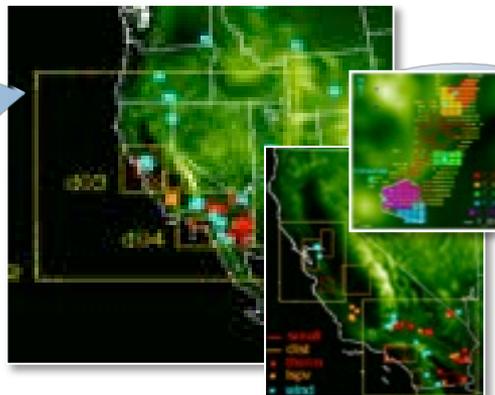
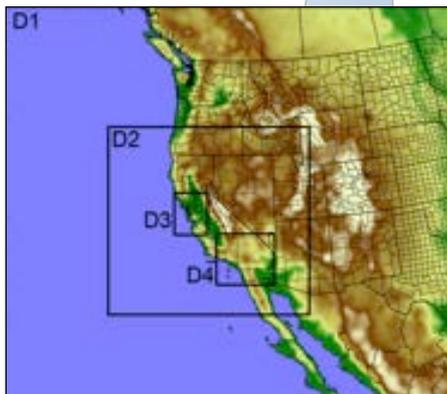
Deepwater Horizon: LLNL produced 24-hour forecasts of potential smoke concentrations from planned oil slick burns.

2010s

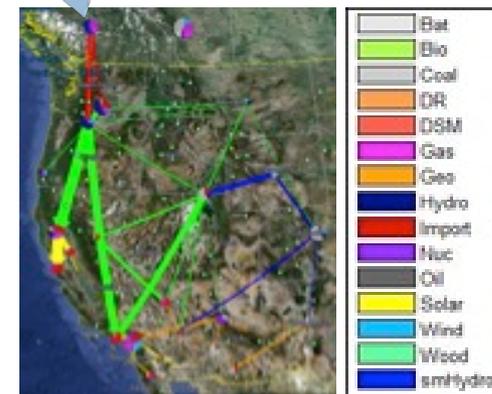
Renewable Energy Forecasting for CEC

End-to-end analysis of DER resource-technology-value chain has been demonstrated at LLNL

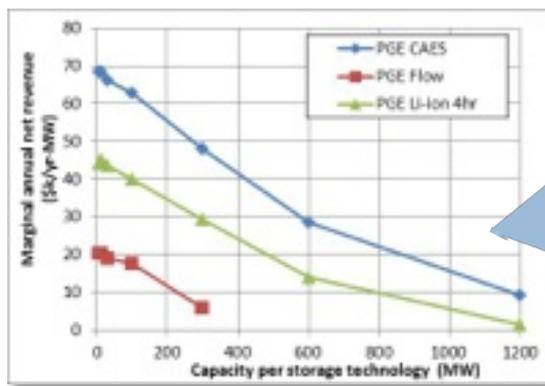
Nested weather simulations drive electricity demand and production



Production and demand simulations drive generation and transmission

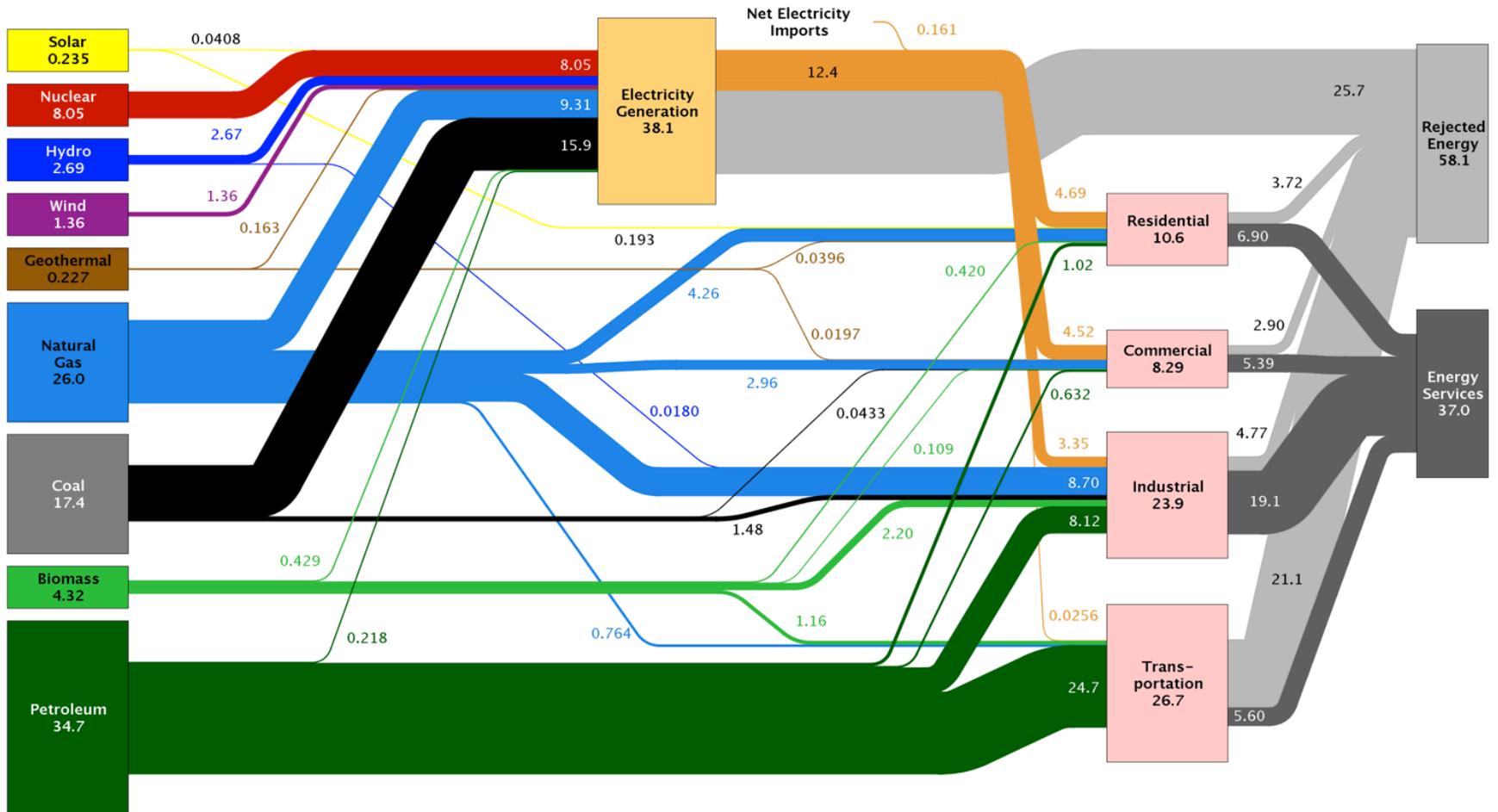


Time- and space-dependent market models drive technology valuation



Systems Thinking drives the QER process

Estimated U.S. Energy Use in 2012: ~95.1 Quads

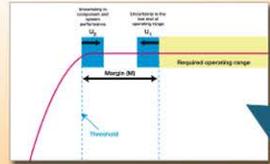


Source: LLNL 2013. Data is based on DOE/EIA-0035(2013-05), May, 2013. If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant "heat rate." The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 65% for the residential and commercial sectors 80% for the industrial sector, and 21% for the transportation sector. Totals may not equal sum of components due to independent rounding. LLNL-MI-410527

Stockpile stewardship is the ultimate application of systems engineering

Mission Impact
Program Solution

Uncertainty Quantification (UQ)



Nuclear Stockpile
High Confidence
Safe & Secure

Design Code Performance Efficiency
Algorithm/code improvements

21st Century Surveillance
Sensors, Design, micro-fab, ...

Integrated Program and ST&E Plan

New Computational Science
Efficient use of Peta- and exa-scale platforms

High risk-high payoff science

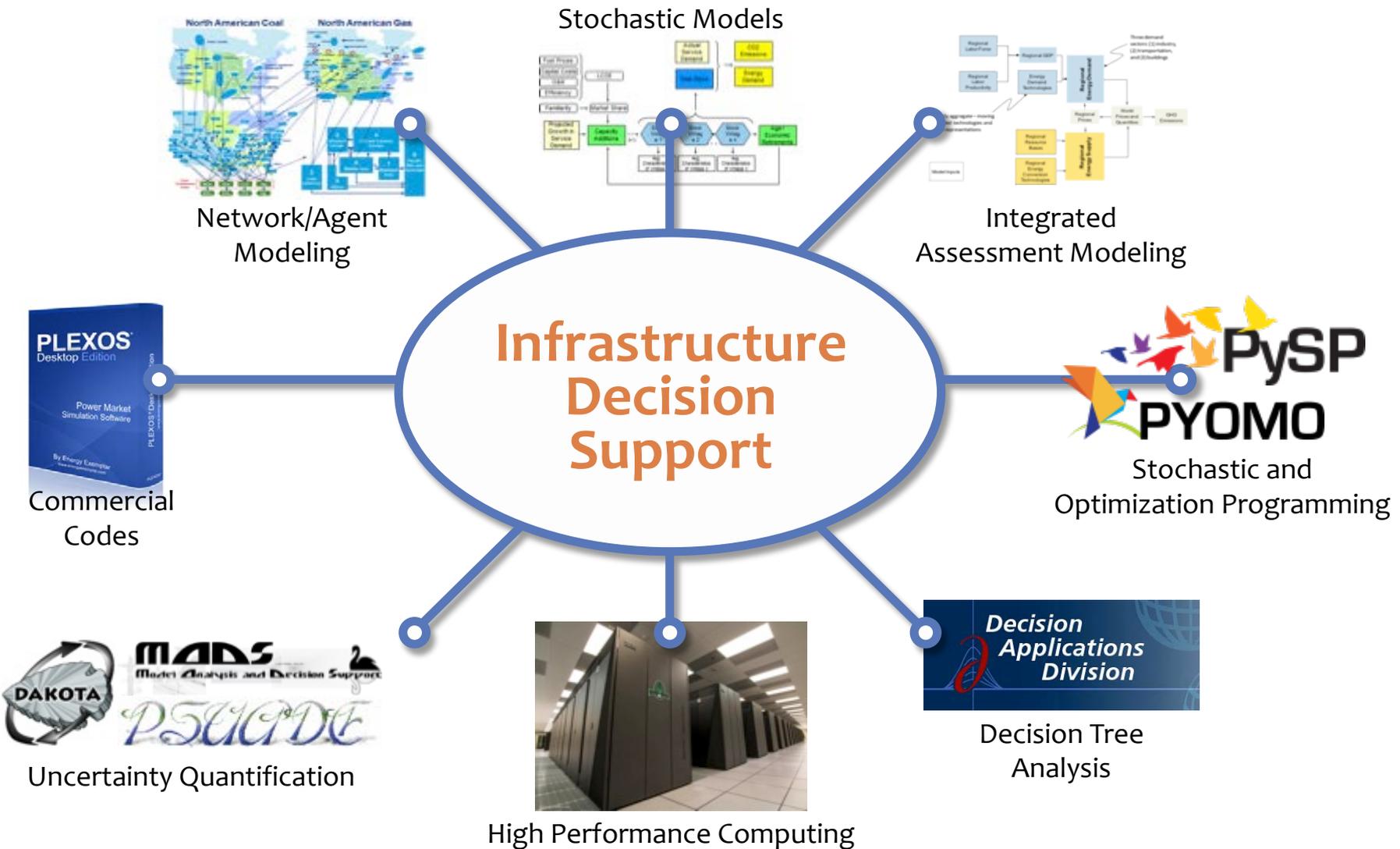
Diagnostics, Materials, HED, Computing, ...

Sensors, Design, micro-fab, ...



ST&E Discoveries
ST&E Discipline Health

The Labs can provide risk- and uncertainty-quantified decision support to Energy Policy & Systems Analysis



We have already identified and reached out to potential academic collaborators



Discussions with these and other institutions are ongoing

The Labs' capabilities are marshaled to support the QER's multi-agency strategy



