Climate Change, Energy and the Adaptation Challenge

Benjamin L. Preston
Senior Research and Development Staff
Environmental Sciences Division
Oak Ridge National Laboratory

U.S. DEPARTMENT OF ENERGY

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Outline

- What is adaptation?
- Dimensions of adaptation
  - What are we adapting to?
  - Who adapts?
  - How do we adapt?
  - What do we want to achieve?
- Opportunities and Barriers
- The Road Ahead. . .

Adaptation means different things to different audiences

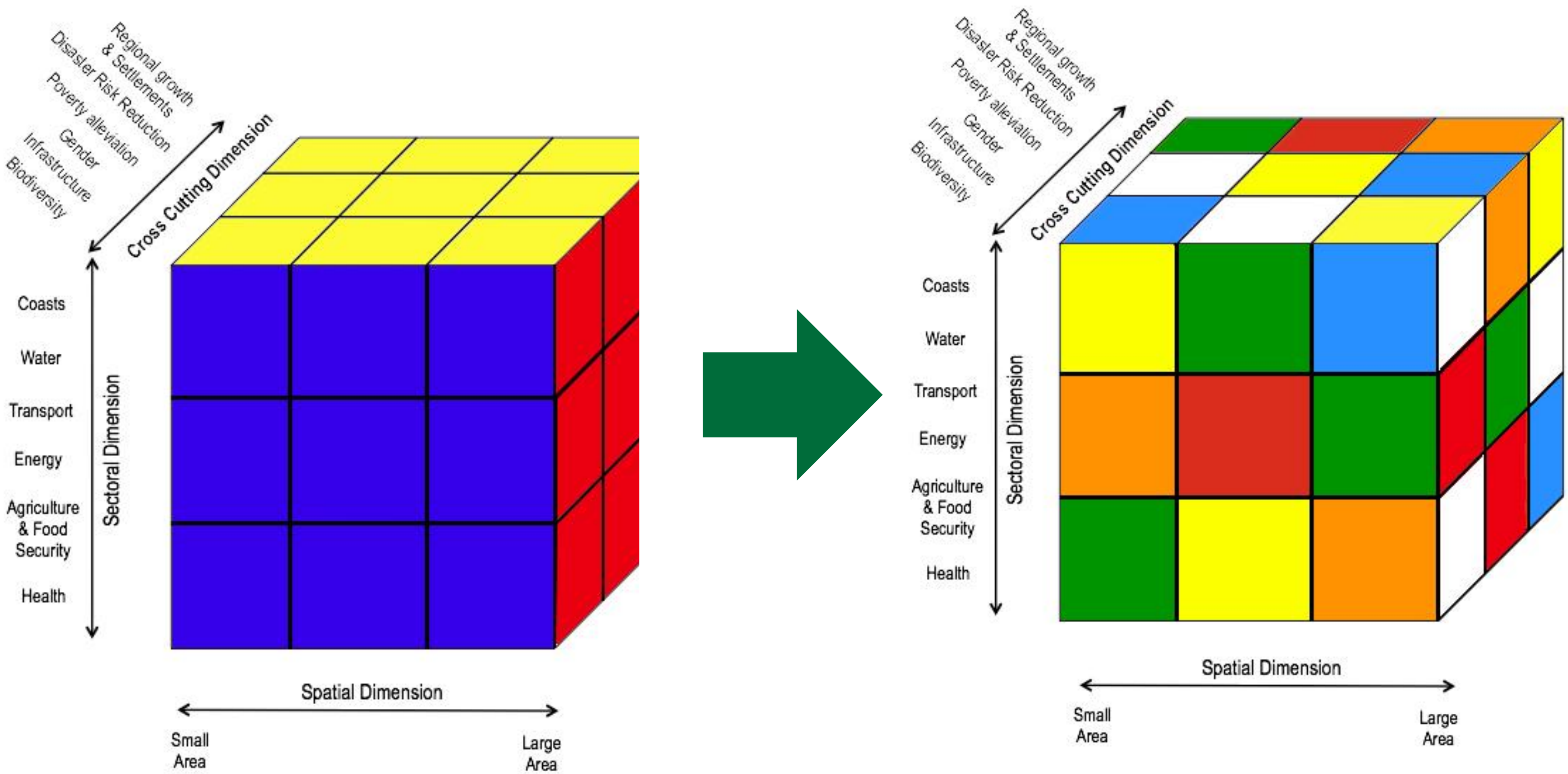
"Adjustment in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts."

IPCC (2001)

"a process whereby institutional actors first abandon their traditional assumptions and behaviours and subsequently adopt a new set that is better-suited to the new circumstances."

Preston et al. (2009), based on Parkes (1971)

Adaptation processes have multiple dimensions

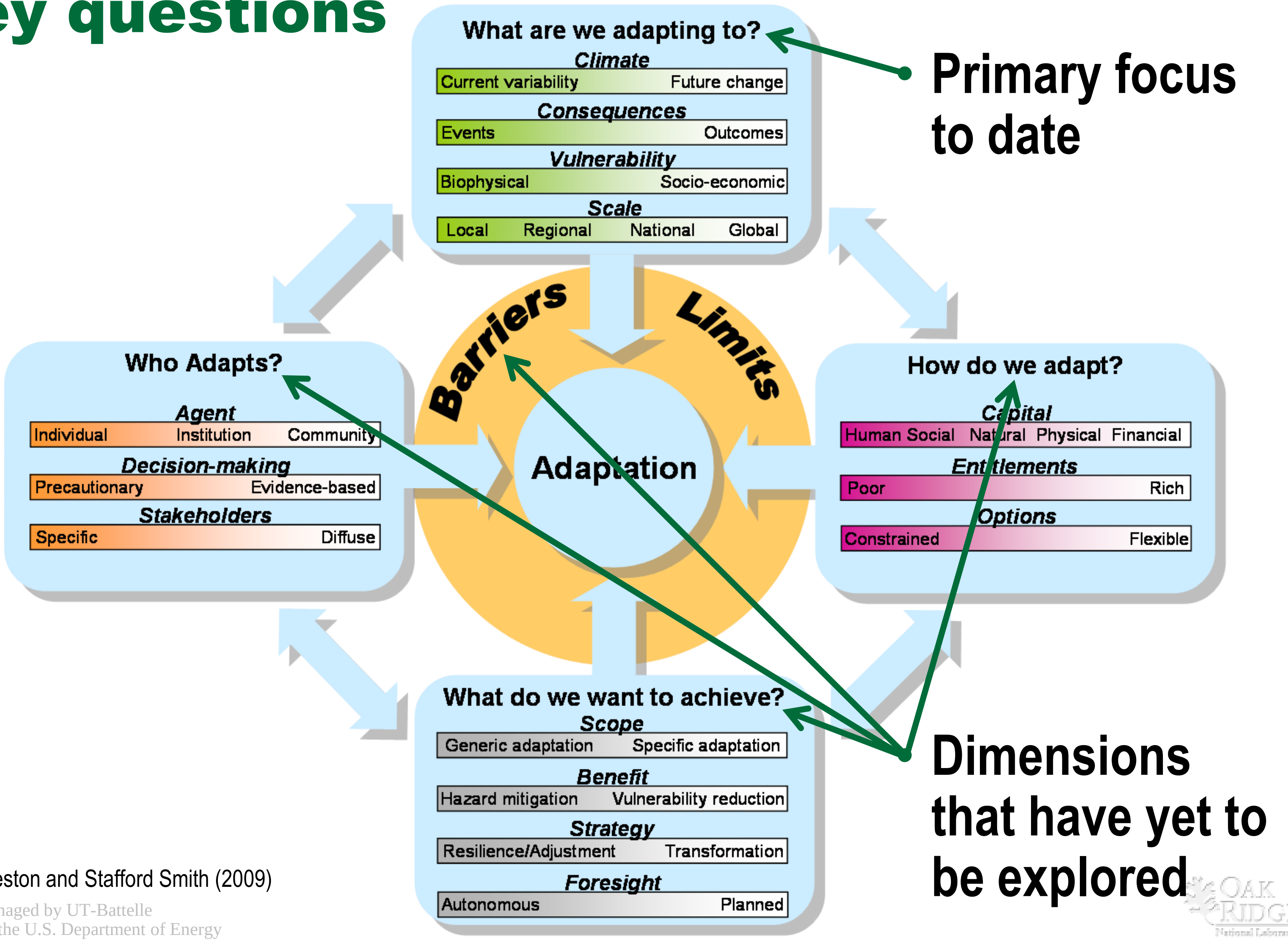


- **The “Adaptation Cube”** **(courtesy Rob Kay)**

Energy systems lend themselves well to illustrating the challenges of adaptation

- **Complexity**
  - Massive infrastructure and investment
  - Extensive linkages across space and time
  - Elaborate governance network and regulatory regimes
- **Integration**
  - Portfolio of energy technologies and transmission systems
  - Diverse end uses
  - Linkages between energy systems and environmental systems
  - Integration between greenhouse gas mitigation and adaptation
- **Criticality**
  - Fundamental to other societal systems and services

Adaptation can be framed around four key questions

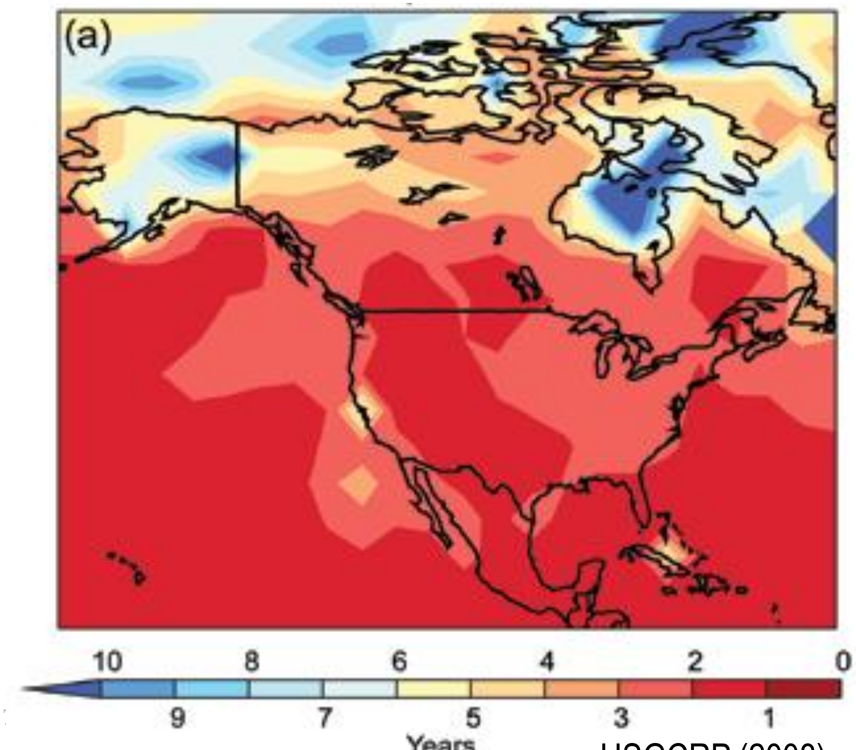


Preston and Stafford Smith (2009)

What are we adapting to?

- **Climate change**
  - Extreme weather events
  - Reduced reliability of natural resources

2090-2099 return period for a current 1 in 20 year heat event



USGCRP (2008)

Energy Impact Supplies		Climate Impact Mechanisms
Fossil Fuels (86%)	Coal (22%)	Cooling water quantity and quality (T), cooling efficiency (T,W, H), erosion in surface mining
	Natural Gas (23%)	Cooling water quantity and quality (T), cooling efficiency (T,W, H), disruptions of off-shore extraction (E)
	Petroleum (40%)	Cooling water quantity and quality, cooling efficiency (T,W, H), disruptions of off-shore extraction and transport (E)
	Liquified Natural Gas (1%)	Disruptions of import operations (E)
Nuclear (8%)		Cooling water quantity and quality (T), cooling efficiency (T,W, H)
Renewables (6%)	Hydropower	Water availability and quality, temperature-related stresses, operational modification from extreme weather (floods/droughts), (T, E)
	Biomass	
	• Wood and forest products	Possible short-term impacts from timber kills or long-term impacts from timber kills and changes in tree growth rates (T, P, H, E, carbon dioxide levels)
	• Waste (municipal solid waste, landfill gas, etc.)	n/a
	• Agricultural resources (including derived biofuels)	Changes in food crop residue and dedicated energy crop growth rates (T, P, E, H, carbon dioxide levels)
	Wind	Wind resource changes (intensity and duration), damage from extreme weather
	Solar	Insolation changes (clouds), damage from extreme weather
	Geothermal	Cooling efficiency for air-cooled geothermal (T)
(Source: EIA, 2004)		

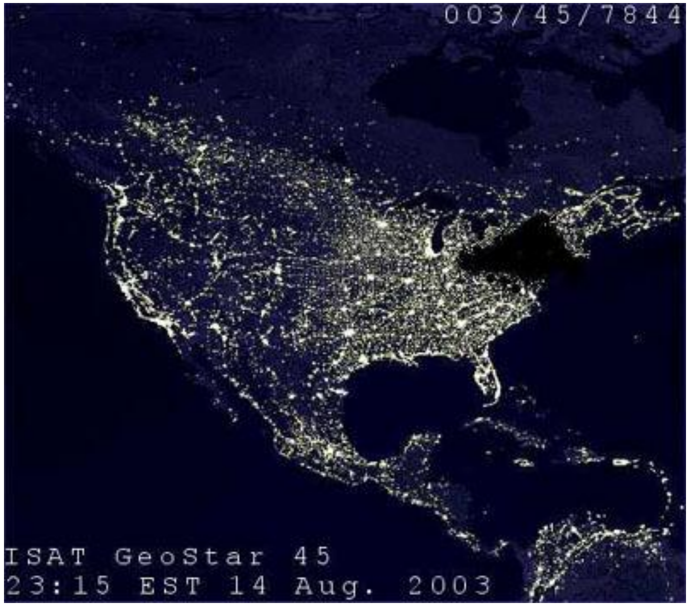
USGCRP (2007)

Climatic extremes frequently reveal the vulnerability of the U.S. energy system

Drought and Cooling Water for Power Plants (NETL, 2009)	Hurricanes and Oil and Gas Infrastructure (EIA, 2005)	Severe Weather and Black Outs (CEIDS, 2001)
• Drought conditions in the Southeast and Midwest in 2006 -2007 forced shutdowns and/or reductions in generation • TVA forced to purchase electricity above costs of production • Costs passed on to consumers	• In 2005, Hurricanes Katrina and Rita damaged oil and gas infrastructure in the Gulf of Mexico (GOM) • GOM oil and gas production was reduced by one-quarter to one-third for several months • Fuel prices were pushed higher	• Heatwaves, lightning strikes, downed trees, and ice storms are frequent contributing factors in U.S. power outages • Outages cause $104-164 billion in economic losses to U.S. businesses each year

We need energy systems that are more robust

Energy systems impacts cascade through other sectors and society



August 14, 2003

First Order

- Impacts on energy infrastructure
- Impacts on energy production
- Impacts on energy transmission
- Impacts on energy demand

Second Order

- Impacts on energy-dependent services and industries

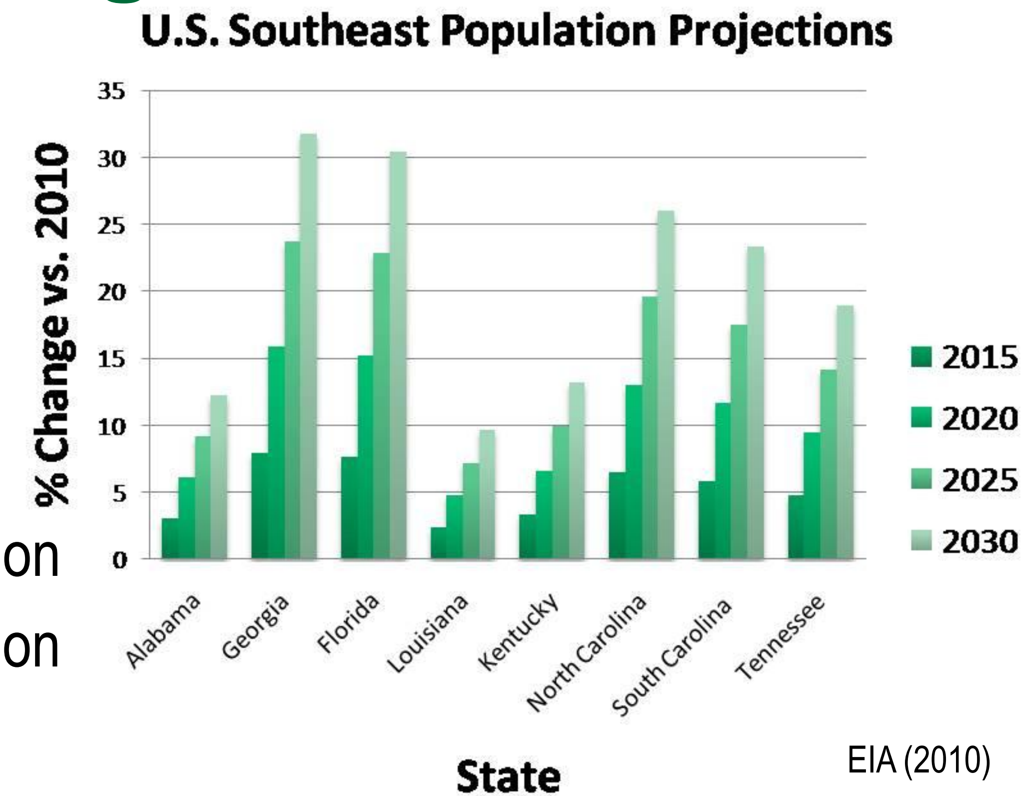
Third Order

- Loss of revenue
- Public health and safety
- Reduced resilience to other threats
- Changes in energy planning, investment, and R&D

Networked energy systems are associated with 'teleconnections' over space and time

What are we adapting to?

- **Climate change**
  – Extreme weather events
  – Reduced reliability of natural resources?
- **Societal change**
  – Population growth, urbanization
  – Increasing wealth, consumption



EIA (2010)

What are we adapting to?

- **Climate change**
  - Extreme weather events
  - Reduced reliability of natural resources?
- **Societal change**
  - Population growth, urbanization
  - Increasing wealth, consumption
- **Technological change**
  - Increasing energy efficiency
  - Deployment of new technologies
- **Policy change**
  - Climate change in NEPA
  - Cap-and-trade

Figure 59. U.S. electricity demand growth, 1950-2035 (percent, 3-year moving average)

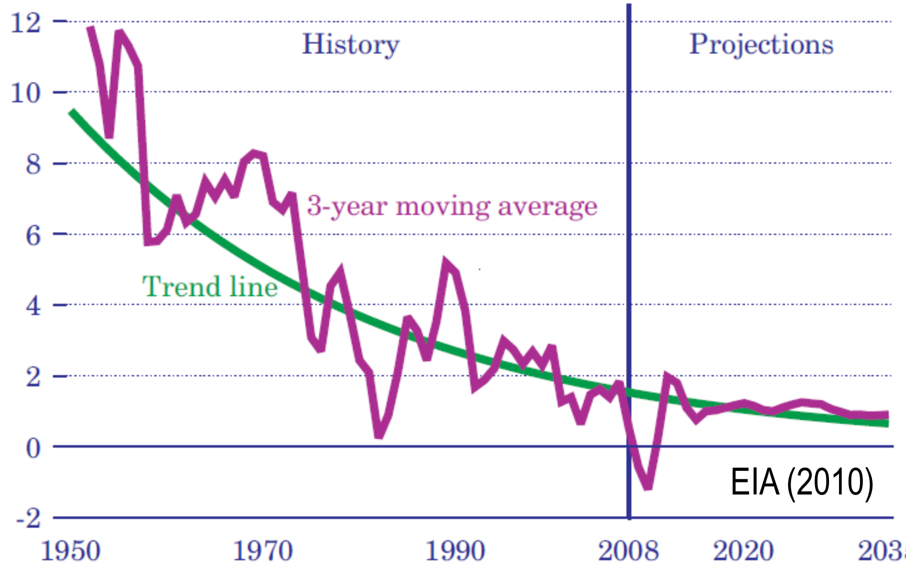
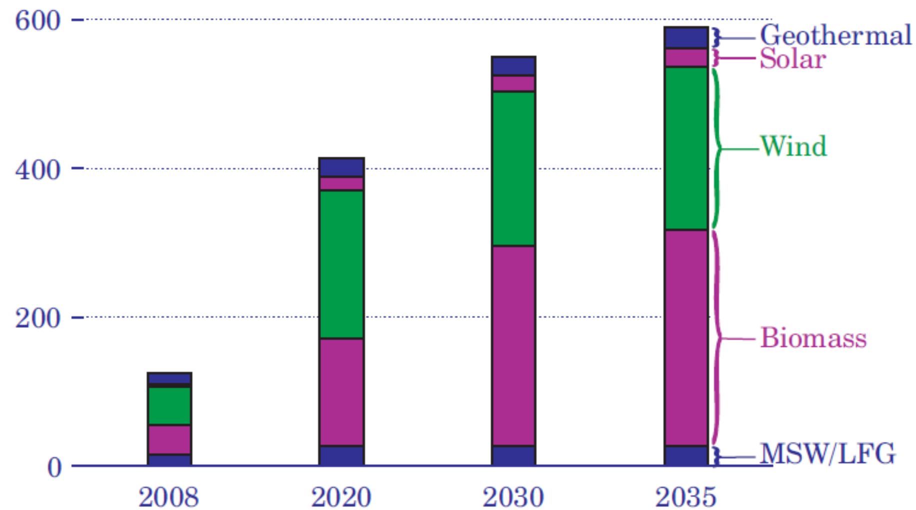


Figure 65. Nonhydroelectric renewable electricity generation by energy source, 2008-2035 (billion kilowatthours)



Key vulnerability of energy systems relates to disparities in scale

- **The scale of energy systems creates many vulnerabilities and high adaptation costs**
- **Investments in new technology are small relative to value of existing infrastructure**
- **Suitability of different technologies is not homogenous over space and time**

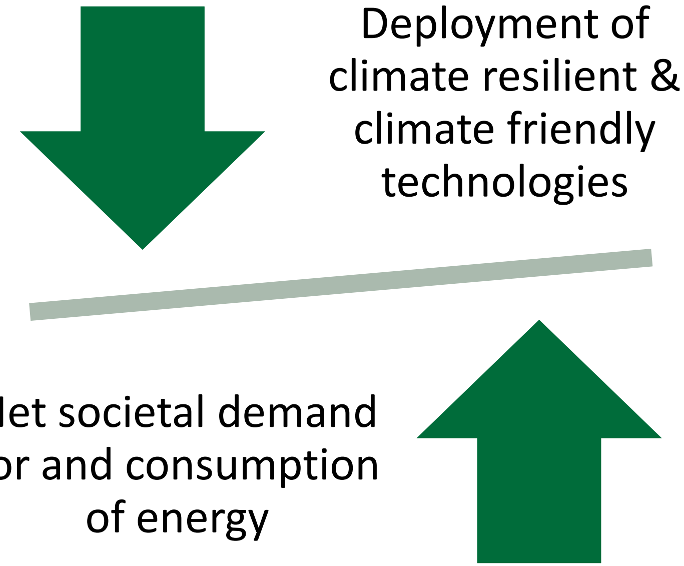


Figure 39. Energy use per capita and per dollar of gross domestic product, 1980-2035 (index, 1980 = 1)

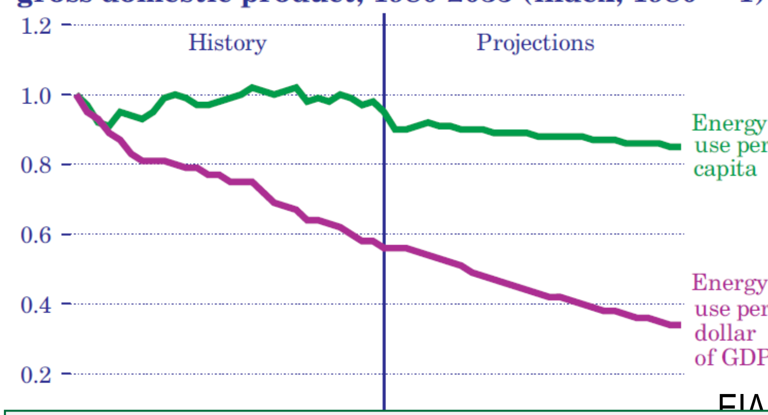
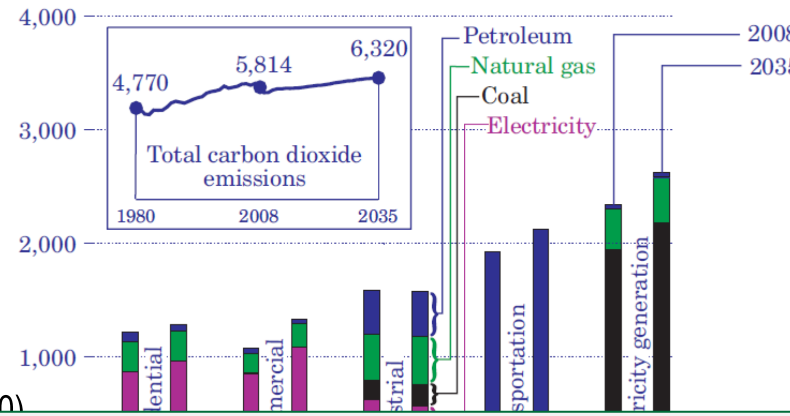


Figure 93. Carbon dioxide emissions by sector and fuel, 2008 and 2035 (million metric tons)

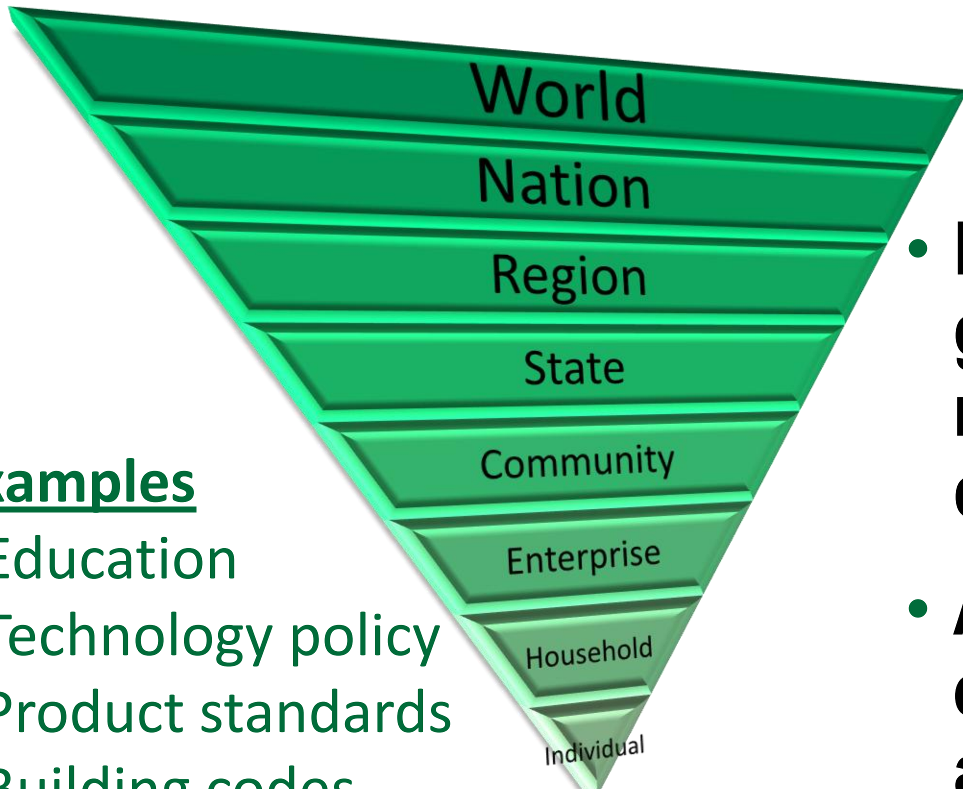


EIA (2010)

To what extent will climate change enable or constrain progress toward a resilient, low-carbon energy future?

Who adapts?

- **Adaptation will be undertaken by different actors at a range of geopolitical scales**
  - Reactive – Responding to past vulnerabilities
  - Anticipatory – Responding to future vulnerabilities



Examples

- Education
- Technology policy
- Product standards
- Building codes

- **Little attention has been given to how responsibilities will be distributed or coordinated**
- **Actions taken at one-scale enable or constrain actions at other scales**

How Do We Adapt?

- **Successful adaptation is dependent upon three core components:**
  1) Viable adaptation options
     - Cost-effective solutions
     - Robust to uncertainty
     - Avoid additional externalities
  2) Sufficient capital for their implementation
     - Financial, physical, natural, social, human
  3) Entitlement of actors to such capital
     - Access to information on climate change and energy impacts
     - Harmonized institutional arrangements and governance networks
     - Establishment of appropriate financial incentives/disincentives

Photo: American Wind Energy Association

Adaptation is a process of enhancing these three areas

What do we want to achieve?

- **What does it mean for a system to be well-adapted to climate change?**
  - Adaptation priorities for the energy sector are poorly defined
  - Few criteria for success (but failure is easy to recognize)

Sector	Incremental Change	Transformational Change
Buildings	• Adjust thermostat	• Install solar photovoltaic array
Transport	• Increase fuel efficiency standard	• Expand public transport systems • Expand biofuel production
Electricity Generation	• Fuel switching (e.g., coal to natural gas)	• Carbon capture and storage • Solar, wind, geothermal
Electricity Transmission	• Smartgrids	• Distributed energy

Adaptation Opportunities and Barriers

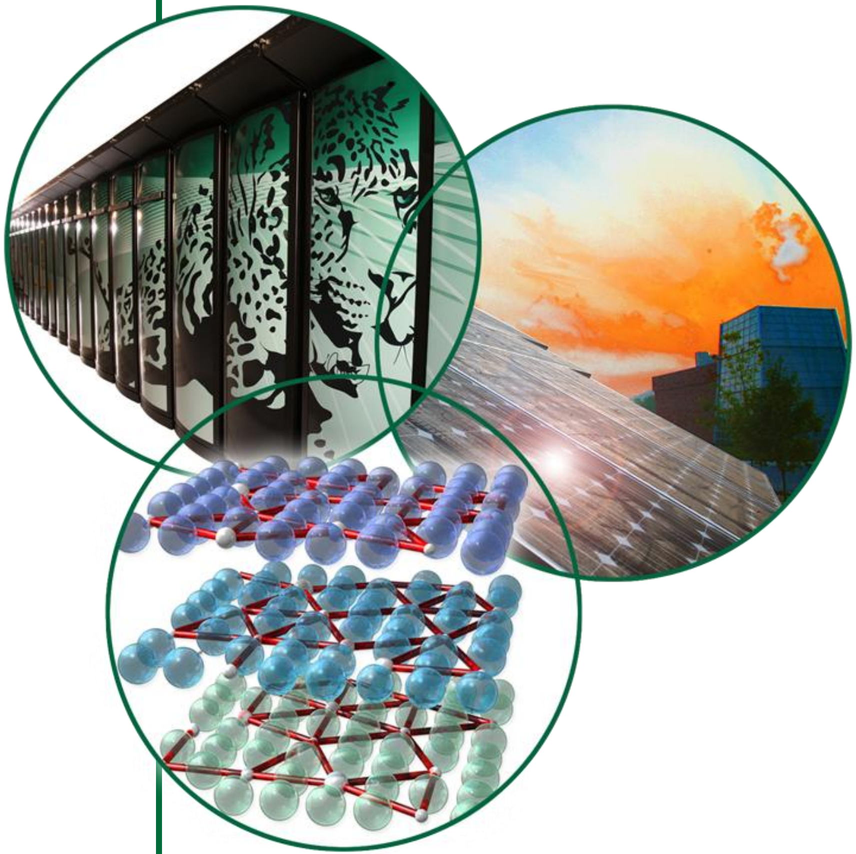
Opportunities	Barriers
Proliferation of real-time monitoring systems are enhancing understanding of system performance, vulnerabilities, and optimal management strategies	**Paucity of high-confidence predictions** of climate change and natural resource availability at local scales
Diversification of energy technologies is enabling tailored deployment based upon end uses and resource availability	**Limited quantitative understanding of energy system sensitivity** including demand, production and distribution to climate variability and change
Advances in design (buildings, appliances, vehicles, urban form) will continue to reduce per capita energy use and energy intensity	**Limited understanding of the portfolio of adaptation options** and their costs and benefits
Turnover of existing capital stocks and technologies will provide windows of opportunity to improve efficiency and resilience	**Limited understanding of the teleconnections** among energy impacts and/or adaptation options
Climate change and technology policy will continue to drive investment in energy system R&D and deployment	**Limited understanding of the potential synergies or trade-offs** between mitigation and adaptation

The Road Ahead. . .

- Adaptation is taking on renewed importance in climate change science and policy
- Deliberate adaptation planning is emerging among a range of geopolitical scales, sectors and institutions
- The U.S. is moving toward a national adaptation strategy
- Such efforts will fuel demand for climate services, impact analysis, and climate risk management
- Ultimately, the goal is to see consideration for climate change impacts routinely embedded within decision-making

Thank You

Benjamin L. Preston
Senior Research and Development Staff
Environmental Sciences Division
Oak Ridge National Laboratory
prestonbl@ornl.gov



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