RD&D Needs for Energy System Climate Preparedness and Resilience

Opening Remarks

Dr. Robert C. Marlay
Director, Office of Climate Change Policy and Technology
Office of International Affairs
U.S. Department of Energy
robert.marlay@hq.doe.gov

13-14 November 2013
Experts Group on R&D Priority Setting and Evaluation
International Energy Agency
Utrecht, The Netherlands

Overview

I. The Changing Climate

II. Energy Technologies Vulnerable to Changes

III. Examples of Remedial Strategies

IV. Workshop Objectives and Desired Outcomes

I. The Changing Climate

- **Key Indicators for Science and Research**
  - **Air Temperature Rise**
  - **Sea Level Rise**
  - **Changing Patterns of Precipitation & Water Availability**
  - **Frequency & Magnitude of Extreme Events**
    - **For Example: Hurricanes & Wildfires**

IPCC AR5 Update to Radiative Forcing

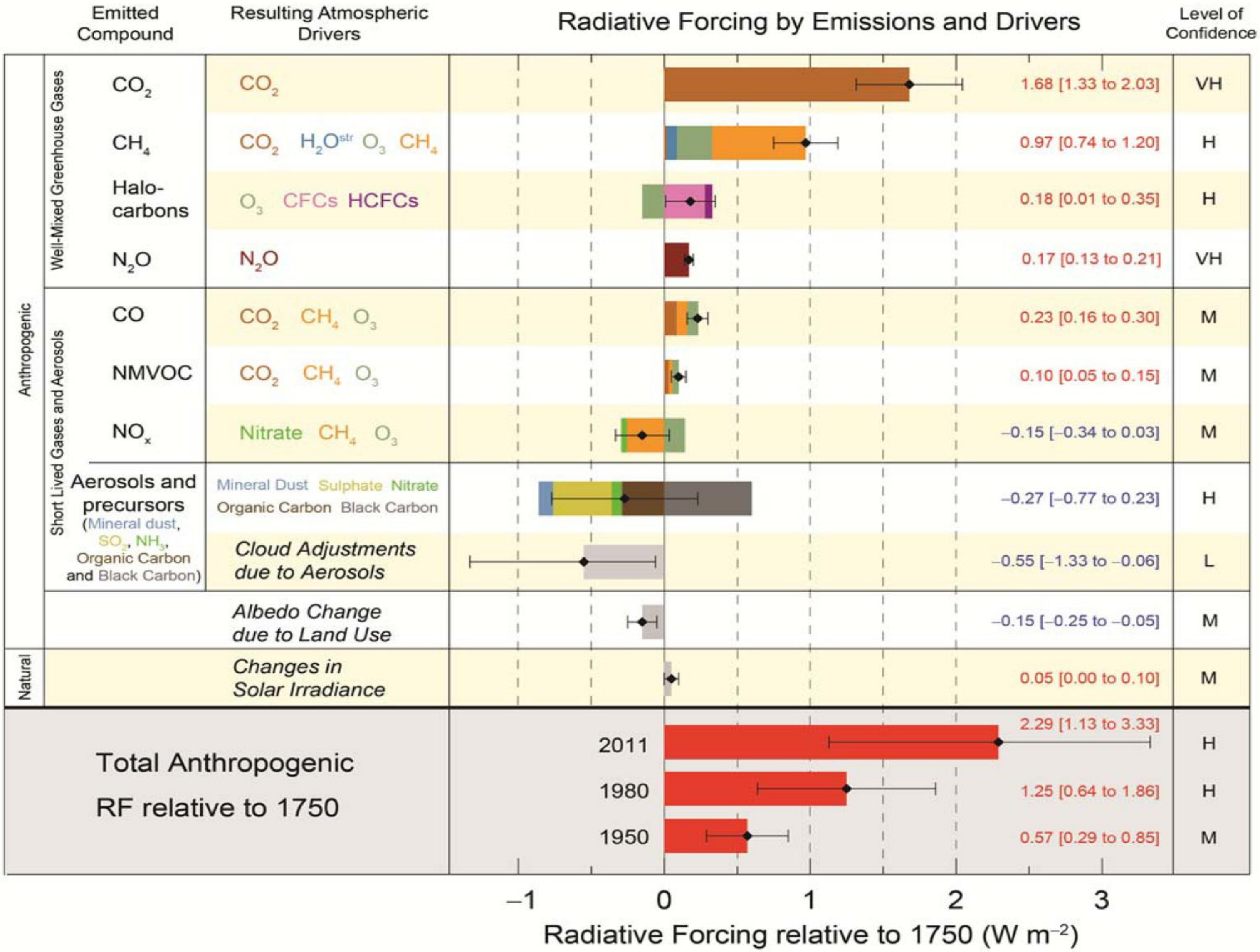
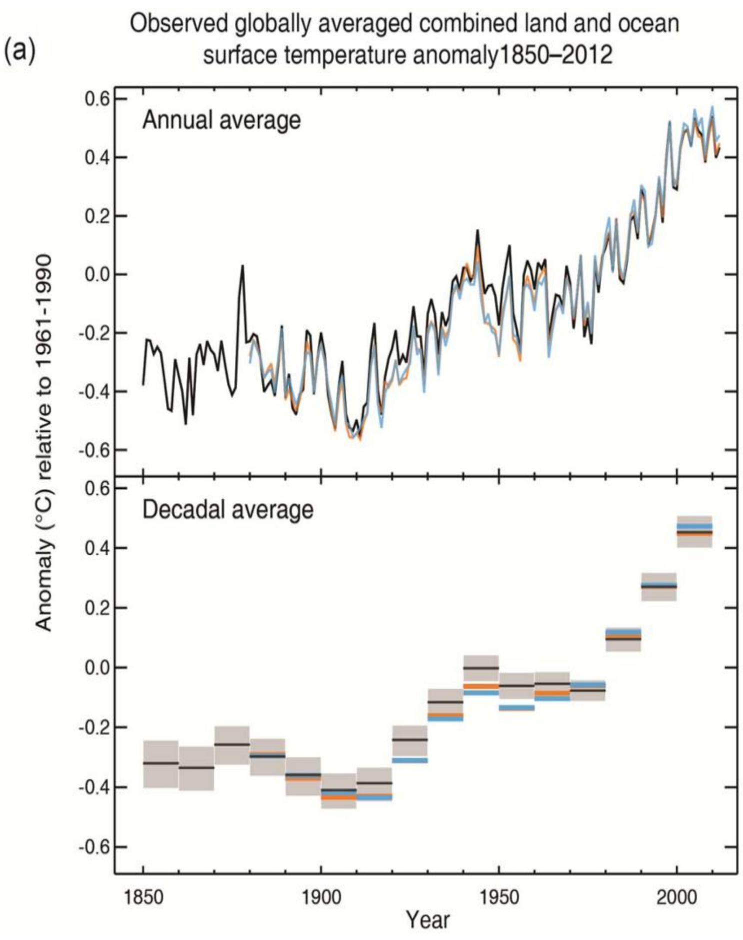


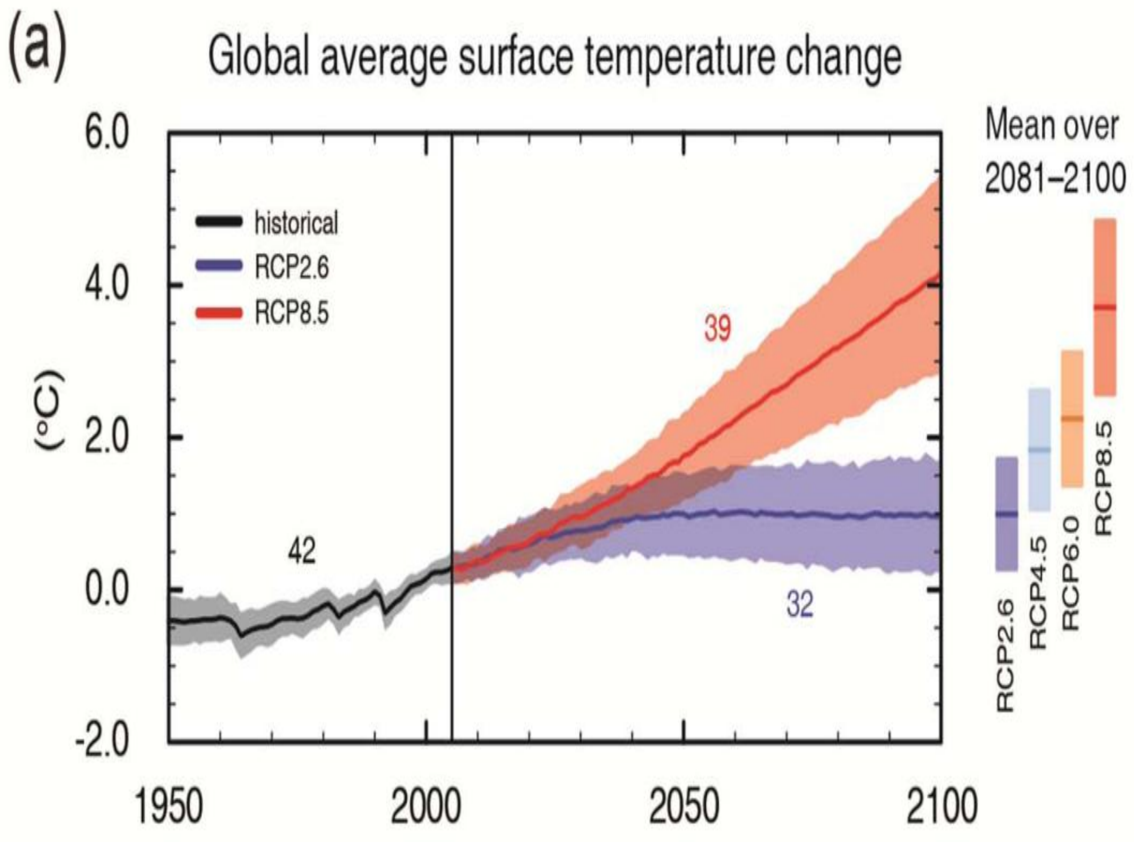
Fig. SPM.5

IPCC AR5 WG1, Summary for Policy Makers, Approved 27Sep. 2013

Air Temperature Rise
-- Past & Projected

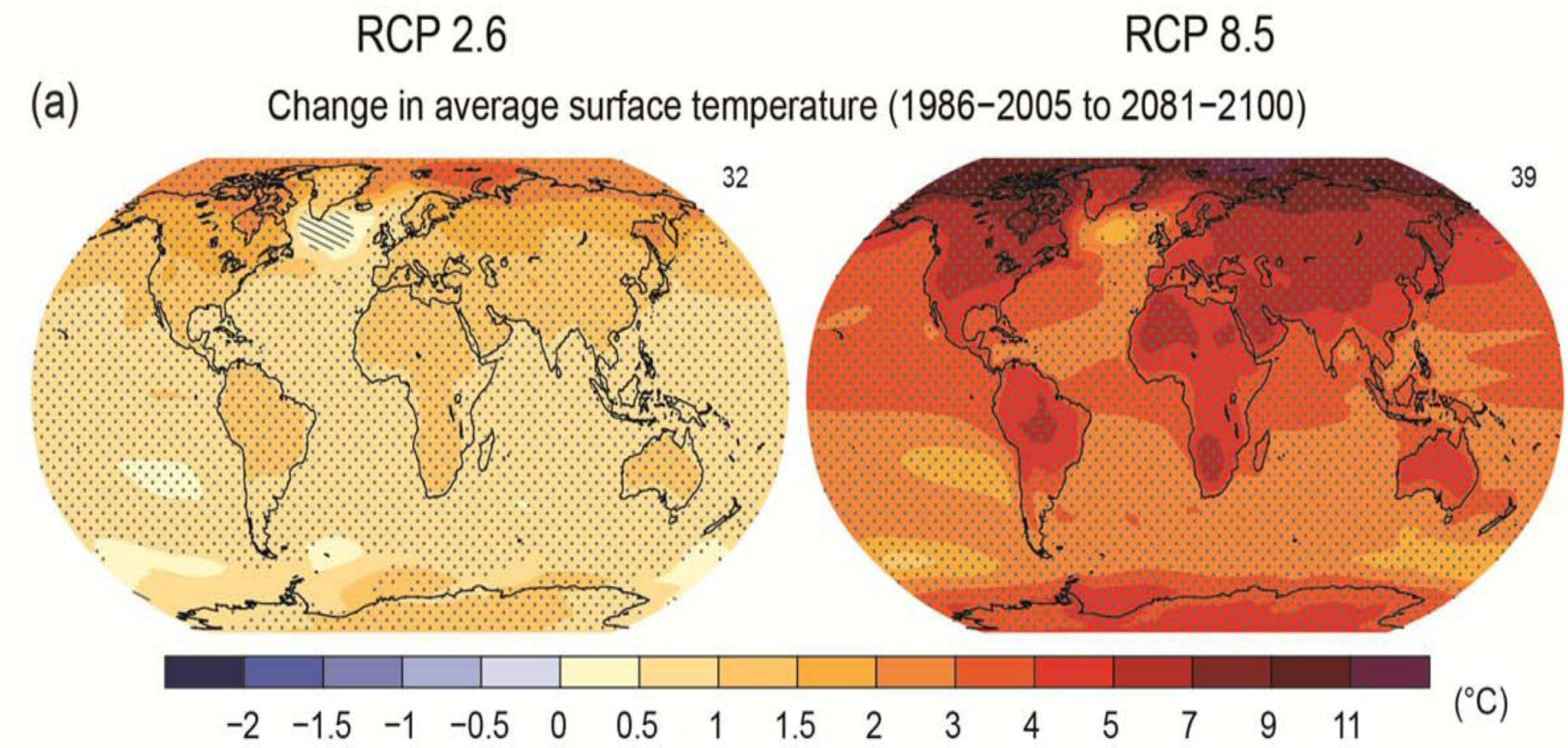


IPCC AR5 WG1, Summary for Policy Makers, Approved 27Sep2013, Fig SPM.1(a)



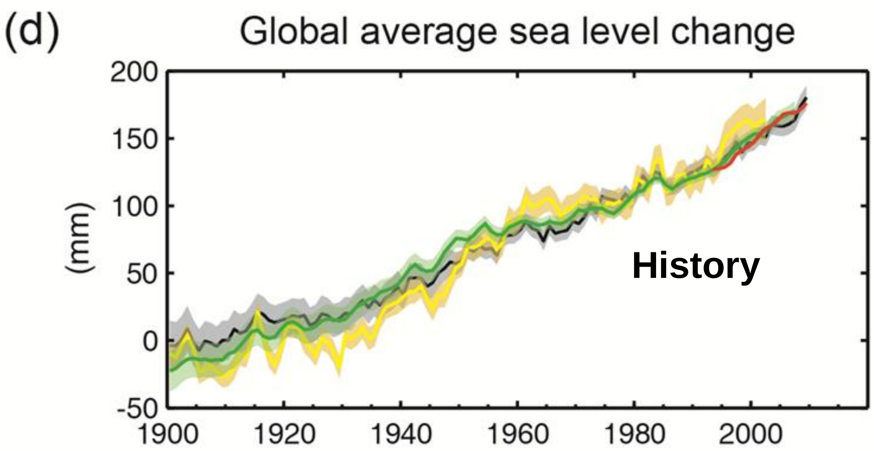
IPCC AR5 WG1, Summary for Policy Makers, Approved 27Sep2013, Fig SPM.7(a)
(change in global annual mean surface temperature relative to 1986 - 2005)

Surface Air Temperature Rise
-- Two Scenarios

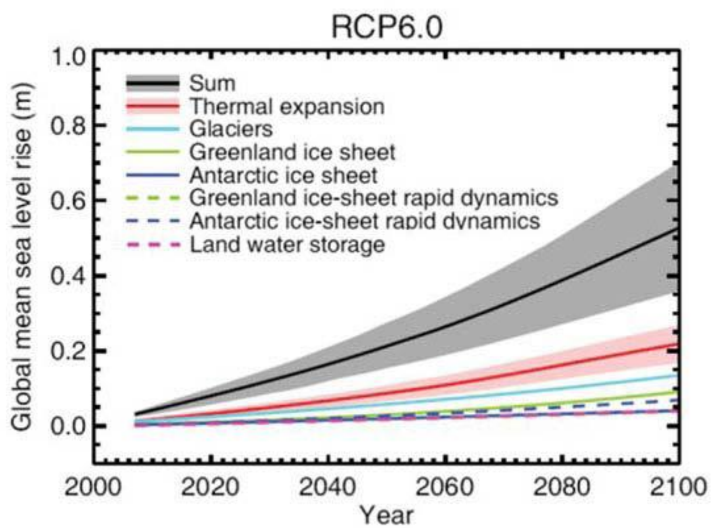


IPCC AR5 WG1, Summary for Policy Makers , Approved 27Sep2013, Figure SPM.8(a)
Maps of CMIP5 multi-model mean results for the scenarios RCP2.6 and RCP8.5.
RCP - Representative Concentration Pathway (at selected radiative forcing in 2100, W/m^2)

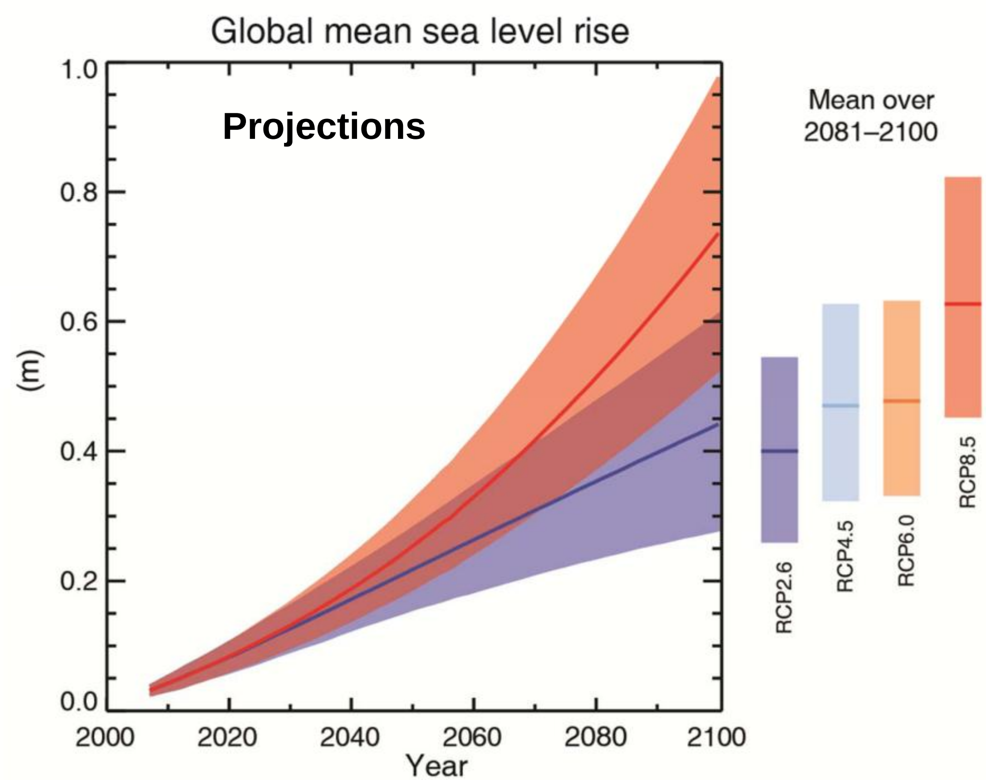
Sea Level Rise
-- Past and Projected



IPCC AR5 WG1, Summary for Policy Makers, Approved 27Sep2013, Fig SPM(3d)

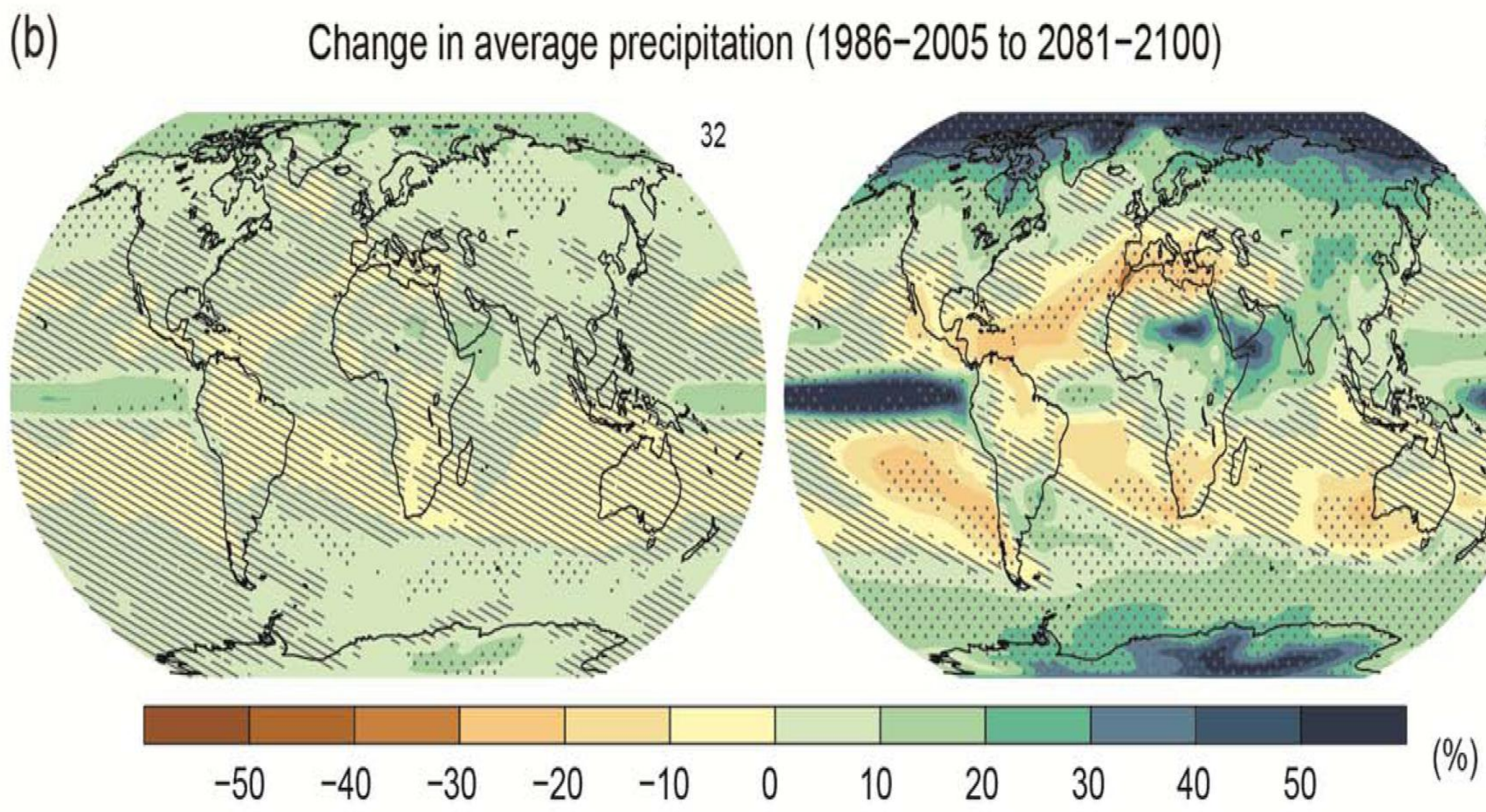


Hausfather, Yale, "IPCC's New Estimates for Increased Sea-Level Rise," Yale, Oct 2013



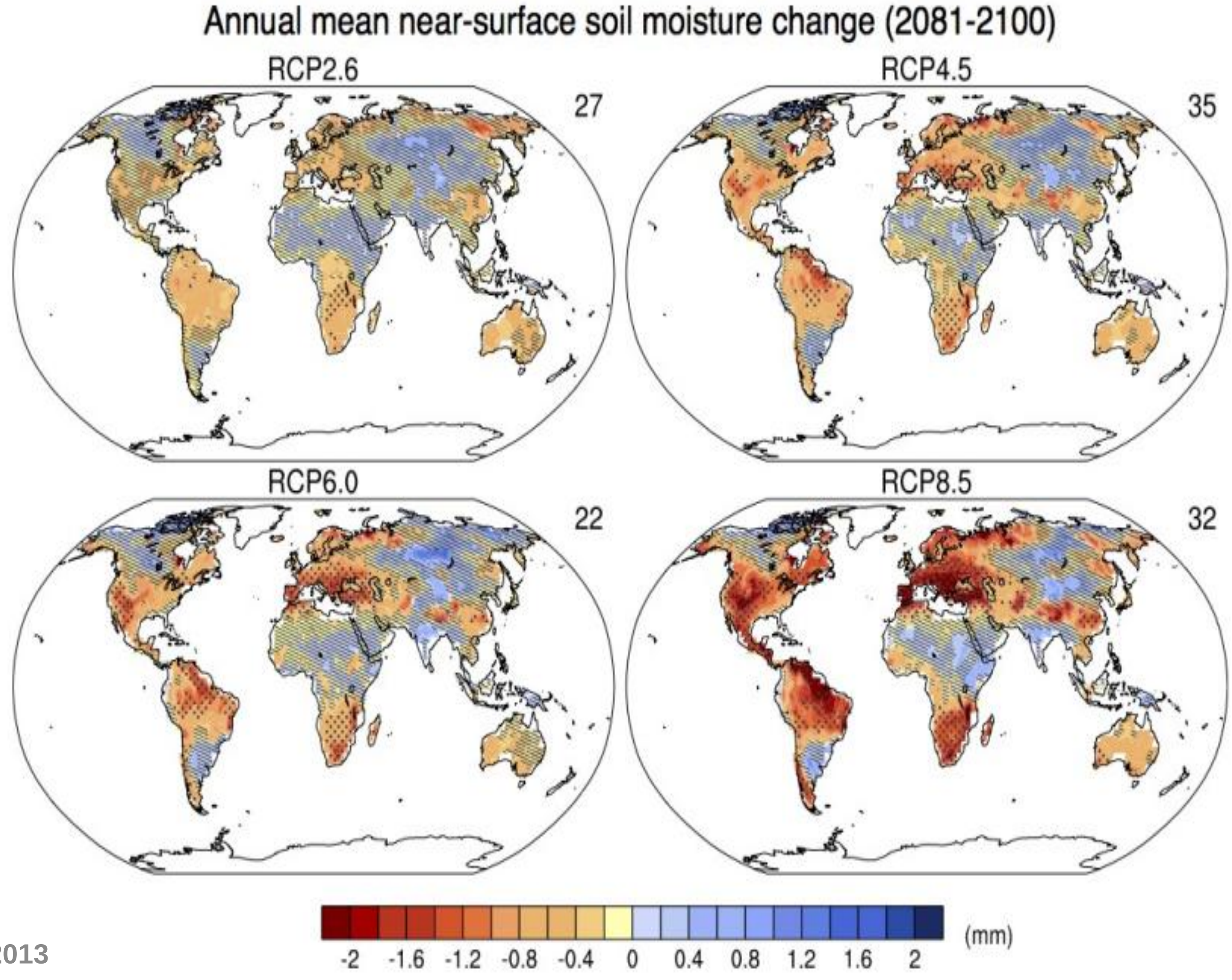
IPCC AR5 WG1, Summary for Policy Makers, Approved 27Sep2013, Fig SPM.9)

Changing Patterns of Precipitation -- Past and Projected



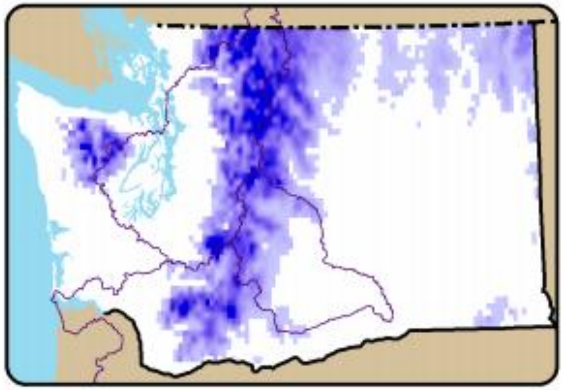
IPCC AR5 WG1, Summary for Policy Makers , Approved 27Sep2013, Fig PM.8(b)
Maps of CMIP5 multi-model mean results for the scenarios RCP2.6 and RCP8.5.

Projected Annual Change in Mean Soil Moisture – 4 Scenarios

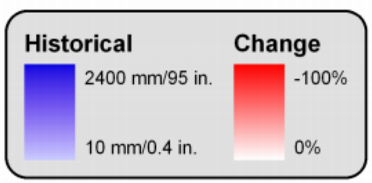


Availability of Water from Snowpack Washington State, U.S. Northwest

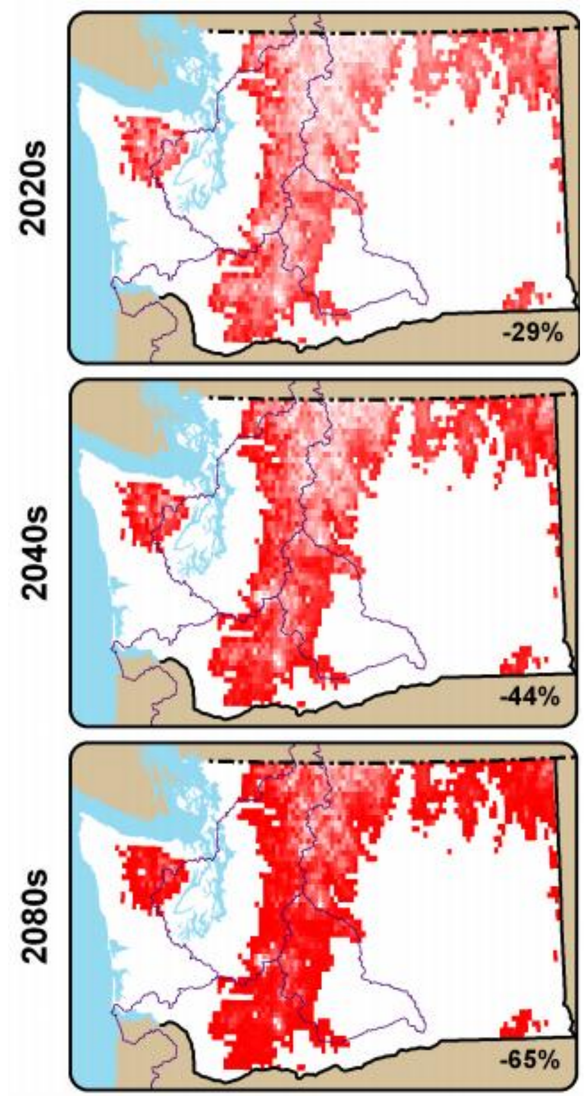
Historical SWE average



April 1 Snow-Water Equivalent



Projected SWE (A1B scenario)



-29%

-44%

-65%

Reduced SWE caused by:

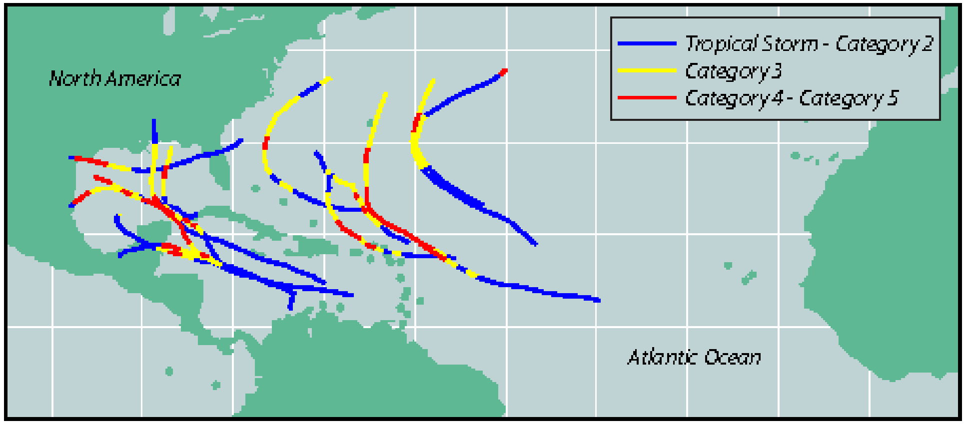
-Greater proportion of precipitation falling as rain rather than snow

- Warmer spring temperatures causing earlier runoff

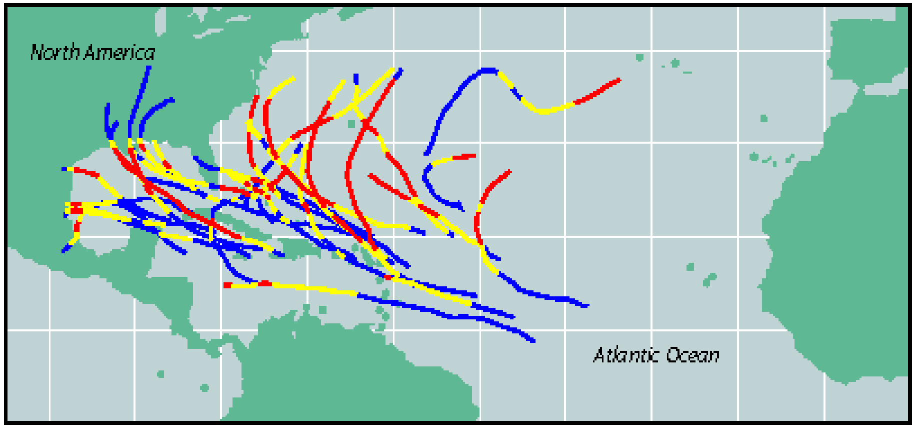
Source: Elsner et. al (2010)

Projected Increase in Number of Cat. 4 & 5 Atlantic Hurricanes – Two 20-Year Periods

Current climate conditions (modeled)

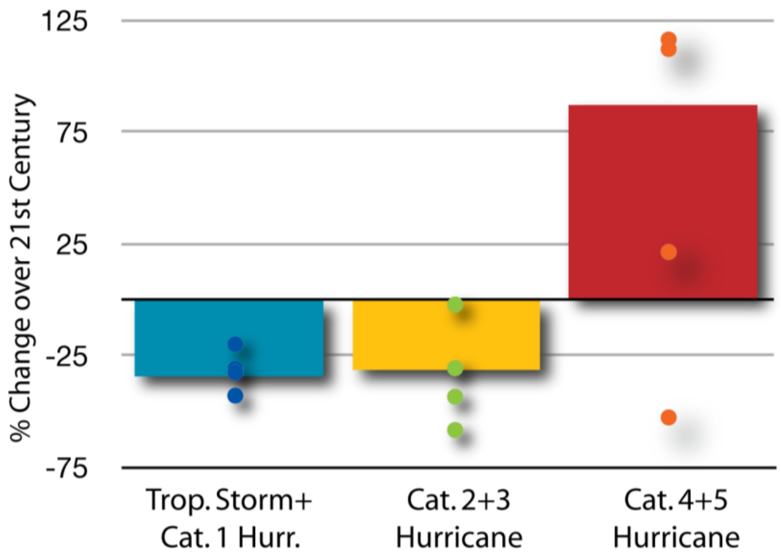


Projected conditions



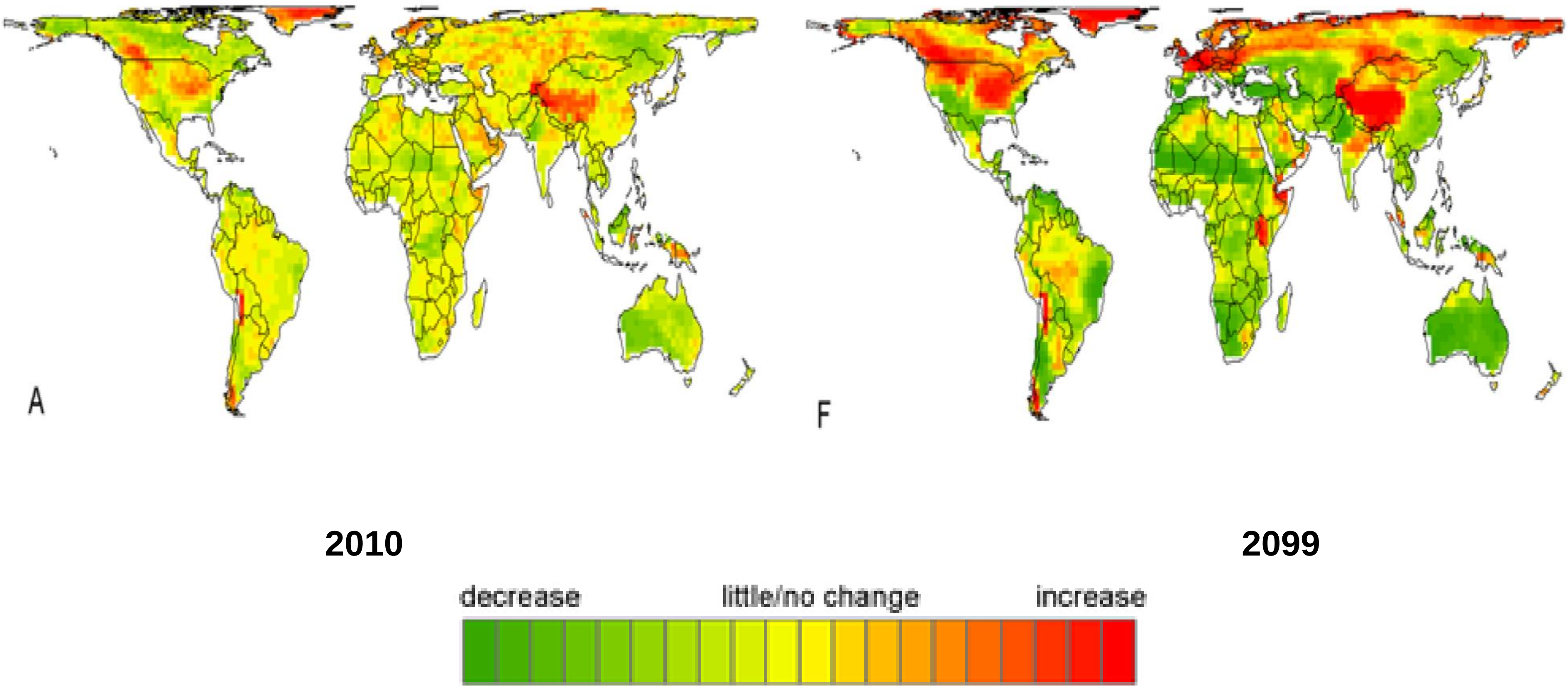
Projected Changes for 2081-2100 compared to 2001-2020

Source: Bender et. al; Modeled Impact of Anthropogenic Warming on the Frequency of Intense Atlantic Hurricanes, Science; 22 Jan. 2010



Projected Changes in Wildfire Distribution

Projected Change in Wildfires for 2010 to 2099

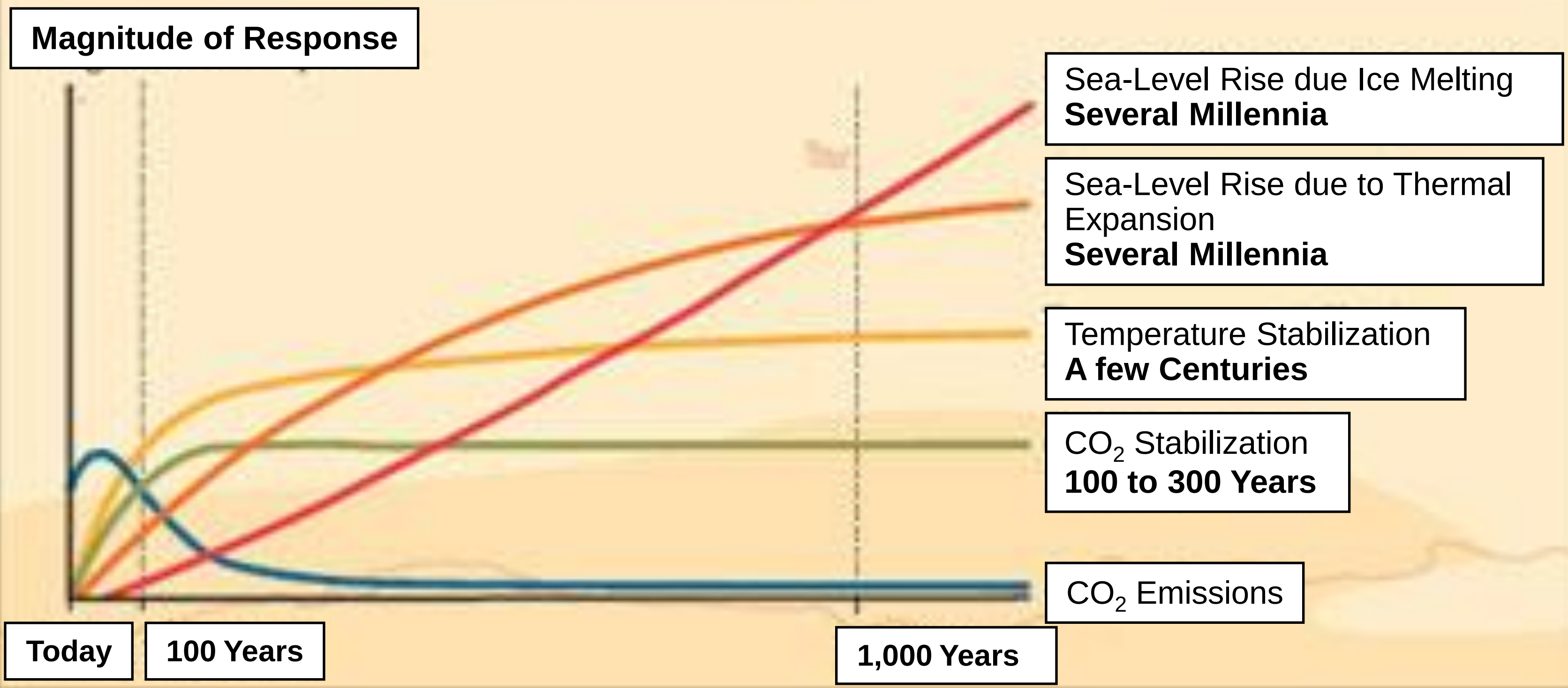


Krawchuk MA, et al, (2009) “Global Pyrogeography: the Current and Future Distribution of Wildfire.“ PLoSONE 4(4): e5102. doi:10.1371/journal.pone.0005102

Time to Equilibrium

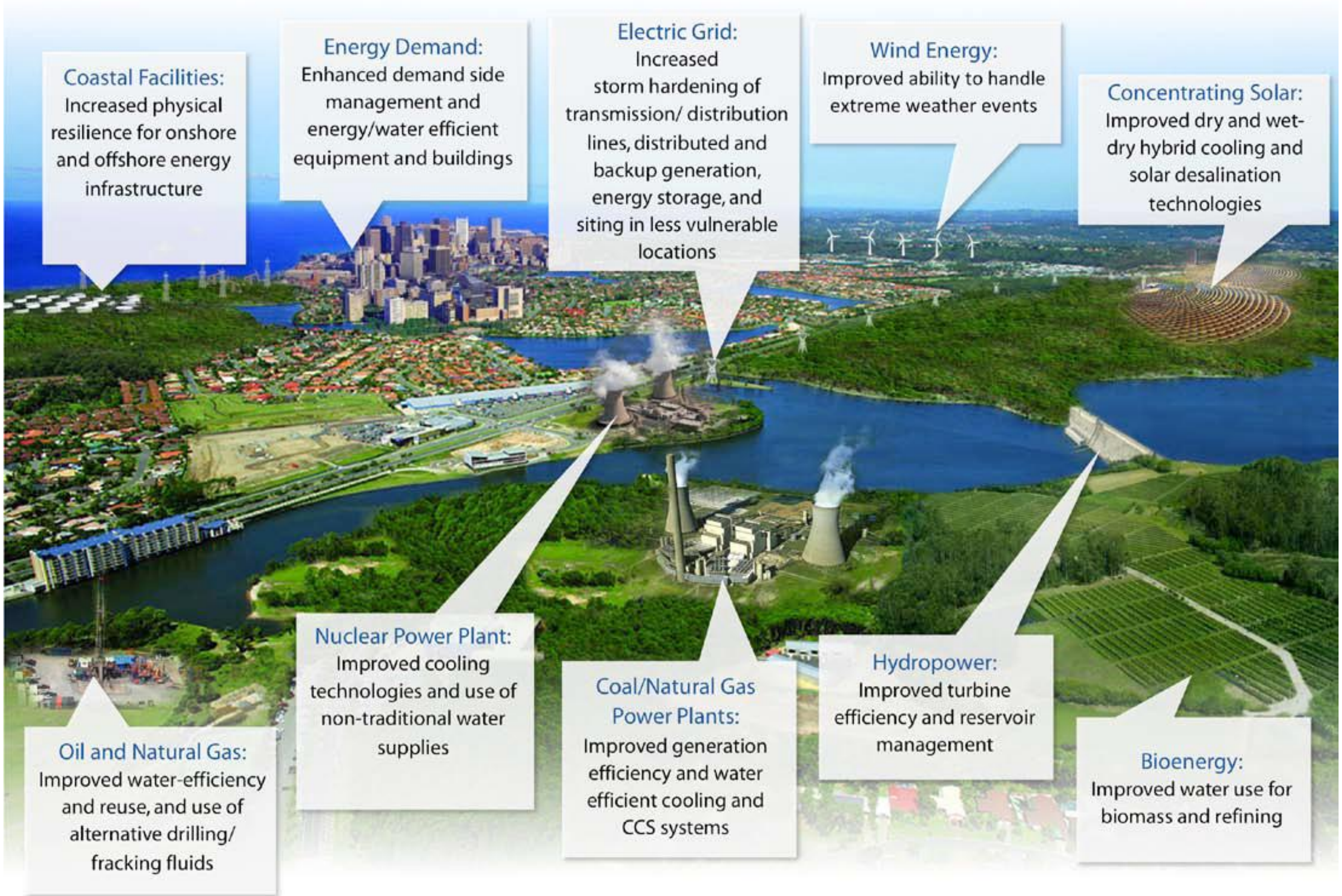
Time to Equilibrium

Climate-change experts predict that even when GHG emissions are curtailed, their effects on the environment will continue to be felt for hundreds, if not thousands, of years.



Jones-Thompson, Maryanne, "Engineering Climate", *Technology Review*, MIT, March 2005

II. Energy Technologies Vulnerable to Change



U.S. Department of Energy, "U.S. Energy Sector Vulnerabilities to Climate Change and Extreme Weather," DOE/PI-0013, July 2013

Energy-Using Technologies

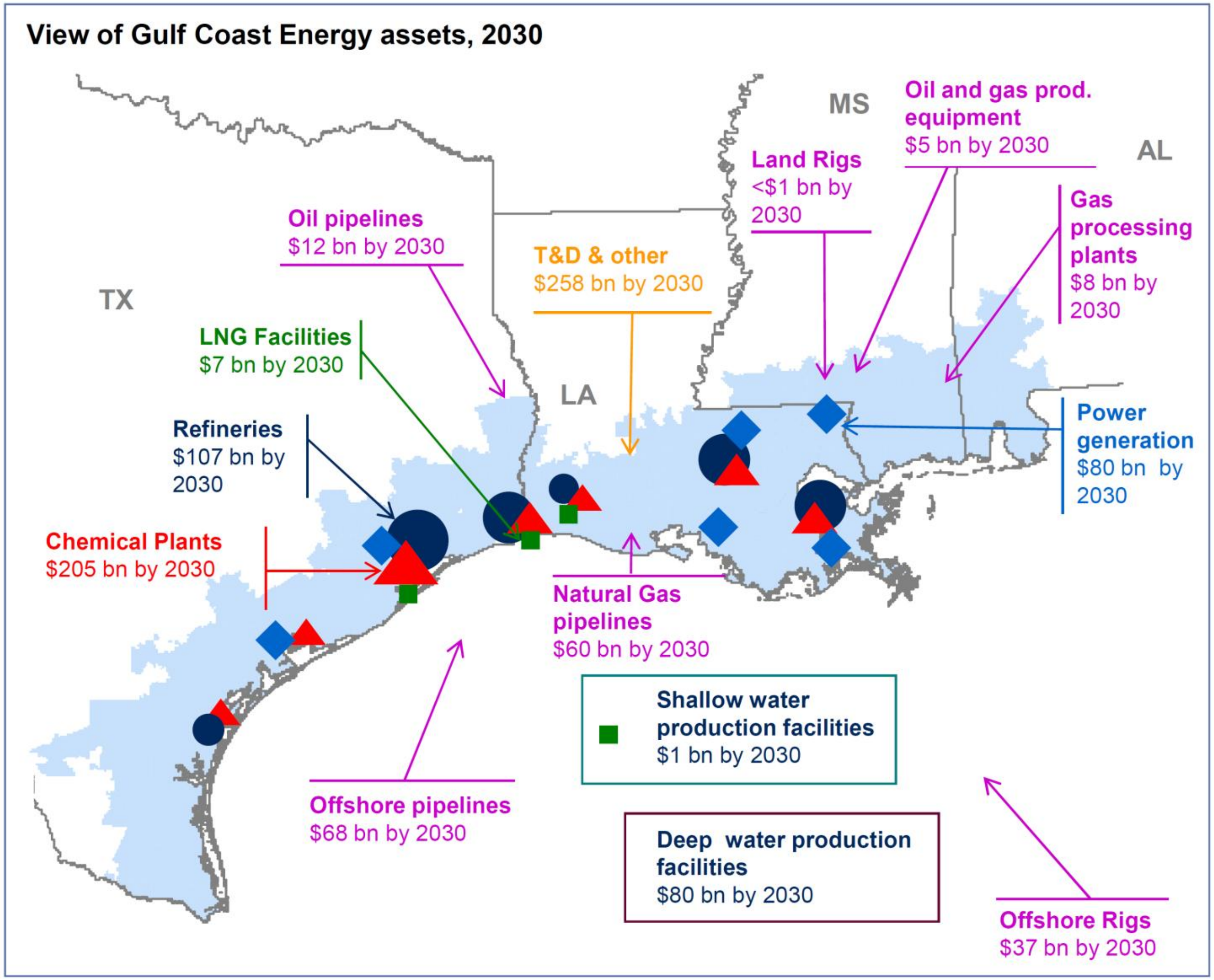
- Increased Air Temperatures Will Increase Demand for Cooling and Refrigeration
- Magnitude and Frequency of Heat Events Will Result in More Extreme Peaking of Energy Demand (For Cooling and to Offset Transmission Grid Efficiency Losses).

Energy Oil & Gas Production Systems

Water Availability

Storms

Gulf Coast Energy Assets at Risk



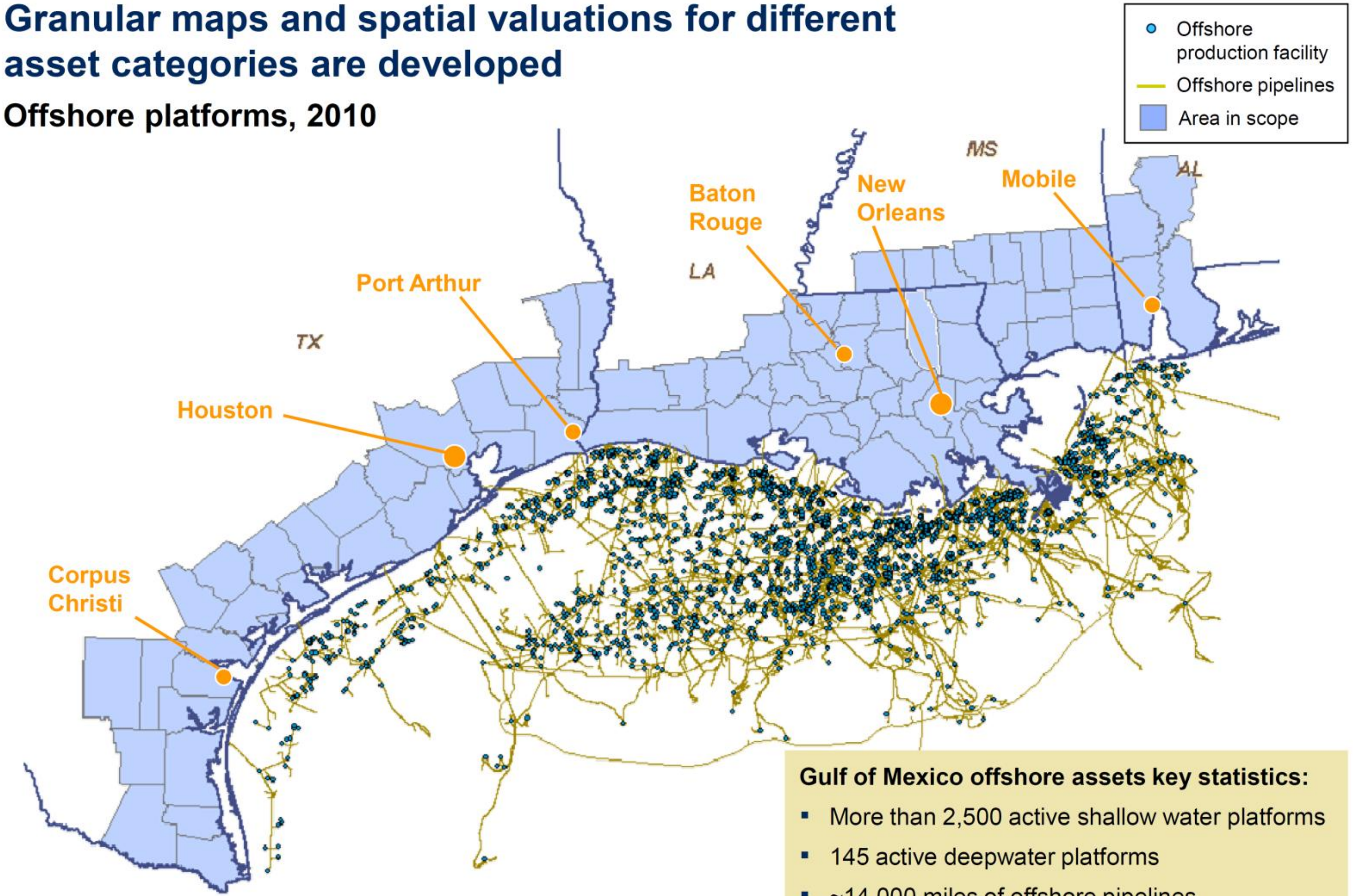
- **Modeled ~ 50,000 oil and gas structures** including 90,000 miles of pipelines, 2000 offshore platforms and 27,000 wells
- **Considered over 500,000 miles of T&D, and ~300 generation facilities**
- **Consolidated information across 10-15 key databases, including** EIA, MMS, Energy Velocity, OGJ, Tecnon, HPDI, Wood Mackenzie, Ventyx, Energy Velocity, Entergy

Entergy: Report CC Adaptation Gulf Coast Oct 2010

Oil/Gas/Chemical Assets

Granular maps and spatial valuations for different asset categories are developed

Offshore platforms, 2010



Gulf of Mexico offshore assets key statistics:

- More than 2,500 active shallow water platforms
- 145 active deepwater platforms
- ~14,000 miles of offshore pipelines

Entergy: Report CC Adaptation Gulf Coast Oct 2010
Source: MMS; Oil and gas journal; Energy Velocity

Thermal Energy Power Systems

Water Availability
& Temperature

Water Availability
& Temperature
Storms & Flooding

Water Availability
& Temperature
Storms & Flooding

Renewable Energy Systems

Wildfires

Temperature & Storms

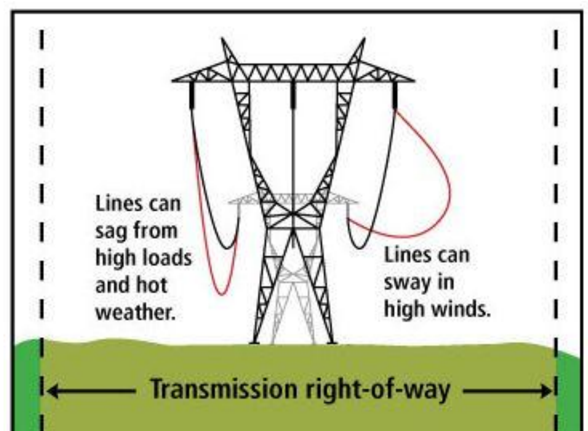
Changes in Wind Patterns

Hydropower
Increase or Decrease?

Electric Grid

Wildfires

Temperature & Storms
Icing of Power Lines



Temperature - Sag

Fuel Distribution Systems

Storms

Thawing Permafrost

Storms & Floods

Climate Impacts on Energy Systems

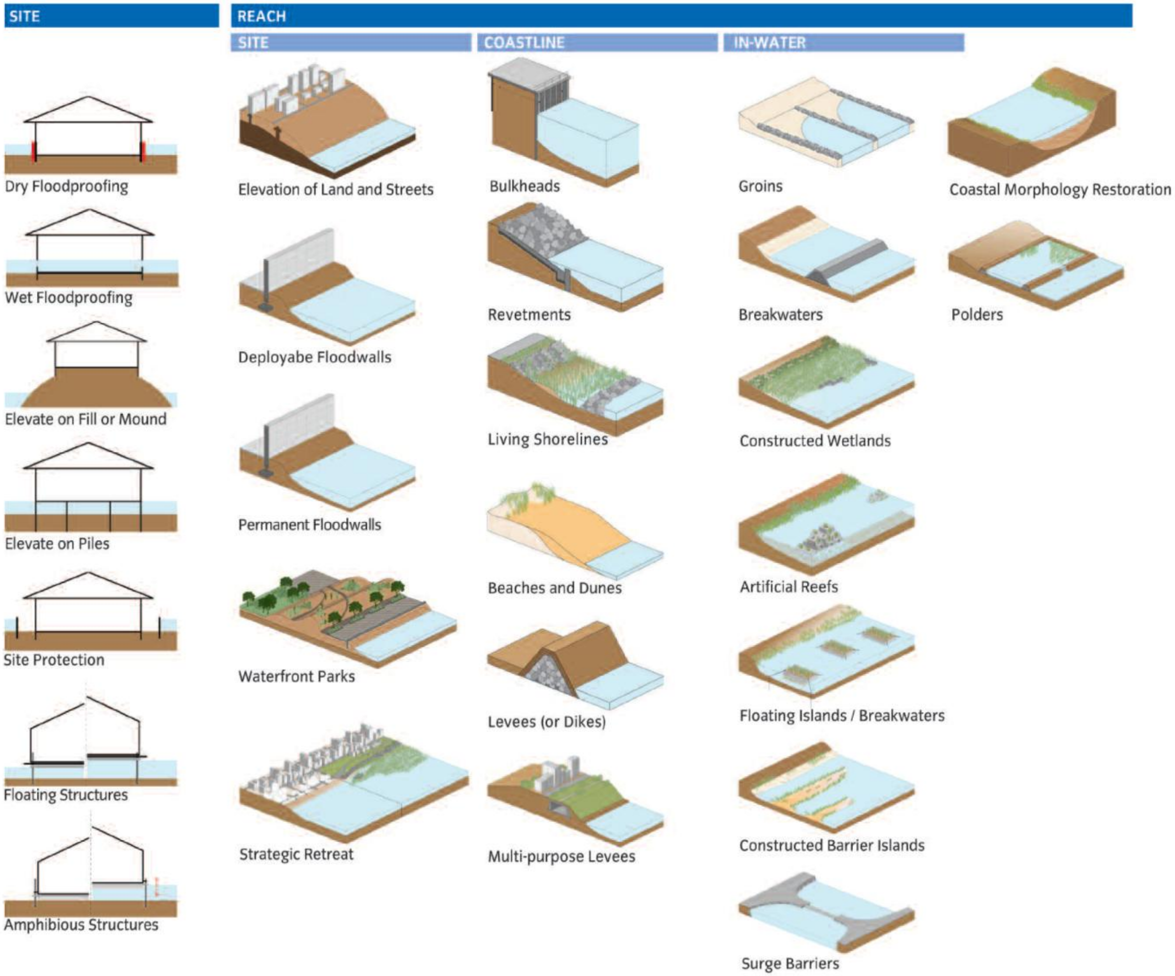
Vulnerability	Temperature	Sea Level Rise	Precipitation	Water Availability	Extreme Events			
Technology					Storms	Floods	Drought	Fires
Energy Demand	√				√			
Oil/Gas Prod	√	√		√	√		√	√
Thermal Power	√	√		√	√	√	√	
Hydro	√		√	√		√	√	
Wind					√			√
Solar	√				√			
Other (CSP, Geo)	√			√	√	√	√	
Bio-Energy/fuels	√	√	√	√	√	√	√	√
Electric Grid	√				√			√
Fuel Transport			√	√	√	√	√	

CSP = concentrating solar power

III. Examples of Remedial Strategies

- **Reduced Energy Demand from Temperature and Infrastructure**
  - **Energy Efficient Buildings**
  - **Improvements to Appliances/Equipment**
  - **Natural Ventilation, Sun Shading**
  - **Improved HVAC, GSHP,**
  - **Water-Conserving Thermal Processes**

Sea Level Rise and Coastal Resiliency Measures



Source: DCP

City of New York, “A Stronger, More Resilient New York,” June 11, 2013
Department of City Planning (DCP)

Reduced Water Demand by Reuse

- **Alternative Water Supplies To Freshwater:**
  - **Brackish or Waste Water for Power Plant Cooling**
  - **Reuse/Recycle Water for Gas Production**
  - **Dry Cooling, Advanced Condensing Cooling Towers**

Reduced Water Demand via Indirect Dry Cooling

This power station in Mpumalanga, South Africa, comprises 6 x 686 MW units, and operates with the largest indirect dry cooling system in service world wide. The indirect cooling plant was built by DB Thermal in 1984. It includes 6 Cooling Towers, each 165m high with a throat diameter of 102m.

IV. Workshop Objectives and Desired Outcomes

- All Energy Technologies Exhibit Some Vulnerabilities to the Consequences of the Changing Climate
- Each Country or Region Will Likely Have a Unique set of Urgencies
- New and Strengthened Technologies Can be Made More Resilient to Many Challenges
- Better Information Can Influence Parameters of Design
- Energy RD&D Planners Should Consider How the Changing Climate Will Alter RD&D Priority-Setting
- What are the Top Priorities for Increased RD&D Investments?
- What are Top-Priority Supporting Policy and Analytical Needs?

Additional Questions Needing Attention

- How do you define climate preparedness and resilience for energy systems?
- What tools, data, and information would be most helpful in evaluating climate preparedness and resilience?
- What lessons can be learned from the private sector, or from public-private partnerships in developing response strategies and deploying climate-resilient energy technologies?
- What are the elements of an effective, integrated framework for monitoring, evaluating and communicating progress towards a climate resilient energy system?
- What approaches would be most effective to communicate results of energy sector vulnerability assessments to climate change, and to inform decision-making for prioritization or restructuring of research investments and related policies, and achieve desired outcome?

Workshop Products and Next Steps

- Summary Report of Workshop
- Key Findings and Recommendations
  - Vulnerabilities to Energy Systems
  - Potential for Technological Remedies
  - Selected R&D Needs
  - Additional Tools & Information
  - Supporting Policy
- Next Steps
  - Communicate Results to CERT and Above
  - Convey Conclusions to IEA Technology Network
  - Take Lessons Home & Influence National Research Agenda