GE Energy

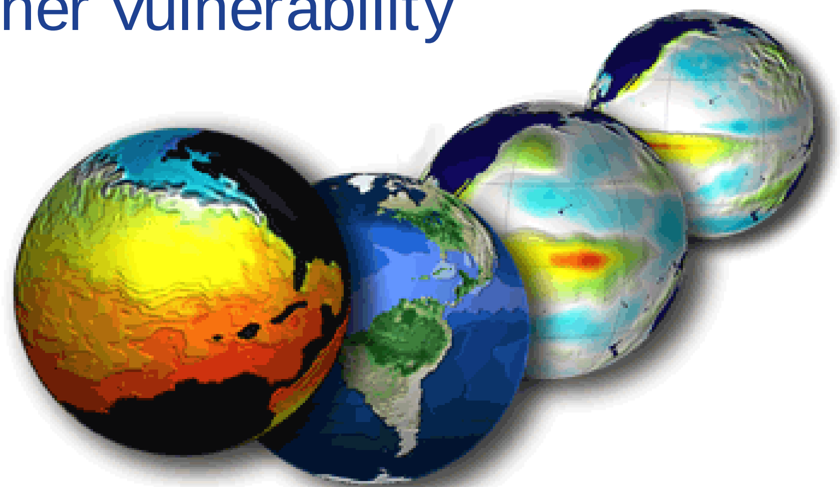
The Rise of Resilience

Building sustainable and resilient energy systems

Climate Change and Extreme Weather Vulnerability

Atlantic Council, Washington DC

July 24-25, 2012



Brandon Owens, Program Manager

Carbon Center of Excellence

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The Rise of Resilience

GE has been addressing resilience for over 100 years.

- We've always been deeply involved in helping our customers build more robust energy systems and recover from natural disasters.
- Our ecomagination initiative is focused on enhancing internal and external energy system sustainability.

What's new?

- Increasing urgency. Growing number of extreme events
- The stakes are higher. More scale, complexity and people impacted.
- Electricity is more important. More dependent upon electricity today for financial and manufacturing processes. The digital wave is here.
- Converging sustainability and resilience narratives

Resilience… the ability to recover faster after a stress or shock, endure greater stress or shock, and/or minimize the impact of a stress or shock.

Technology @Work: Rapid deploy and integration technologies add or replace energy assets anywhere

45-days:

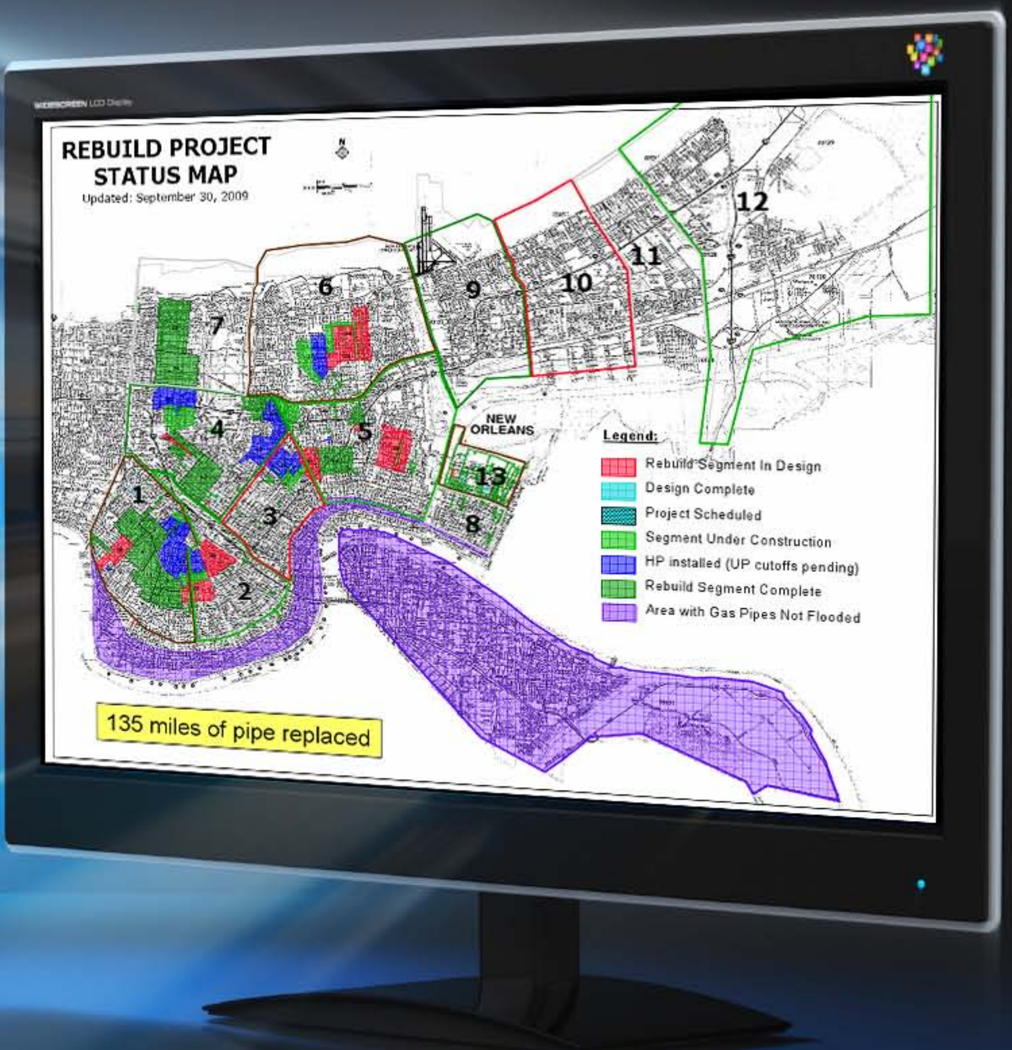
GE's FastPower delivers fully functional, onsite power plant

Technology triumphs take many forms:

Reliable data and a manageable plan are as important as spare parts

New Orleans – Katrina

Natural gas infrastructure came online faster and under cost estimates – GIS-enabled, real-time asset management focused resources, decision making and planning



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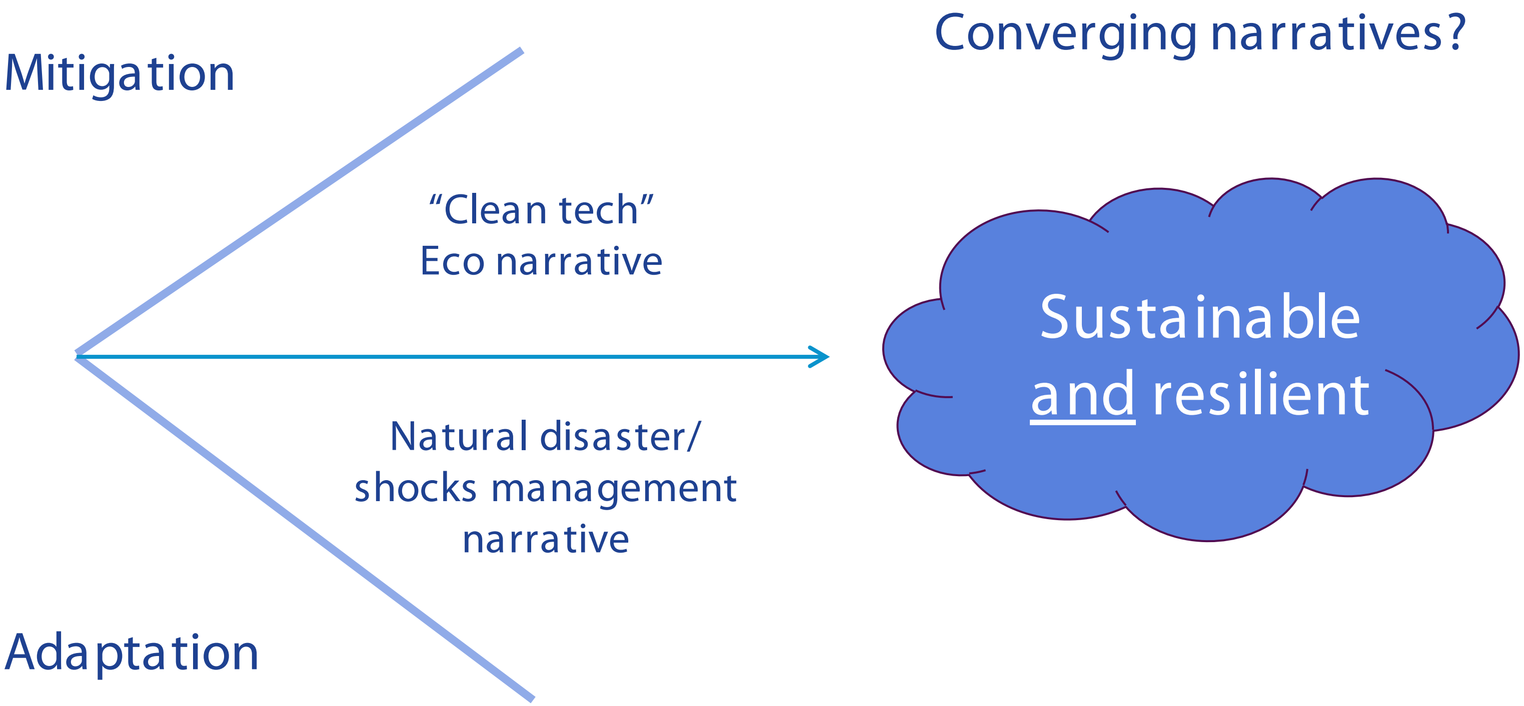
Shifting global narrative

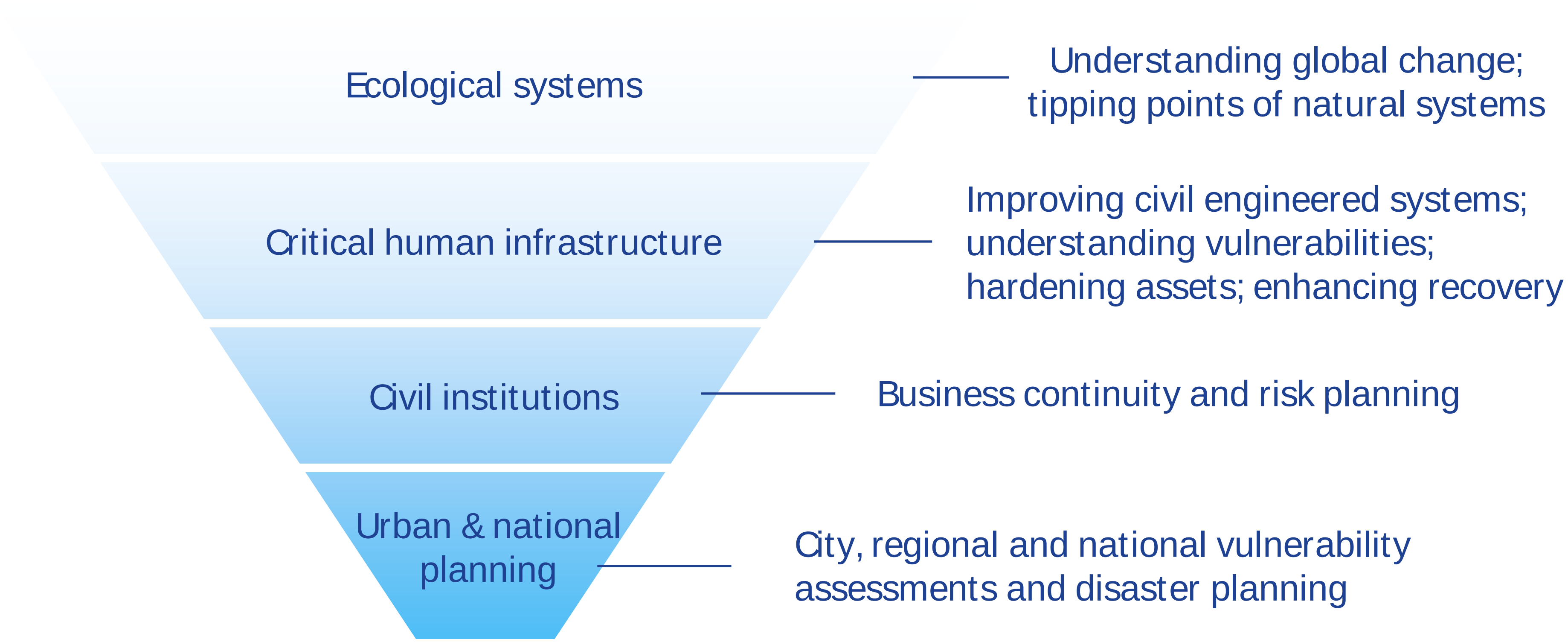
Growing attention to both mitigation and adaptation



Building sustainable and resilient social, economic and ecological systems

Resilience thinking

Multilayered perspectives, roles and responsibilities



Global attention to the concept of resilience is growing

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Forces driving need for resilience

Complex interlinked issues arising from global change

Rapidly expanding human built environment

- The human built environment is growing globally at a rapid rate
- In the next 15 years global output will grow between $40 and $65 trillion dollars.
- The growth of the built environment enhances livelihoods but it also increases the exposure to naturally occurring hazards ranging from earthquakes to tropical storms.

Dependence on critical infrastructure

- Technological change is increasing prosperity but it is also increasing dependence.
- As economies become more advanced they have become more dependent on critical supporting infrastructure including:
  - energy
  - information technologies
  - transportation networks
  - supply chains

Rising economic damage from chronic and acute shocks

- Growing global concern about ecosystem dynamics and the potential for thresholds and tipping points.
- Rising economic damage associated with the impact of natural disasters, which climbed to an all time high of $380 billion in 2011.

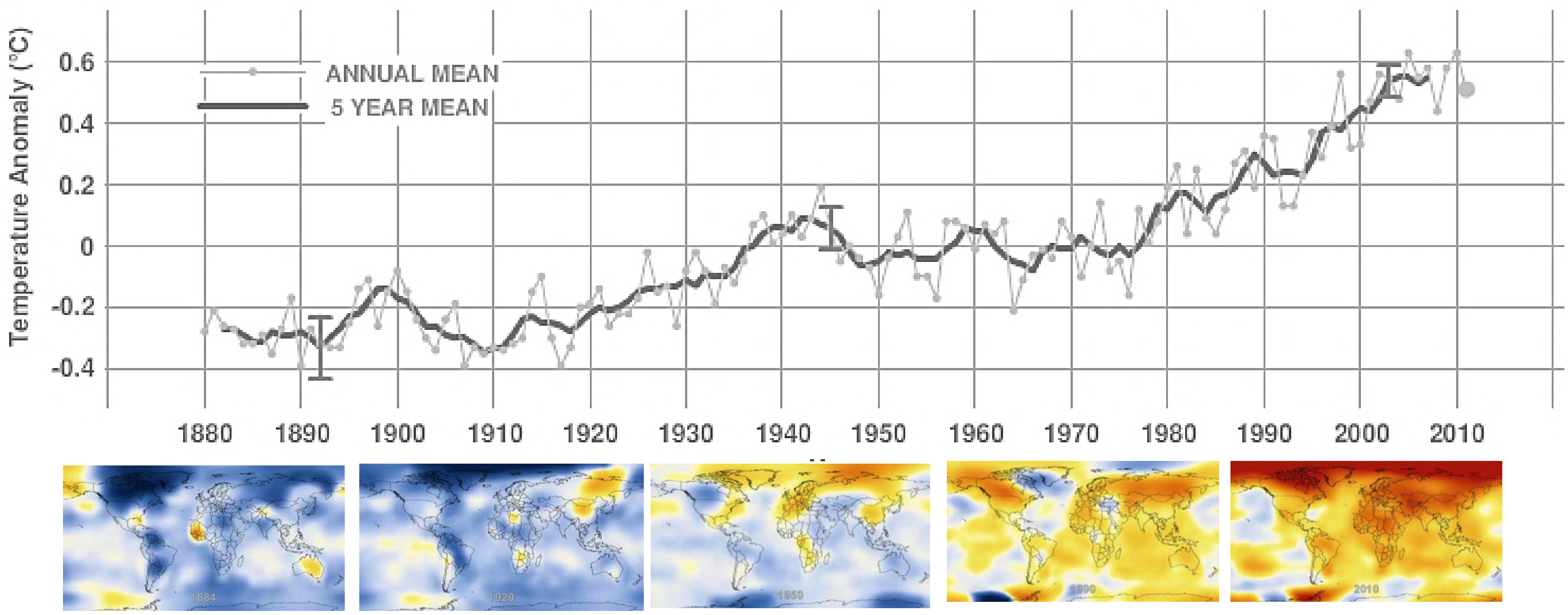
Source: GE Energy, 2012; Munich Re, 2012

Climate change physical indicators

Global surface temp anomaly climbs above 0.5°C

GLOBAL LAND-OCEAN TEMPERATURE INDEX

Data source: NASA's Goddard Institute for Space Studies (GISS) This trend agrees with other global temperature records provided by the U.S. National Climatic Data Center, the Japanese Meteorological Agency and the Met Office Hadley Centre / Climatic Research Unit in the U.K. Credit: NASA/GISS



2000-2009 was the warmest decade on record

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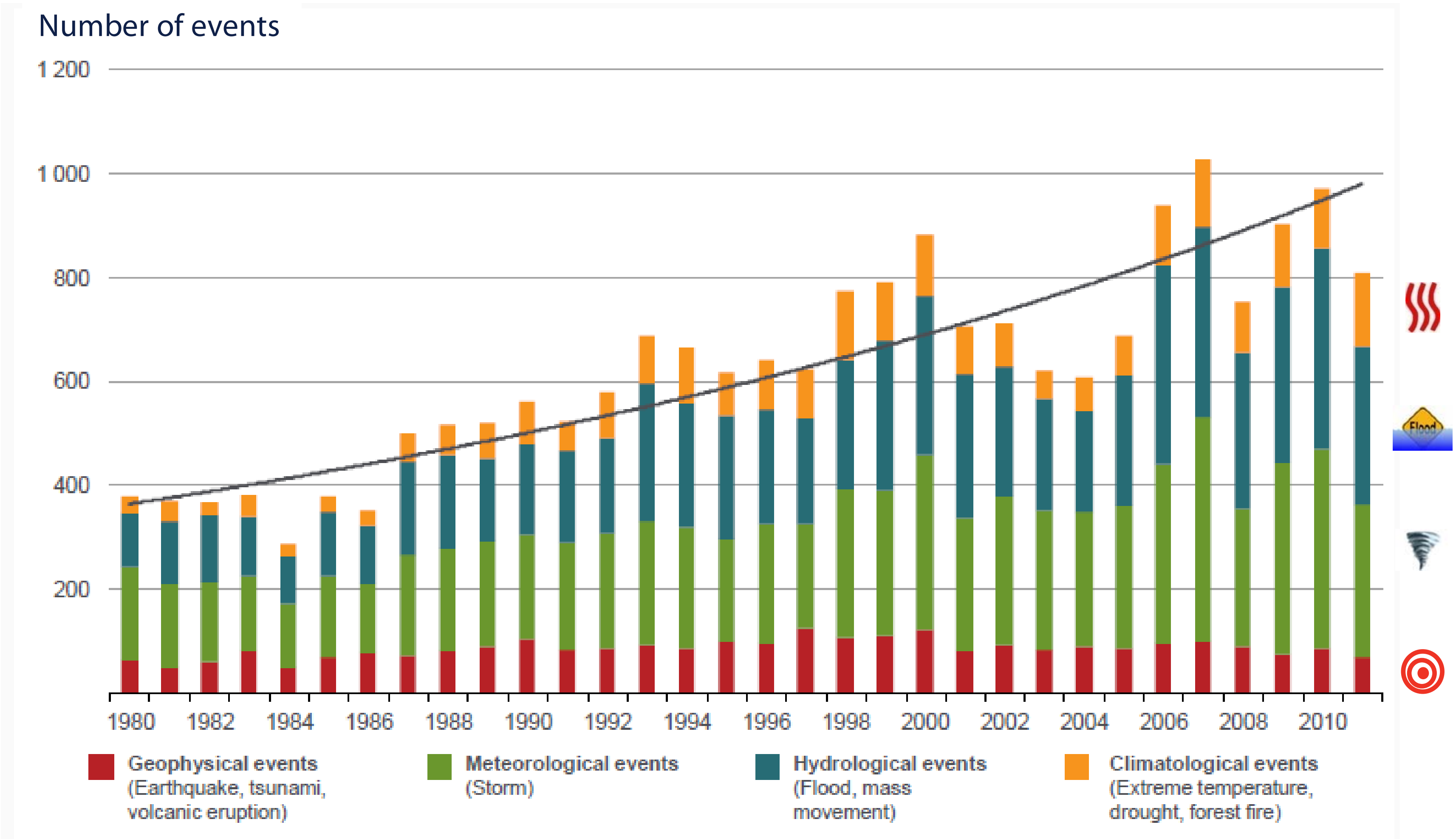
Source: NASA, http://climate.nasa.gov/keyIndicators/

World-wide natural disaster trend

Annual rate of over 800 events in recent years



Source: Munich Re, January 2012

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Energy infrastructure vulnerability

Examples of sever damage caused by natural hazards

Hurricane Katrina shut off 19% of US refining capacity; damaged 457 pipelines and destroyed 113 offshore platforms

Hurricanes Gustav and Ike destroyed 60 offshore platforms in the Gulf of Mexico.

Japan **earthquake and tsunami** destroyed or damaged over 27 GW of power including the Fukushima nuclear plant

2005 2006 2007 2008 2009 2010 2011 2012

Heat wave causes France, Spain and Germany to power down nuclear plants because of heat and water problems

Chile **earthquake** knocked out 3 GW of power and destroyed transmission networks

Severe **flooding** in Thailand damages or destroyed 1.3 GW of power

Source: GE Energy, 2012; Munich Re, 2012

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Data infrastructure vulnerability

Examples of severe damage caused by natural hazards

Several datacenters survived **Hurricane Katrina** on backup power only to be taken down when fuel for the generators ran out

Flooding in Bothell, WA shuts down a T-Mobile datacenter affecting customer support and activations

Severe **flooding** in Turkey knocked out a Vodafone datacenter disrupting phone service

Colorado **wildfires** force the evacuation and shutdown of HP data center

Japan **earthquake** knocks over many server cabinets and disrupts datacenter power

Thunderstorm in mid-Atlantic causes power failure to Amazon datacenter knocking out Netlflix, Pintrest, Instagram and others

2005 2006 2007 2008 2009 2010 2011 2012

Source: GE Energy, 2012; Munich Re, 2012

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What's next.. the missing pieces

Expand speed and scope of technology deployment

Incentivize more rapid deployment of technology and services across the spectrum of resilience: prior to, during and after disruptions.

Close governance and policy gaps

Enhance coordination across government bodies responsibility for sustainability on the one hand and natural hazards preparedness on the other at the local, state and international levels.

Send the right market signals

Take measures to encourage innovation around resilience. Devise new policy architecture and incentives for resilient energy systems.

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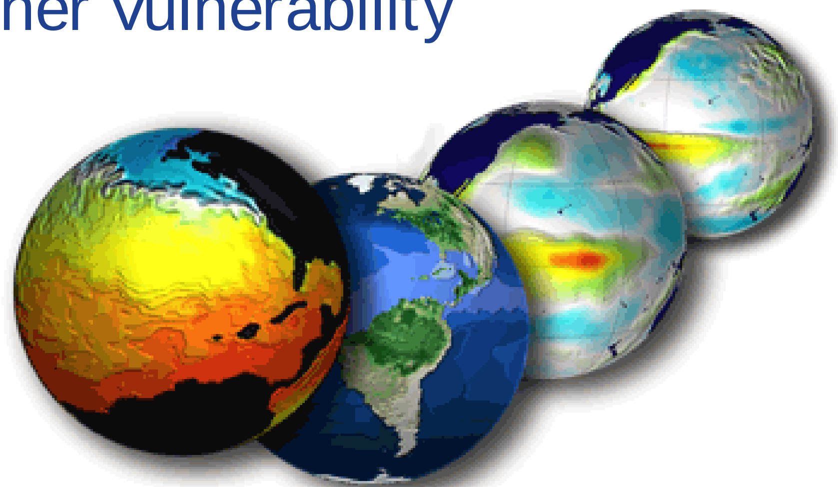

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