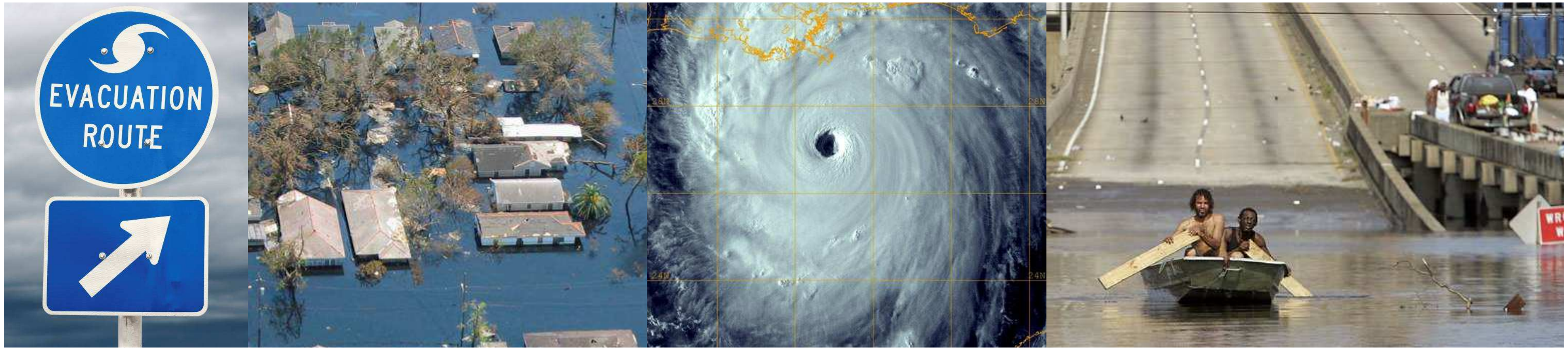


Effectively addressing climate risk through adaptation for the Energy Gulf Coast

America's WETLAND FOUNDATION

SHORE UP America's Energy Coast FUEL THE NATION

Entergy

October, 2010

Project objective and approach

Objective: Develop a comprehensive, objective, consistent fact base to quantify climate risks in the U.S. Gulf Coast and inform economically sensible approaches for addressing this risk

First comprehensive analysis of climate risks and adaptation economics along the U.S. Gulf Coast

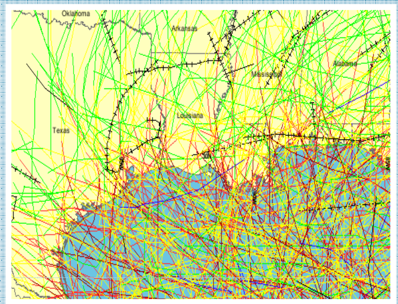
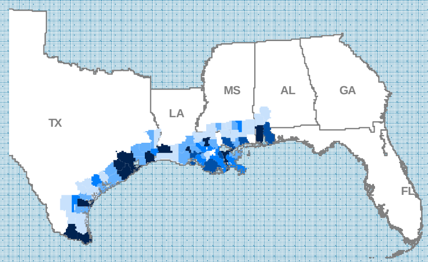


Illustration of hurricane paths/ intensities

- **Granular, “bottom-up” analysis using a risk framework**:
  - Modeled **23** asset classes across residential, commercial, infrastructure, oil, gas and utility
  - Modeled **800** zip codes across **77** counties
  - Simulated ~**10,000** hurricane “years” across multiple climate scenarios
  - Modeled over **50** adaptation measures



Engaged with experts across the Gulf Coast

- **First time broad range of Gulf Coast stakeholders and experts** engaged
  - **Discussed with over 100** global, regional academics, government officials, industry experts and NGOs
  - **Used credible, publicly available sources** (e.g., IPCC climate scenarios, FEMA, BEA, DOE EIA, MMS, Energy Velocity,)

Messages from adaptation work (1 of 2)

1 The Gulf Coast is vulnerable to growing environmental risks today with >$350 billion of cumulative expected losses by 2030

- Losses continue to increase (20%+) due to subsidence and asset base growth
- $350 billion of loss represents
  - A Katrina-like hurricane becomes a once in every generation event
  - 7% of total capital investment for the Gulf Coast area; 3% of annual GDP
  - This is equivalent to reconstructing New Orleans buildings 6X over
- Impact of severe hurricane in the near-term could also have a significant impact on any growth and reinvestment trajectory in the region

2 However, key uncertainties to address this vulnerability include (1) the impact of climate change, (2) the cost and effectiveness of measures to mitigate and adapt and (3) the ability to gain alignment and overcome obstacles moving forward

- Long-standing debate on impact of climate change; impact of surface temperatures on hurricane strength clear (long-standing fact-base)
- For mitigation, most discussed measures, like solar, wind and EV, in the public forum represent expensive options
- Uncertainty on benefit of adaptation measures (impacted by timing of hurricanes)
- Actions represent a wide range of stakeholders that have conflicting interests, different timeframes, and different levels of effectiveness; in some cases existing policies may present obstacles

Messages from adaptation work (2 of 2)

3 Driving a "practical" solution that takes Gulf Coast "resilience" to the next level represents an optimal solution to balance the cost requirements with the risks that impact the Gulf Coast

- Several "no regrets" moves exist for adaptation that have low investment requirements, high reduction of expected losses (regardless of impact of climate change) and additional benefits (e.g., wetlands restoration);
- These investments will avoid "mortgaging our future" with a heavy burden of ineffective actions, which is of utmost importance for the Gulf Coast
- Focus on adaptation in the near term and mitigation for the longer-term
- Industry can and must take a leadership role in driving a coordinated response

Quick facts on the context of climate risks in the Gulf Coast

Gulf Coast energy assets are $800 bn today and a key engine for the economy, making up 90% of industrial assets

Regardless of climate change, the Gulf Coast faces increasing risk. Parts of Louisiana are subsiding rapidly, and will sink by 1 foot by 2050

Regardless of climate change, the region will face more risk. Asset growth and subsidence will increase loss by ~30% over the next 20 years

Cumulative losses due to climate events over the next 20 years may be ~$370 bn - enough to reconstruct New Orleans buildings 6 times over, or ~700 superdomes

With climate change we should expect a Katrina/Rita-type year occurring once every lifetime by 2030

LA faces significant risk, with ~12 % of capital investment being "locked in" towards rebuilding each year

Growth is occurring disproportionately in some of the most at-risk areas

Offshore assets make up 20% of expected loss in the region

The Netherlands builds protection to a 1/10,000 year event; as opposed to less than a 1/100 yr event in the Gulf Coast

There are 3 key climate hazards we examined along the Gulf Coast

Hazards	Brief overview	Effect of climate change
	▪ **Damage can occur across the Gulf Coast region** and in areas further inland	▪ Potential **increase in wind speed of 1.4-2.9% in 2030** (2.1 - 10.2% in 2100) due to warmer sea surface temperatures
	▪ **Key risk is along the coastline** ▪ The Louisiana gulf coast already experiences significant deltaic land loss/subsidence[1]	▪ Relative sea level may **rise by 5-6 inches in 2030** (2.5 - 5 feet by 2100)[2]
	▪ **Risk is along the coastline,** linked to hurricane events	▪ **Storms can increase the impact of even modest levels of sea level rise** ▪ Could lead to more frequent/severe flooding of coastal zones

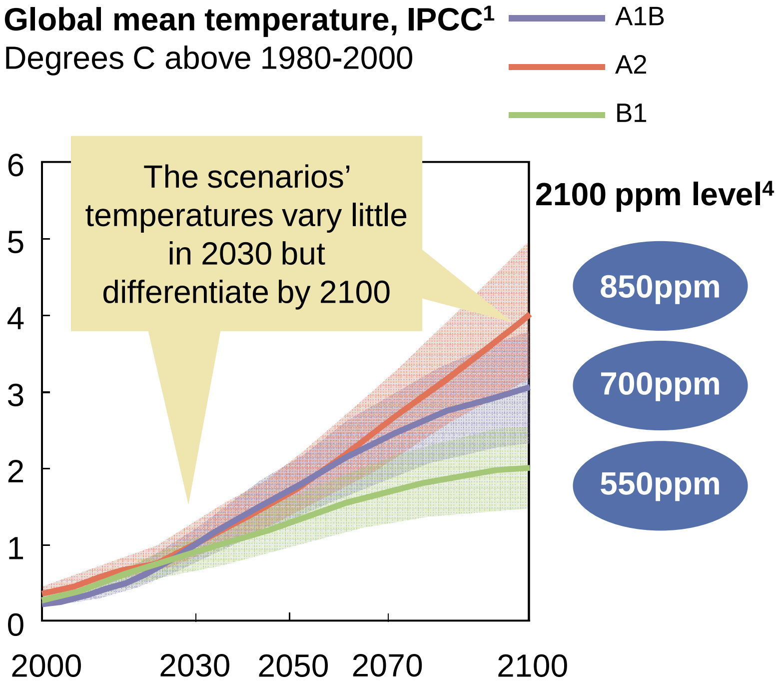
1 Estimates for subsidence vary significantly along the coastline; e.g., 8-31 inches per century
2 Based on Vermeer and Rahmstorf. “Global sea level linked to global temperature.” 2009.

Source: National Hurricane Center, NOAA, American Geophysical Union (AGU), Union of Concerned Scientists (UCS); IPCC AR4; vemeer and Rahmsorf

We have modeled different climate change scenarios

Emission pathways largely impact temperature over the long run

Global mean temperature, IPCC[1]
Degrees C above 1980-2000



Year	Scenario modeled	Increase in sea level rise (in)[1,2]	Increase in hurricane wind speed (%)[1,3]
2030	Low – No change Mid – A1B mid High – A1B high	• 0 inches • 5 inches • 6 inches	• 0.0% • 1.4% • 2.9%
2050	Low – No change Mid – A1B mid High – A1B high	• 0 inches • 13 inches • 15 inches	• 0.0% • 3.5% • 5.9%
2100	Low – B1 low Mid – A1B mid High – A2 high	• 29 inches • 45 inches • 57 inches	• 2.1% • 7.1% • 10.2%

- **Little variation is observable in different emission pathway scenarios in the 2030-2050 timeframe**
- **Over the long term, impact of different mitigation pathways becomes meaningful**

1 Relative to 2010 levels
2 Based on Vermeera and Rahmstorf. "Global sea level linked to global temperature." 2009.
3 Based on Emanuel (2005) "Increasing destructiveness of tropical cyclones over the past 30 years." Nature 436; Knutson and Tuleya (2004) "Impact of CO2-induced warming on simulated hurricane intensity and precipitation: Sensitivity to the choice of climate model and convective parameterization". J. Climate 17; Bengtsson et al (2007) "How may tropical cyclones change in a warmer climate?", Tellus 59.
4 2050 ppm levels: A1b – 550, A2 – 550, B1 - 500

Source: IPCC Fourth Assessment, Working Group II, Chapter 6

There is over over $2,000 bn in asset value along the energy Gulf Coast

Key areas examined within 70 miles of the coast

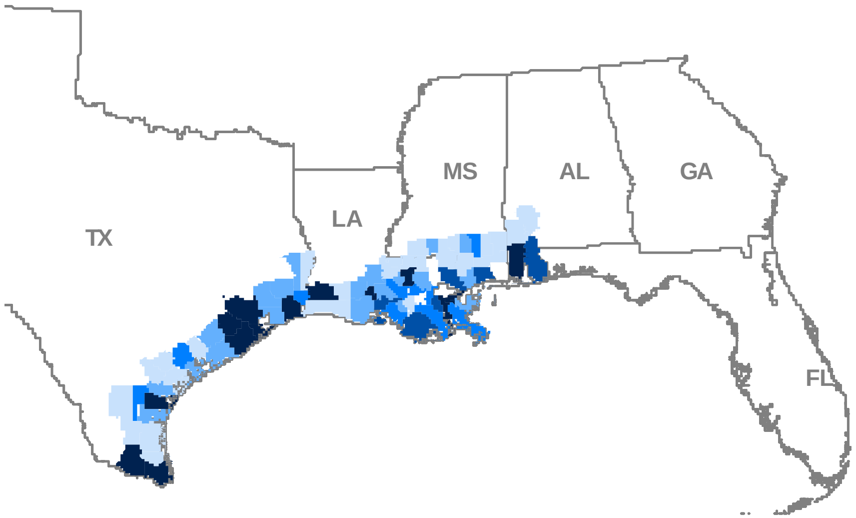
US Gulf Coast region and counties in scope[1]

2010 GDP ($M)

- ≤1,000
- 1,000-2,500
- 2,500-5,000
- 5,000-10,000
- >10,000

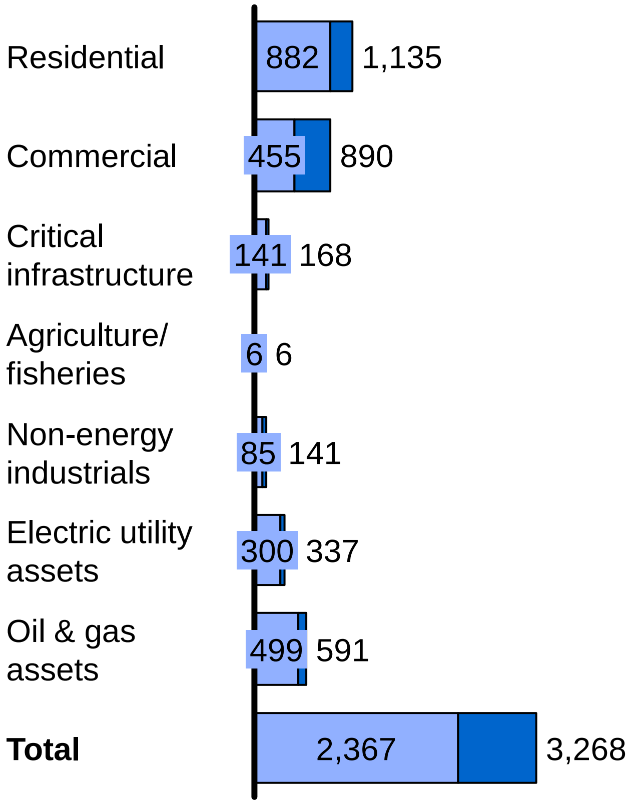
Basic metrics

Counties	77
Area	61,685 sq. mi
GDP	$634 B
Population	11.7 million



Asset values by class

Replacement value by class
$ Billions, 2010 dollars

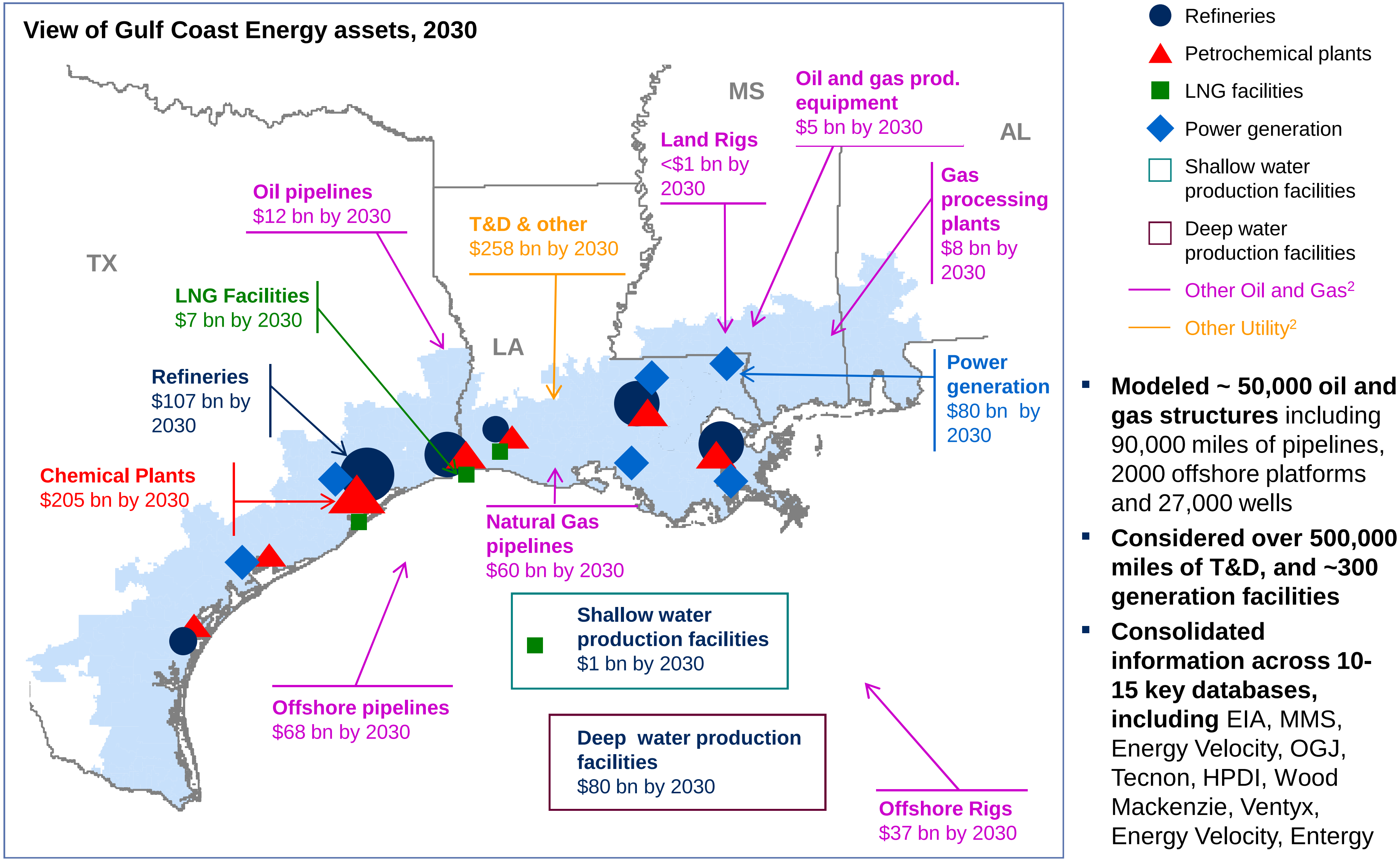


1 Includes 30 Louisiana parishes

Source: ESRI; Energy Velocity

We have also conducted a detailed analysis of oil and gas structures

View of Gulf Coast Energy assets, 2030

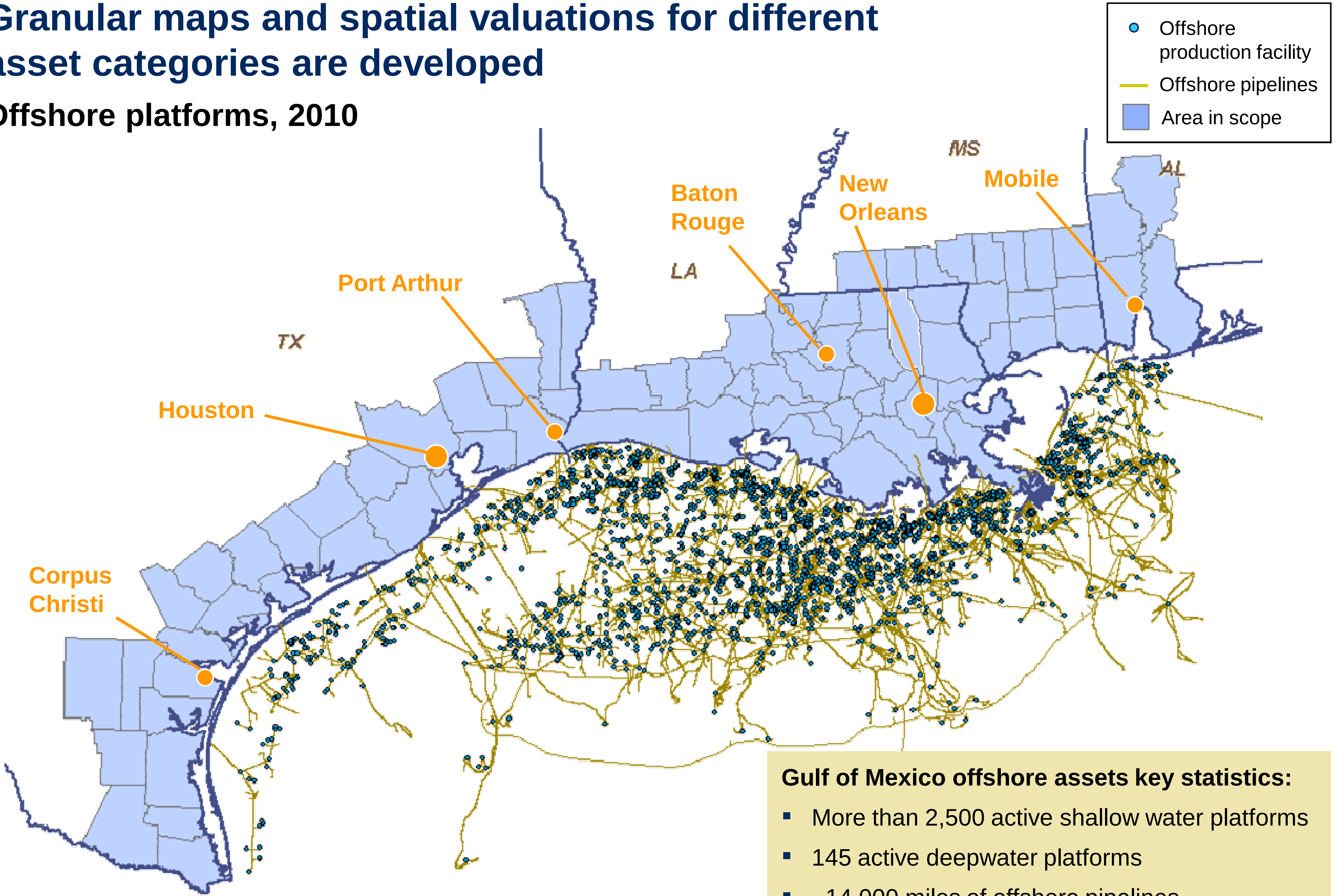


- **Modeled ~ 50,000 oil and gas structures** including 90,000 miles of pipelines, 2000 offshore platforms and 27,000 wells
- **Considered over 500,000 miles of T&D, and ~300 generation facilities**
- **Consolidated information across 10-15 key databases, including** EIA, MMS, Energy Velocity, OGJ, Tecnon,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

Example: 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

Source: MMS; Oil and gas journal; Energy Velocity

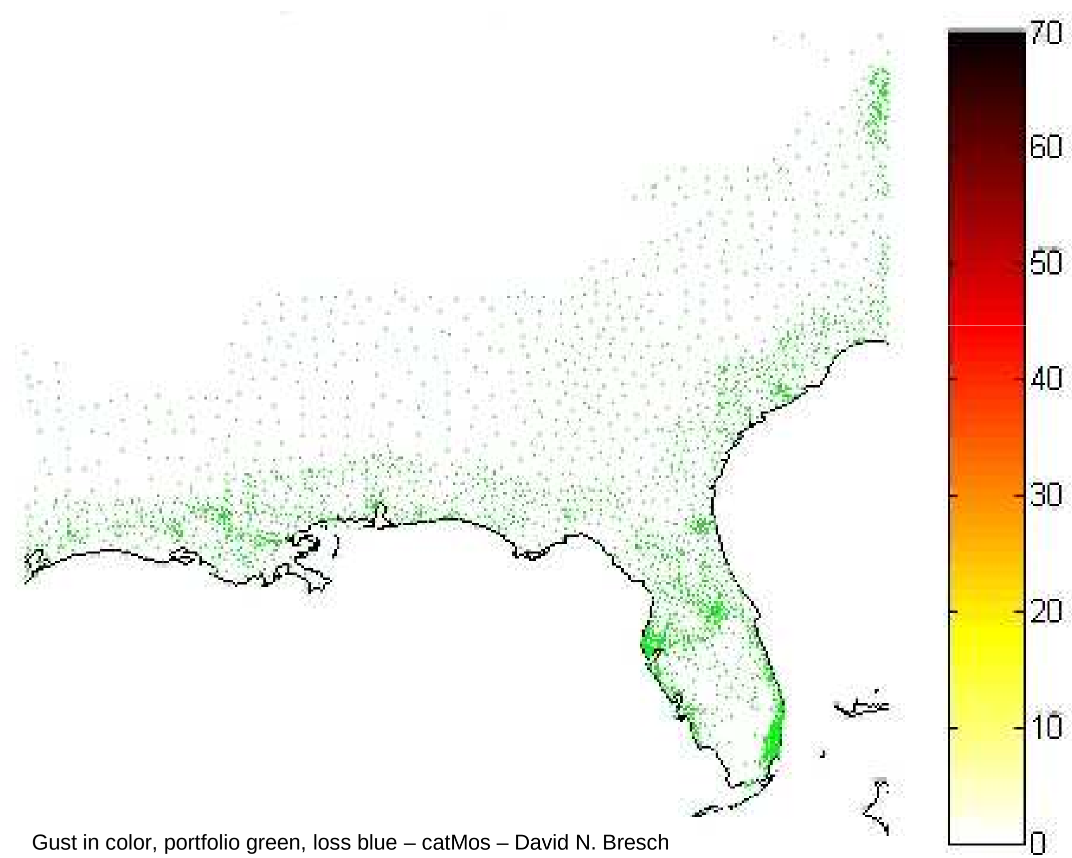
We used models from Swiss Re to simulate natural hazards and their impacts on assets

Loss modeling animation of hurricane Katrina

Wind gusts
Portfolio
Loss

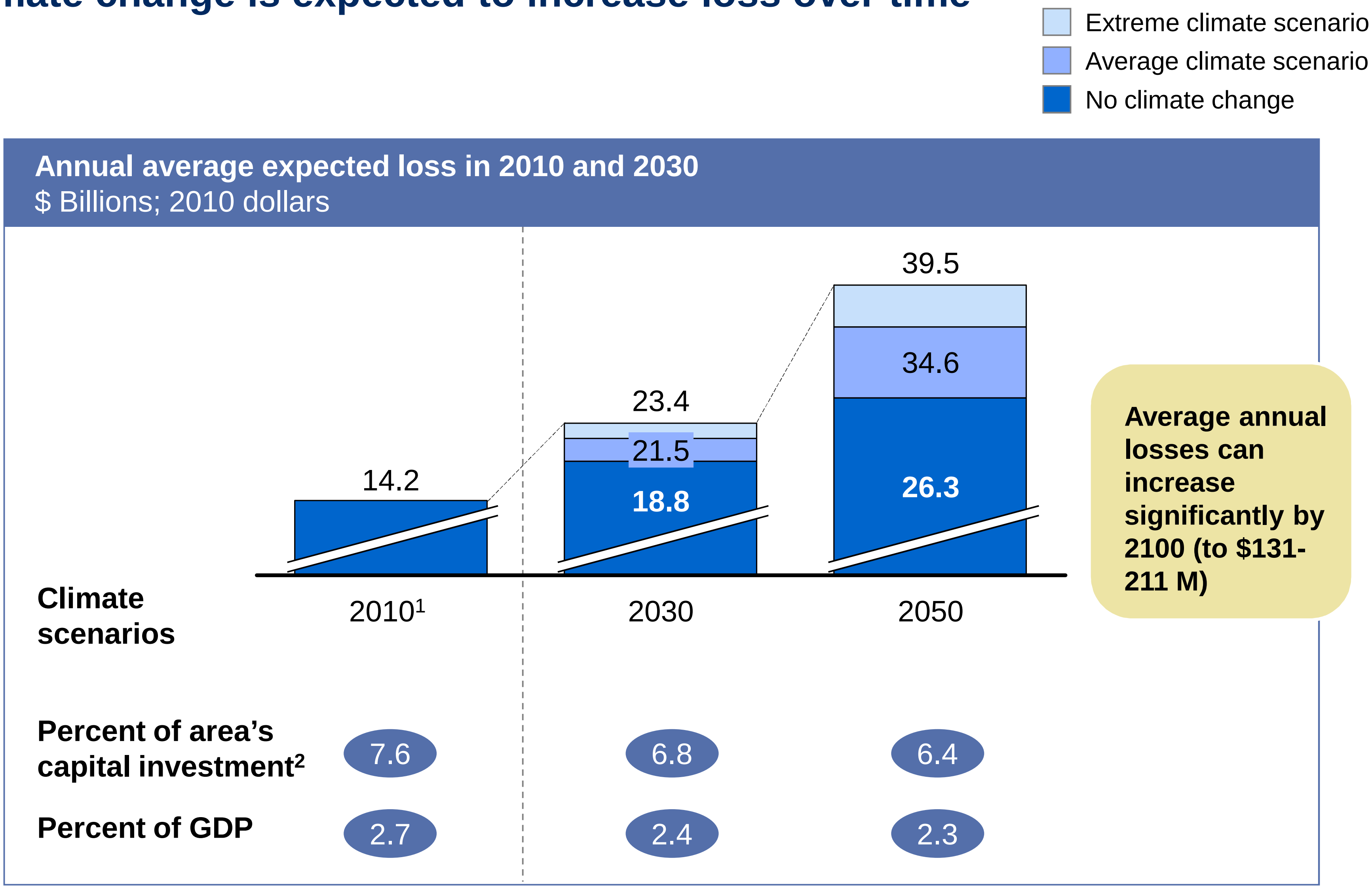
- **Animation shows Hurricane Katrina's path**, and asset damage from the storm
- Swiss Re models involve **simulating multiple factors to estimate loss**
  - >10,000 "years" of hurricane tracks for each climate scenario
  - Detailed spatial asset portfolio
  - Individual asset vulnerabilities

Katrina 2005/08/25 13h 0.000%



Gust in color, portfolio green, loss blue – catMos – David N. Bresch

Climate change is expected to increase loss over time

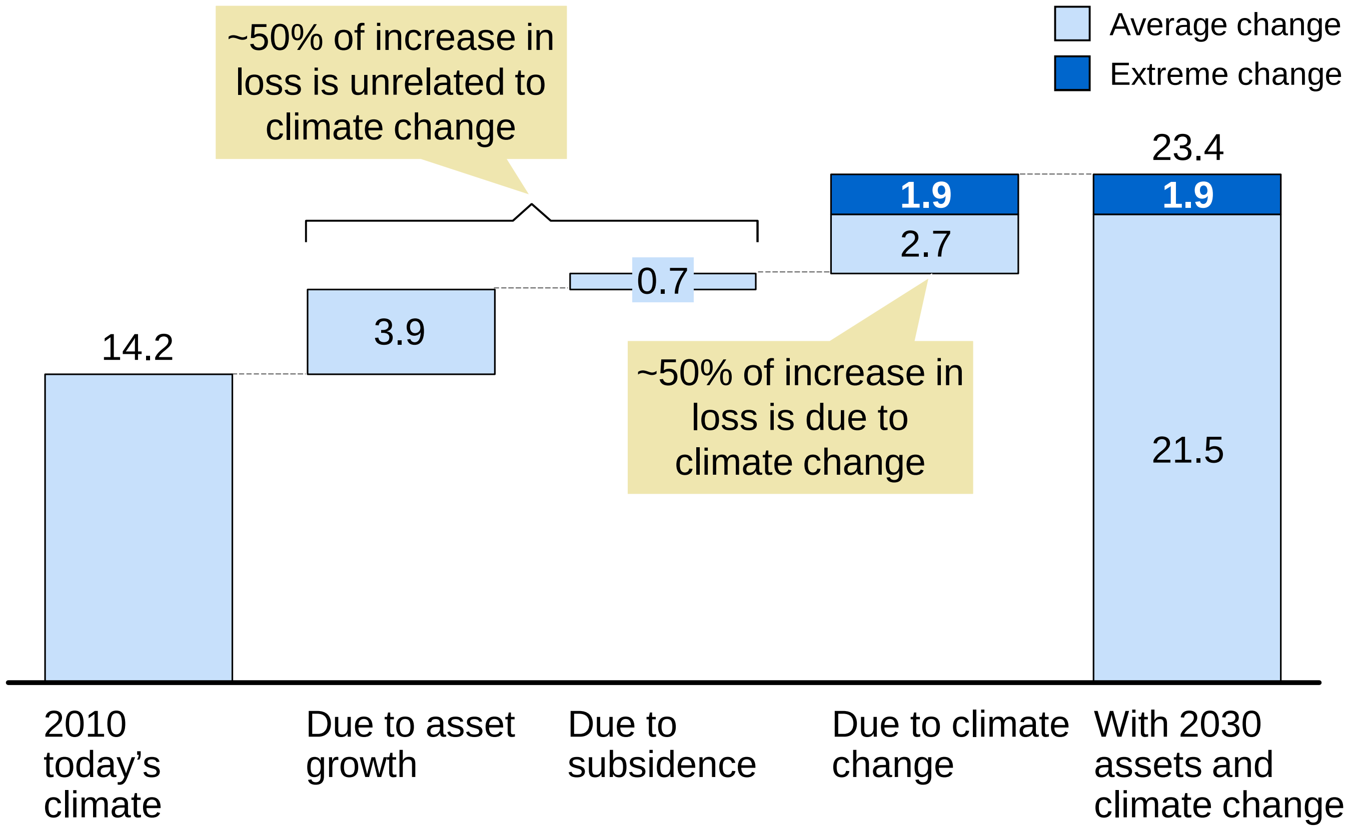


1 No climate change; includes impact of subsidence
2 Based on BEA historical average of capital investment (private and total government expenditures) as a percentage of GDP

Source: Swiss Re

However, regardless of climate change, the Gulf Coast faces increase in risks from natural hazards

Average annual expected loss in Gulf Coast region by cause
$ Billions; 2010 dollars

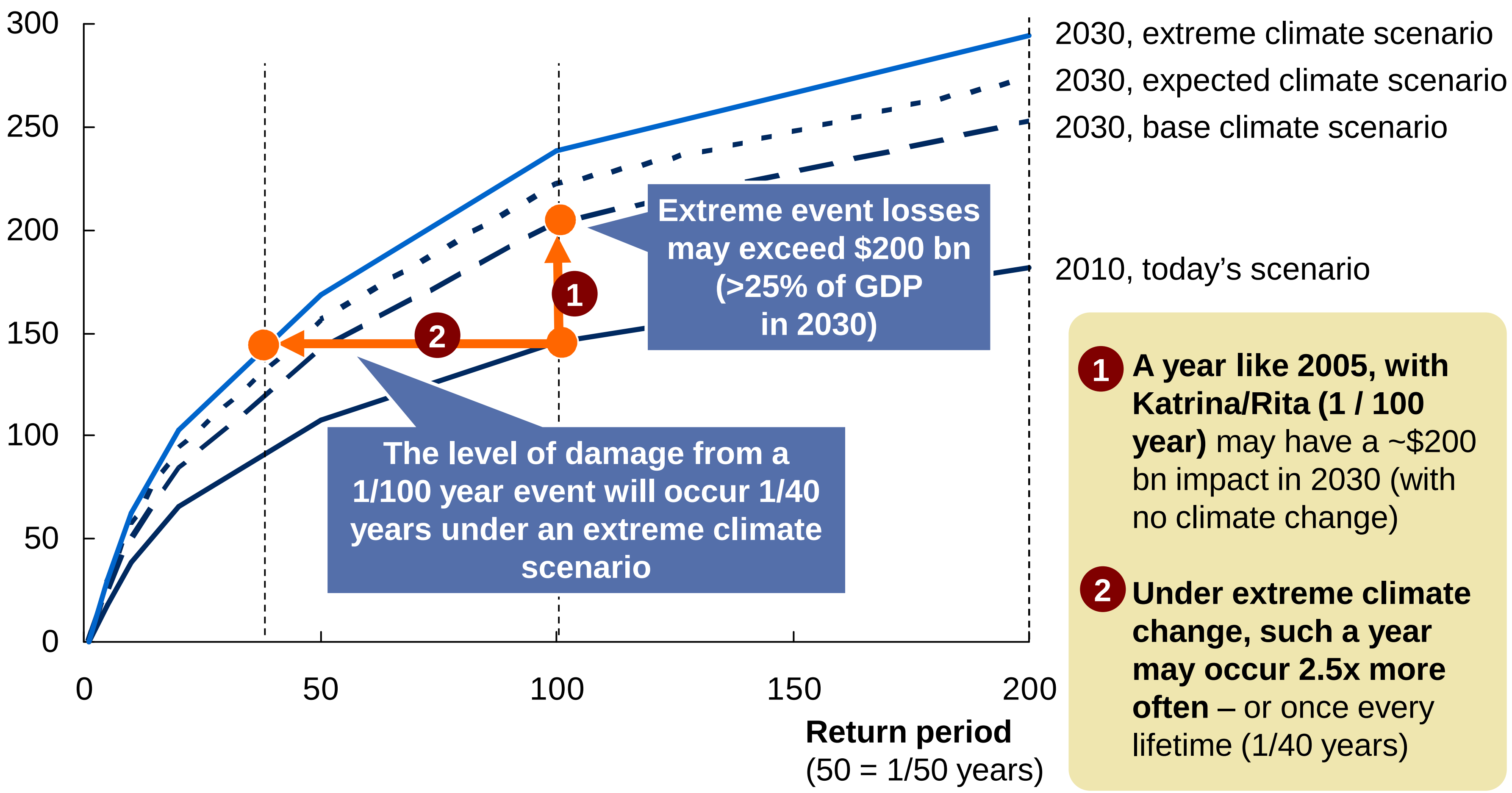


Regardless of climate change, the Gulf Coast needs to act to reduce increasing loss, primarily driven by asset growth. Subsidence has a lower overall impact in 2030, because it primarily affects southern LA

Source: Swiss Re

Furthermore, even in the near term, loss from extreme event "tail risks" may increase and occur more often

Loss frequency curve for annual loss
$ Billions; 2010 dollars



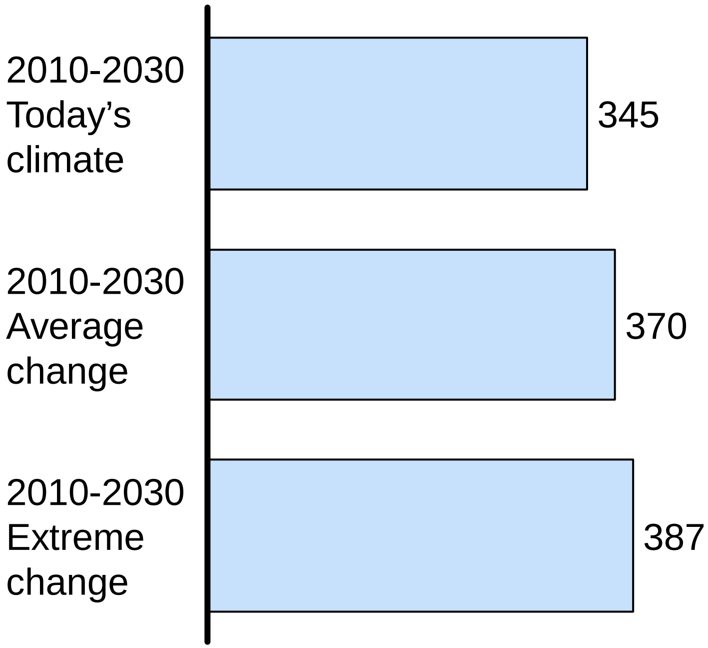
1. **A year like 2005, with Katrina/Rita (1 / 100 year)** may have a ~$200 bn impact in 2030 (with no climate change)
2. **Under extreme climate change, such a year may occur 2.5x more often** – or once every lifetime (1/40 years)

Source: Swiss Re; Press searches

Cumulative losses in the Gulf Coast may amount to ~$370 bn[1] between today and 2030

2010 – 2030 cumulative losses

Cumulative annual expected losses
$ Billions; 2010 dollars



New Orleans skyline

To place this in context, this $370 bn could be used to rebuild New Orleans six times over[2]

1 Represents cumulative of average expected losses between 2010 and 2030
2 Asset value (replacement cost) for New Orleans is $60 bn

Source: Swiss Re; Moody's; FEMA; MMS; EIA; OGJ; Wood Mackenzie; Energy Velocity; others

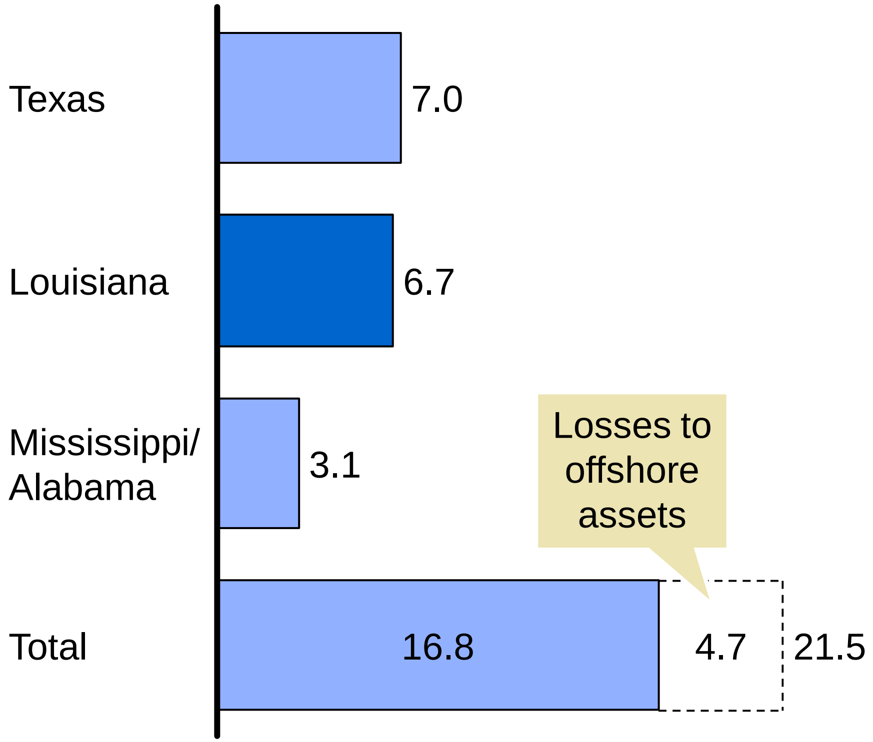
Louisiana faces significant impact from climate risks

2030, MID SCENARIO

Key state affected

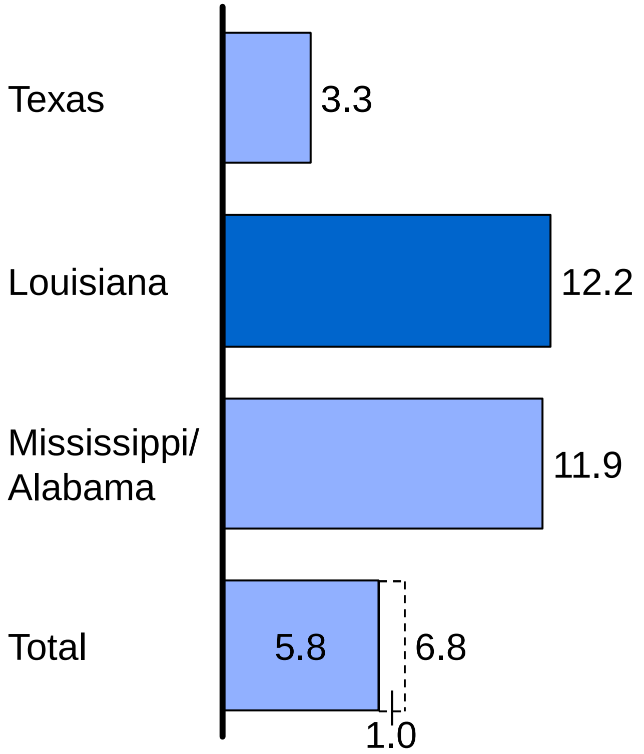
LA faces significant loss from climate risks

Average expected losses, 2030
$ Billions; 2010 dollars



A significant capital investment in LA goes to recovering from loss

Loss as a share of capital investment, 2030[1]
Percent



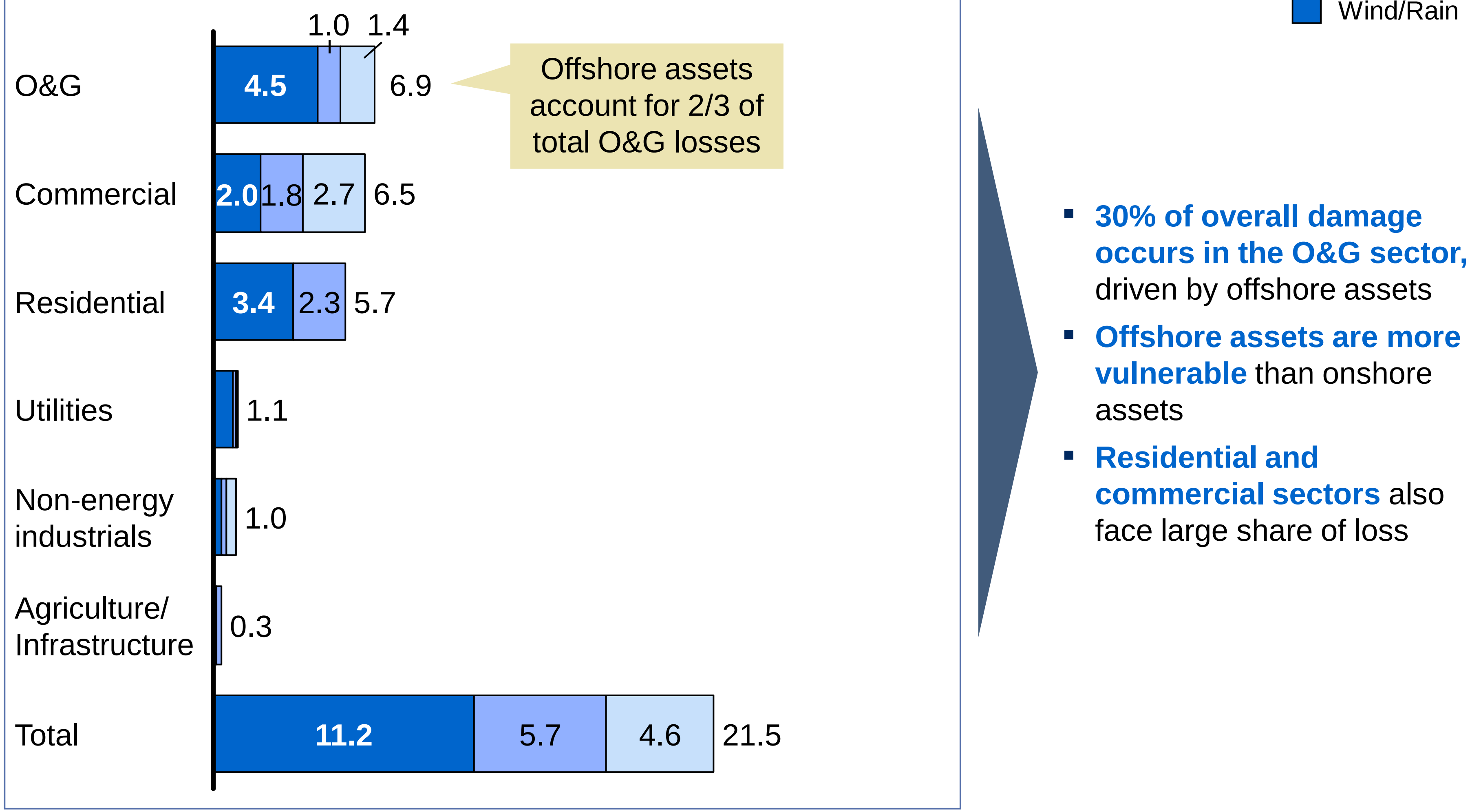
1 Loss is expressed as a share of capital investment in the region of focus within each state

Source: Swiss Re; BEA; Moody's

Among economic sectors, oil and gas assets are particularly vulnerable

2030, MID SCENARIO

2030 annual average expected loss
$ Billons; 2010 dollars



- **30% of overall damage occurs in the O&G sector,** driven by offshore assets
- **Offshore assets are more vulnerable** than onshore assets
- **Residential and commercial sectors** also face large share of loss

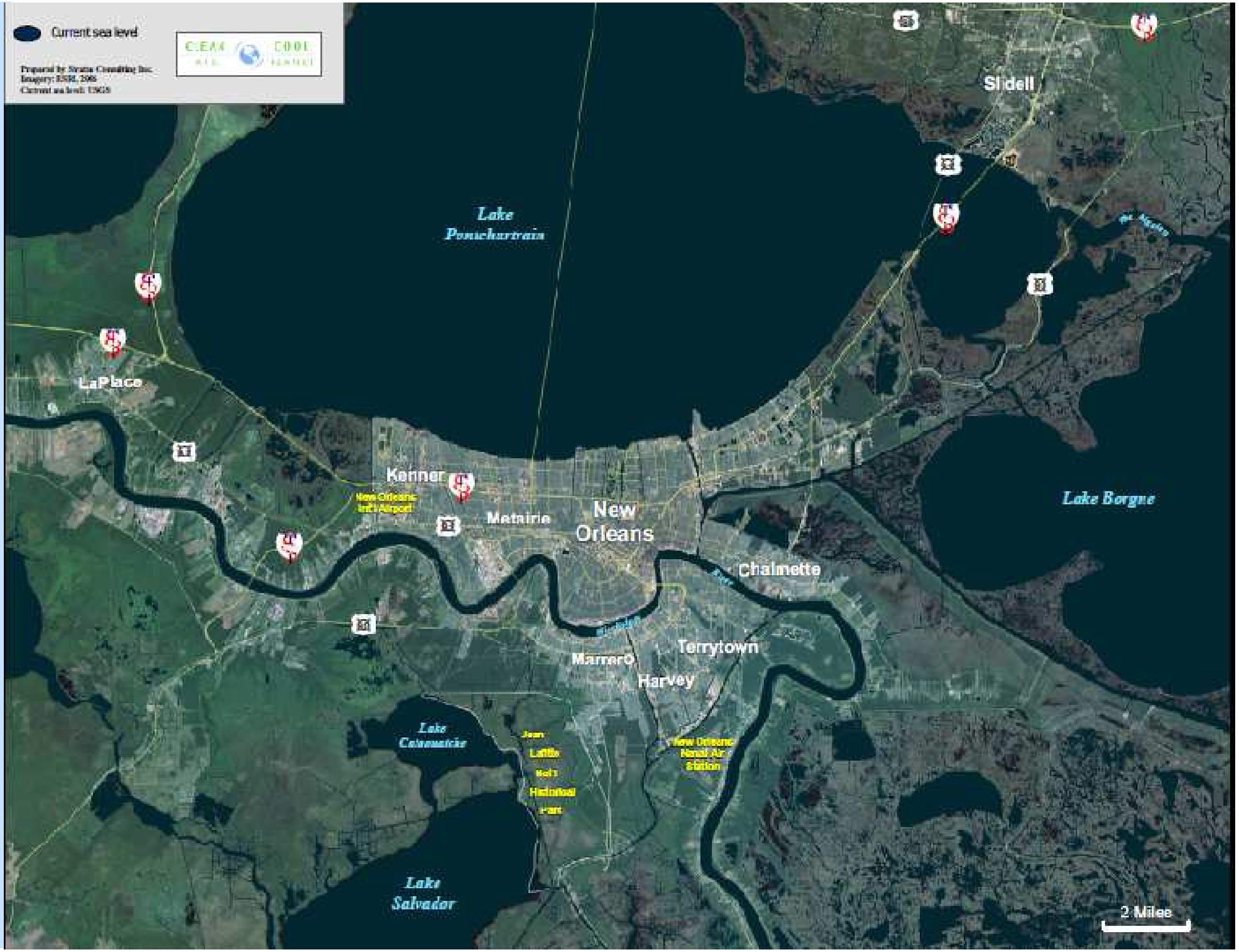
SOURCE: Swiss Re

New Orleans has large water bodies surrounding it today

New Orleans as it is today

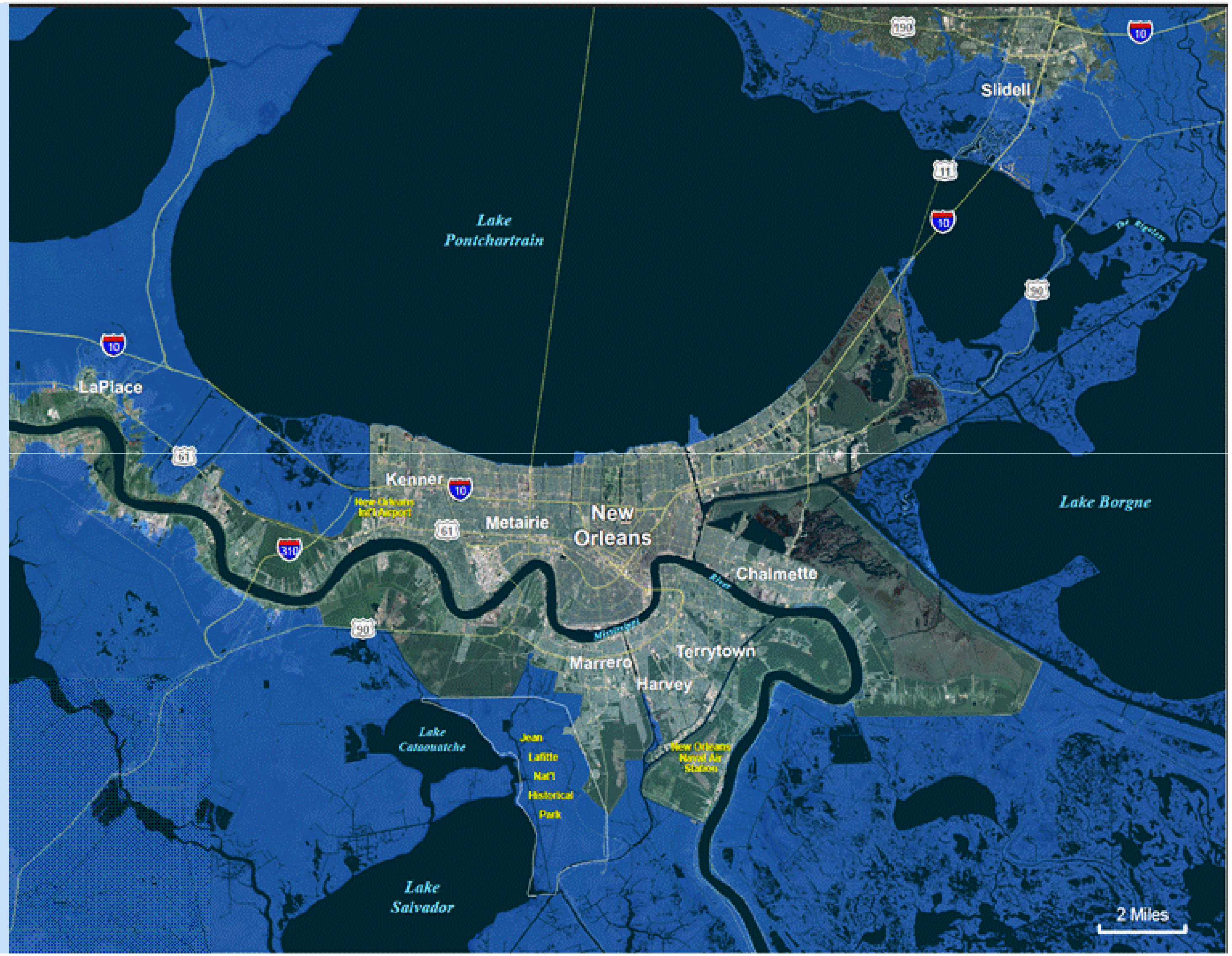
Current Sea Level

Prepared by Stratus Consulting, Inc.
Elevation data: USGS, 2007
Imagery: ESRI, 2006



By 2100, New Orleans may potentially be surrounded by water

Area at risk of inundation from 1-meter (3.3 ft) rise in sea level with 1-meter (3.2 ft) relative sea level rise



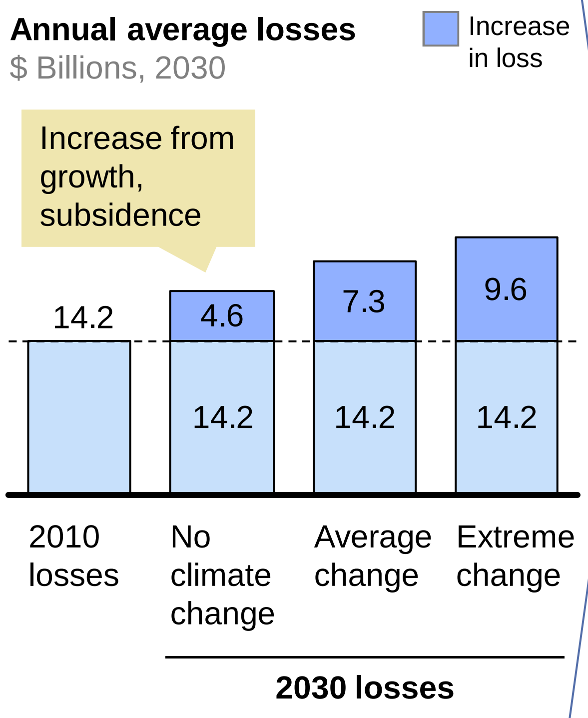
Current Sea Level

Estimated Sea Level

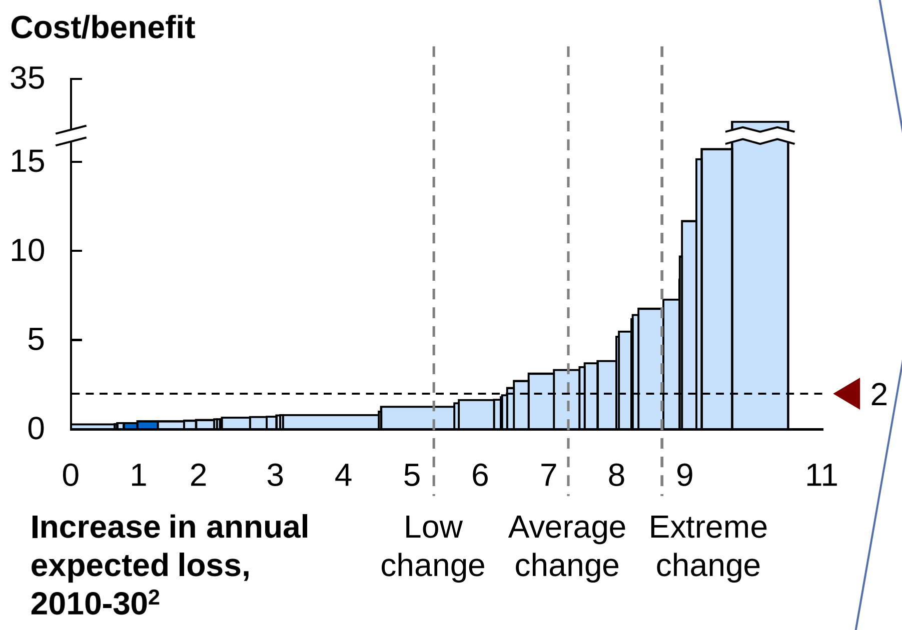
Prepared by Stratus Consulting, Inc.
Elevation data: USGS, 2007
Imagery: ESRI, 2006

In the near-term, potentially attractive measures can address almost all the increase in loss and keep the risk profile of the region constant

In the near-term, losses are expected to increase



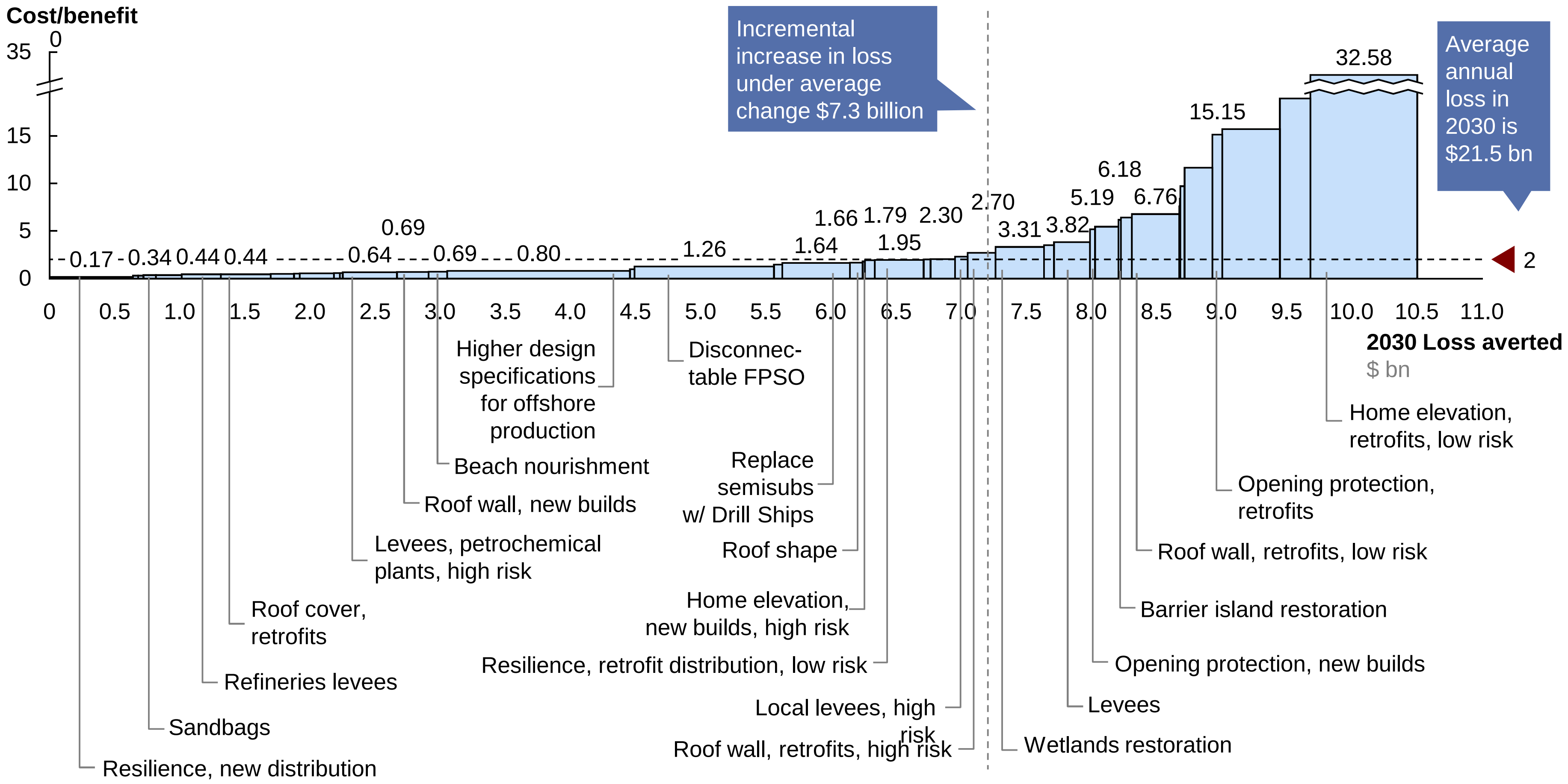
But there are several potentially attractive measures[1] that can address almost all the increase in loss



Investing in these measures will place the Gulf Coast on a resilient path now – that will also help the region over the longer term

1 Defined as measures with C/B<2, that would make sense to pursue based on co-benefits and risk aversion
2 "Low change" and "extreme change" loss increases are scaled, because the cost curve is calibrated to "average change". True "low change" loss increase is $ 4.6 bn, and "extreme change" loss increase is $ 9.2 bn

Potentially attractive measures can address the increase in annual loss between today and 2030 and keep the risk profile of the region constant



Some measures may be considered despite a high cost/benefit ratio because of co-benefits, such as wetlands

BACKUP

There are a range of potential co-benefits

Economic

- Energy efficiency from building codes
- Increased revenue from fishing due to wetlands restoration

Environ-mental

- Increased biodiversity from beach nourishment
- Greenhouse gas emission reductions from building codes

Social

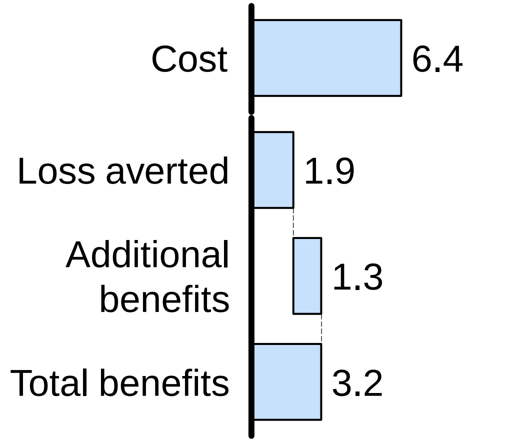
- Increased protection for vulnerable populations through constructing levees

For example, wetlands restoration can generate co-benefits through other environmental services

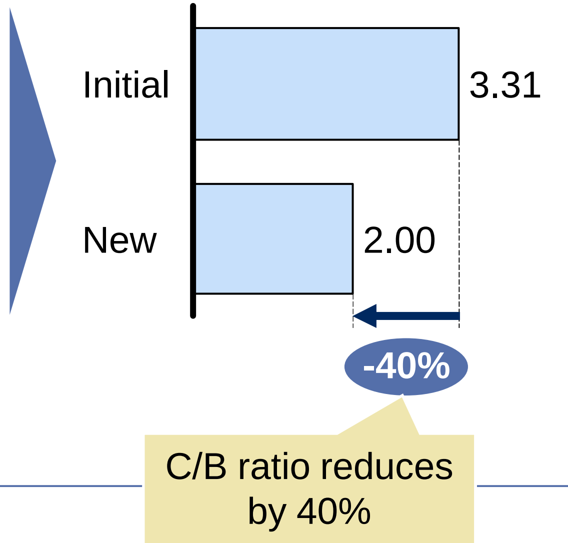
Description

Wetlands restoration generates co-benefits through supporting fishing, leisure, and water purification

Costs and benefits from wetlands restoration[1,2]
$ Billions



Cost-benefit ratio



1 Present value of costs and benefits
2 Estimates of co-benefits from wetlands vary widely between sources; analysis derives from an average across analyses

Source: Valuation and Management of Wetlands Ecosystems, Costanza et al, 1989; *"The Economic Value of the World's Wetlands,"* World Wildlife Foundation, 2004

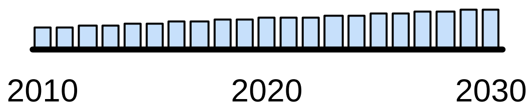
Other measures may be considered despite a high cost/benefit ratio because of risk aversion, such as levees

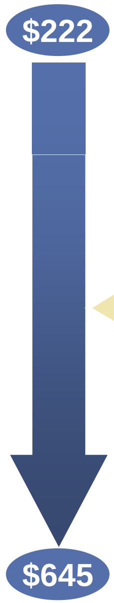
BACKUP

If we assume that a Katrina-scale loss is certain in the next 20 years, the present value of losses will rise

Hypothetical loss profile without Katrina-scale event
$ Billions

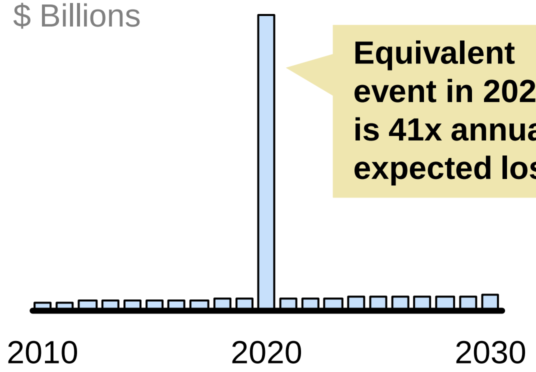
$X NPV of loss, 2010-2030, $ bn





NPV of loss increases by a factor of 2.9x

Hypothetical loss profile with Katrina-scale event
$ Billions

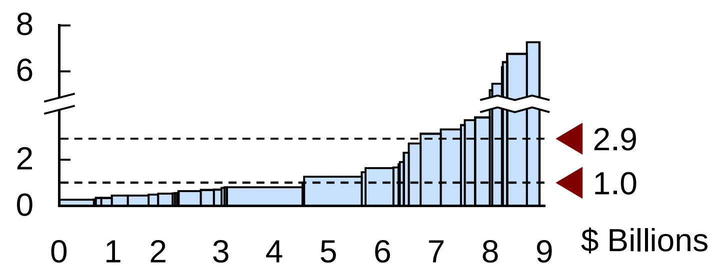


Equivalent event in 2020 is 41x annual expected loss

Increase in loss will cause measures to be more attractive (since more loss is averted)

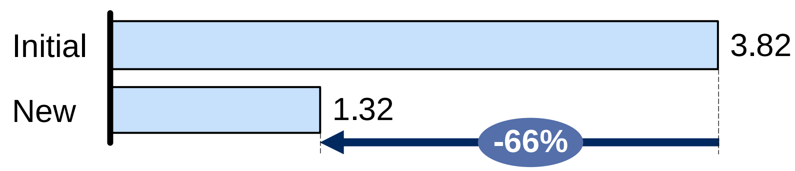
Measures with C/B ratios of up to ~2.9 will become attractive

Cost/benefit

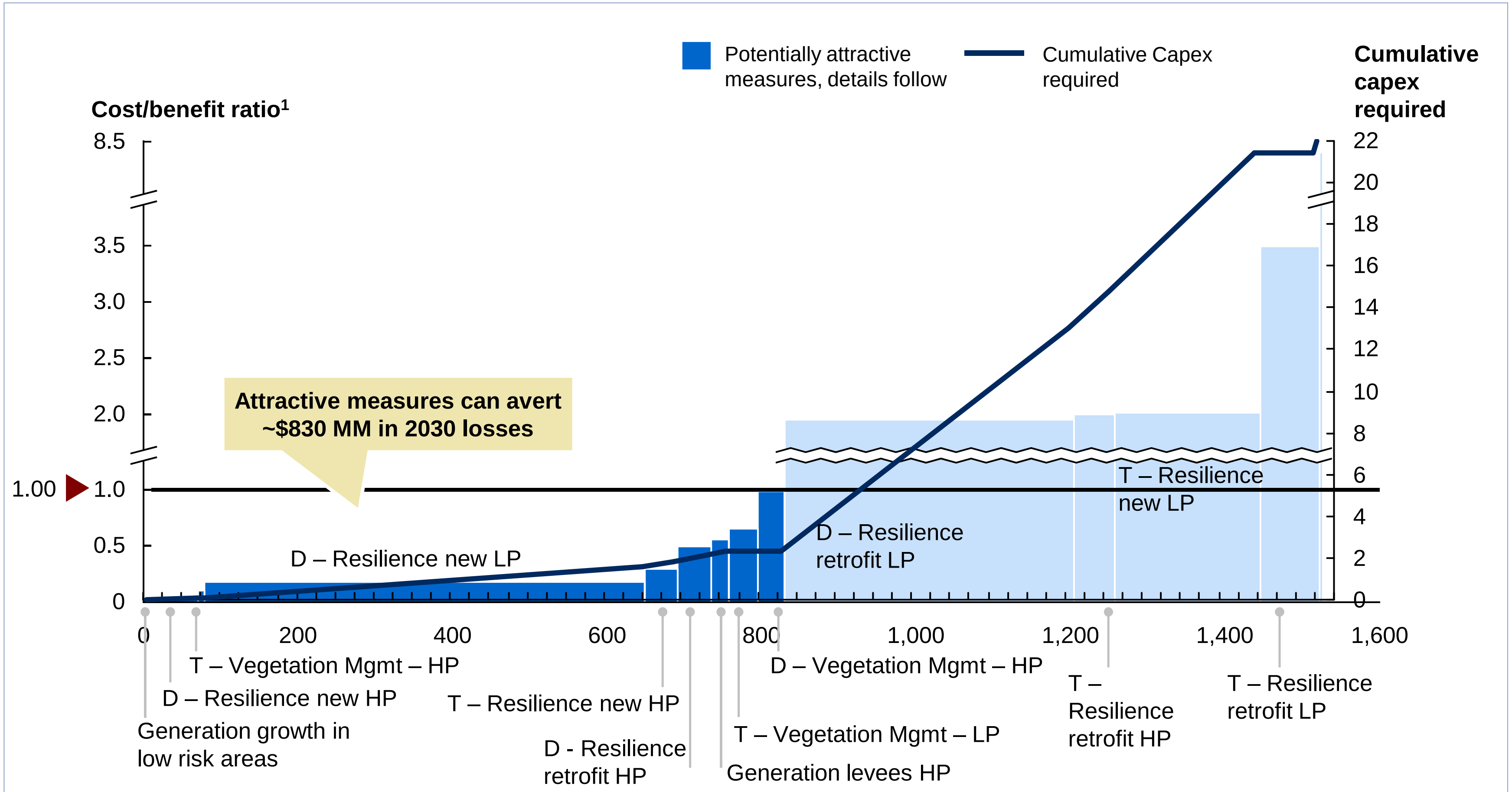


For example, levees reduce risk for the overall economy, and merit consideration from a risk aversion standpoint

Cost-benefit ratio, levees



Cost beneficial utility measures can address $830 million of loss in 2030

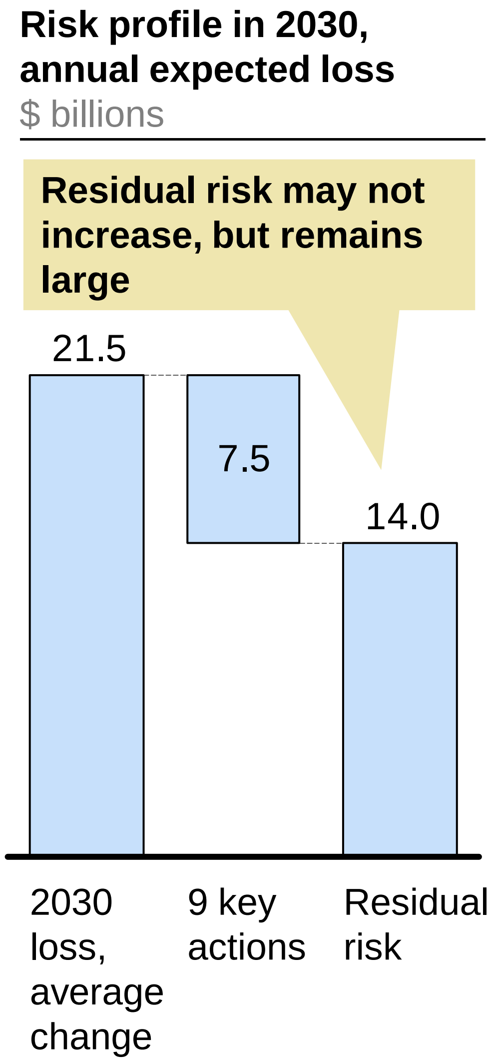


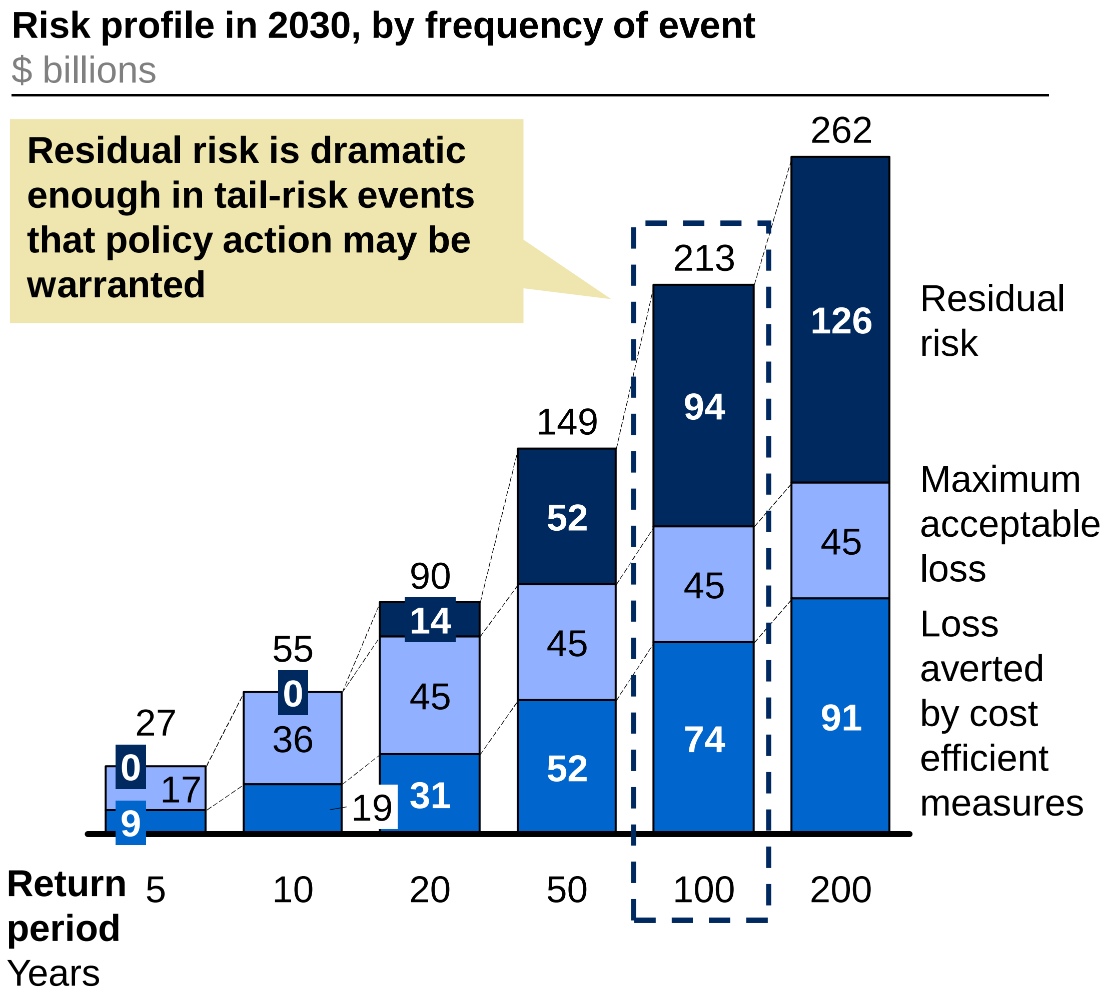
- Resilient distribution lines (both new builds and retrofits) are key actions
- Vegetation management has potential to reduce losses at C/B < 1
- Transmission resilience efforts tend to be attractive only in high risk areas

Note: HP refers to High Priority areas (zip codes with high average losses) ; LP refers to Low Priority areas (zip codes low average losses)
1 Benefits include utility property damage + utility business interruption + commercial and non-energy industrial business interruption aversion

Source: Swiss Re

Even after the measures are put in place, there is still residual risk to address, especially related to tail risk events





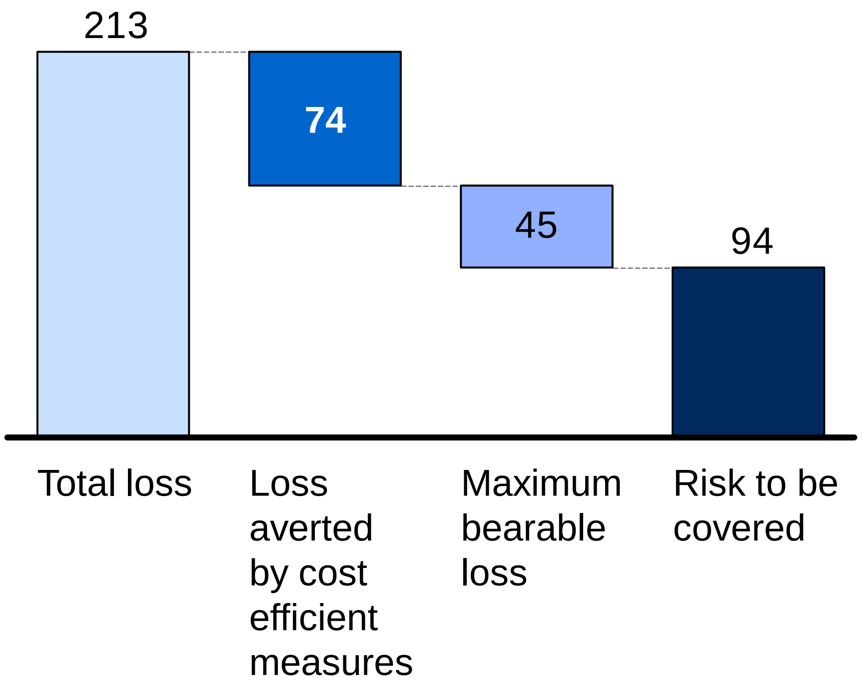
1 There is some uncertainty around the future extent of insurance coverage

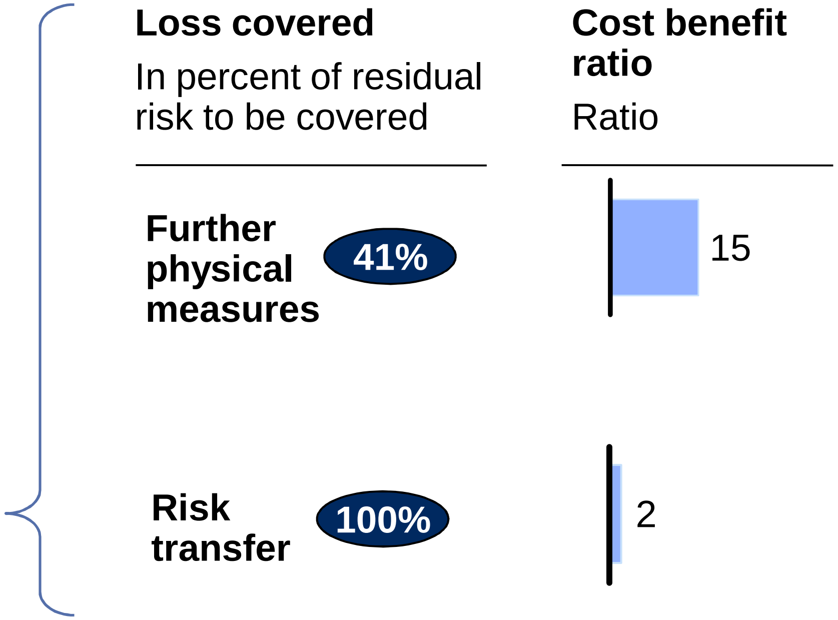
Source: Swiss Re, Wharton Project on Managing and Finance; Sigma database

Risk transfer may be more cost efficient than physical measures in providing financial coverage for low frequency events

Example of evaluation of alternative options to cover residual risk

Loss for 100-year event
$ Billions



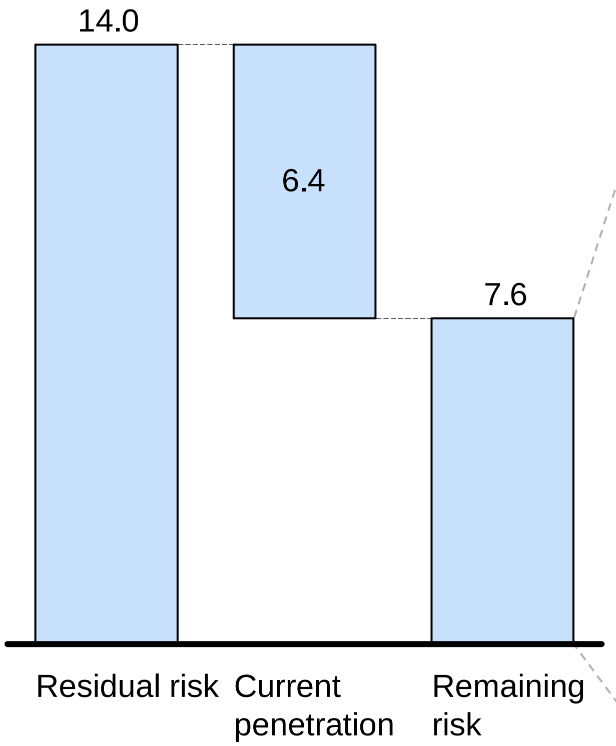


Risk transfer offers the full desired level of coverage and is more cost-effective than remaining physical measures

Source: Swiss Re, Wharton Project on Managing and Finance; Sigma database

While some residual risk is already managed through conventional insurance, other risk will require policy action

$ Billions



Potential actions to transfer risk

Increasing coverage by decreasing risk
- Implementing other measures will decrease the expected loss, lowering premiums and increasing the affordability of insurance

Decreasing the prevalence of underinsurance
- Providing incentives to update the insured value of homes will prevent asset appreciation from decreasing insurance penetration

Enhancing self-insuring low-value, high-frequency risks
- For large entities, self-insurance may be more cost effective than purchasing insurance

Transferring top-layer risk
- Catastrophe bonds or reinsurance can effectively transfer risk for high-value, low-frequency risks

Source: Swiss Re; Wharton Project on Managing and Finance; Sigma database; expert interviews