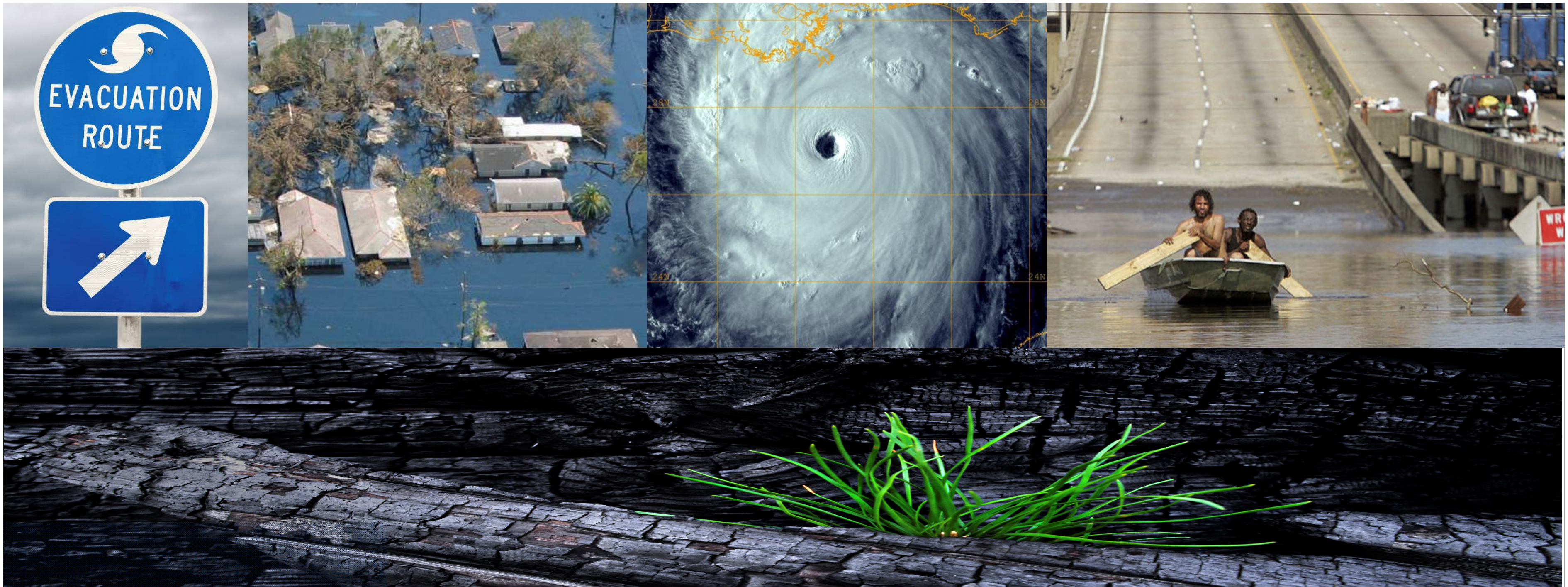

Increasing resilience to natural hazards: framework for utility and societal impacts

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HEPG discussion

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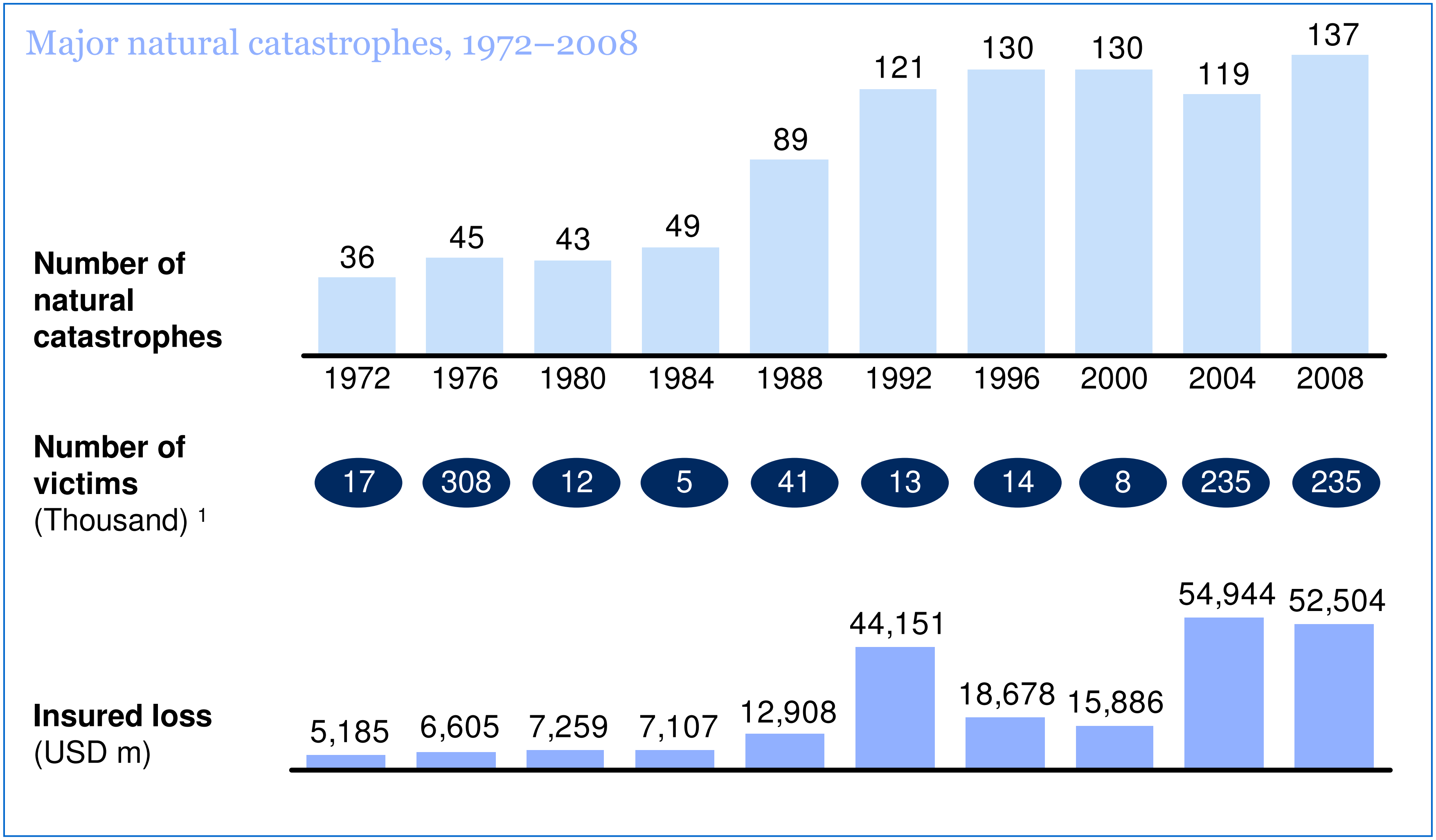
McKinsey&Company

Executive summary

- **Damages from natural hazards are rising**, given the growing propensity to put high value structures in high risk areas, increasing building density, and aging infrastructure.
- **Utility customers have increasingly been exposed to to natural hazard risk and second order effects** (Gulf, Northeast, Florida, West Coast)
- **To put a fact-base approach to determining risk, McKinsey has done significant work on the economics of natural hazards in collaboration with Swiss Re,** and developed approaches to help understand risk resilience.
- **The approach has several purposes, including helping utilities and PUCs better quantify their economic risk from natural hazards;** using advanced analytic techniques, we quantify the size of the potential risk and develop estimates for needed system improvements the reduction in the risk level they can provide.
- **The approach is meant to facilitate a discussion with a broader stakeholder group beyond utilities and PUCs.** Our work typically involves analysis of all infrastructure in a geography (not just utility assets). This helps engage PUCs, utilities and other stakeholders in a meaningful discussion on how to best mitigate risk across the whole system.
- We have applied this to a number of regions—**we will draw from our work in the Gulf Coast as the case example for today's discussion**

Globally, natural hazard-related losses have been increasing, primarily driven by increasing economic development in the riskiest areas



1 Dead and missing

SOURCE: SwissRe sigma catastrophe database

We use a 3-step process using a unique data set and probabilistic modeling capability – across a range of scenarios

Modules	Description	Calculation	Output
H – Hazard module	Severity and frequency of hazard(s)		
VA – Value module	Value of assets, economic output	H x VA x V	Economic loss – both expected losses and distribution across potential scenarios
V – Vulnerability module	Vulnerability curves for different assets, economic output based on hazard severity		

SOURCE: SwissRe and McKinsey

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

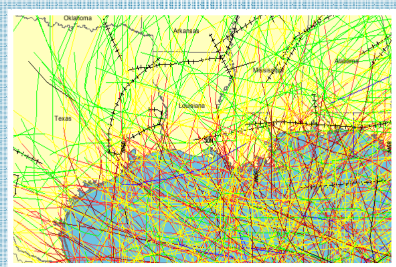
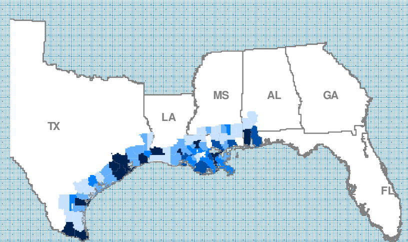


Illustration of hurricane paths/ intensities

- **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)

There is greater than $2 trillion in asset value along the energy Gulf Coast

Key areas examined within 70 miles of the coast

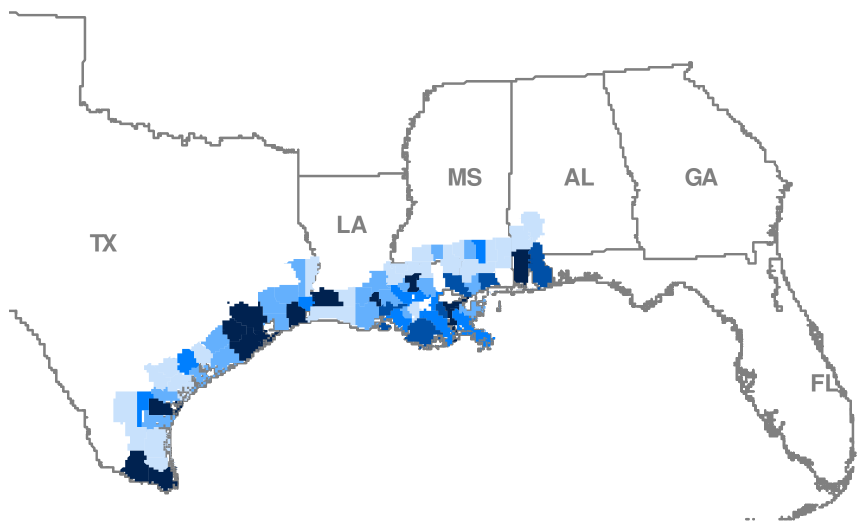
US Gulf Coast region and counties in scope[1]

2010 GDP ($M)

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

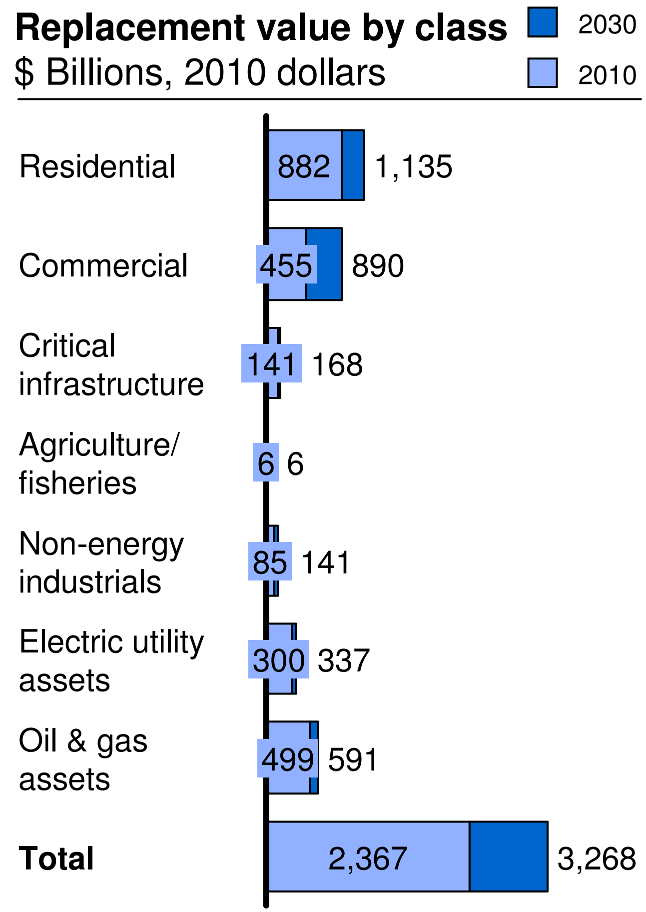
Basic metrics

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



Asset values by class

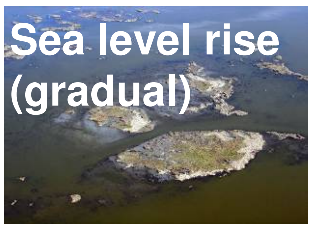
Replacement value by class
$ Billions, 2010 dollars



1 Includes 30 Louisiana parishes

Source: ESRI; Energy Velocity

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

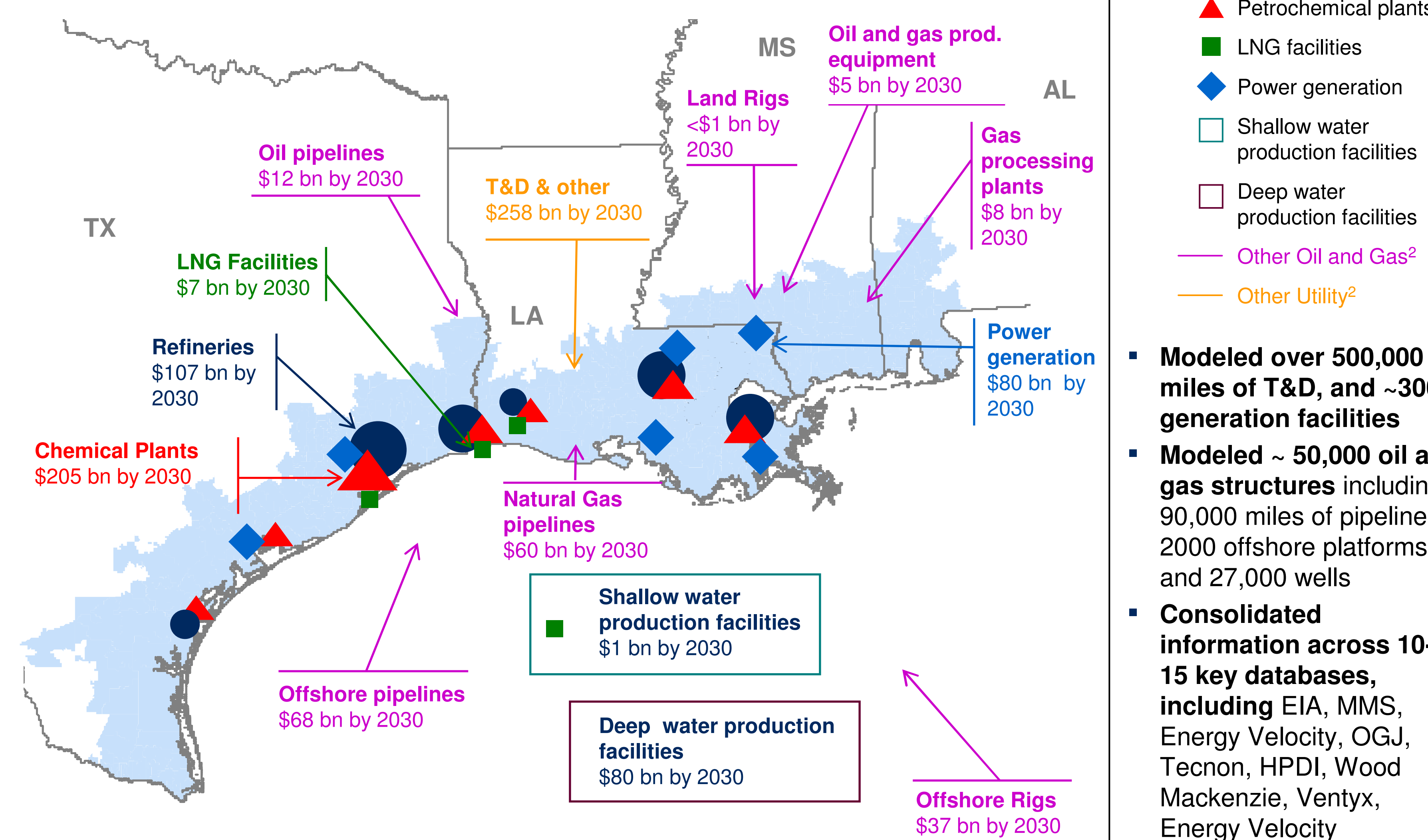
Hazards	Brief overview	Effect of climate change
	▪ **Damage can occur across the Gulf Coast region** and in areas further inland	▪ Potential **increase in wind speed of 1.4-2.9% in 2030** (2.1 - 10.2% in 2100) due to warmer sea surface temperatures
	▪ **Key risk is along the coastline** ▪ The Louisiana 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 conducted a granular analysis of all infrastructure in the geography

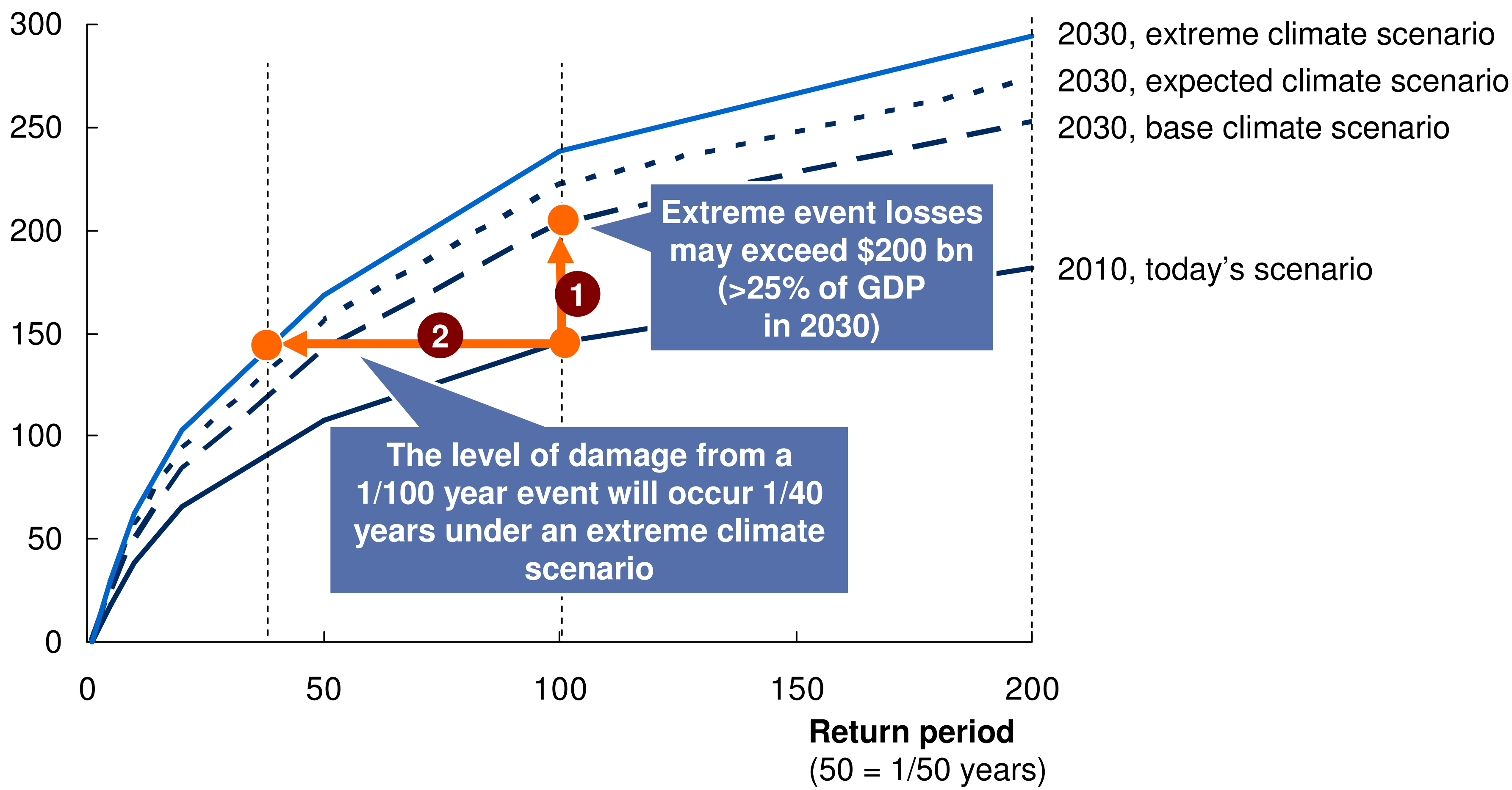
View of Gulf Coast Energy assets, 2030



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

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

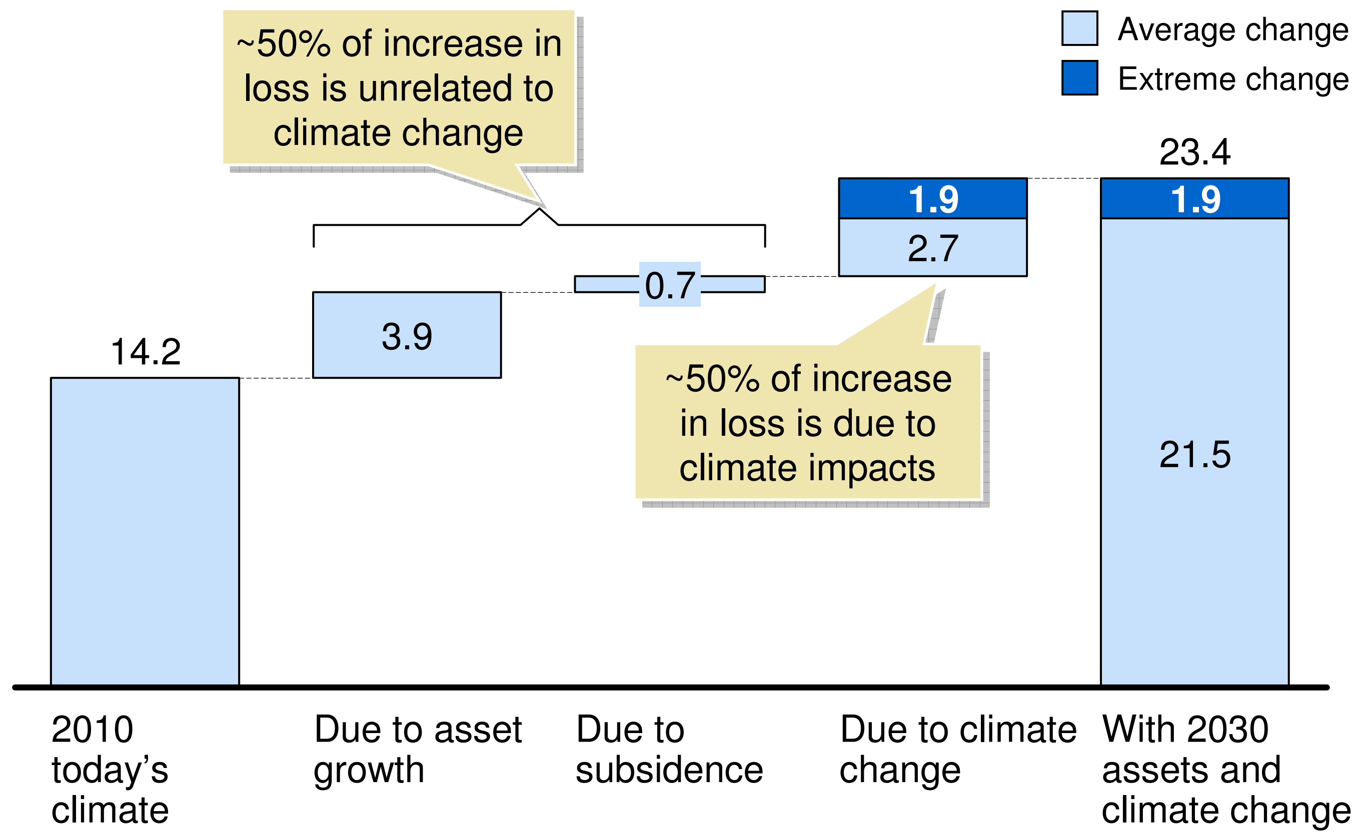
Loss frequency curve for annual loss
$ Billions; 2010 dollars



Source: McKinsey team analysis; Swiss Re; Press searches

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



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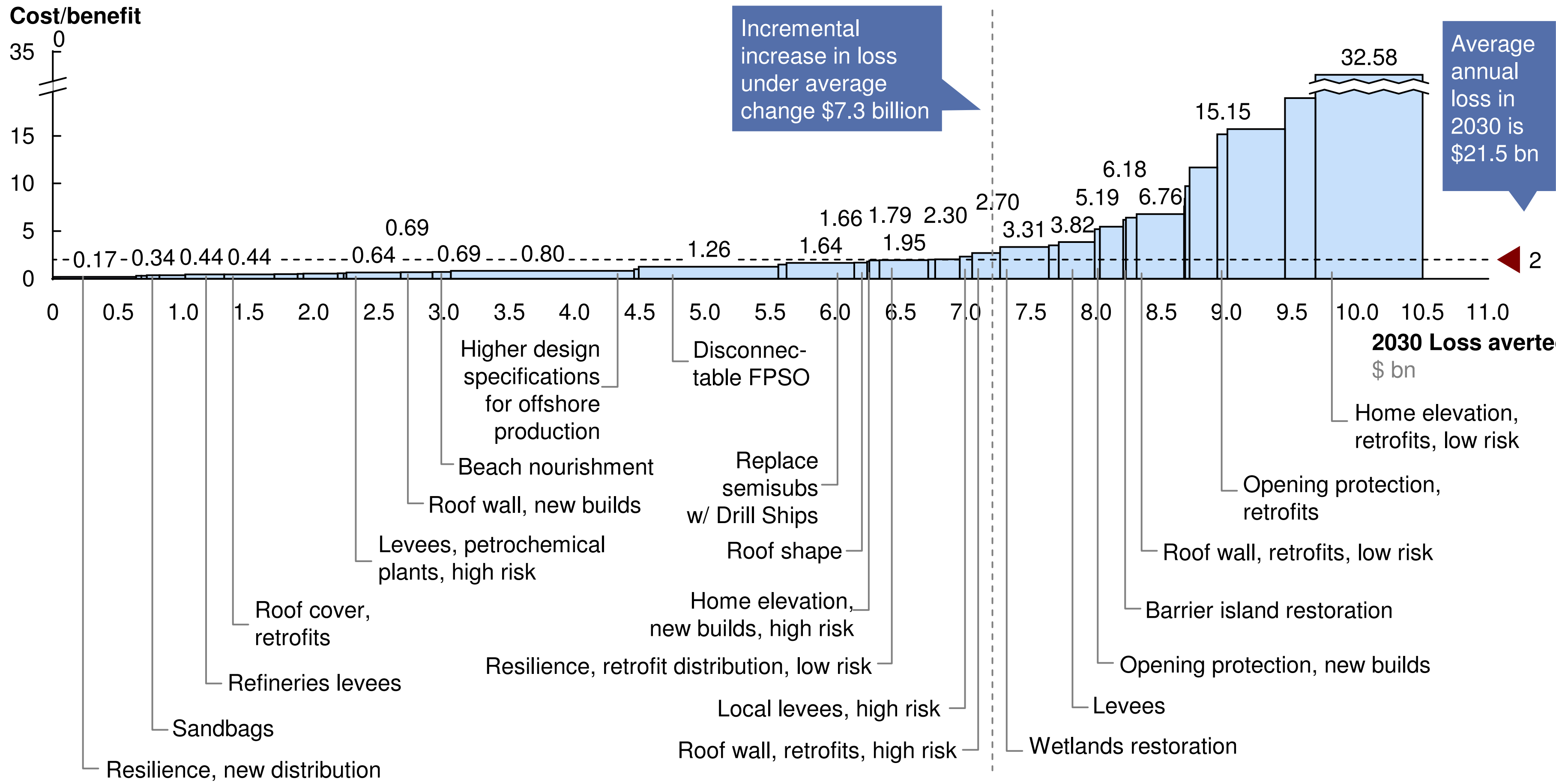
Source: McKinsey team analysis; Swiss Re; Press searches

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



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We assessed potential risks to the utility and identified economically attractive capex investments to increase T&D resilience

	Capex needed $ millions, 2010	Loss averted $ millions, 2010	Total cost/ benefit[1] Ratio
New plants in low risk areas	0	70	0.0
D - Hardening new HP	47	1,142	0.05
T - Vegetation Mgmt - HP	0	145	0.1
D - Hardening new LP	1,552	9,803	0.2
T - Hardening new HP	224	732	0.3
D - Hardening retrofit HP	324	751	0.5
Generation levees HP	189	388	0.6
T - Vegetation Mgmt - LP	0	644	0.7
D - Vegetation Mgmt - HP	0	599	1
Total	**2,336**	**14,275**	

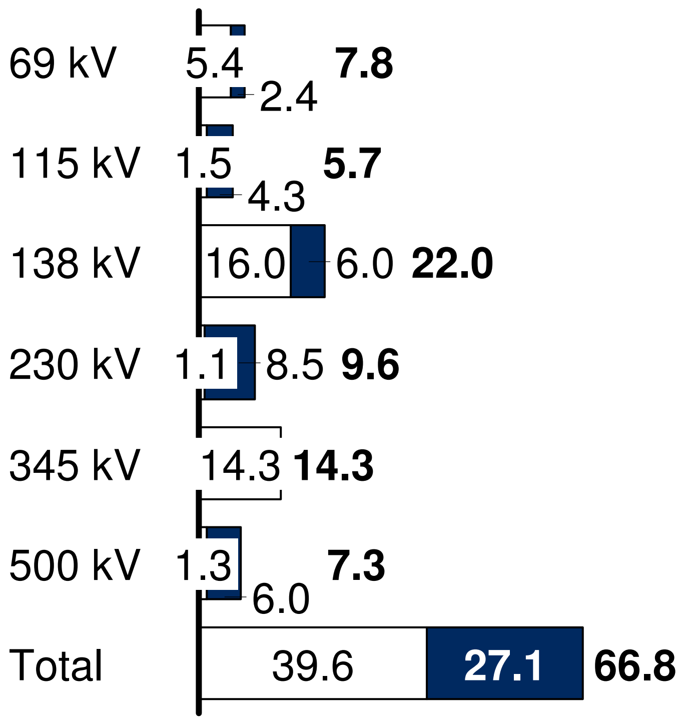
1 Includes all costs and benefits in NPV terms

Source: McKinsey team analysis; Swiss Re; Press searches

Transmission example: exposure based on replacement value

Drylands, 2010
Wetlands, 2010
2010 value
2030 value

Miles of transmission, 2010
Thousands of miles



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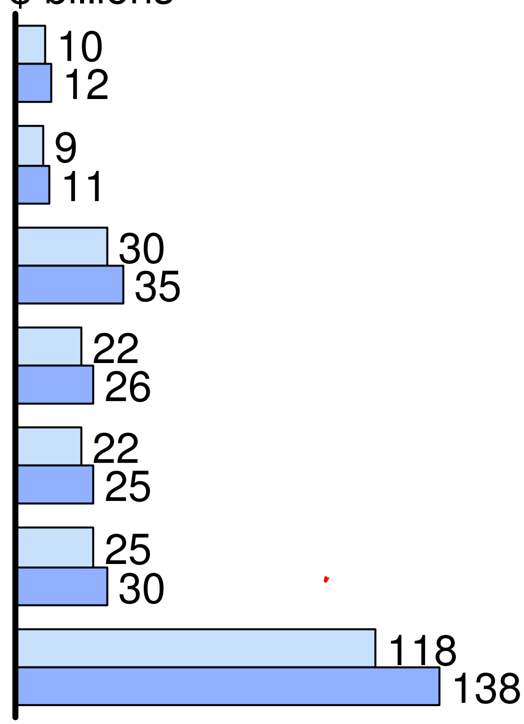
Total replacement value, 2010 v. 2030
$ billions

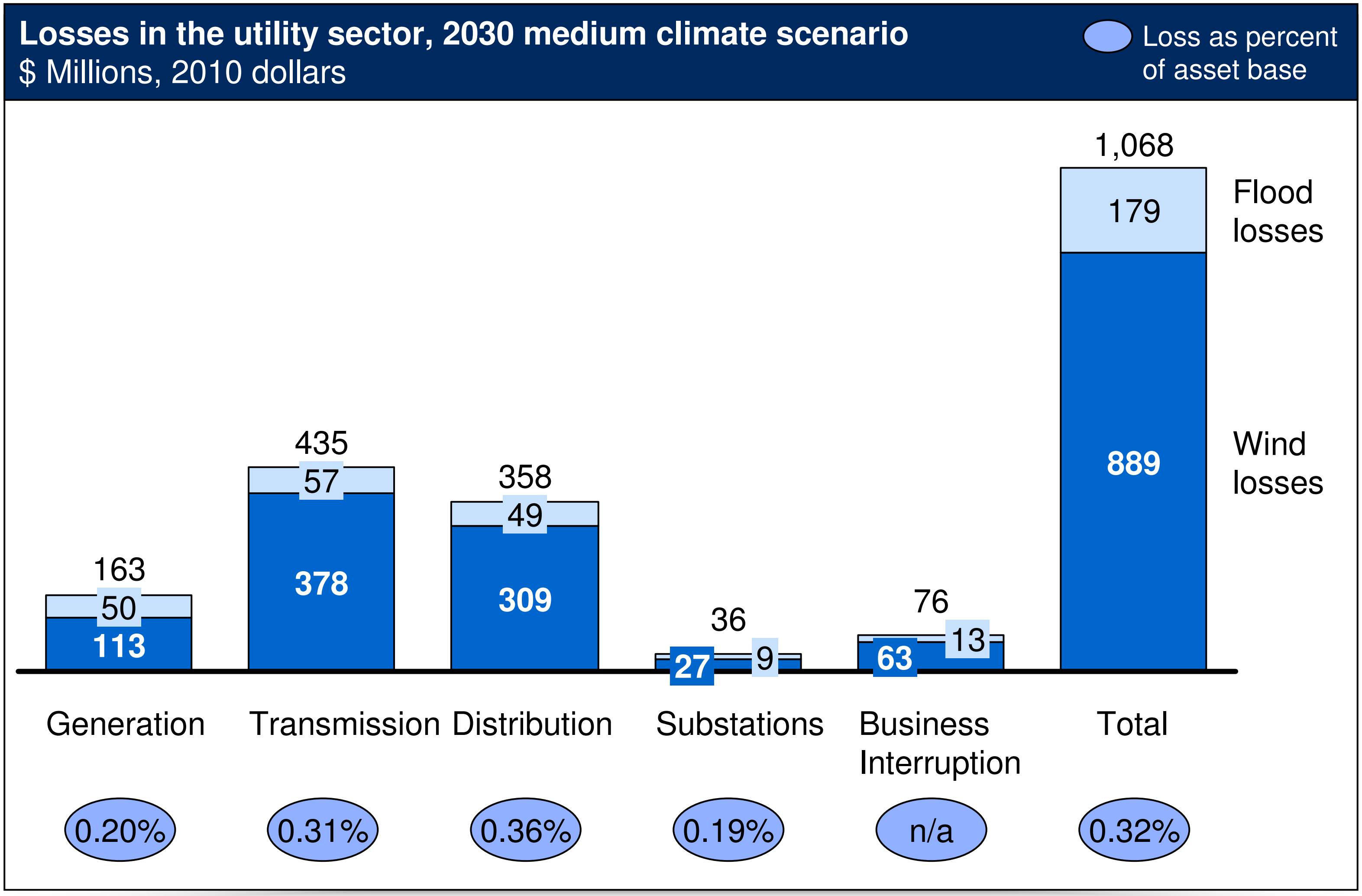


2030 values are based on 2010-2030 growth in generation (22%)

SOURCE: Energy Velocity, Ventyx, Platts, DOE Annual Energy Outlook, ERCOT Long-Term Systems Analysis, ISTEP, Handy-Whitman index, client data, expert interviews, team analysis

Utility economic loss is driven by impact to transmission and distribution assets

Swiss Re



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SOURCE: Energy Velocity; Ventyx; AEO; ERCOT Long-Term Systems Analysis; Client data; Expert interviews; Swiss Re; Team analysis

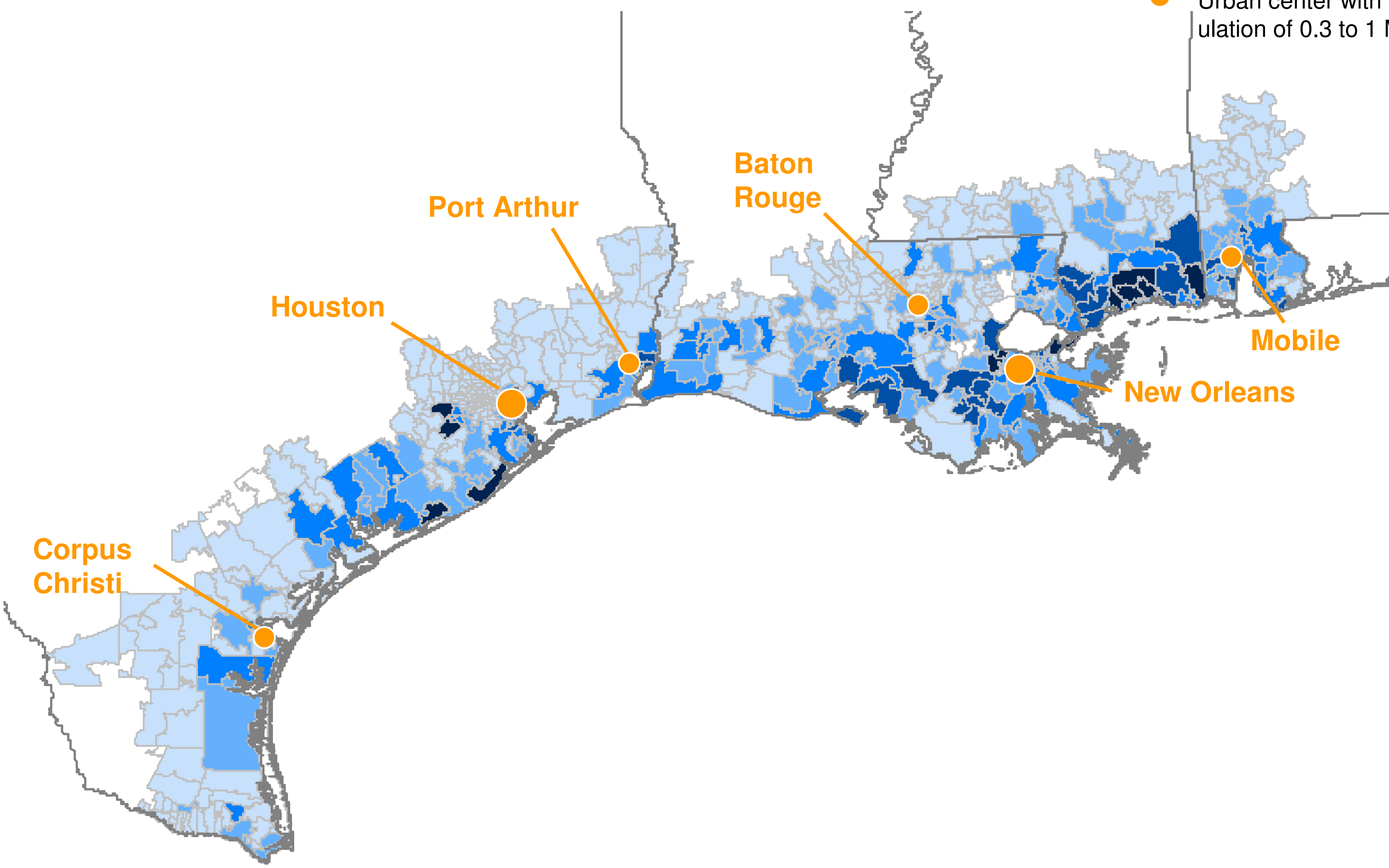
Electric utility assets

Utility losses are relatively widespread across the region

Swiss Re

Utility annual average expected losses across the U.S. Gulf Coast 2030

Average climate change



- Urban center with population of 1 MM+
- Urban center with population of 0.3 to 1 MM

Losses
$ MM, 2010 $

- >8
- 4-8
- 2-4
- 1-2
- 0-1
- 0

SOURCE: Swiss Re; Team analysis

We also identified “beyond the utility” actions to reduce societal risk

Category	#	Action	Loss averted, 2010-30 ($ Billions)	CapEx required[2] ($ Billions)	Average C/B ratio
Residential/ commercial	1	Improved building codes	23.4	12	0.7
Infrastructure/ Environmental	2	Beach nourishment	2.4	1	0.7
	3	Wetlands restoration1	6.4	25	3.3
	4	Levee systems1	4.7	18	3.8
Oil and gas	5	Improved standards for offshore platforms	28.7	16	0.7
	6	Floating production systems	18.4	18	1.3
	7	Replacing semi-subs with drill ships	8.9	11	1.6
	8	Levees for refineries and petrochemical plants	12.9	5	0.5
Electric utility	9	Improving resilience of electric utility systems	14.2	2	0.4
		Total	**127.4**	44 (public) / 64 (private) / **108**	

Legend: X Average C/B ratio; Public funding; Private funding

Public sector may need to support or incentivize some private capital investment flows, e.g., by supporting homes in low-income areas built to higher building codes

1 Included despite high C/B ratios due to strong co-benefits, risk aversion
2 Total capital investment, non-discounted, across 20 years
3 Includes all costs and benefits in NPV terms

Source: McKinsey team analysis; Swiss Re; Press searches