Natural Gas Delivery Reliability

An Historical Assessment of Incidents, Outages and Major Disruptions on Natural Gas Transmission System from 2005-2015

35TH USAEE/IAEE NORTH AMERICAN CONFERENCE

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Background: Electric Grid Increasingly Dependent on Just-in-Time Natural Gas

- Delivery infrastructure (pipelines and storage) have become potential single points of failure for electric reliability
- Gas dependency prompted calls for maintaining “fuel diversity” and supporting generators with onsite fuel storage
  - Natural gas industry considered reliable but limited data available to quantify outage rates leads to worries about catastrophic outage impacts
  - DOE studied need for baseload power in “60-day study”
  - FERC considering subsidizing plants with on-site fuel storage to mitigate fuel disruptions
- Project collects initial reliability track record of incidents and outages frequency on natural gas transmission to assess disruption risk

Natural Gas Delivery Reliability Assessment to Inform Generation Fuel Disruption Planning

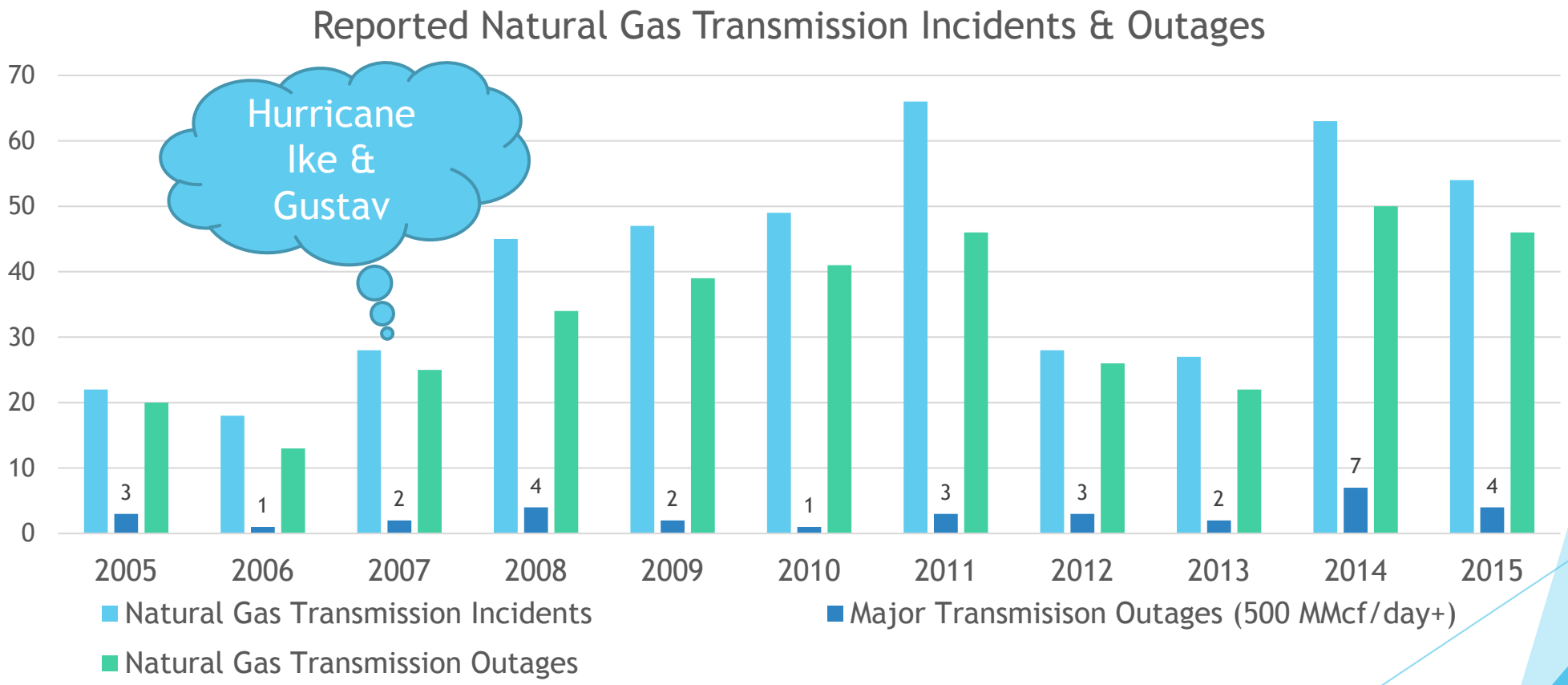
This study is

- Historical review of public information on gas disruptions and damage (2005-2015) based on U.S. Department of Energy Office of Electricity's Energy Assurance (EA) report database
- Compilation of natural gas transmission, delivery and storage incidents
- Categorization of incidents and outages by volumetric impact: outage, major outage, force majeure
- Identification of the common causes of damage to and outages

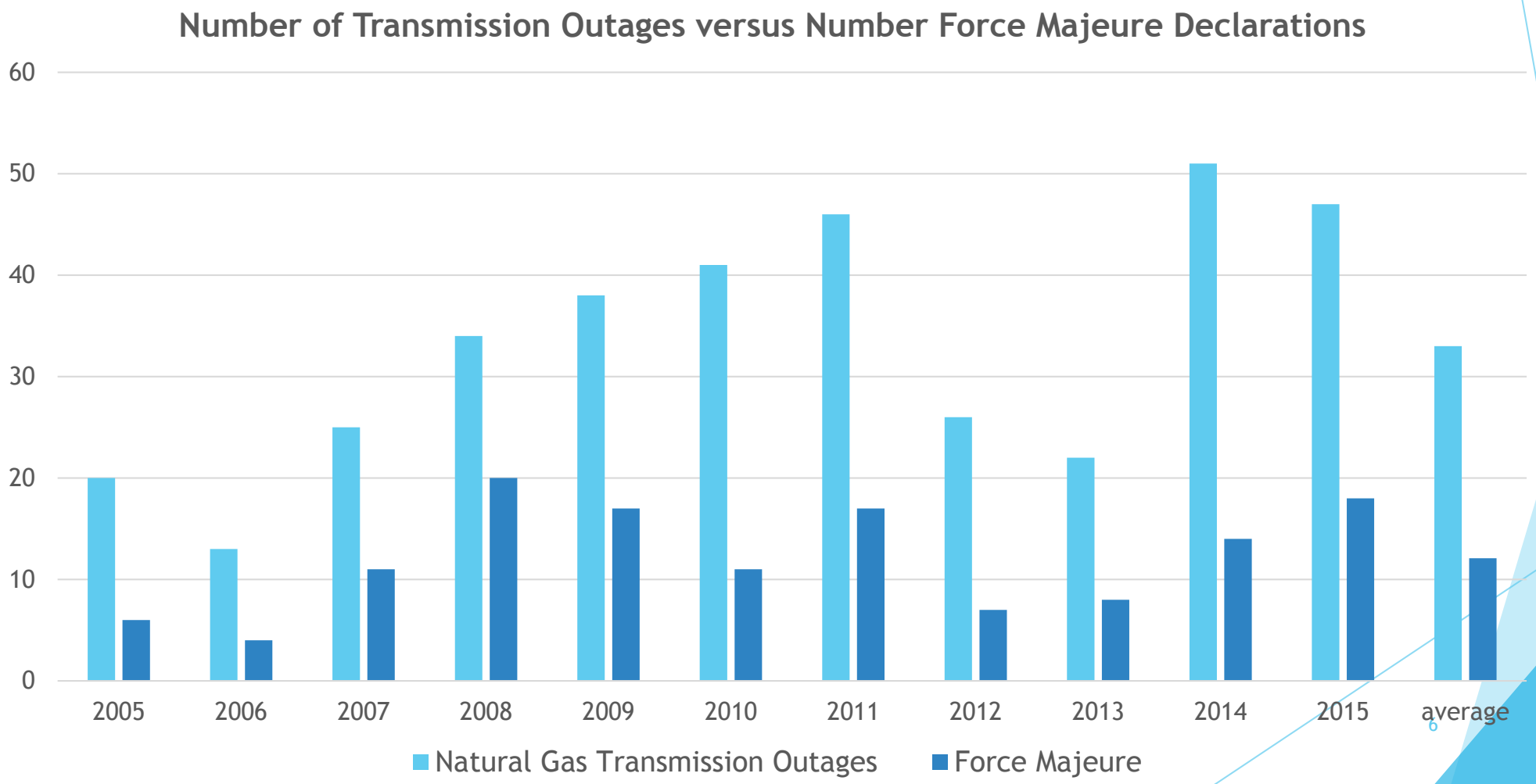
This study is not

- An assessment of company-specific data or proprietary information
- Information on accidents, injuries and costs related to natural gas industry activities
- Description of full downstream impacts of each incident, *i.e.* this does not show how much natural gas did or did not make it to customers' burner tip
- An estimate of downstream impacts of natural gas disruptions

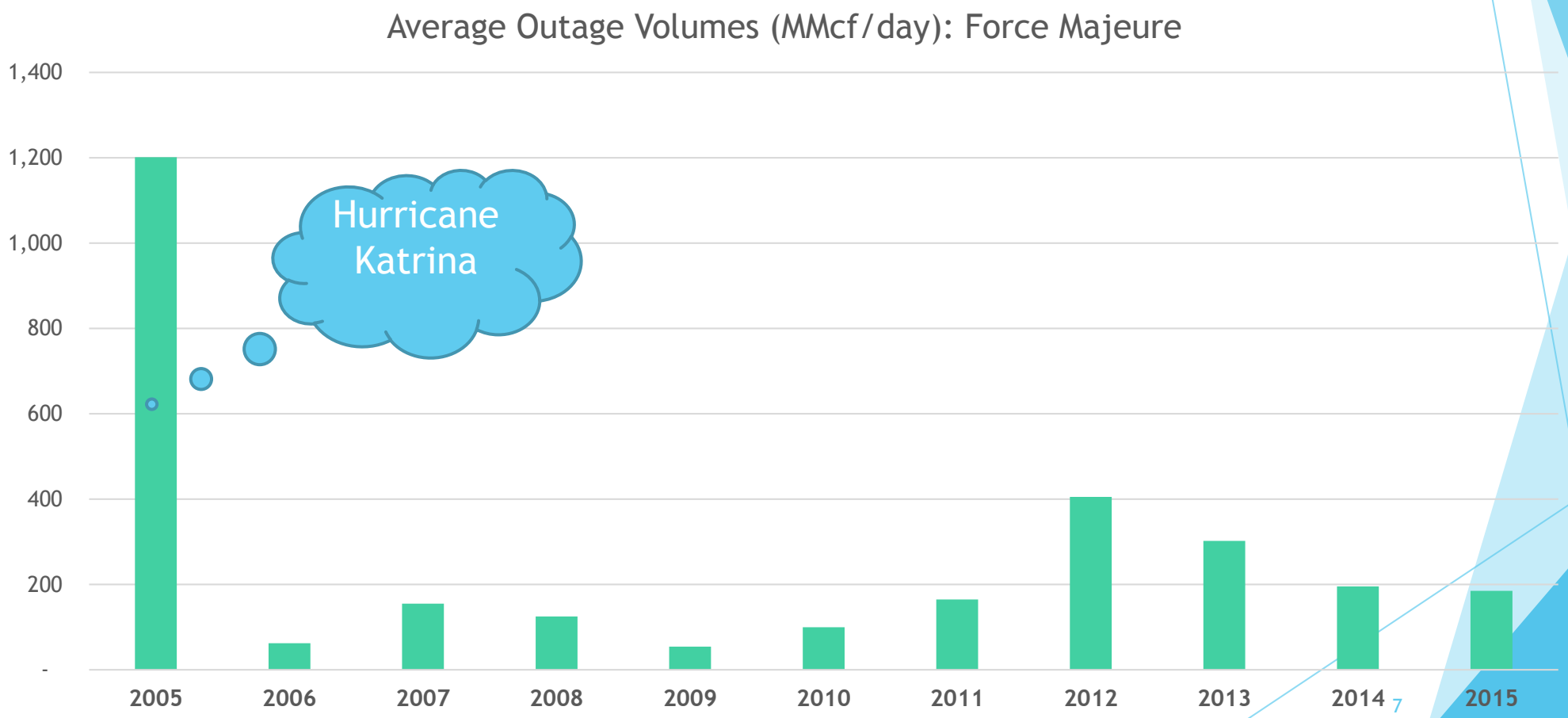
Reliability: Major Natural Gas Transmission Outages Relatively Rare



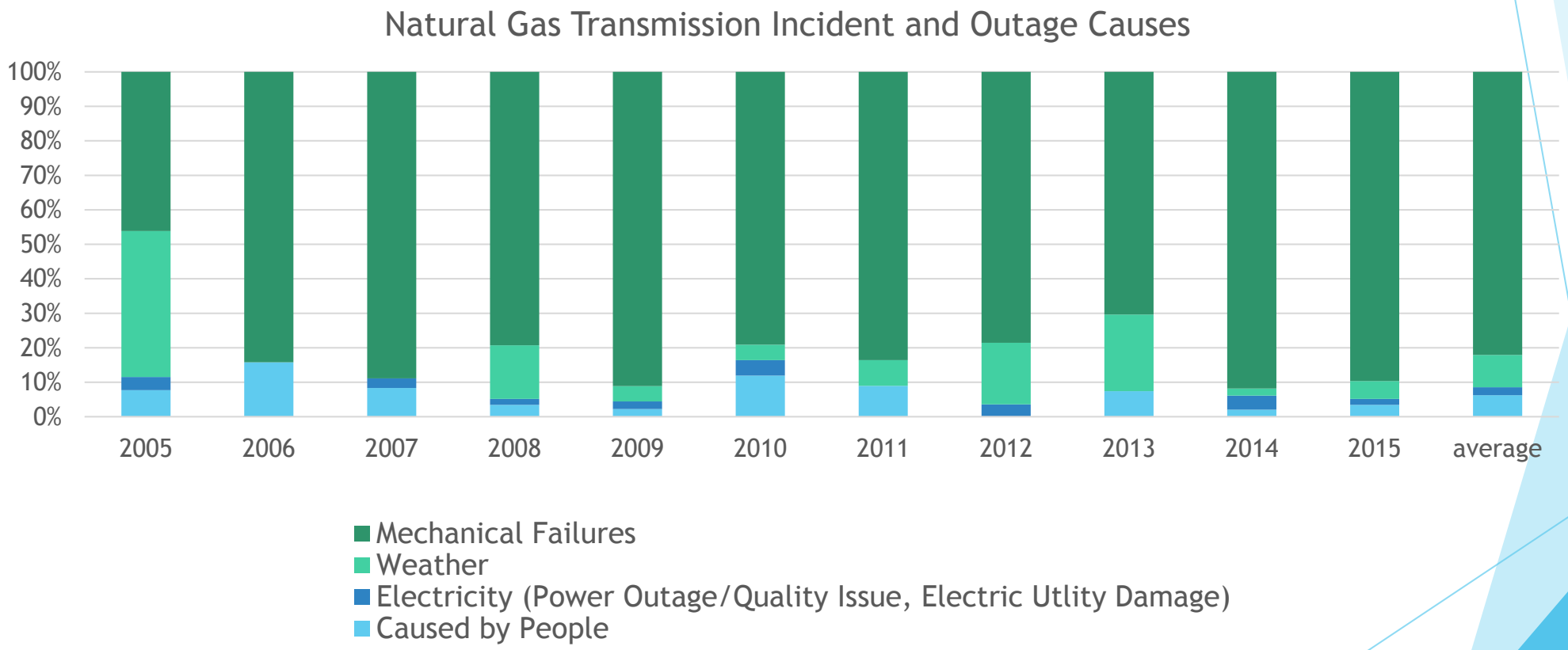
Resilience: Most Pipeline Incidents Do Not Prevent Shippers From Using Capacity



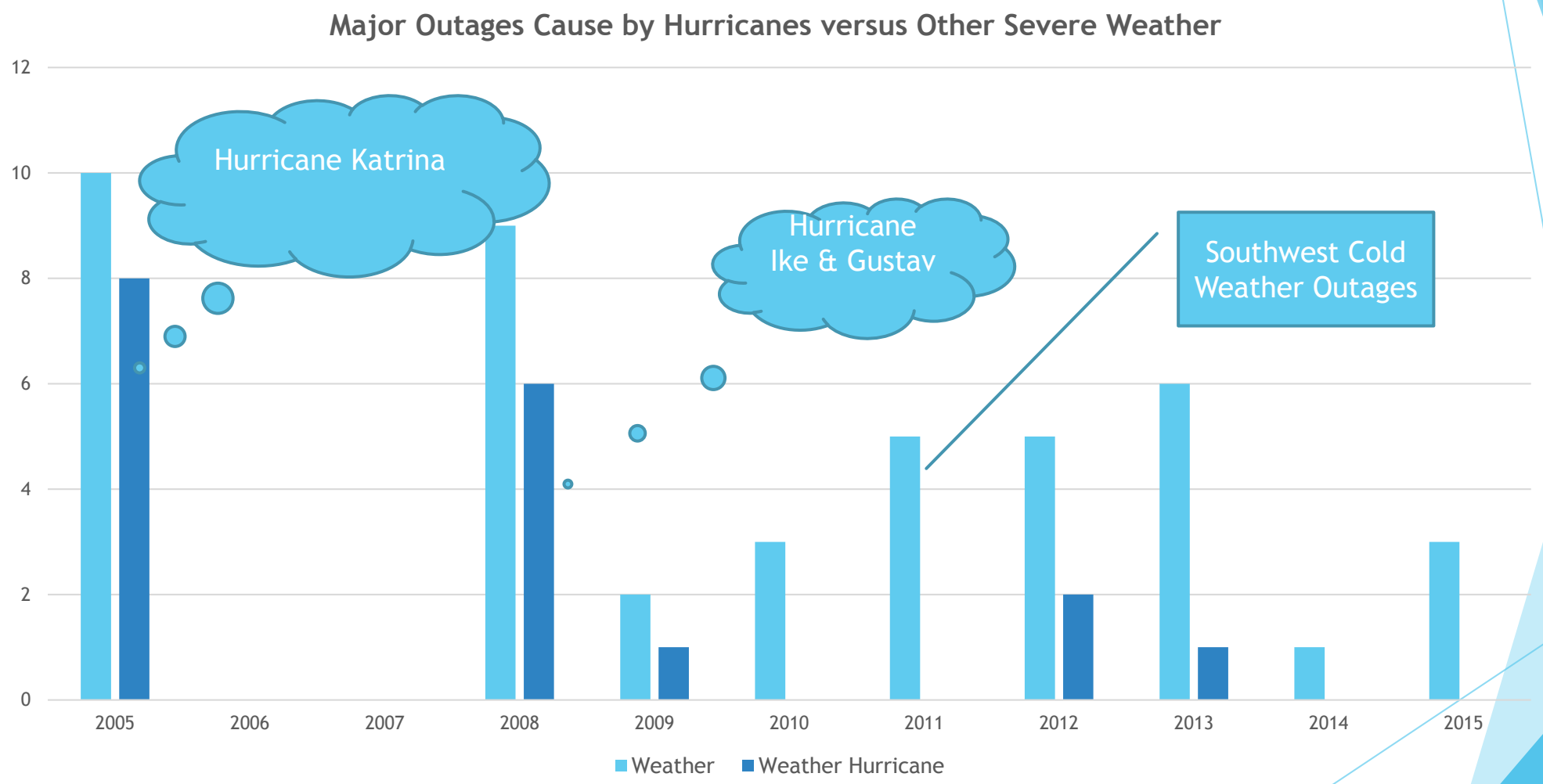
Resilience: Force Majeure Outages Impose Small Volumetric Impacts



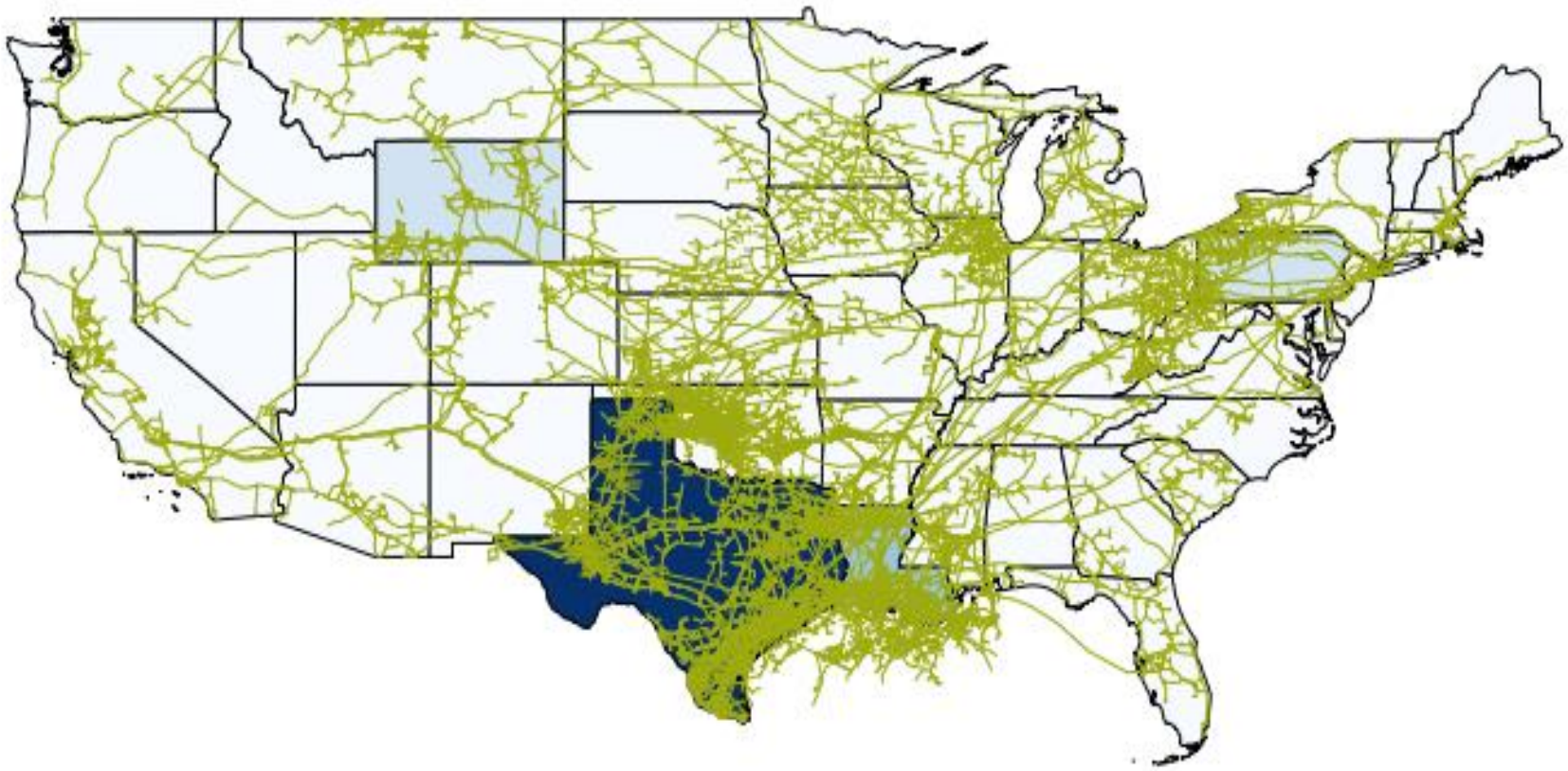
What causes incidents, outages and disruptions on natural gas transmission?



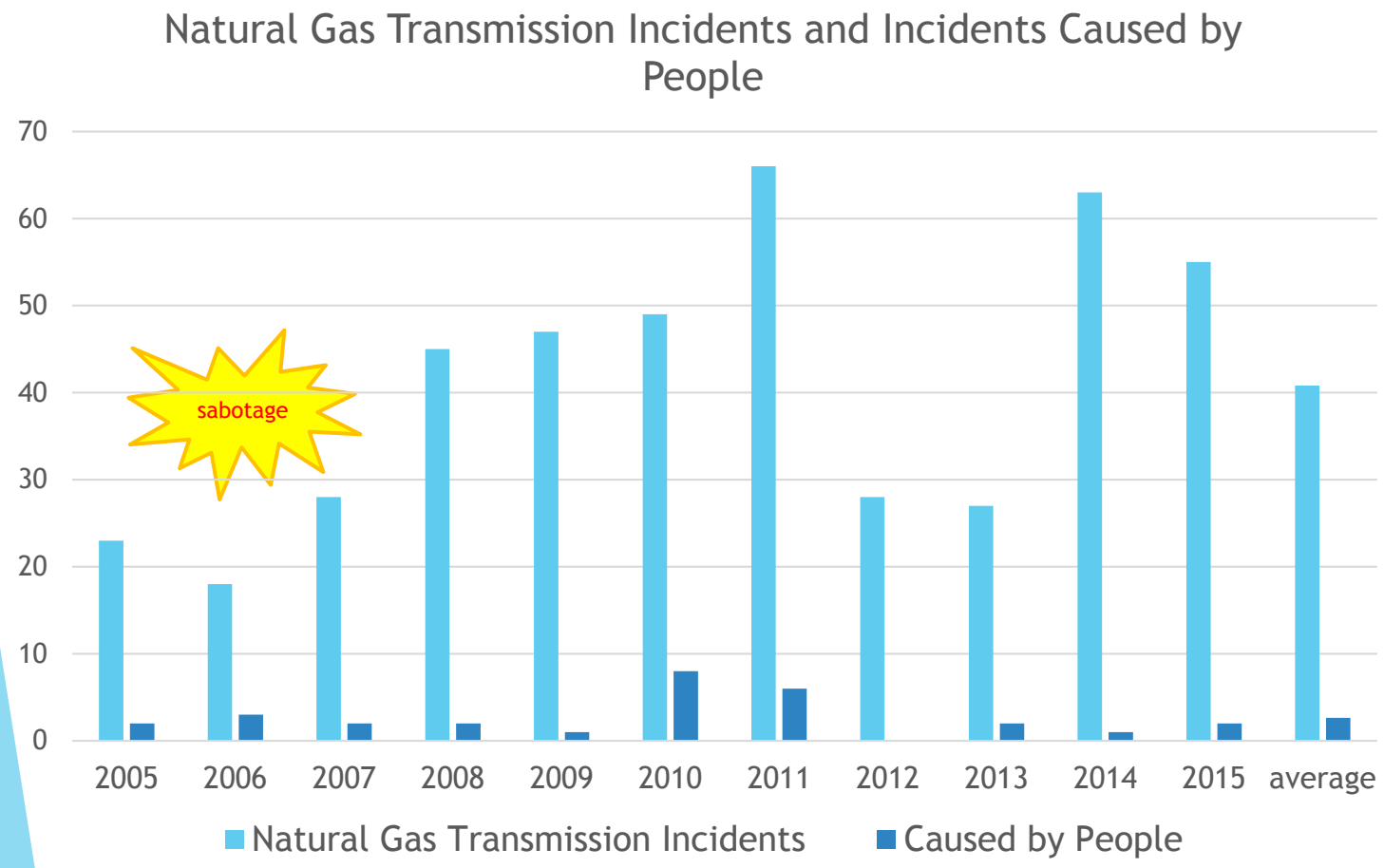
Natural Causes



Transmission Incidents More Frequent in States with More Infrastructure

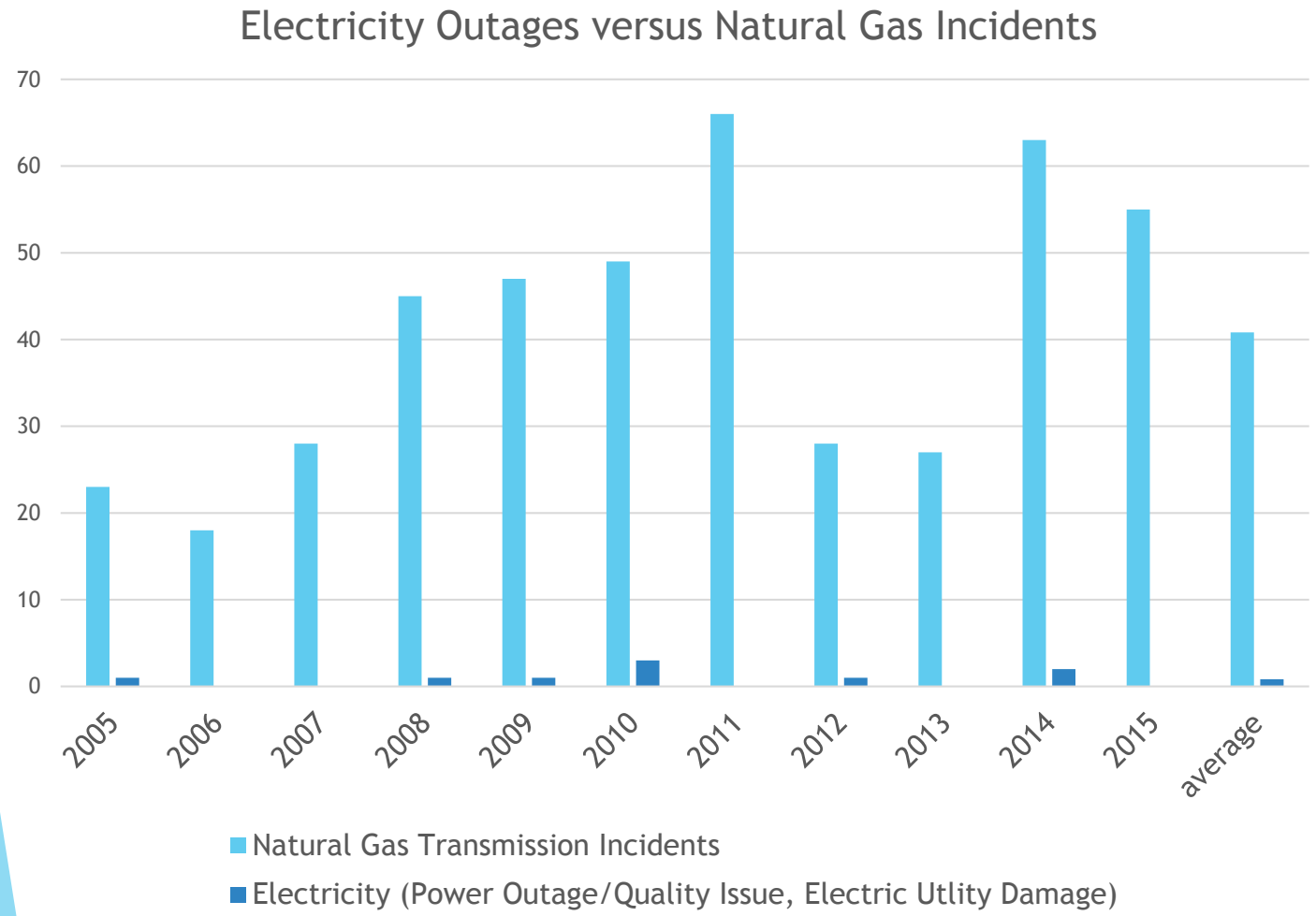


Human Error, Accidents and Sabotage



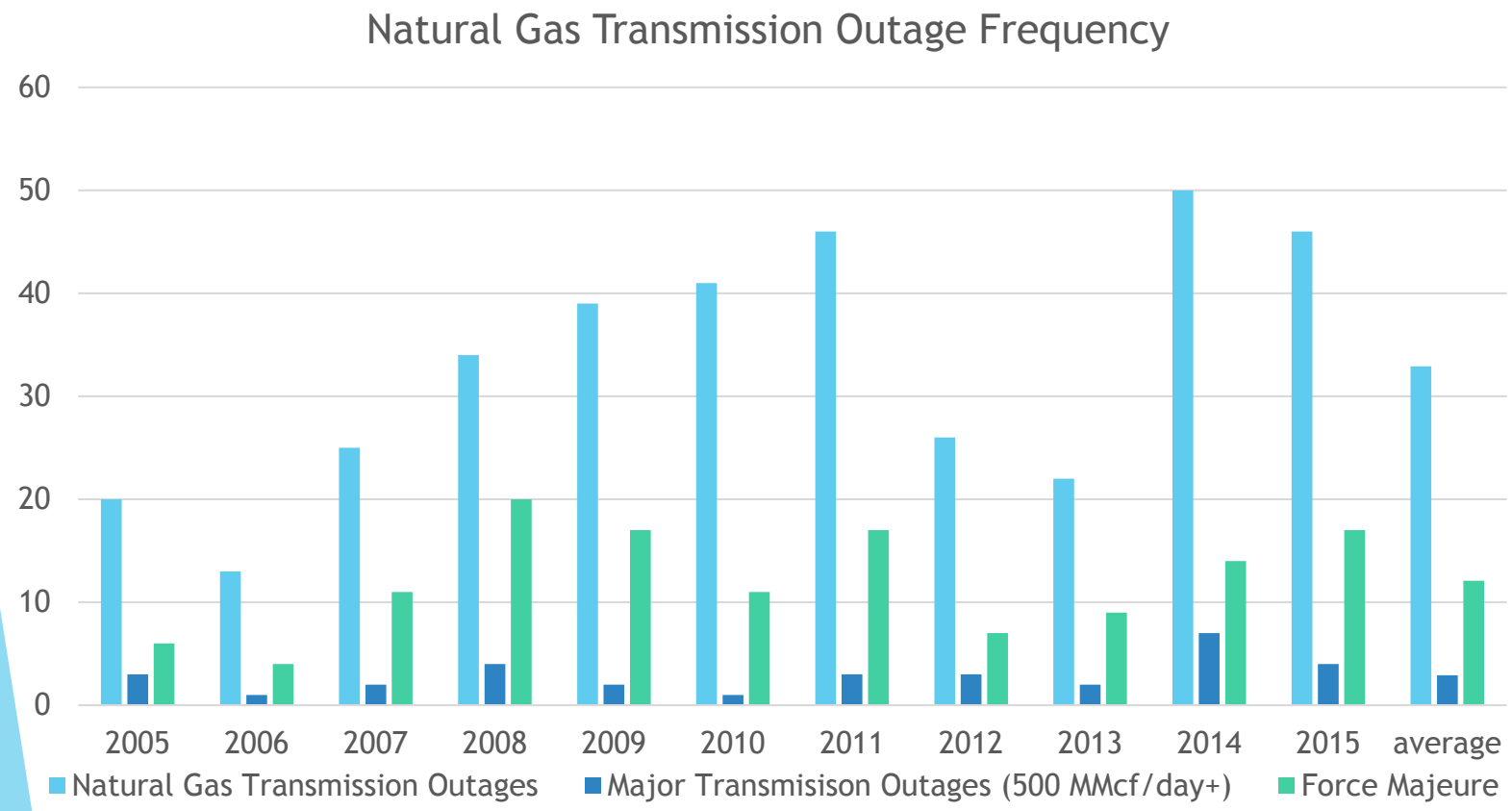
- A bulldozer hit a 31-inch diameter pipeline in northwest Houston on Saturday evening, causing a massive explosion. Despite the company's efforts, the pipeline ignited around 6:35 p.m. A company spokesman said he didn't know how long it would take to repair the damaged pipeline but Company is routing natural gas through other lines and doesn't expect any significant disruptions to customers.
- A dredging vessel struck an 8-inch pipeline August 4 near Little Tinicum Island in Pennsylvania causing a natural gas leak at the bottom of the Delaware River. Authorities closed the shipping channel for 75 minutes while they inspected the leak.

Gas/Electric Interdependency: Some Concerns Remain; Outages Infrequent



- A power failure forced offline a compressor unit in New Jersey on January 11, 2010, reducing throughput at the site by about 150 MMcf/d.

Overall Positive Natural Gas Transmission Reliability, Resilience Track Record



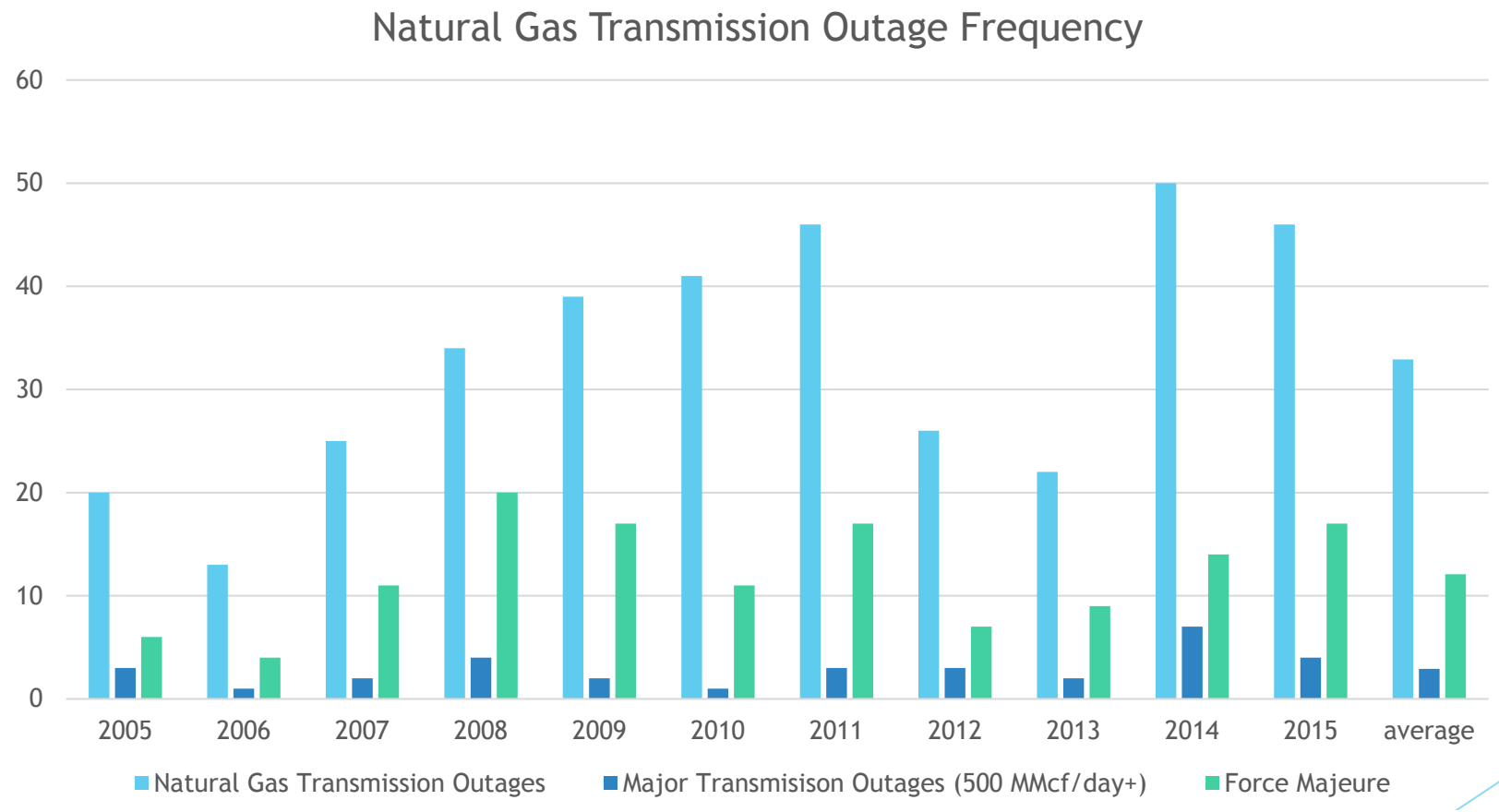
- Outages infrequent
- Disruptions avoidable with redundant infrastructure
- Rerouting indicates resilience
- More work needed to develop outage risk profile before backup sources selected

Appendix

Summary

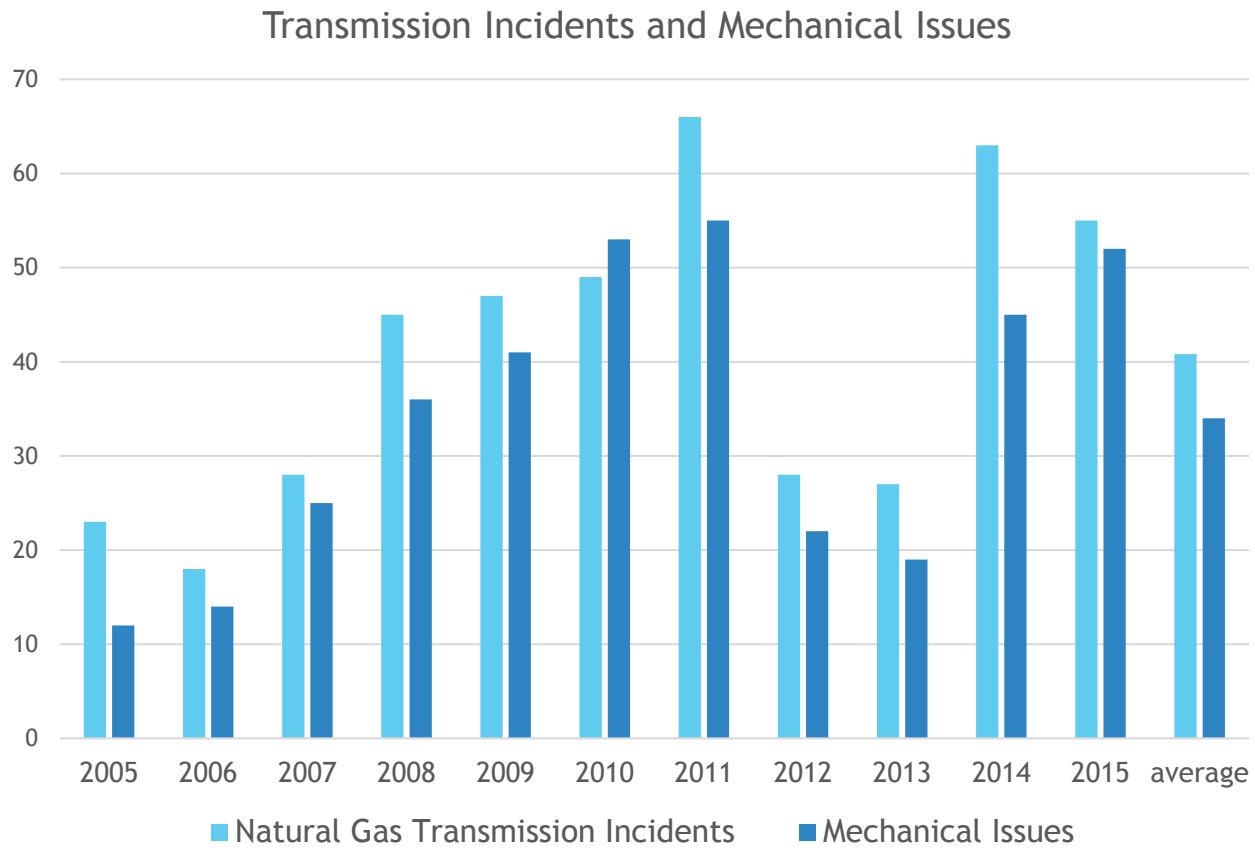
Year	Number of Events (with Production)	Major Gas Disruptions (with Production)	Natural Gas Transmission Incidents	Natural Gas Transmission Outages	Major Transmisison Outages (500 MMcf/day+)	Caused by People	Caused by People (sabotage only)	Electricity (Power Outage/Quality Issue, Electric Utlity Damage)	Weather	Weather Hurricane	Weather Cold/ Freezeoffs	Mechanical Issues	Force Majeure	Average Outage Volumes: Force Majeure
2005	363	8	22	20	3	2	0	1	8	6	2	12	6	1,202
2006	121	3	18	13	1	3	1	0	0	0	0	14	4	62
2007	206	3	28	25	2	2	0	0	0	0	0	25	11	155
2008	474	25	45	34	4	2	1	1	5	4	0	36	20	125
2009	458	2	47	39	2	1	0	1	3	1	1	42	17	61
2010	610	3	49	41	1	8	0	3	3	0	1	53	11	87
2011	771	6	66	46	3	6	0	0	5	0	2	55	17	179
2012	410	7	28	26	3	0	0	1	5	2	0	22	7	405
2013	366	5	27	22	2	2	0	0	6	1	0	19	9	302
2014	357	7	63	50	7	1	0	2	1	0	0	45	14	176
2015	338	5	54	46	4	2	0	0	2	0	0	51	17	235
average	406.73	6.73	40.64	32.91	2.91	2.64	0.18	0.82	3.45	1.27	0.55	34.00	12.09	271.73

Outage Frequency with Average Volumes



Average Outage Volumes: Force Majeure	1,202	62	155	125	61	87	179	405	302	176	235	271.73

Incident Causes: Mechanical Malfunctions



- **Pipeline rupture throws pipe segment 400 feet from right of way.** The explosion occurred as the company was increasing the pressure on the pipeline under testing protocols. The gas line was immediately closed down. No one was injured. Witnesses compared the geyser to Old Faithful in Yellowstone National Park.

Natural Gas Delivery Reliability Assessment

- Categorizes U.S. Department of Energy Office of Electricity's Energy Assurance (EA) report database
  - Transmission (storage and pipelines) focus separate from upstream production and downstream distribution (LDCs)
  - Incident causes, volumes impacted and location by State
- Identifies trends:
  - Equipment failure relatively frequent incident cause
  - Accidents, weather and power loss less frequent cause of incidents & outages but can be impactful
  - Outages on natural gas transmission relatively rare; system resilient to incidents that do occur and reroutes supplies
  - States with high infrastructure concentrations have more incidents

Next Steps: Assess Upstream & Downstream Reliability; Consider Other Uses for Data

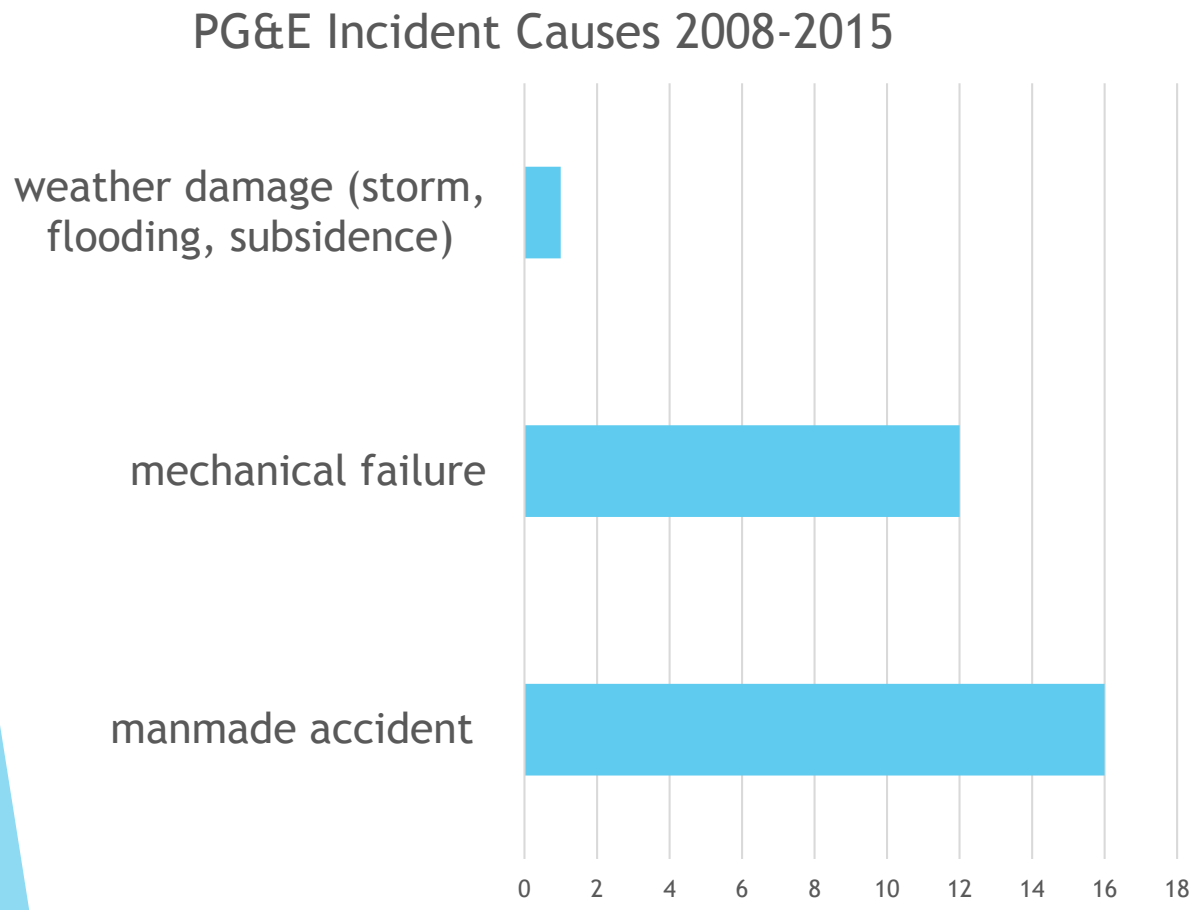
Planned Tasks

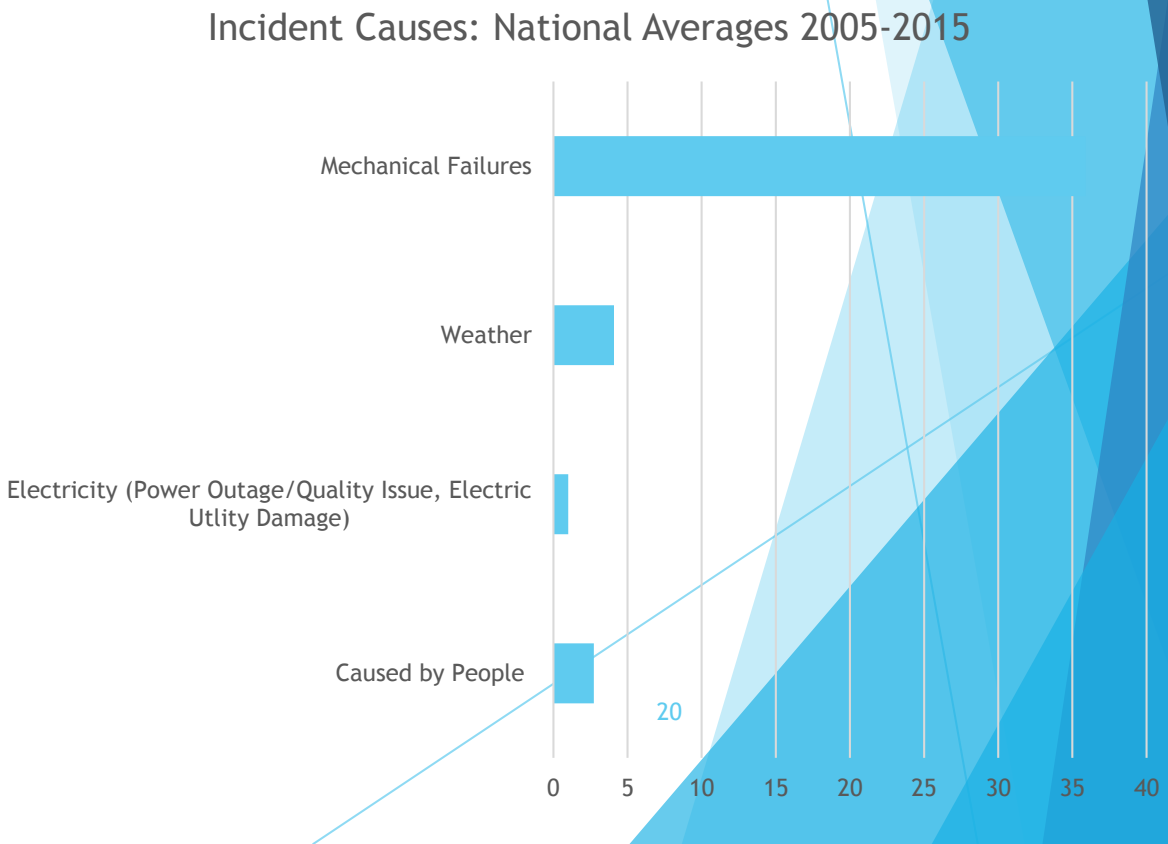
- Look at upstream and downstream delivery reliability
  - Assess production trends (production, gathering, processing)
  - Assess LDC trends (past the city gate), particularly in California
- Share spreadsheet with other offices for use in any other projects
- Complete 2016 and 2017 1st & 2nd Quarter incident categorization
- Seek additional input from industry on downstream outage impacts

Options for Other Projects

- Assess role of GOM production in resiliency
- Consider reliability impacts of large state LDCs operating **intrastate** infrastructure networks on interstate scales without federal oversight: CA, TX (30% of US population)
- What would be useful categories?
  - Hurricane-caused outages/destruction data use for climate research
  - Sabotage incidents for use in cybersecurity impact assessments
  - Gas/electric interdependency assessments
- Use dataset to inform reports on future disasters
- Promote continued maintenance of reliability track record

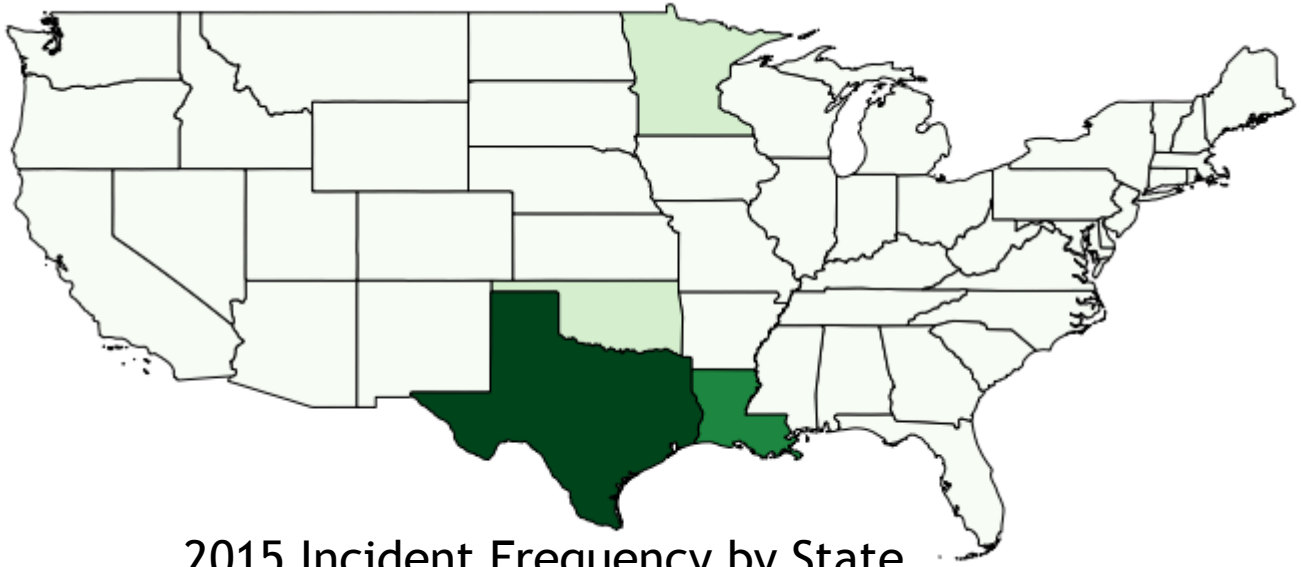
Example Large LDC: PG&E Incidents & Outages
(recorded since 2005 only for comparison)



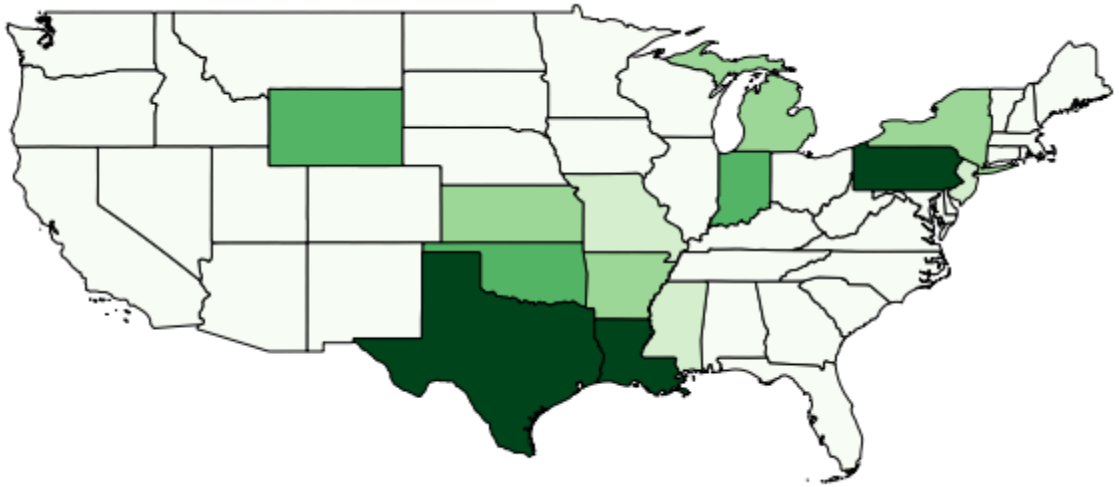


Transmission Incidents More Frequent in States with More Infrastructure

2005 Incident Frequency by State

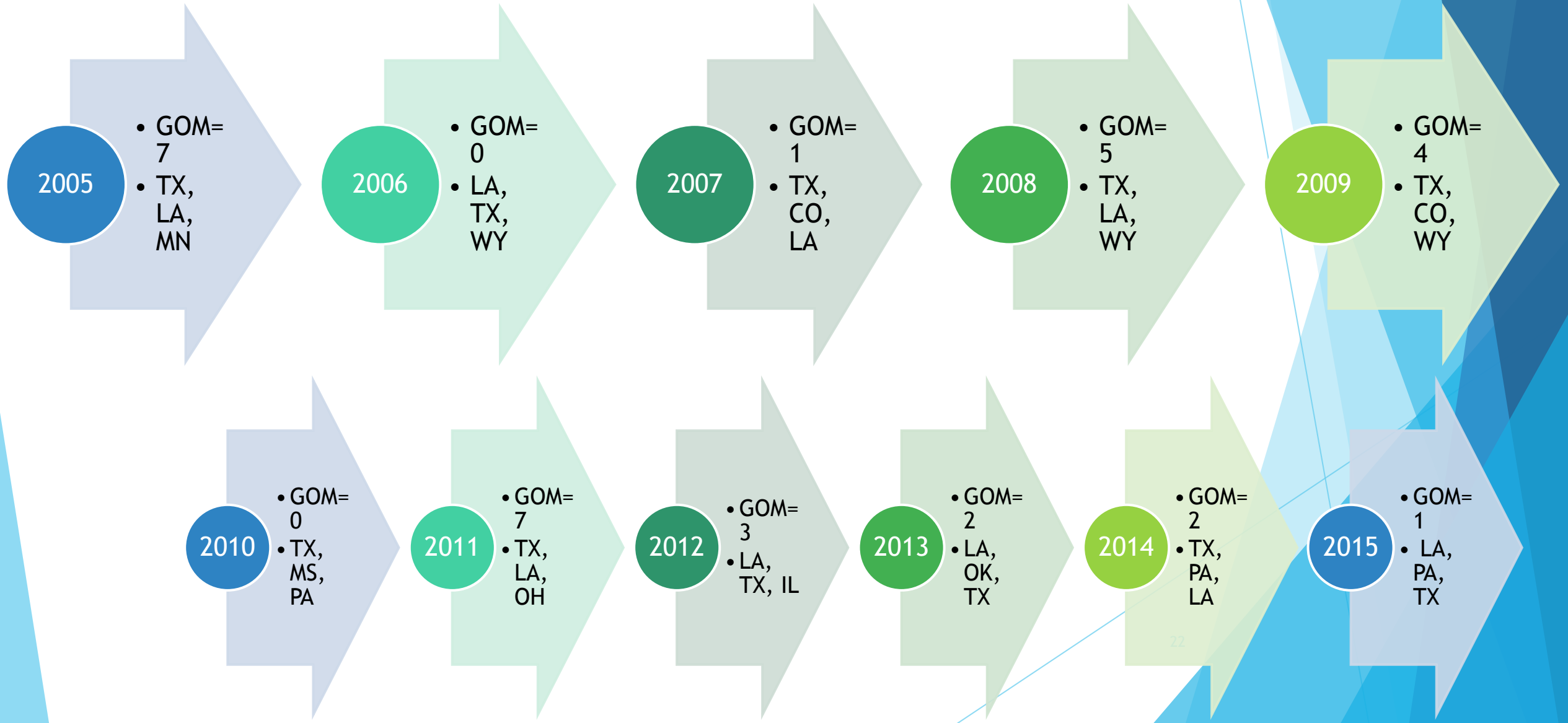


2015 Incident Frequency by State

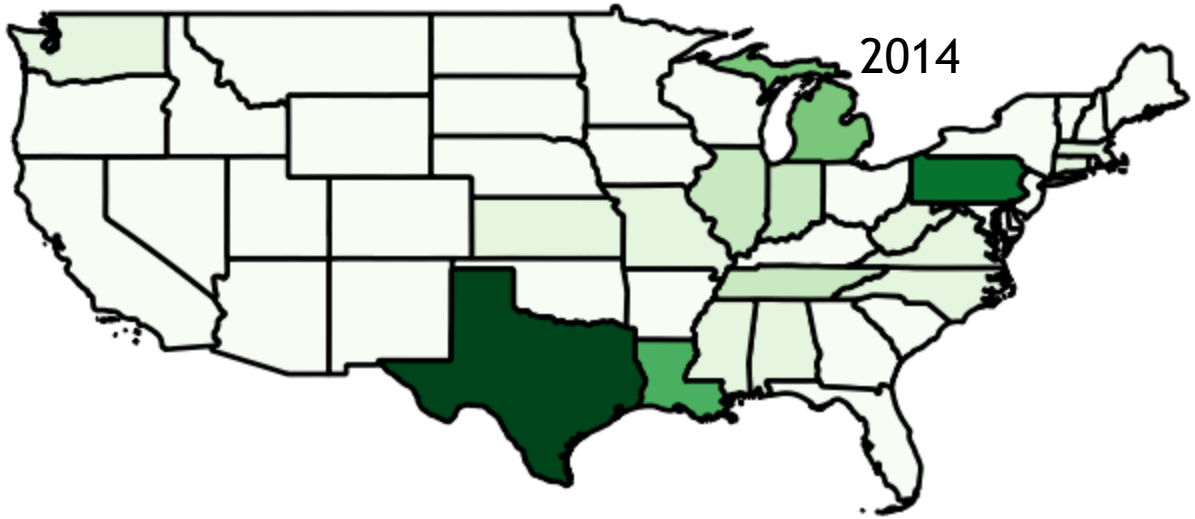


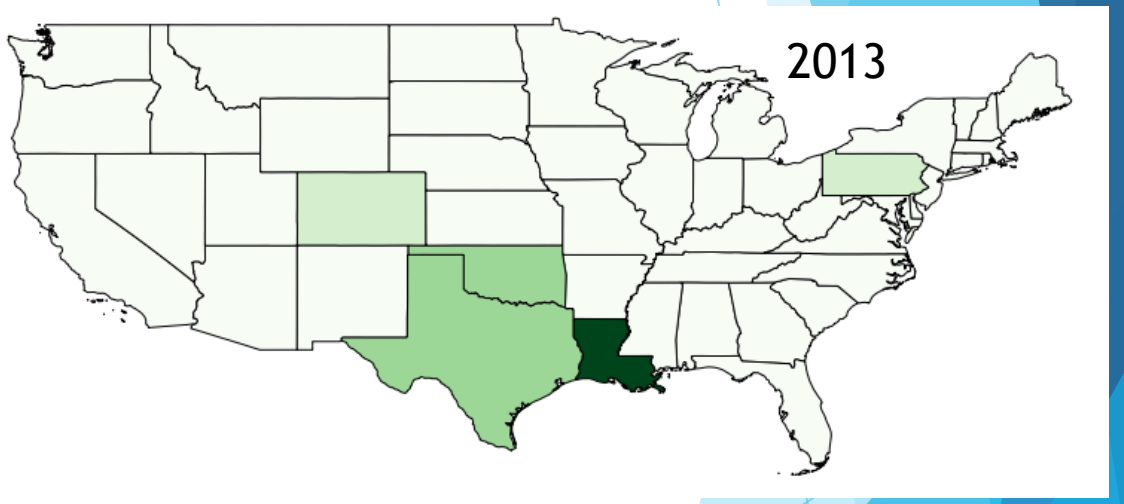
- Most Frequent
- 3-5
- At least 1
- None

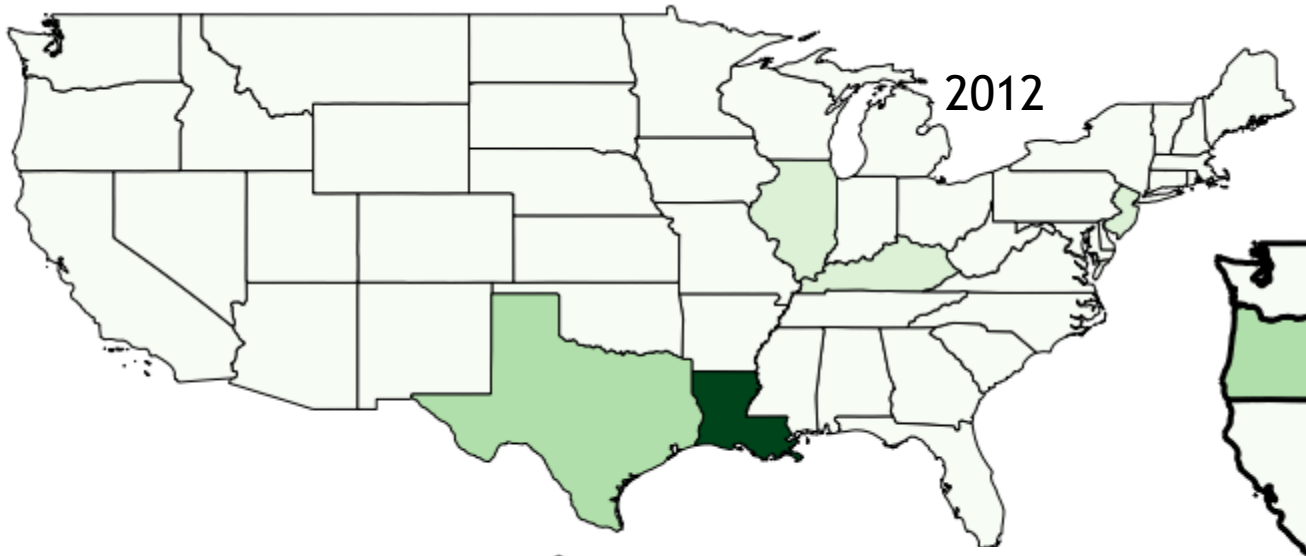
Incidents in Gulf of Mexico (GOM) and Top Three States with Most Incidents Each Year

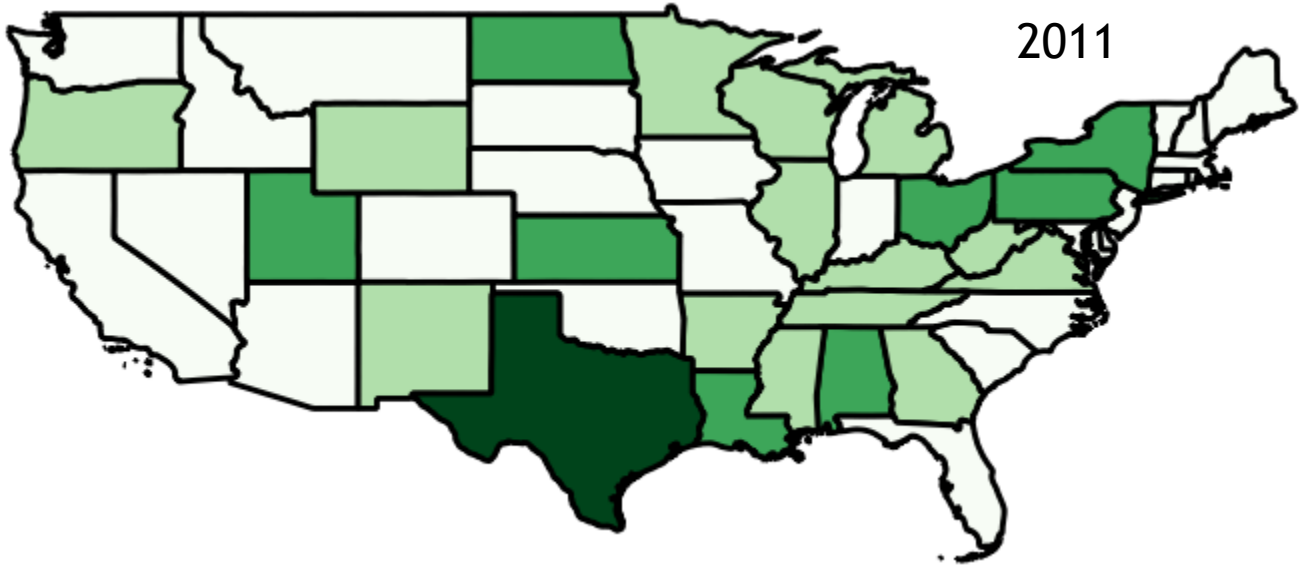


Annual incidents

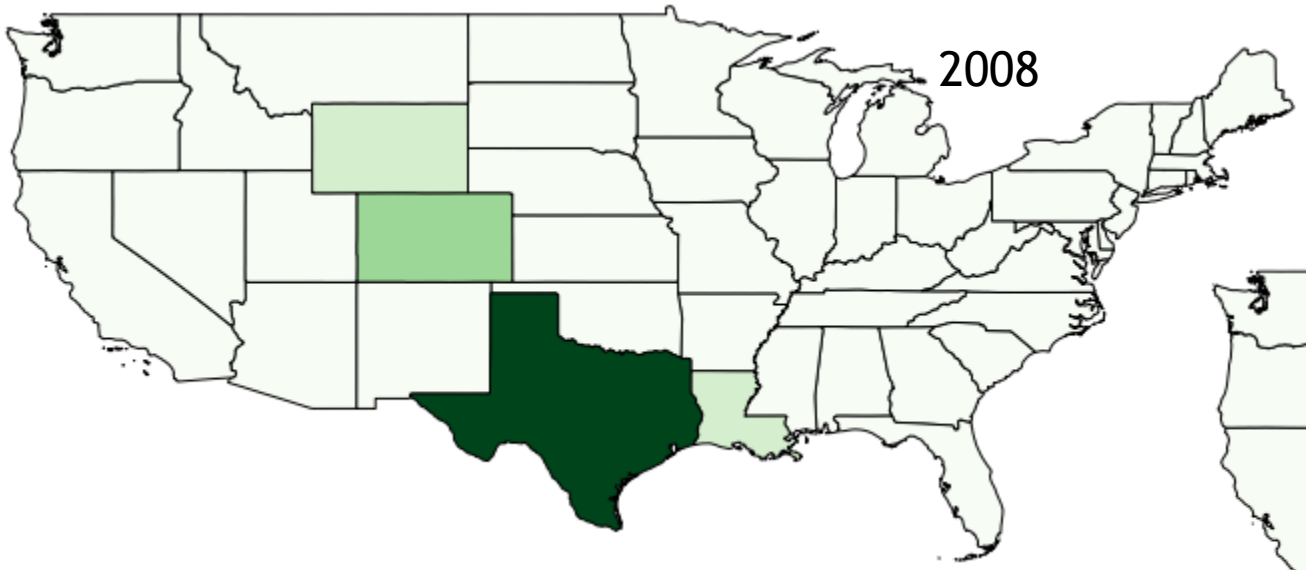


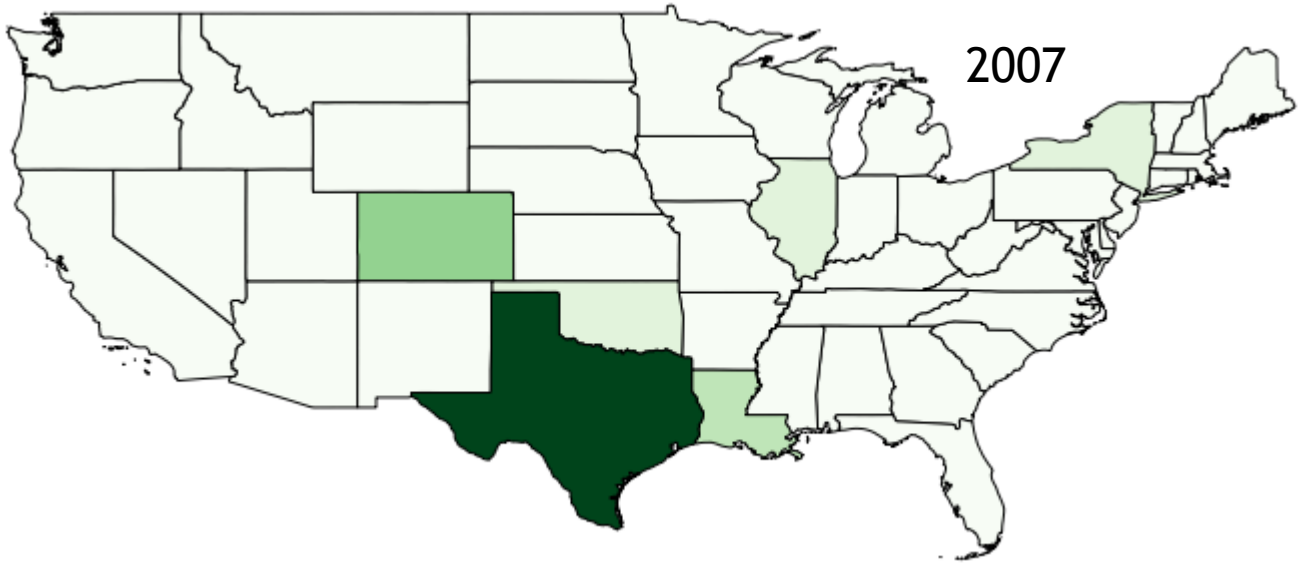


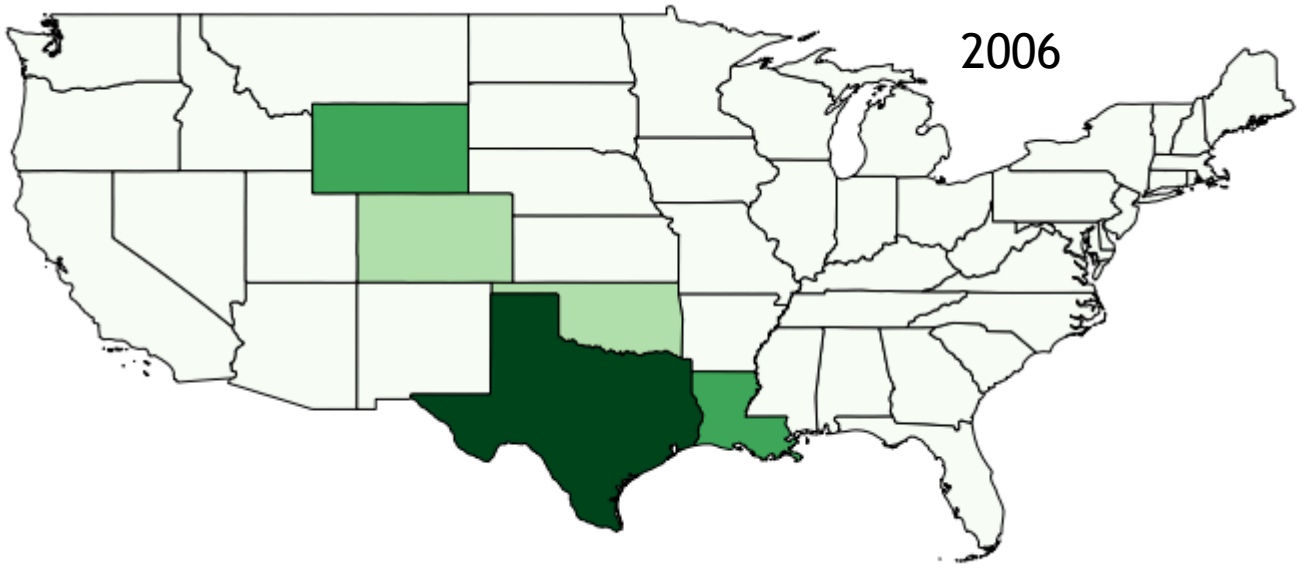

2012


2011

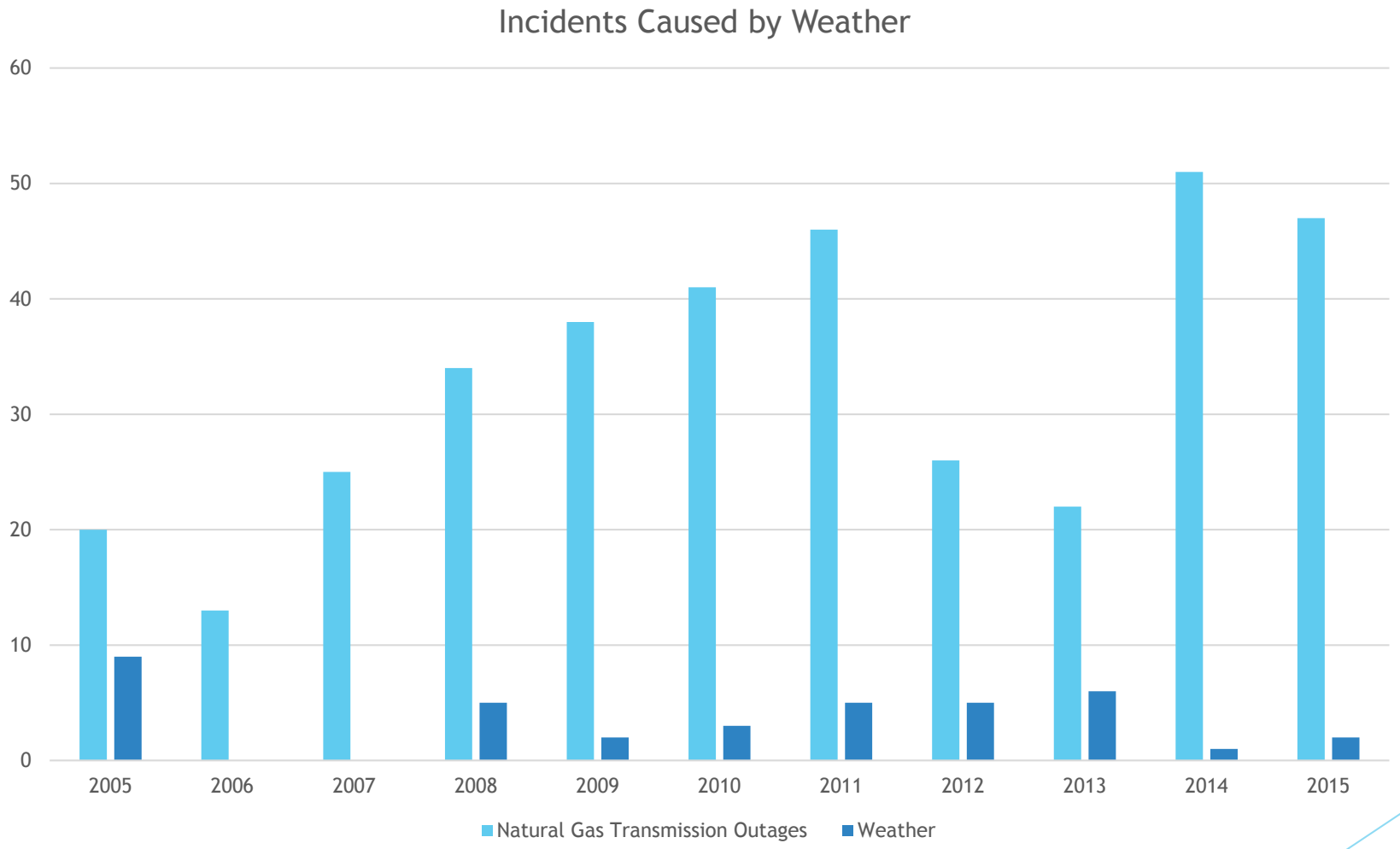

2010


2008

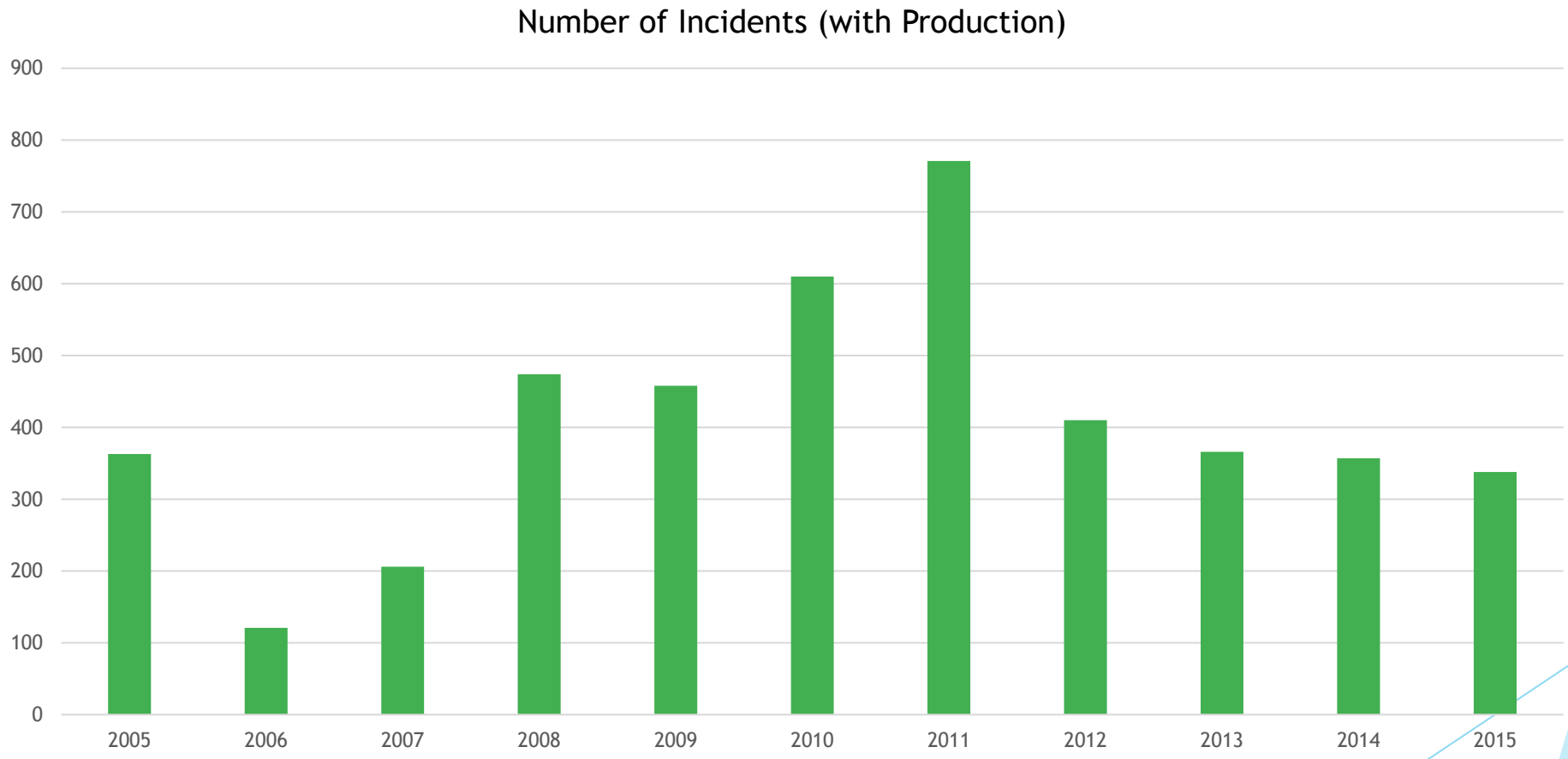

2007


2006

Natural Causes/Weather



Incidents Including Production



PHMSA Significant Incidents: Physical Damage, Accidents and Injuries More Common Than Throughput Reductions