Mitigating and Adapting to Climate Change in Nebraska – An Energy Perspective

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UNL Energy Roundtable

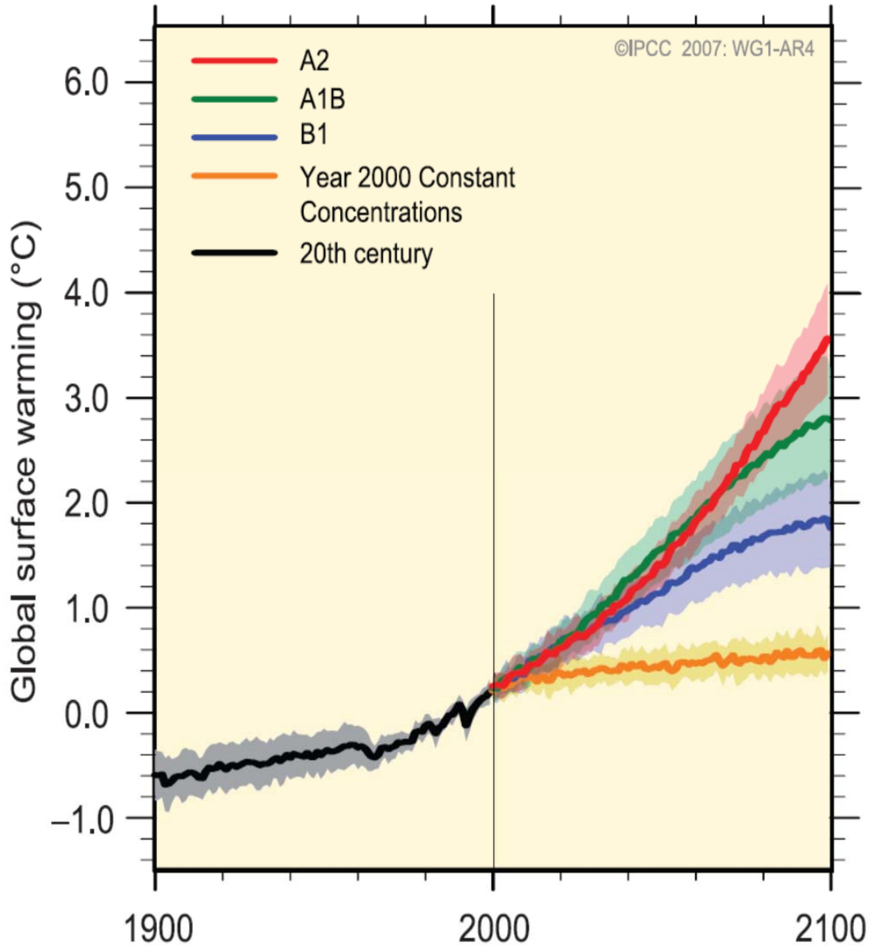
Lincoln, Nebraska
October 22, 2015

Topics

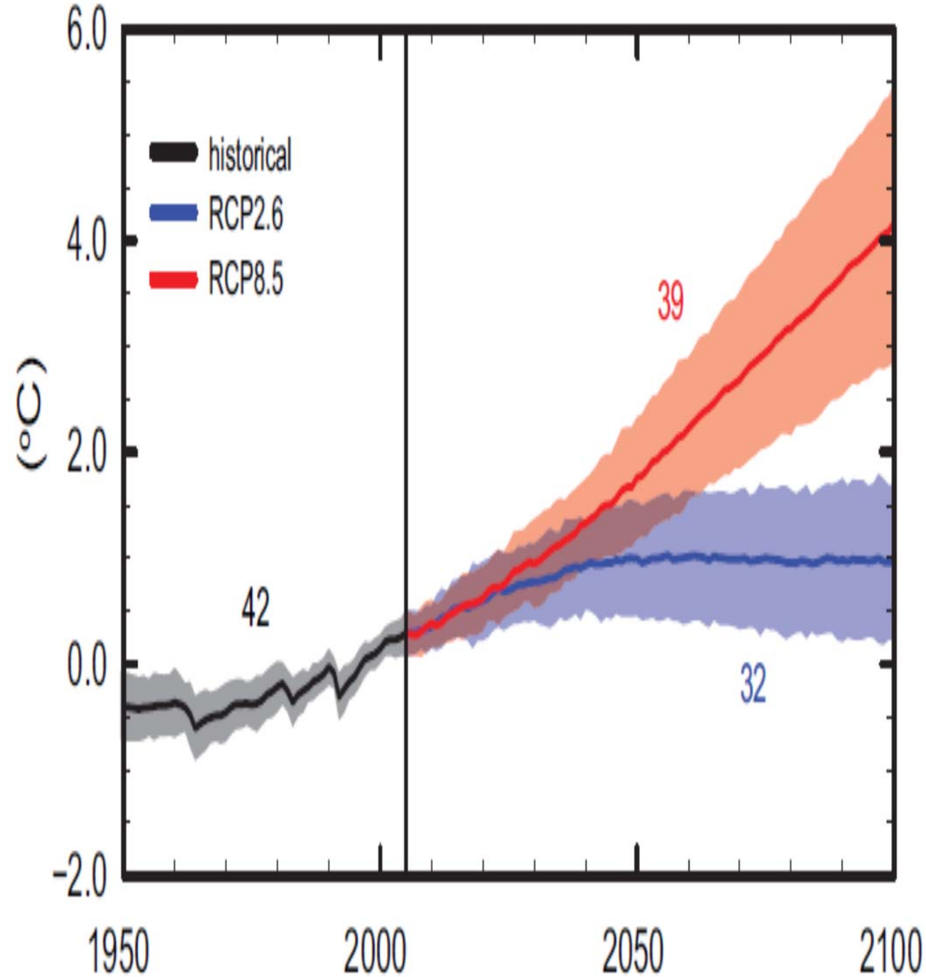
- The inevitability of climate change
- The implications depend…
- Greenhouse gas mitigation
- Climate change vulnerability
- Concluding thoughts

The inevitability of climate change – globally

IPCC WGI (2007)



IPCC WGI (2014)



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The inevitability of climate change – globally

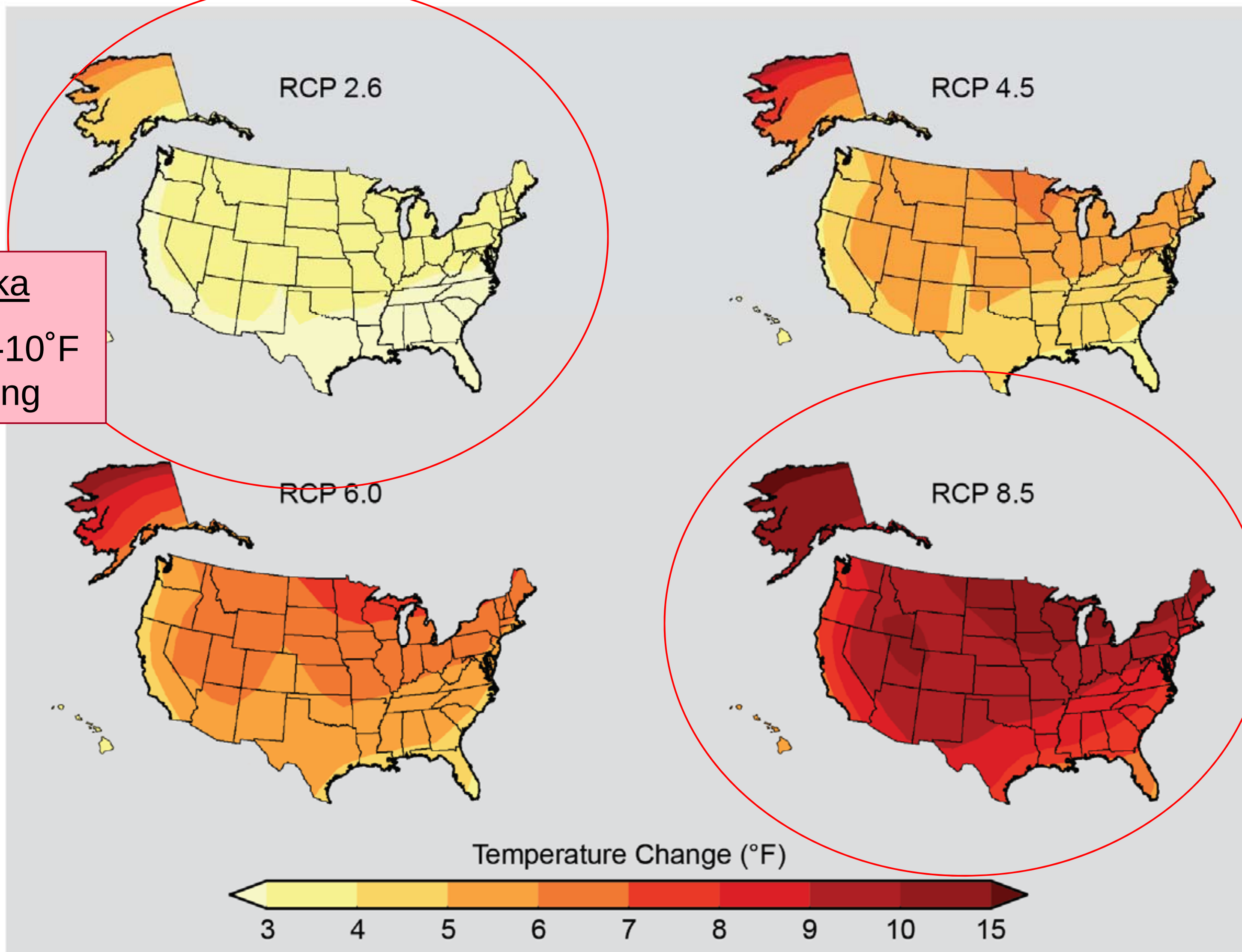
Greenhouse gas emissions & climate characteristics
for different socioeconomic transformations

Type of scenario	Concentrations in 2100 (CO_2-eq ppm)	CO_2-eq emissions		Change in CO_2-eq emissions relative to 2010		Change in global average annual temperature by 2100 (˚F)
		2050	2100	2050	2100	
Baseline futures	> 1000	74 to 96	85 to 136	52 to 95%	74 to 178%	3.9 to 12.9
	720 to 1000	58 to 75	46 to 84	18 to 54%	-7 to 72%	2.7 to 9.3
Climate policy futures	650 to 720	44 to 57	23 to 39	-11 to 17%	-54 to -21%	2.3 to 7.0
	580 to 650	30 to 61	-17 to 25	-38 to 24%	-134 to -50%	1.6 to 6.5
	530 to 580	26 to 52	-41 to 20	-47 to 7%	-183 to -59%	1.4 to 5.4
	480 to 530	21 to 37	-7 to 13	-57 to -25%	-114 to -73%	1.1 to 4.8
	430 to 480	14 to 29	-9 to 11	-72 to -41%	-118 to -78%	0.7 to 3.9

Rose (2015)

The inevitability of climate change – U.S.

Change in average annual temperature in 2071-2099 relative to 1970-1999



Nebraska

3-4 ˚F to 9-10˚F of warming

NCA (2014)

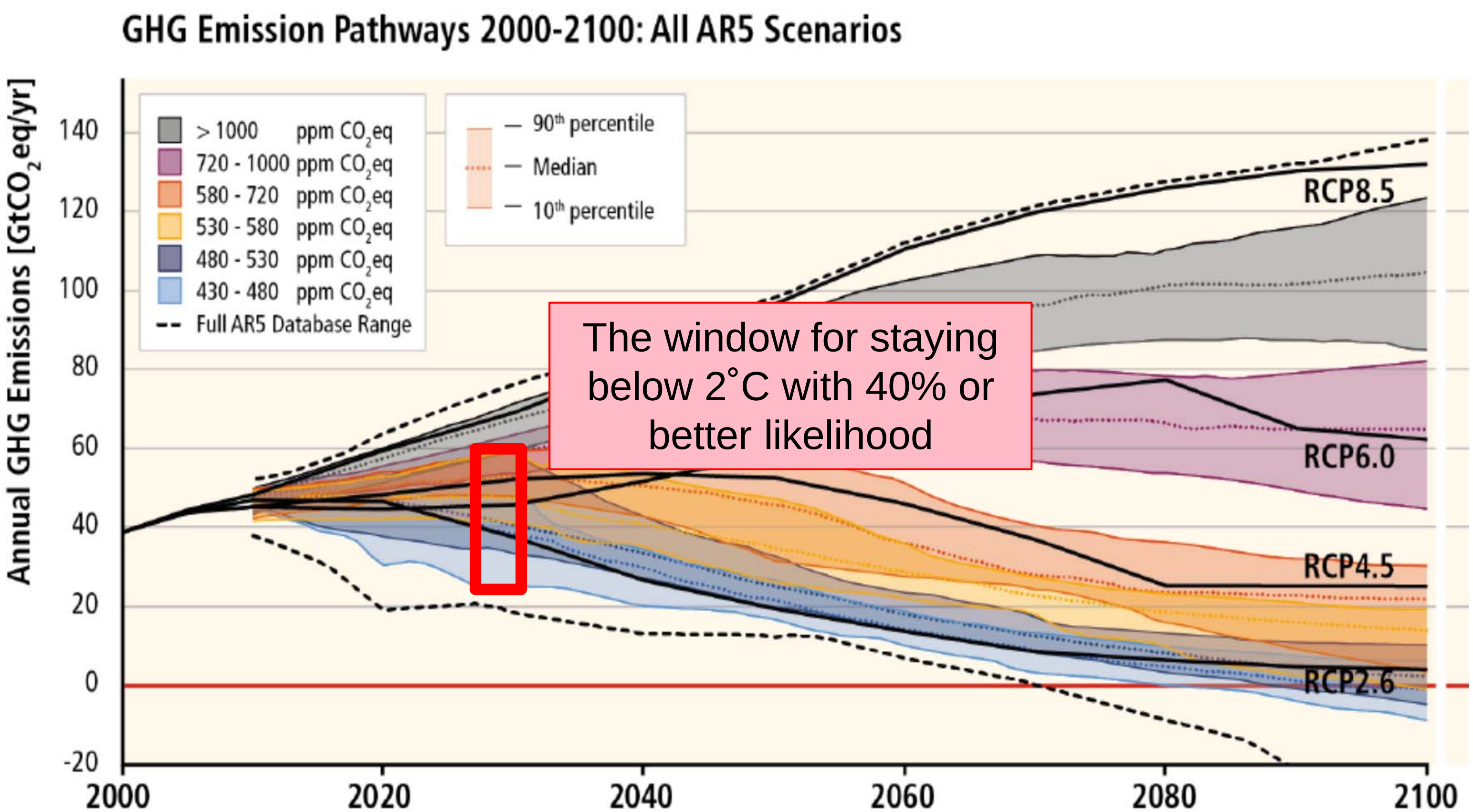
The implications of climate change?

The implications of climate change will depend on the **level of climate change** and **vulnerability**:

- The level of climate change depends on mitigation
- Vulnerability depends on resiliency and adaptation investment

Greenhouse gas mitigation

The Challenge – shifting global emissions trends to stabilize/reverse climate change



IPCC WGIII (2015)

AR5 430-530 ppm CO_2e pathways are consistent with staying below 2˚C with 40% or better likelihood.

2025-2030 10th – 90th percentile window is ~25-60 $GtCO_2$e.

Current international climate policy – INDCs

Some Country Intended Nationally Determined Contribution (INDC) pledges for COP-21

Country/Region	Pledge	Target year
USA	Economy-wide Kyoto GHGs 26-28% below 2005	2025
EU	Economy-wide Kyoto GHGs 40% below 1990	2030
China	Peak in total CO_2	2030
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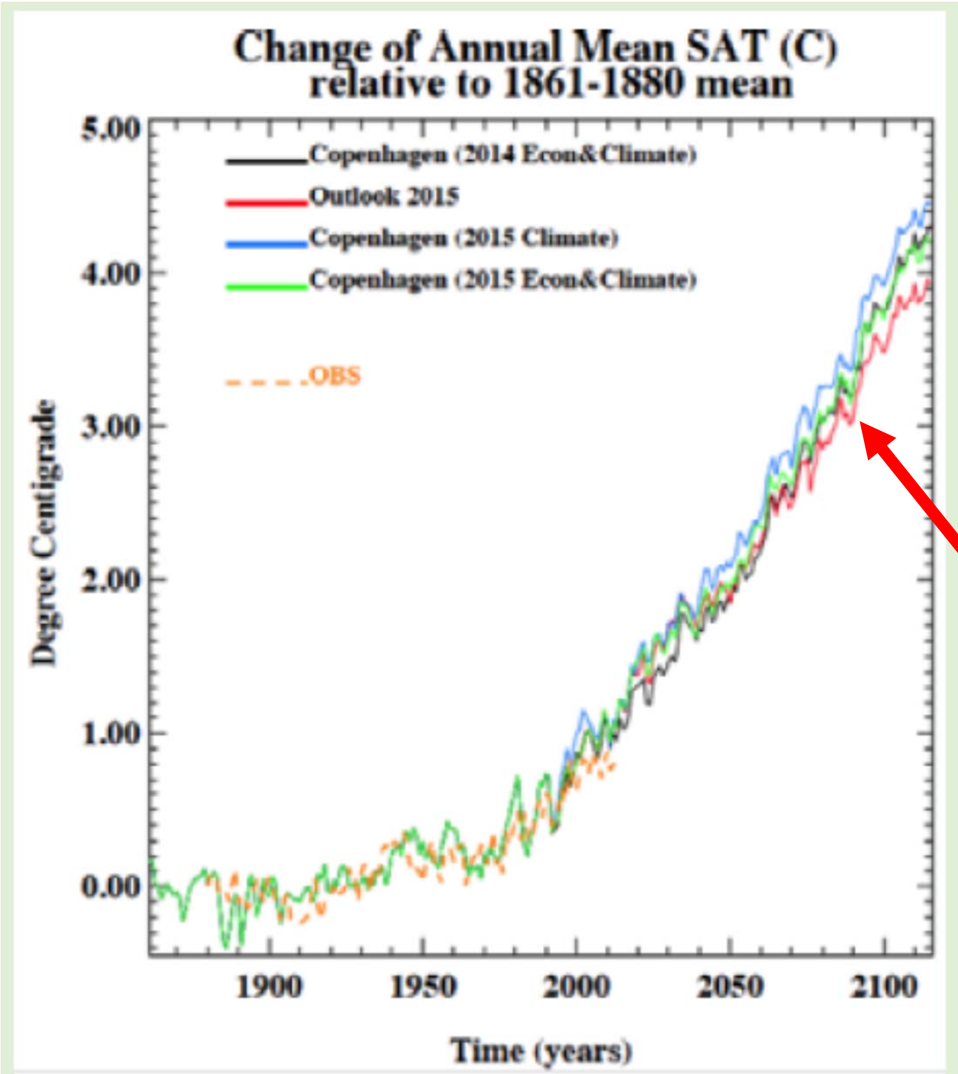
125 INDCs submitted as of Oct. 21, 2015

Not on track for staying below 2 degrees Celsius without greater reductions beyond 2030

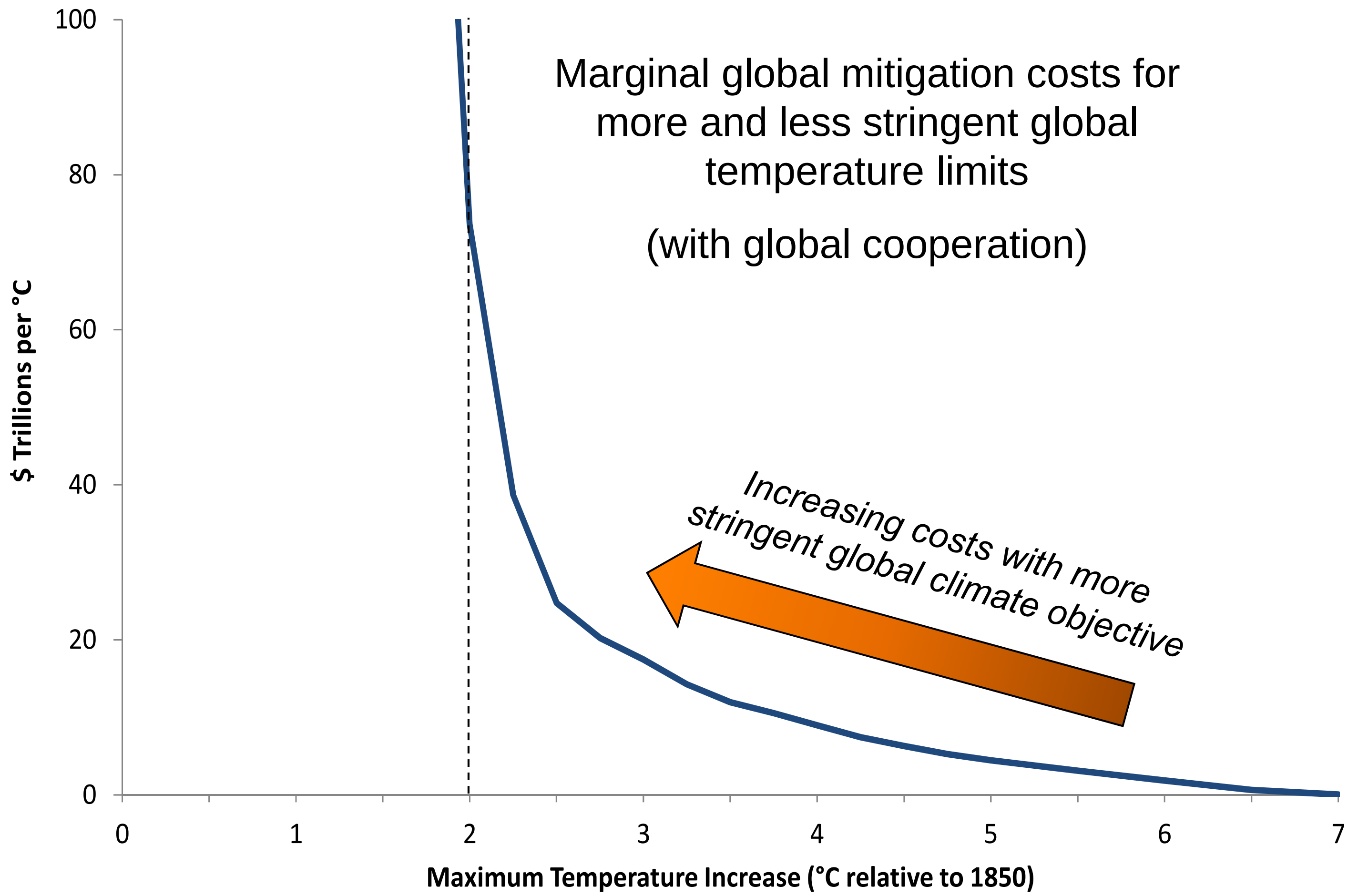


"Assuming the proposed cuts are extended through 2100 but not deepened further, they result in about **<u>0.2°C less warming by the end of the century</u>**…"

Reilly et al. (2015)

With INDCs buy no additional reductions beyond

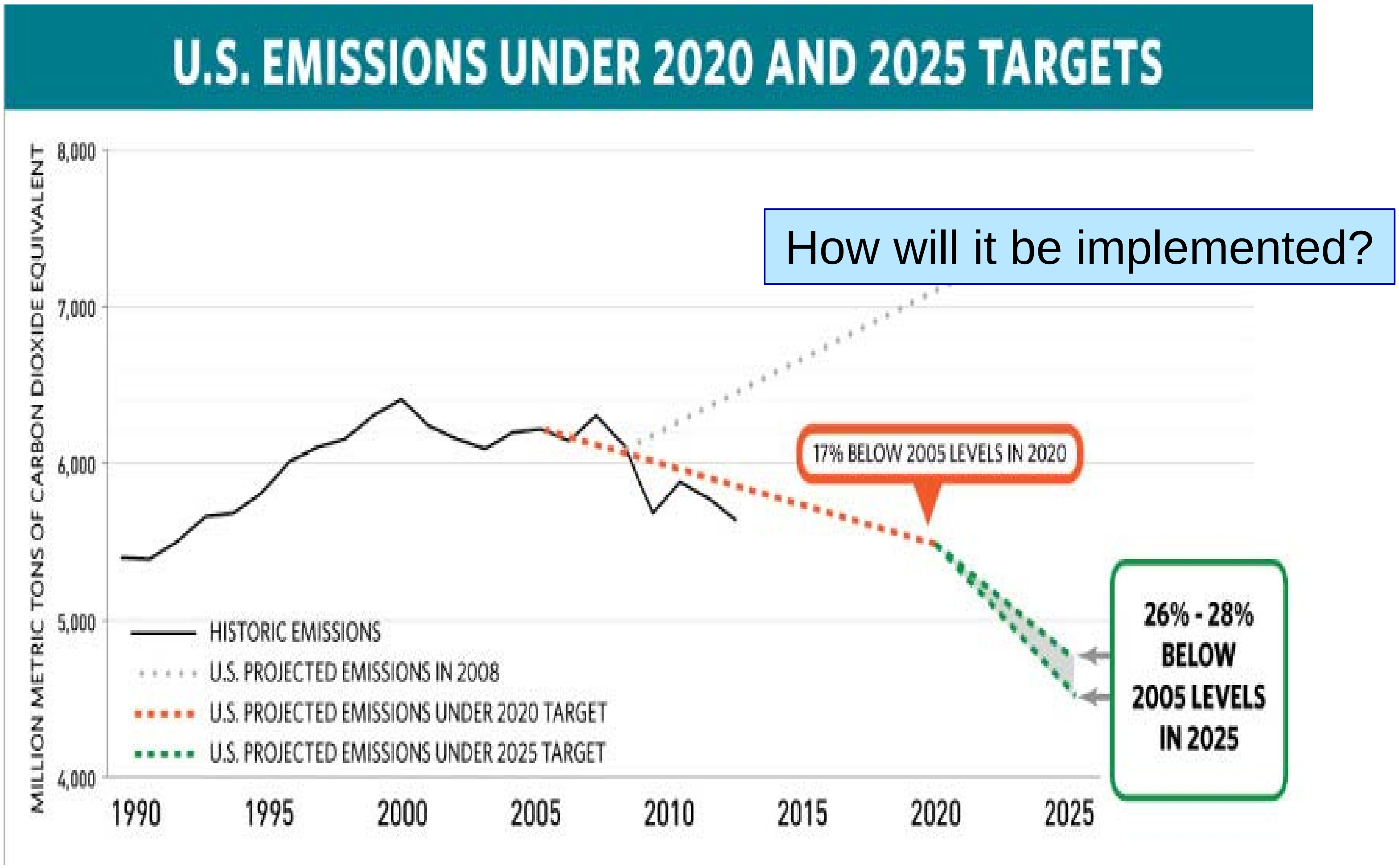
And, aggressive climate targets likely expensive



Blanford et al. (forthcoming).

* *Figure has b*enchmark assumptions. Shape robust to other assumptions.

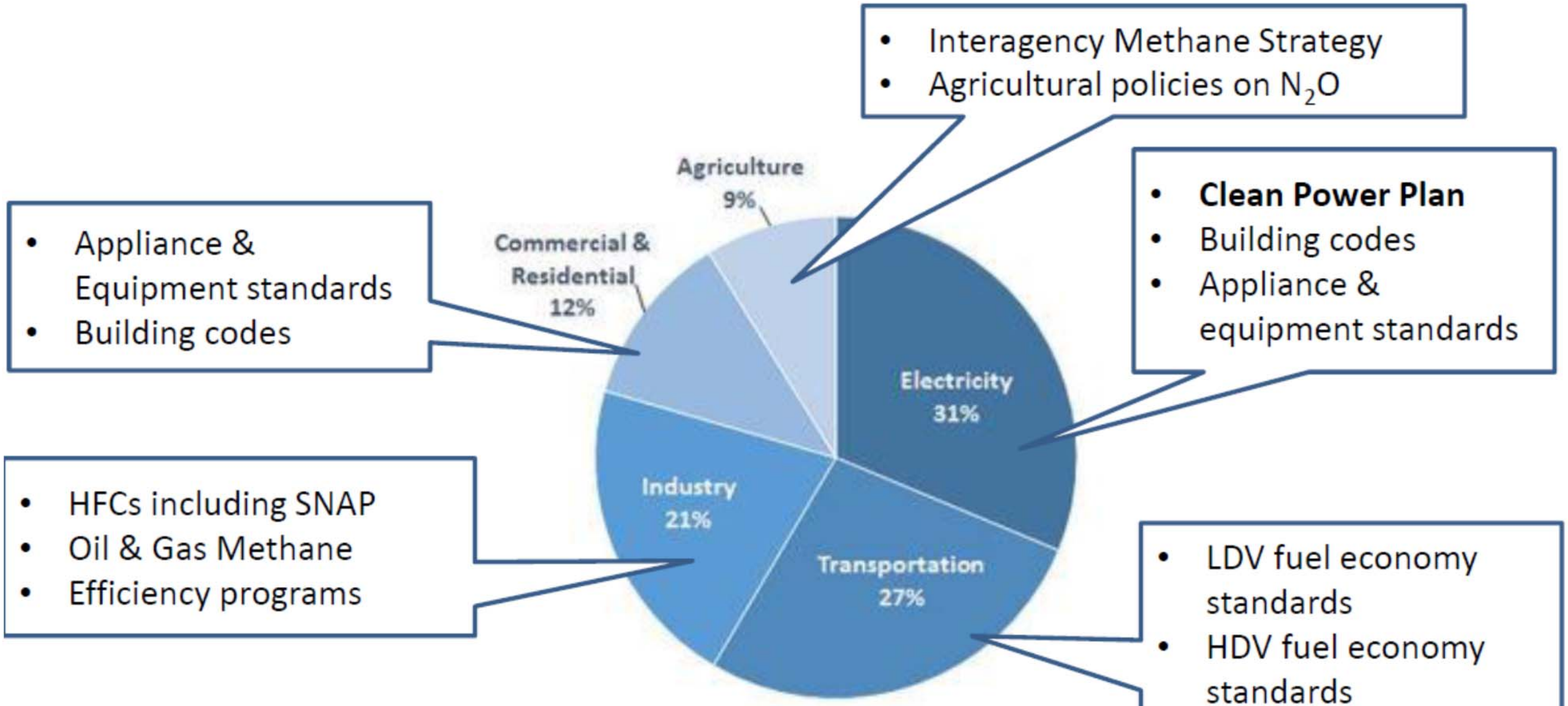
U.S. Intended National Determined Contribution (INDC)



US INDC (2015)

U.S. current approach – primarily sectoral & regulatory

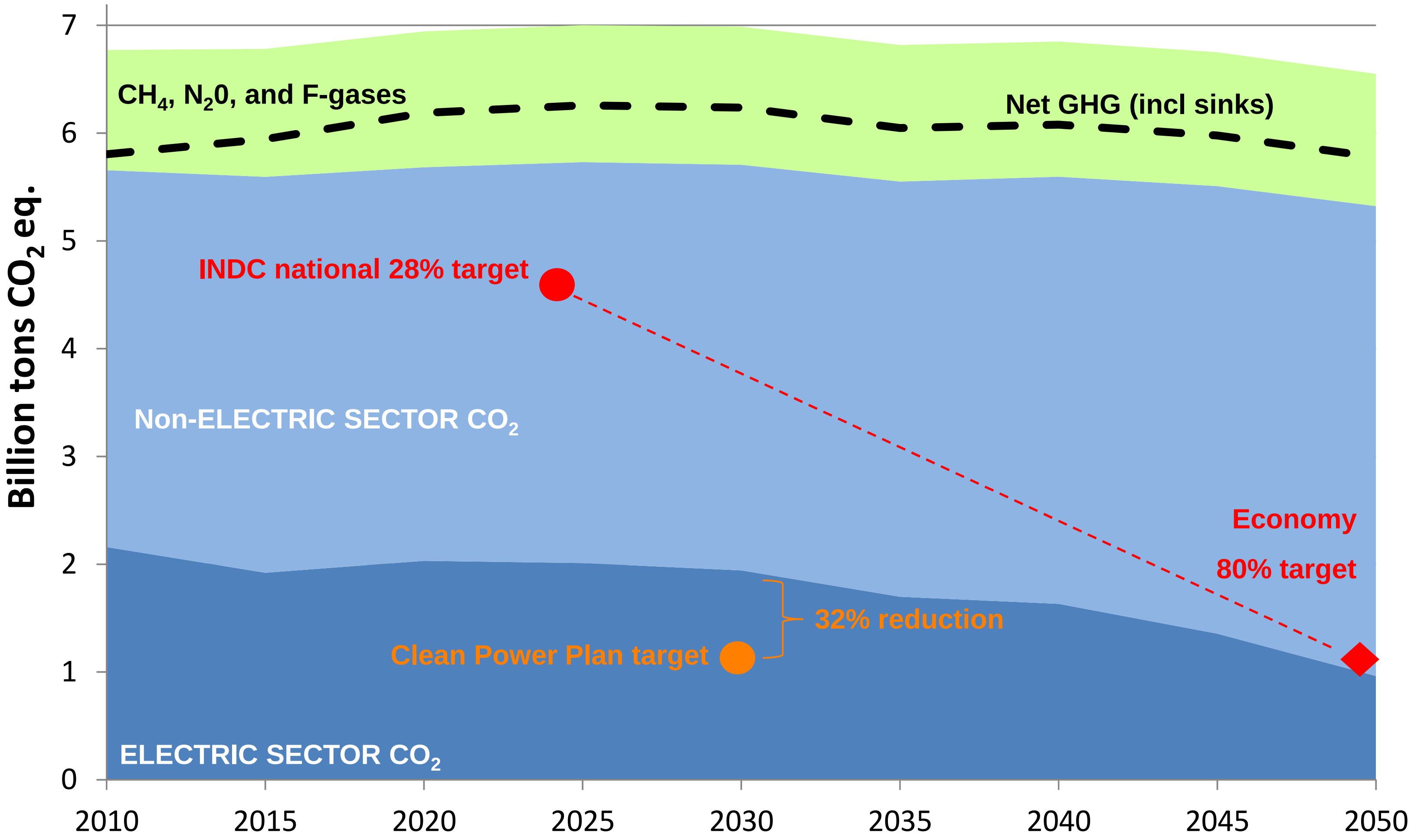
17% reduction below 2005 levels by 2020 and
26-28% reduction below 2005 levels by 2025



Sector Breakdown of 2013 Emissions

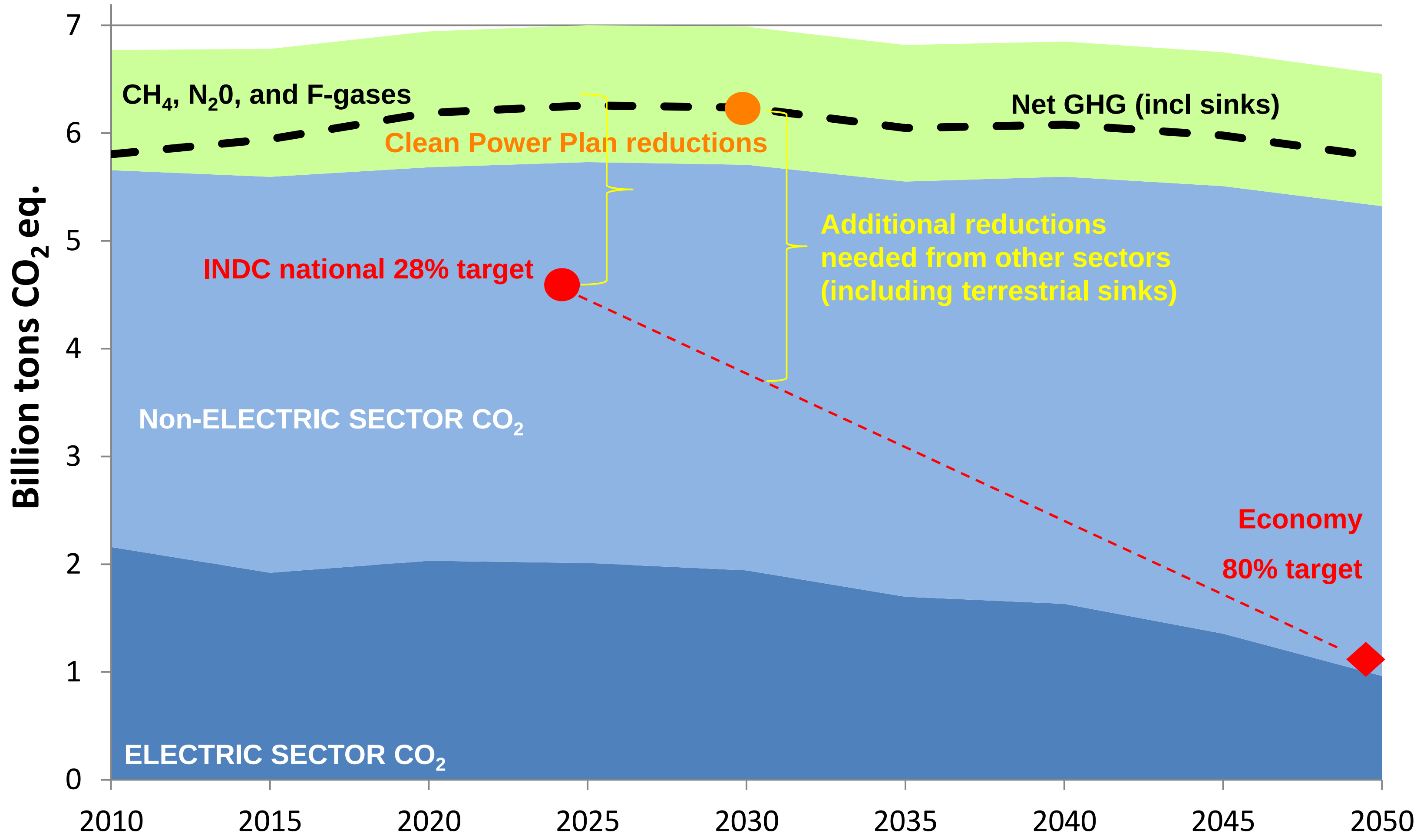
Also non-regulatory policy (e.g., NEPA, land policy) & state policies (e.g., AB32, RGGI, RPS)

Current U.S. mitigation approach – INDC greenhouse gas reduction pledge and sectoral specific policies



Source: US-REGEN data; Energy Modeling Forum 24

Current U.S. mitigation approach – INDC greenhouse gas reduction pledge and sectoral specific policies



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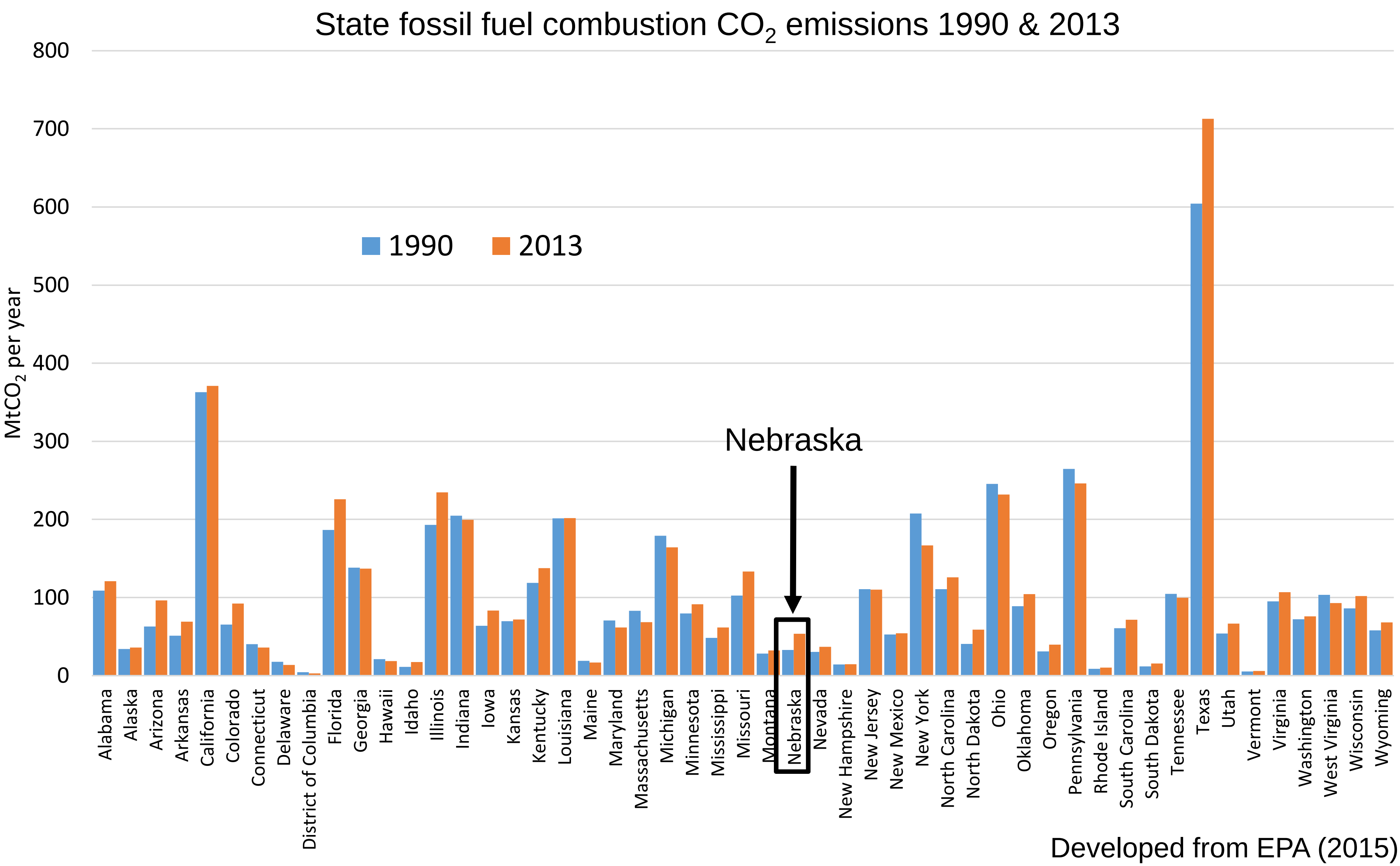
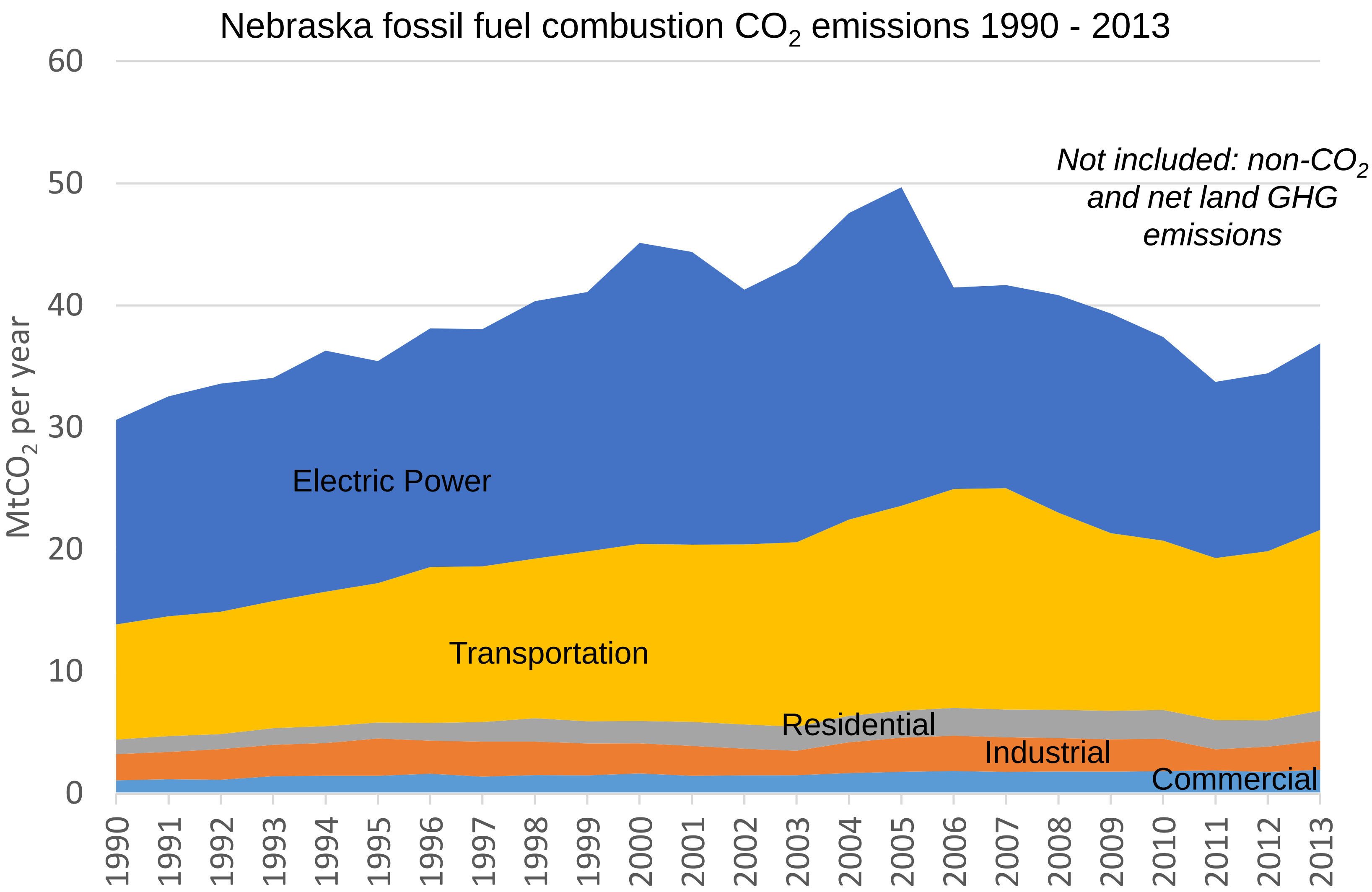
U.S. state GHG emissions trends



Developed from EPA (2015)

Nebraska GHG emissions trends



Developed from EPA (2015)

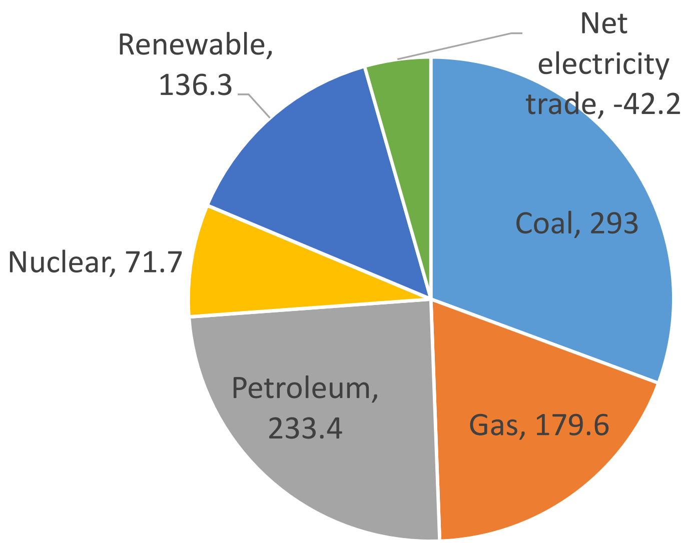
Mitigation options

Sectors

- Electric Power
- Transportation
- Industry
- Commercial
- Residential
- Agriculture and forestry
- Government

Strategies

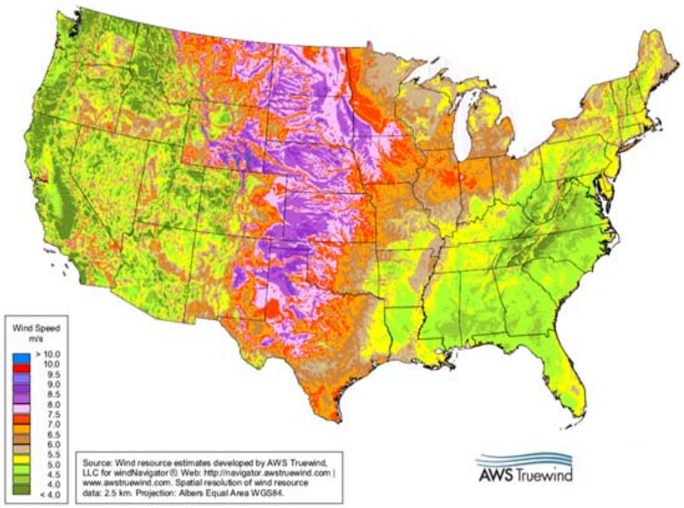
- Fuel switching
- Renewable energy
- Energy efficiency (all sectors)
- Non-CO_2 GHGs
  - landfills, coal mines, agriculture, oil & gas production/distribution
- Land carbon sequestration



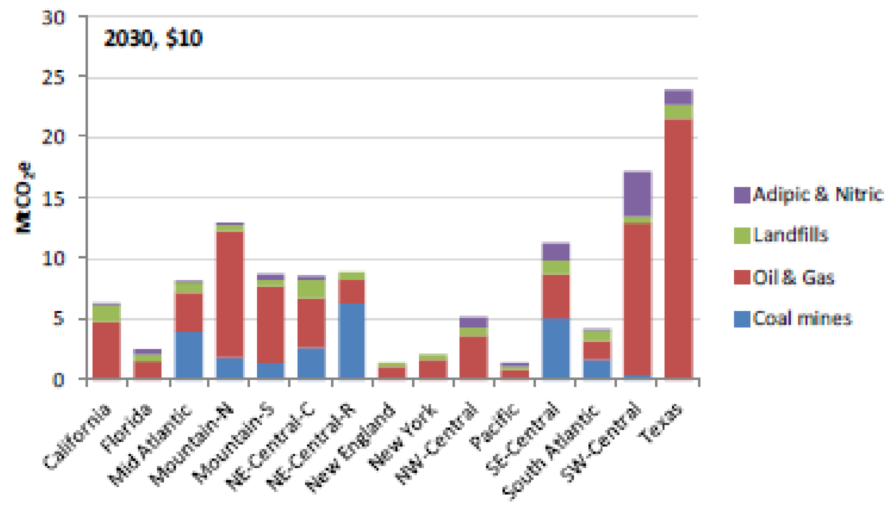
Nebraska 2013 Energy Consumption, Trillion Btu
(Developed from EIA, 2015)

Some regional mitigation resources – wind, biomass, and non-CO_2

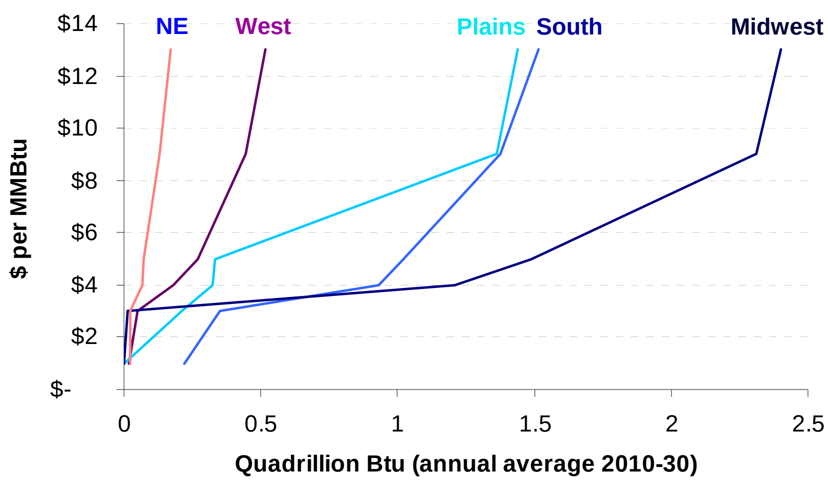
Wind resource



Non-CO_2 mitigation supply



Biomass supply



And, agriculture and forestry mitigation opportunities

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An important issue: mitigation policy design

<u>Options for U.S. INDC Implementation</u>

1. Sectoral – primarily regulatory
2. National (economy-wide)
3. International cooperation (bi- to multi-lateral)

Not all equal

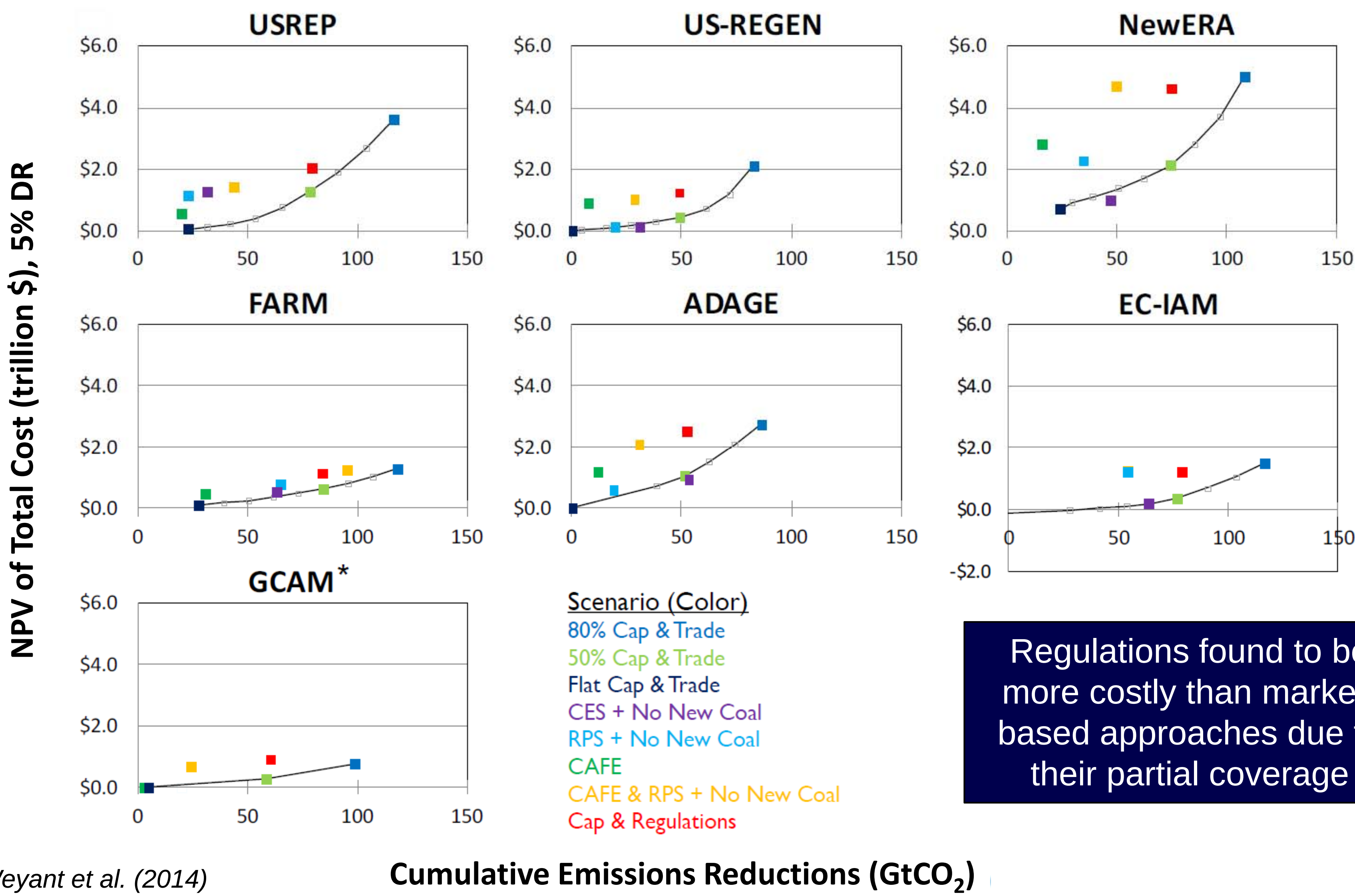
The regulatory approach precludes…

1. Realization of lower cost **cross-sector** emissions reduction opportunities

2. Realization of lower cost **international** emissions reduction opportunities

3. Cost-effective **long-run mitigation investment**

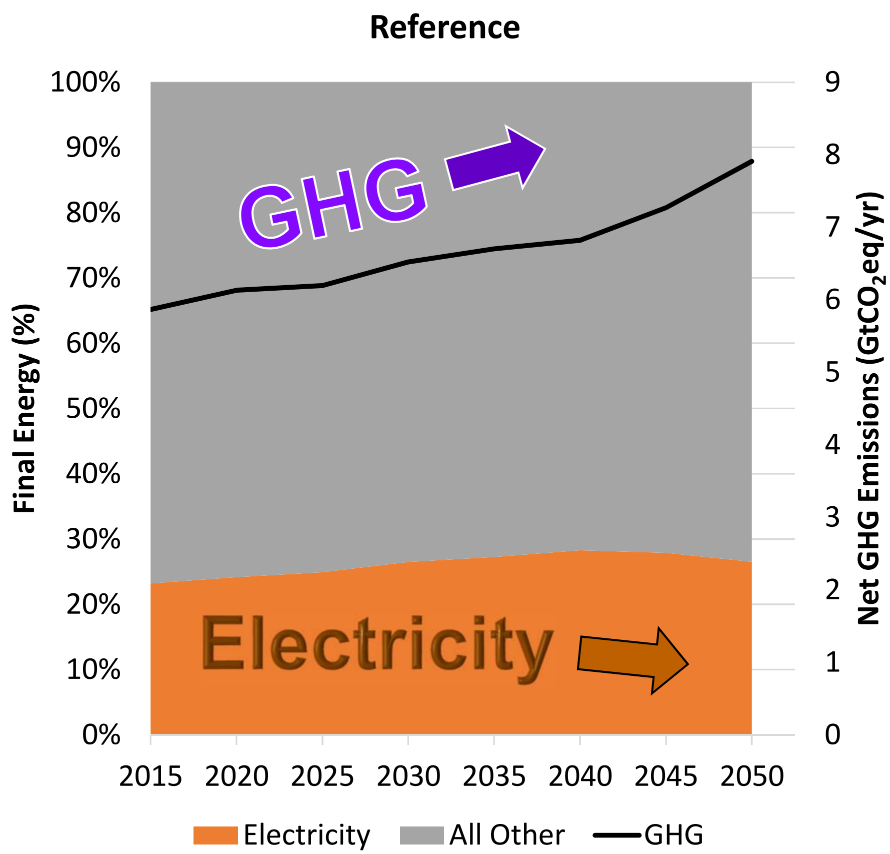
Cost comparisons of different U.S. climate policy architectures

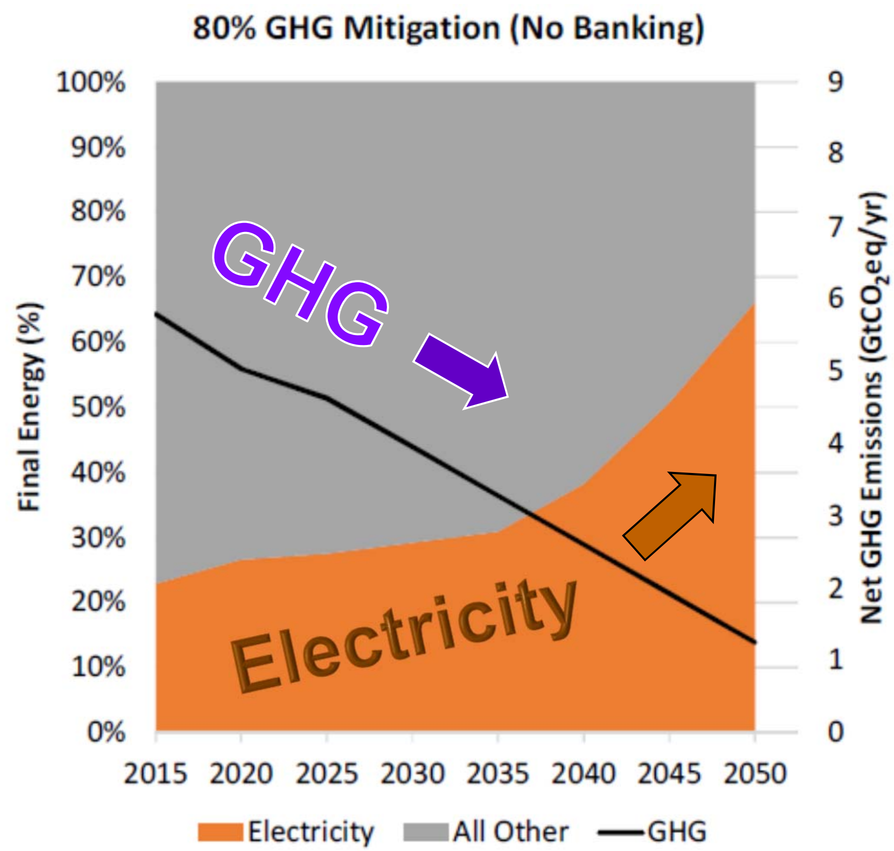


Regulations found to be more costly than market-based approaches due to their partial coverage

Weyant et al. (2014)

Electrification potentially more cost-effective for reducing GHGs





Illustrative (not for citation)

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Opportunities for international cooperation?

Some Country Intended Nationally Determined Contribution (INDC) pledges for COP-21

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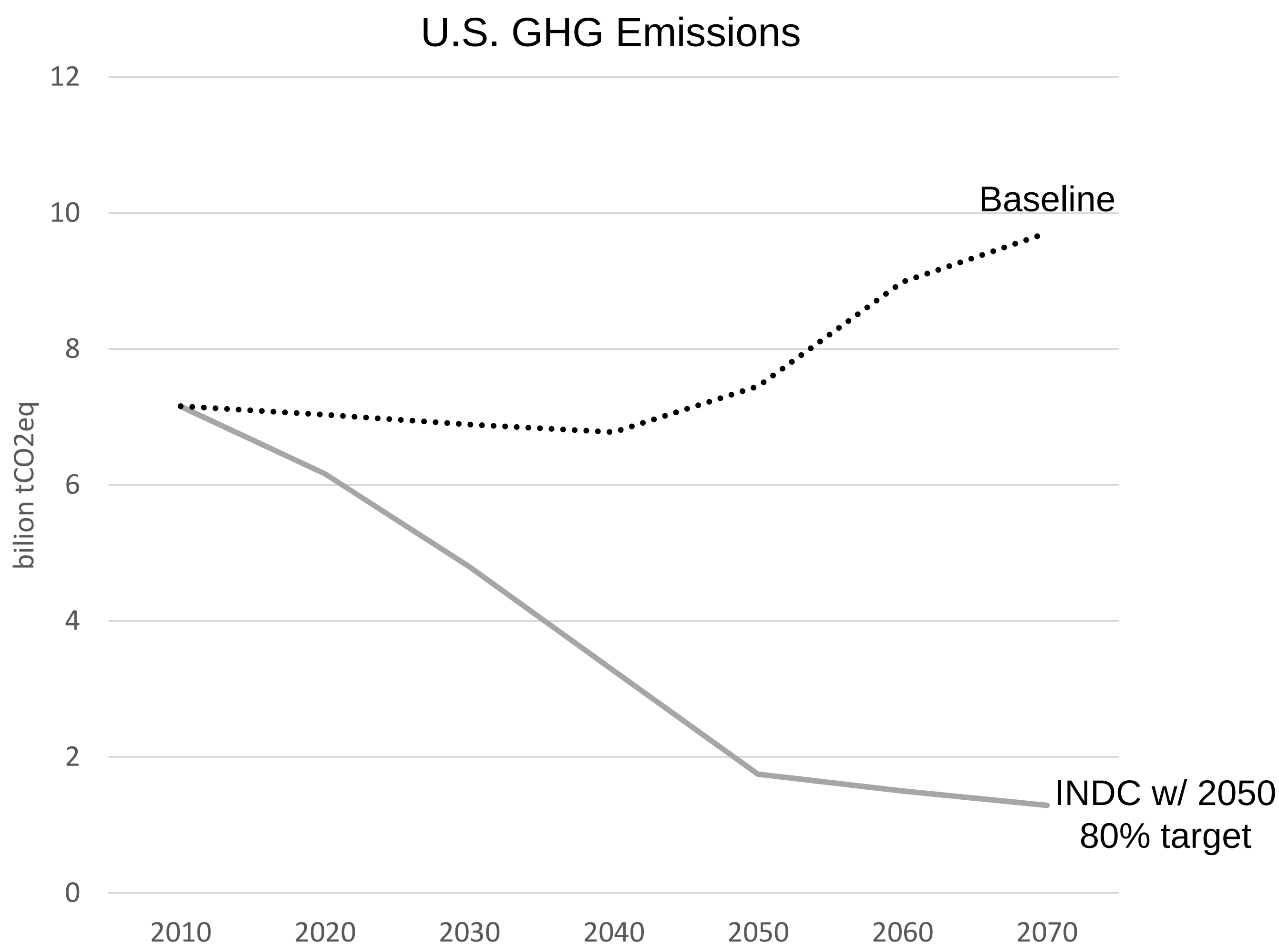
U.S. emissions & potential US-China permit trading

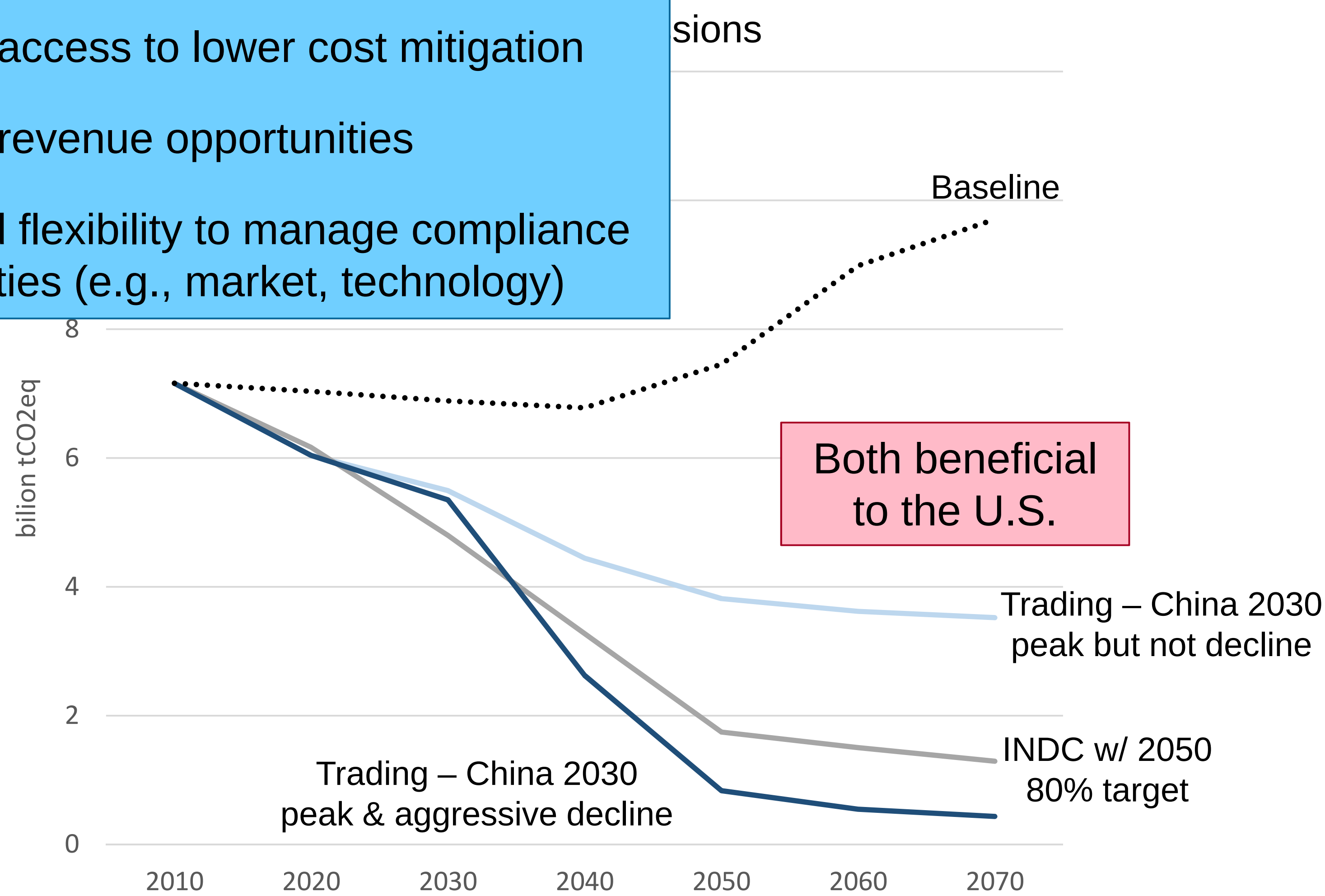


Illustrative (not for citation)

U.S. emissions & potential US-China permit trading

International Cooperation Potential

- Potential access to lower cost mitigation
- Potential revenue opportunities
- Increased flexibility to manage compliance uncertainties (e.g., market, technology)



Illustrative (not for citation)

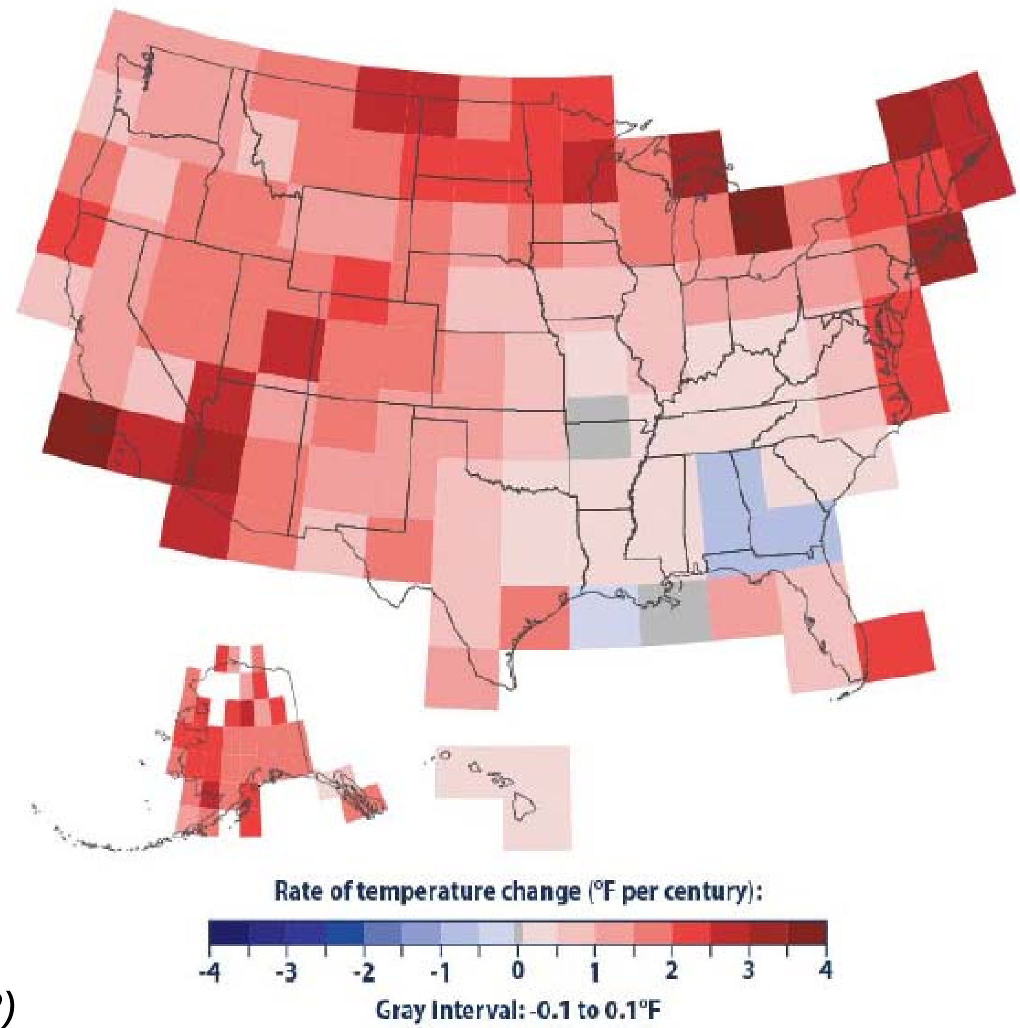
Climate vulnerability

Types of potential climate effects on energy

- Demand
- Resources – e.g., wind, water, land productivity
- Infrastructure
- Operations (constraints, variability, costs, reliability)
- Returns on investments

U.S. climate change trends

Rates of Warming in the U.S. 1901-2011

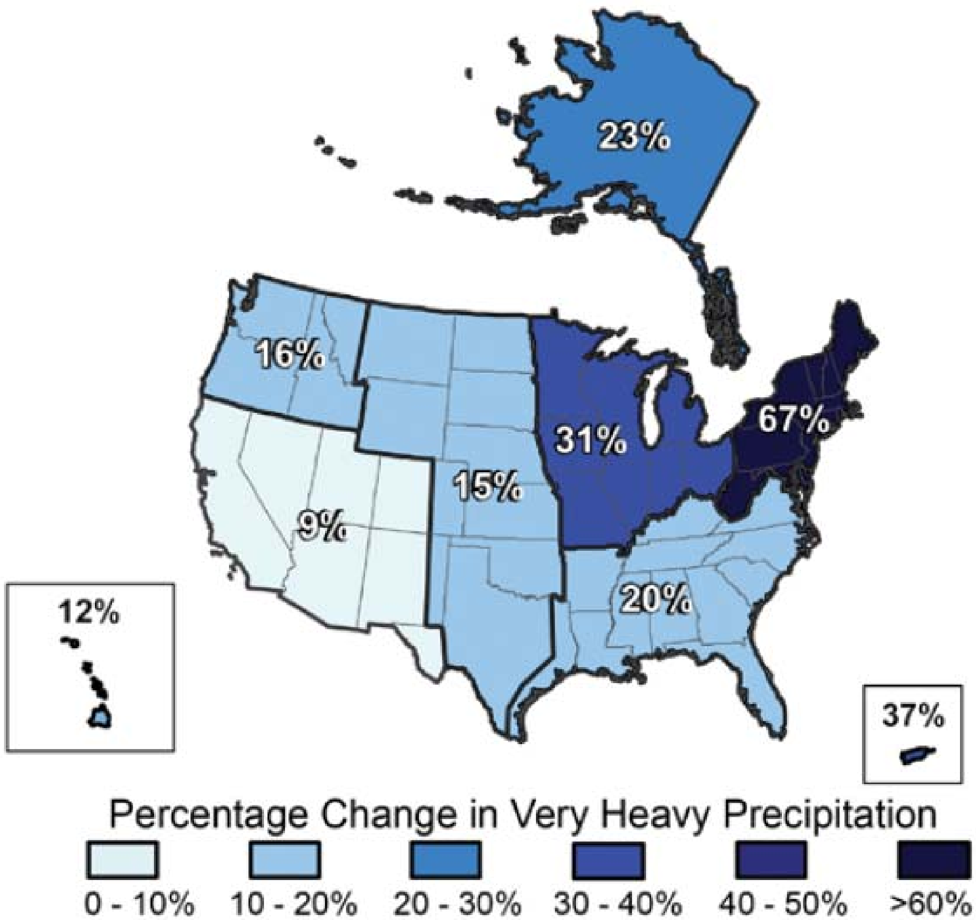


Nebraska: 0.5 to 1.5˚F of warming per century. An issue? What if faster?

EPA (2012)

U.S. climate change trends

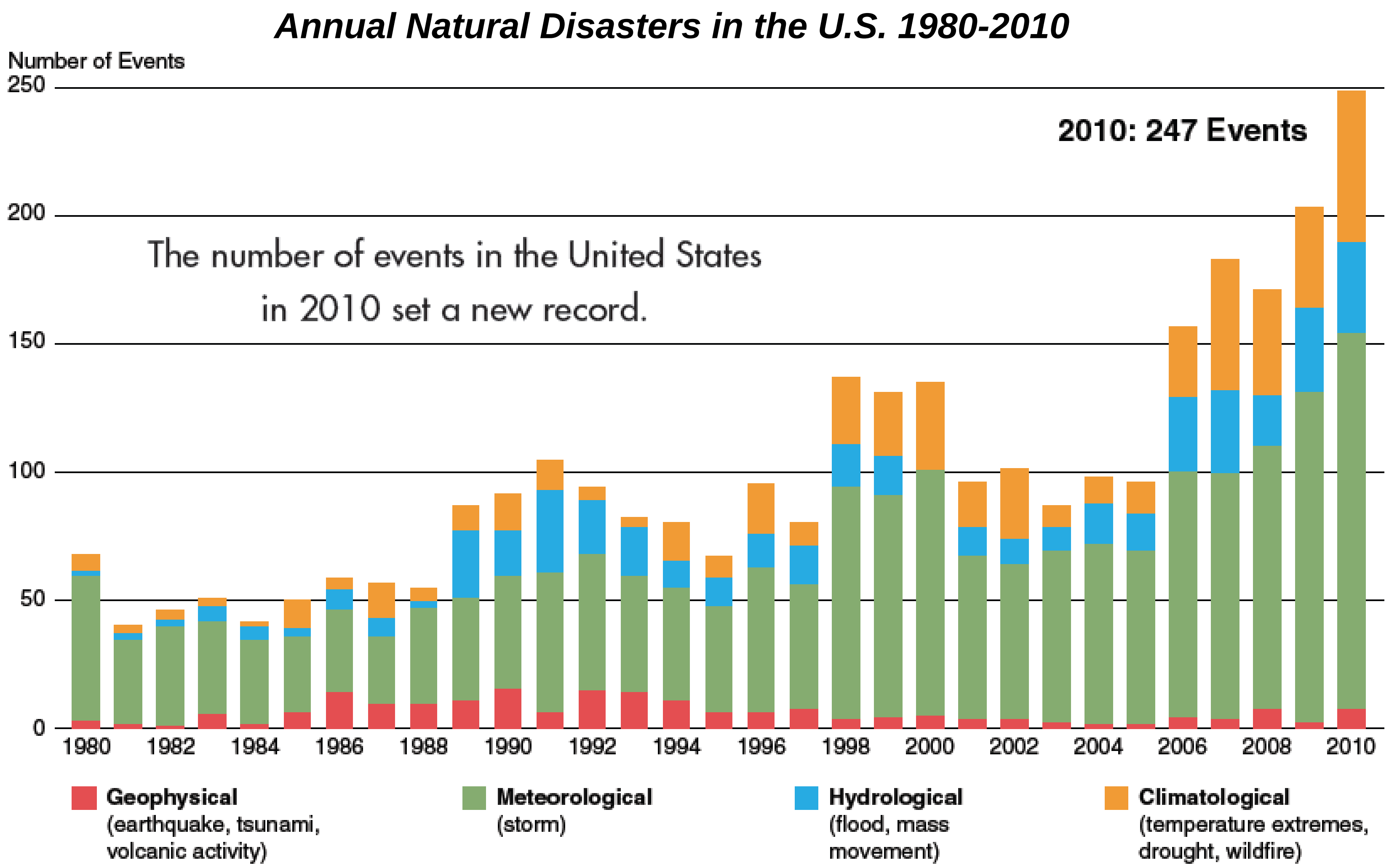
Percentage Changes in Very Heavy Precipitation 1958-2007



Central: 15% more rain in very heavy rain events

USGCRP (2009)

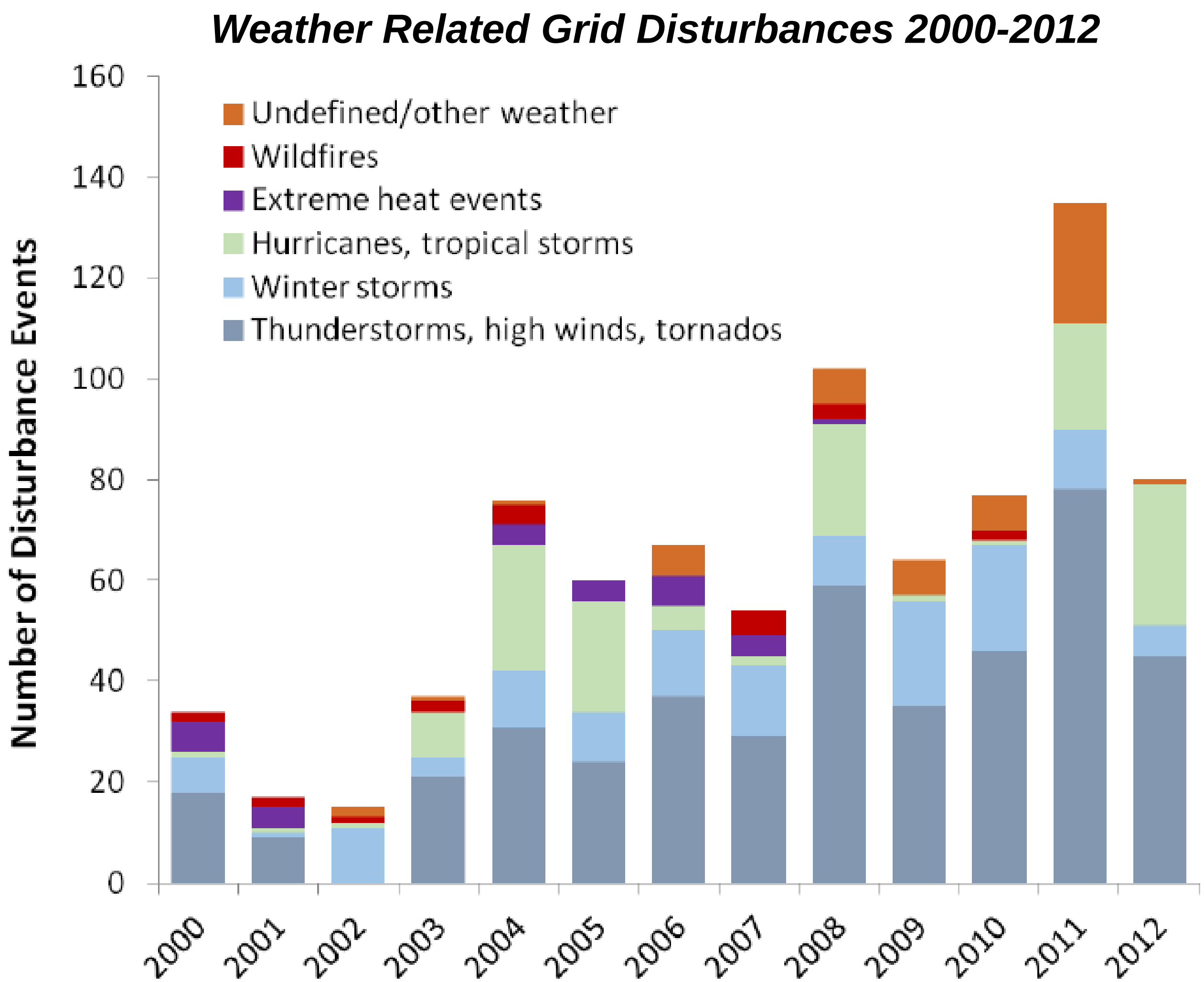
U.S. climate change trends



Munich Reinsurance America (2011)

U.S. energy system trends

Potentially changing weather trends and increased electricity sector risk?



DOE (2013)

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The inevitability of climate change – U.S.

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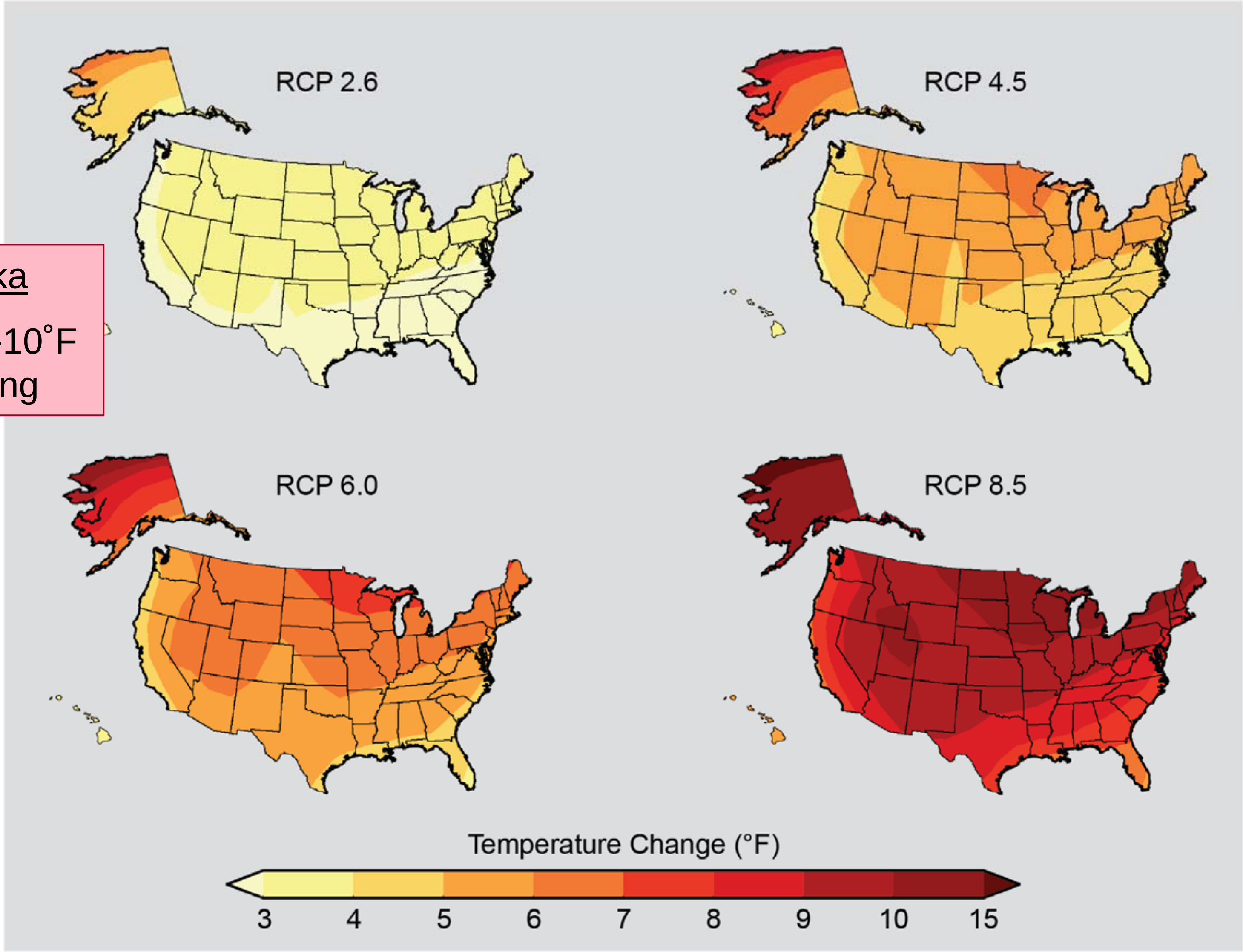

<u>Nebraska</u>

3-4 ˚F to 9-10˚F of warming

NCA (2014)

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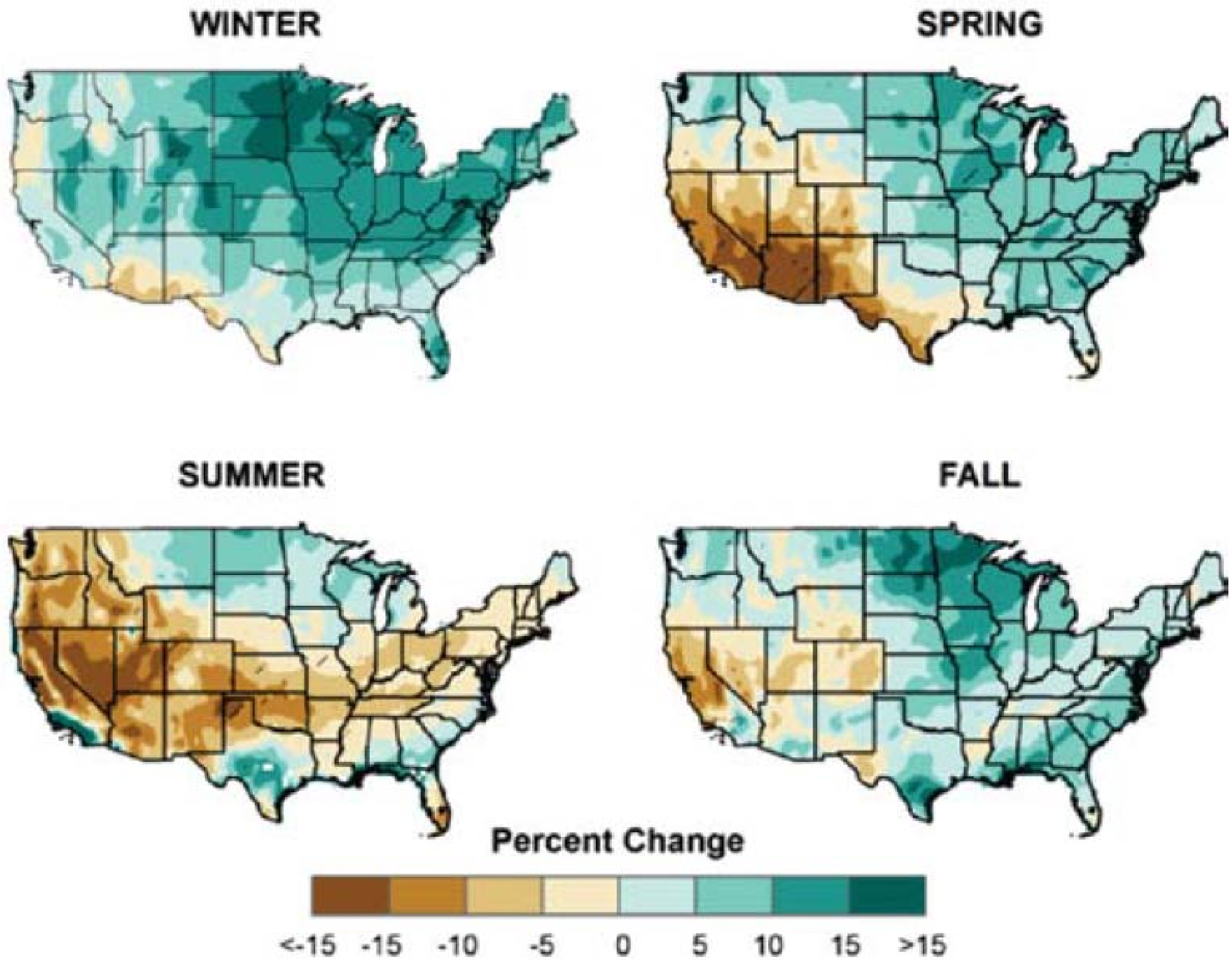
U.S. climate change projections

Nebraska

Over next 50 years, increases in winter precipitation, decreases in summer precipitation.

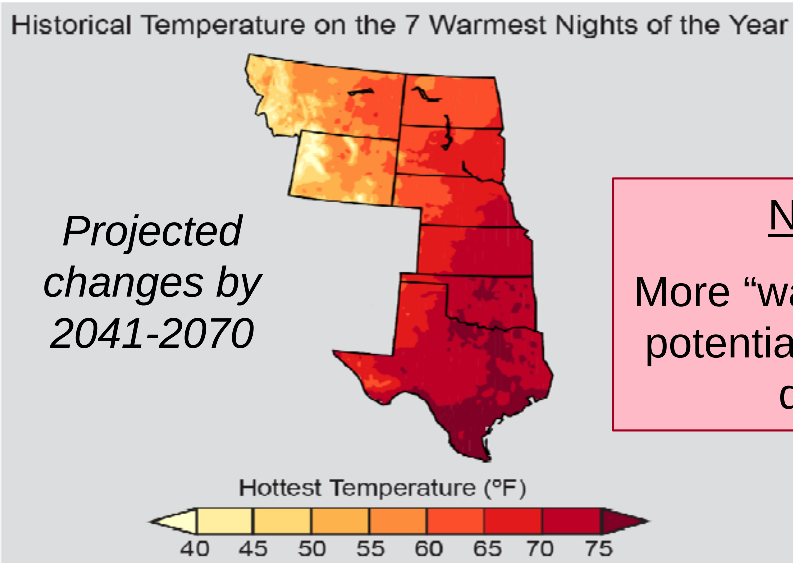
Projected Percent Changes in Seasonal Precipitation (2041-2070 compared to 1971-2000) for A2 Emissions Scenario



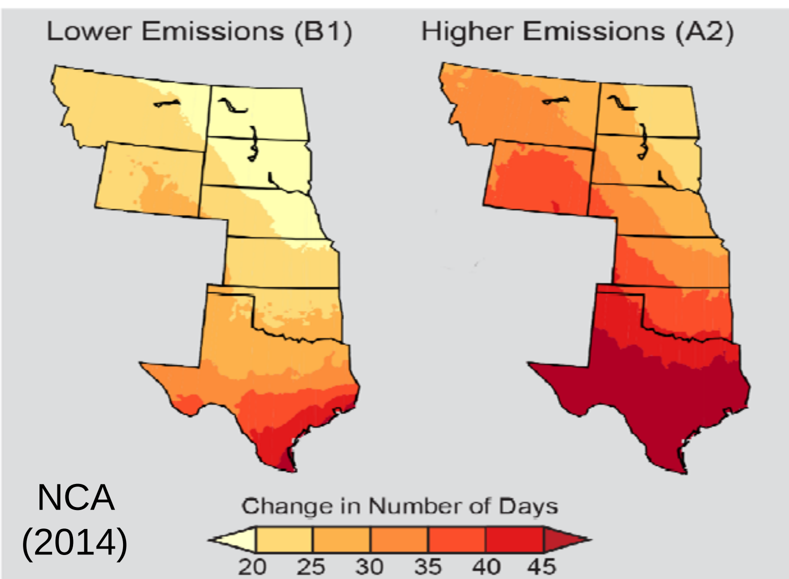
NOAA (2013)

Projected changes in regional weather extremes

Projected changes by 2041-2070



Projected Change in Number of Warm Nights

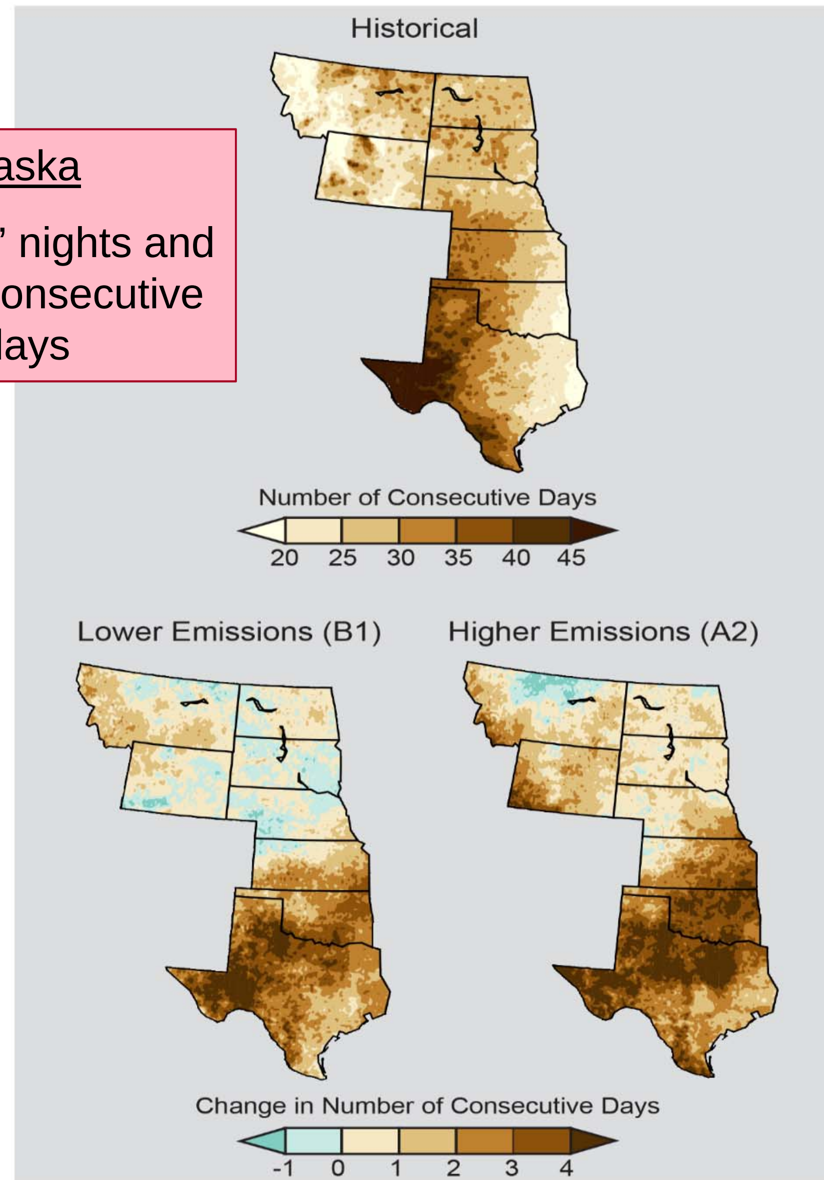


NCA (2014)

Nebraska

More "warm" nights and potentially consecutive dry days

Projected Change in Number of Consecutive Dry Days



Energy implications? Tier of perspectives needed.

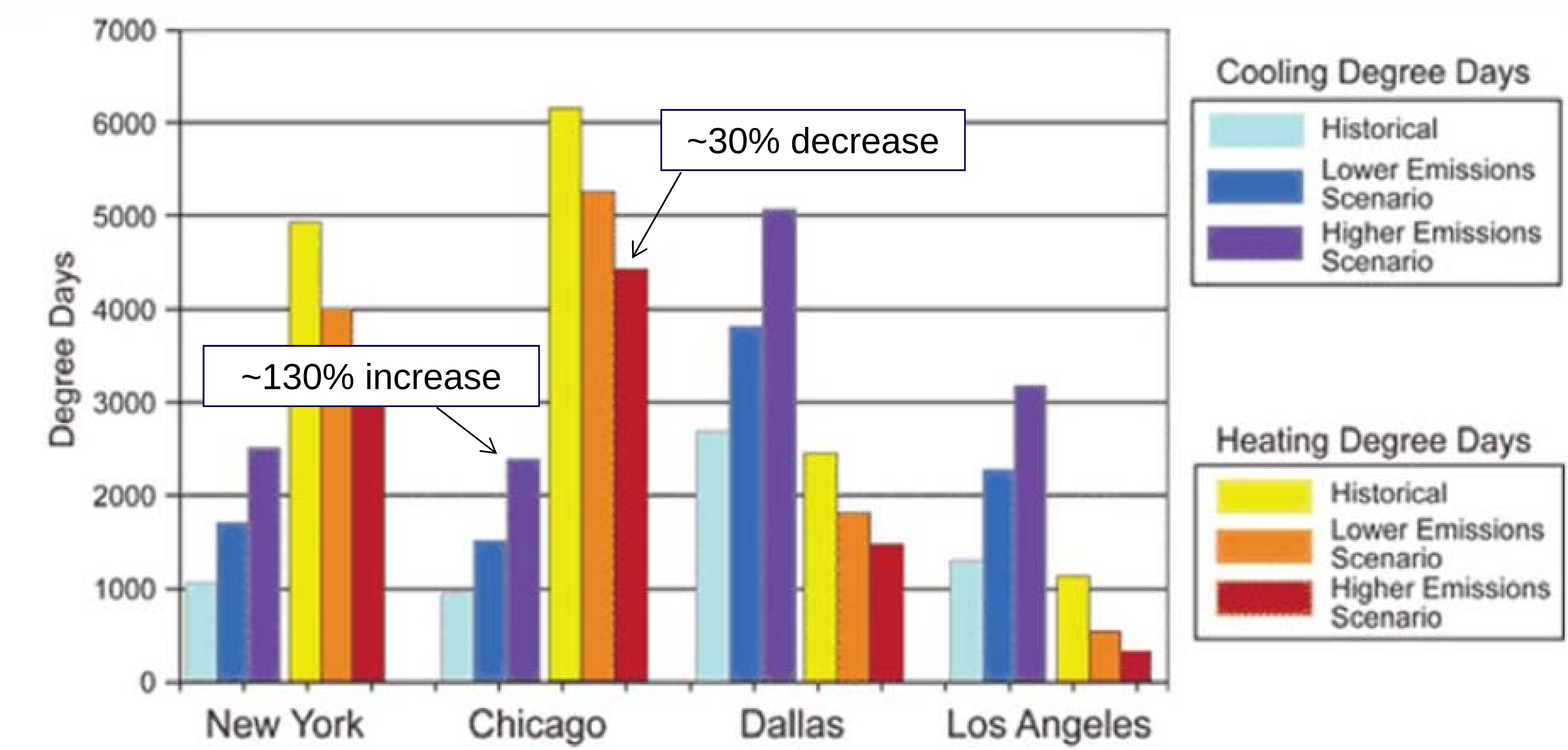
- Tiers of potential risk (and analyses)
  - Facility
  - System
  - Sector
  - Energy system
  - Economy
  - Other societal impacts

Direct sector risks (e.g., generation, distribution, load)

Direct risk implications & Indirect risks (e.g., energy markets, demand relocation)

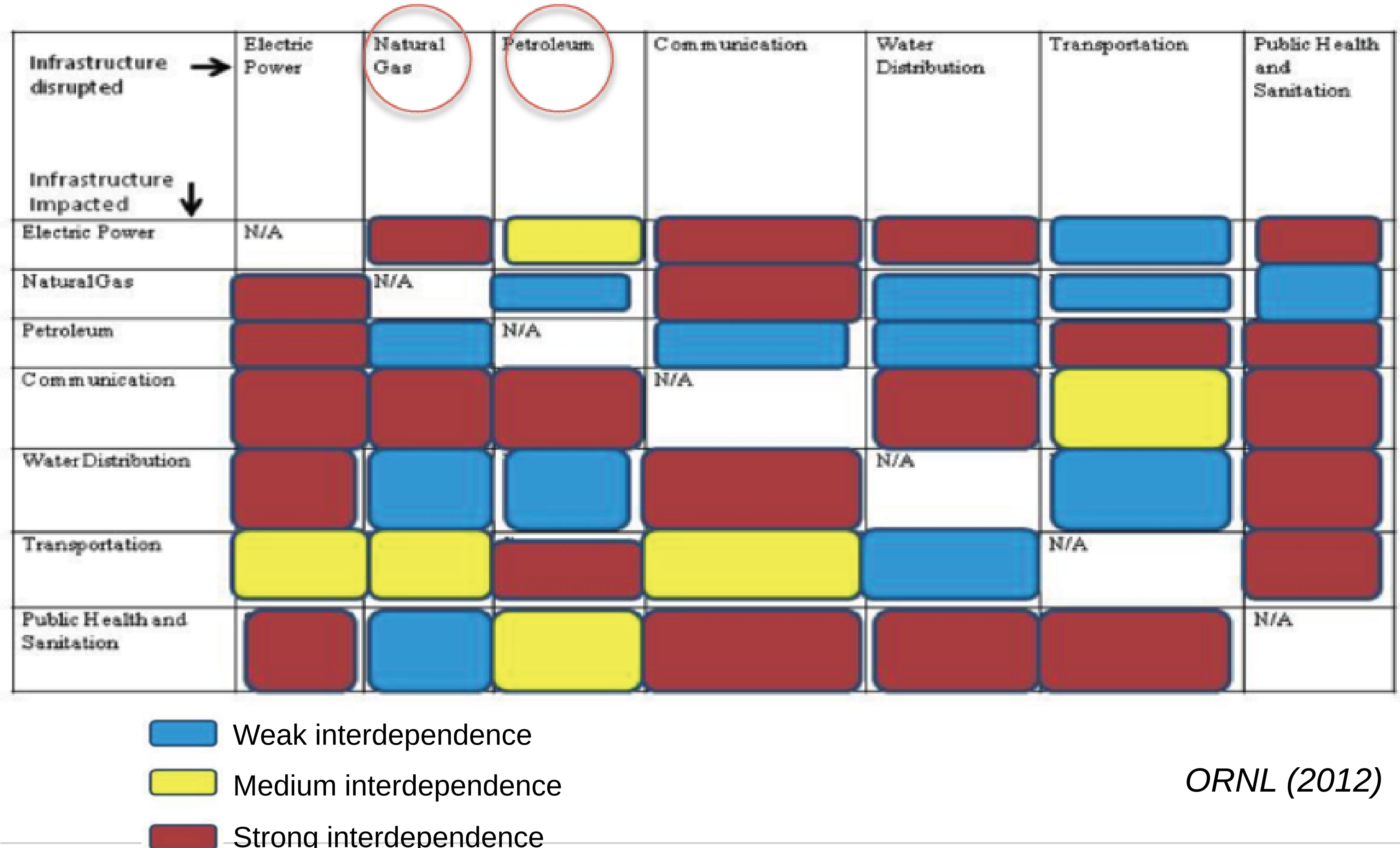
U.S. climate change projections

Projected Changes in Cooling and Heating Degree Days by 2080-2099



USGCRP(2009)

Climate risk through energy system interdependence



ORNL (2012)

Categories of climate adaptation responses/investments

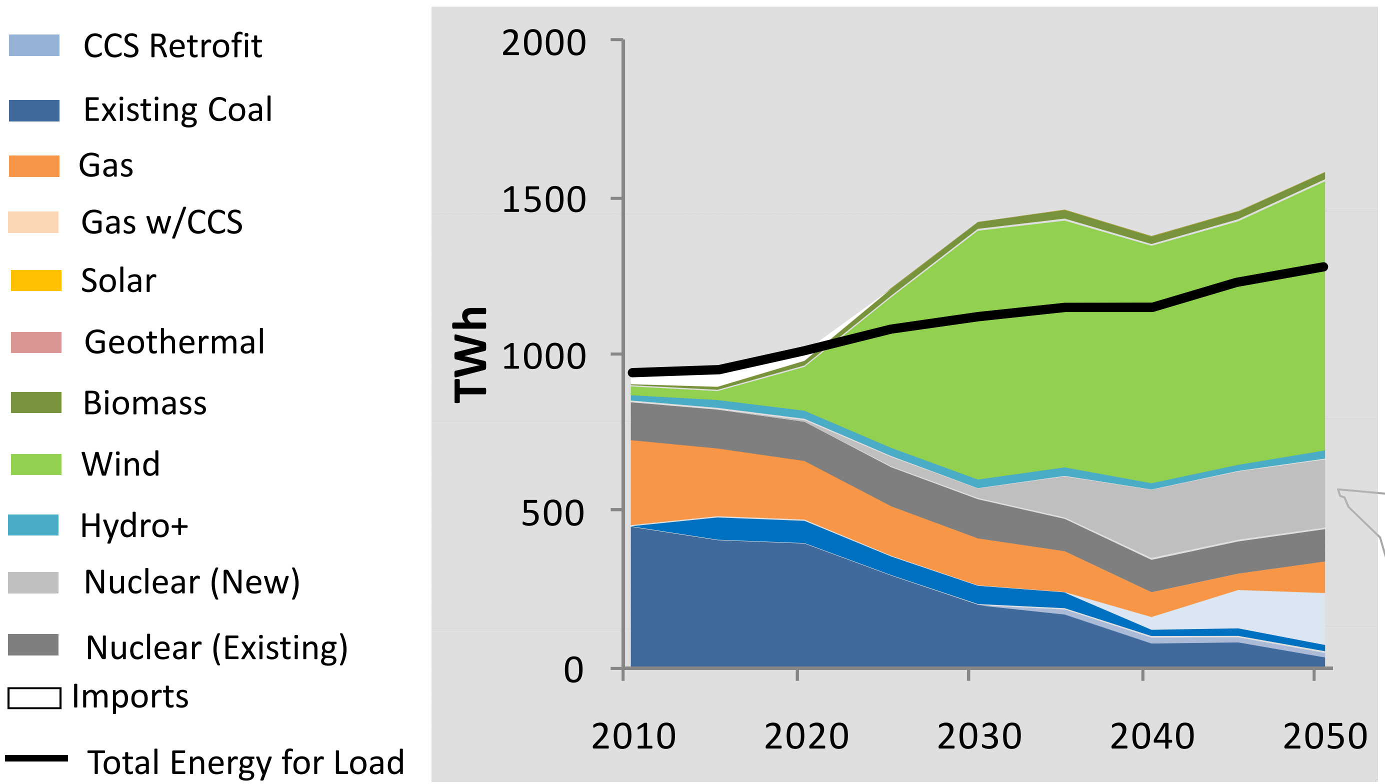
- None (current design adequate)
- Planning
- Preventive
- Restorative (response strategies)
- R&D

Need to characterize risk and return on investments – but challenging

Intersection between mitigation and adaptation

Mitigation climate vulnerabilities and opportunities?

Illustrative example of a Central US generation portfolio for a clean energy standard



2011 EPRI Summer Seminar

Concluding thoughts

- Some degree of climate change is inevitable
- We need to better characterize the risk to make informed response decisions
  - Can't avoid all risk and probably do not want to
- There are emissions mitigation opportunities, but policy design matters
  - Aggressive climate action requires looking beyond sectors, borders, and 2030
- There are adaptation possibilities, but which make sense?

Thank you!

Steven Rose

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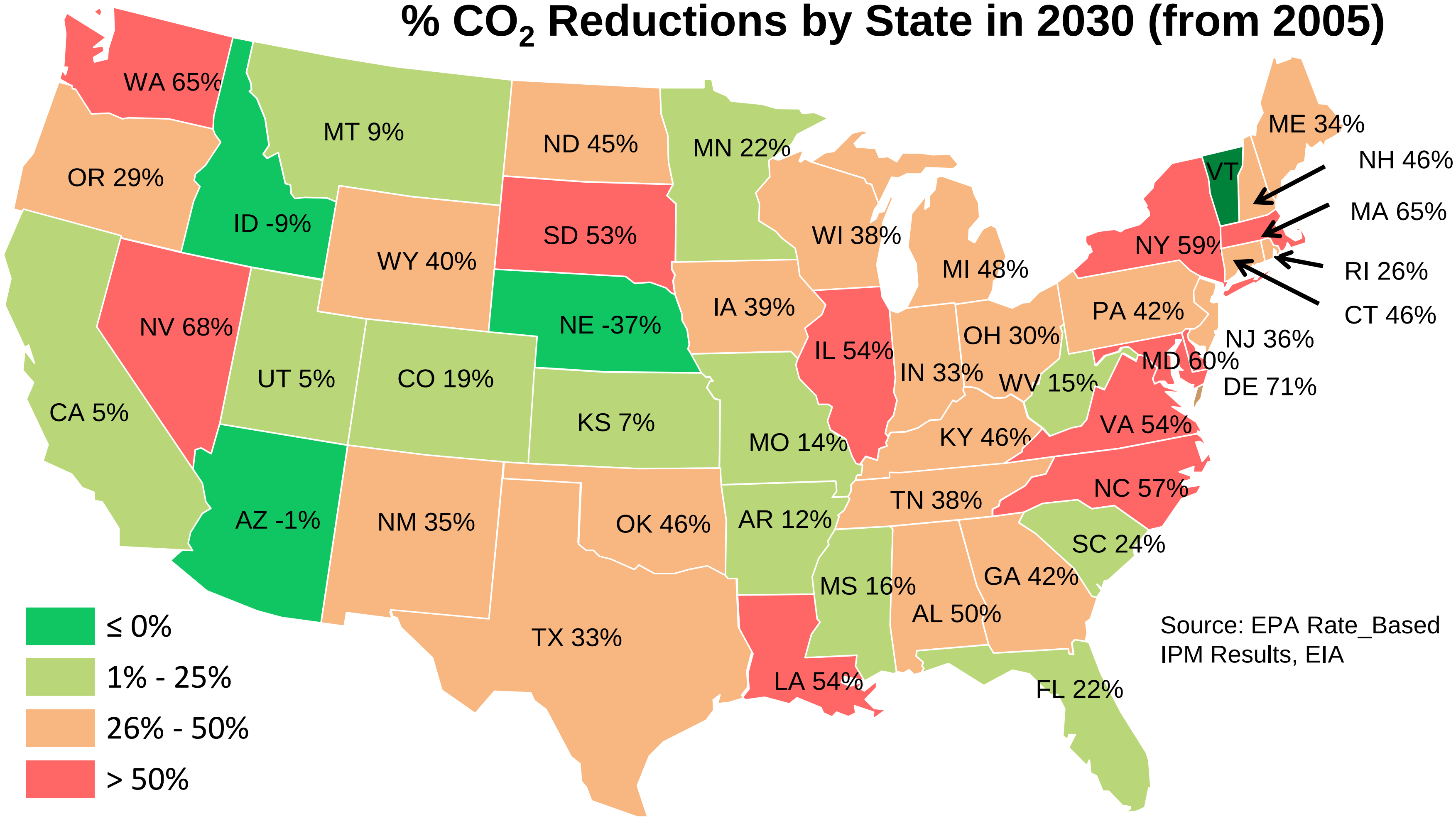
Together…Shaping the Future of Electricity

EPA's FINAL Proposal Will Have Varying State Impacts

% CO_2 Reductions by State in 2030 (from 2005)



Source: EPA Rate_Based IPM Results, EIA

Wide range in variation, but reduced from variation in Proposed Rule

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Table 3-1. Statewide CO_2 Emission Performance Goals, Rate-based and Mass-based

State	Rate-Based (Adjusted Output-Weighted-Average Pounds of CO_2 Per Net MWh From All Affected Fossil Fuel-Fired EGUs)		Mass-Based (Adjusted Output-Weighted-Average Short Tons of CO_2 From All Affected Fossil Fuel-Fired EGUs)	
	Interim Goal	Final Goal	Interim Goal	Final Goal
Alabama	1,157	1,018	62,210,288	56,880,474
Arkansas	1,304	1,130	33,683,258	30,322,632
Arizona	1,173	1,031	33,061,997	30,170,750
California	907	828	51,027,075	48,410,120
Colorado	1,362	1,174	33,387,883	29,900,397
Connecticut	852	786	7,237,865	6,941,523
Delaware	1,023	916	5,062,869	4,711,825
Florida	1,026	919	112,984,729	105,094,704
Lands of the Fort Mojave Tribe	832	771	611,103	588,519
Georgia	1,198	1,049	50,926,084	46,346,846
Iowa	1,505	1,283	28,254,411	25,018,136
Idaho	832	771	1,550,142	1,492,856
Illinois	1,456	1,245	74,800,876	66,477,157
Indiana	1,451	1,242	85,617,065	76,113,835
Kansas	1,519	1,293	24,859,333	21,990,826
Kentucky	1,509	1,286	71,312,802	63,126,121
Louisiana	1,293	1,121	39,310,314	35,427,023
Massachusetts	902	824	12,747,677	12,104,747
Maryland	1,510	1,287	16,209,396	14,347,628
Maine	842	779	2,158,184	2,073,942
Michigan	1,355	1,169	53,057,150	47,544,064
Minnesota	1,414	1,213	25,433,592	22,678,368
Missouri	1,490	1,272	62,569,433	55,462,884
Mississippi	1,061	945	27,338,313	25,304,337
Montana	1,534	1,305	12,791,330	11,303,107
Lands of the Navajo Nation	1,534	1,305	24,557,793	21,700,587
North Carolina	1,311	1,136	56,986,025	51,266,234
North Dakota	1,534	1,305	23,632,821	20,883,232
Nebraska	1,522	1,296	20,661,516	18,272,739
New Hampshire	947	858	4,243,492	3,997,579
New Jersey	885	812	17,426,381	16,599,745
New Mexico	1,325	1,146	13,815,561	12,412,602