Introduction

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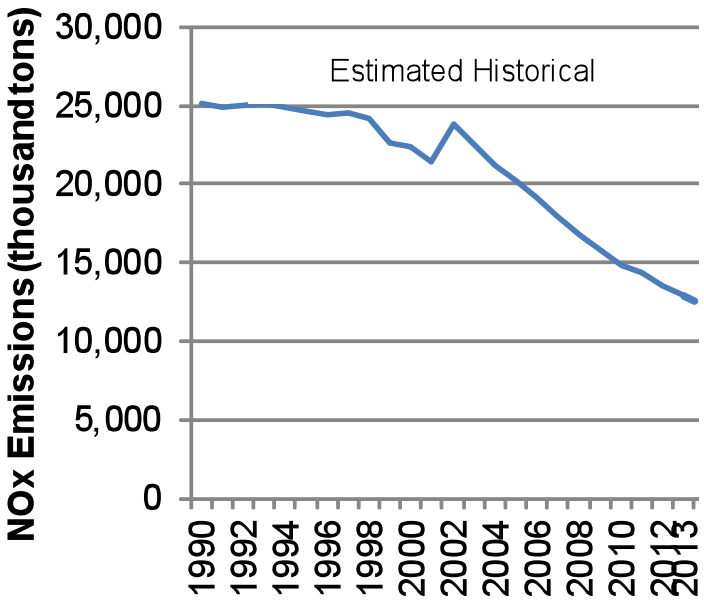
Estimating the costs of complying with a tighter ozone NAAQS involves many uncertainties that include:

1. The future baseline levels of ozone by region;
2. Responsiveness of ozone levels to reductions in NO_X and VOC;
3. How many tons will need to be reduced and where; and
4. Technologies available to make reductions and their costs.

This presentation discusses EPA's method of estimating costs, and alternative methods developed by NERA.

Historical and Projected Baseline NO_X Emissions



Notes: Blue line: estimated historical emissions; red line: emissions to attain 65 ppb on schedule

Source: NERA Calculations based on EPA information

- The U.S. has made great progress in reducing NO_X emissions to date
- The majority of these reductions have come from large EGUs and motor vehicles
- EPA projects a 40% decline in *baseline* NO_X from 2011 to 2025
- Future reductions will likely need to come from smaller and more dispersed sources

EPA Used Air Quality Modeling to Estimate Required Reductions in 2025

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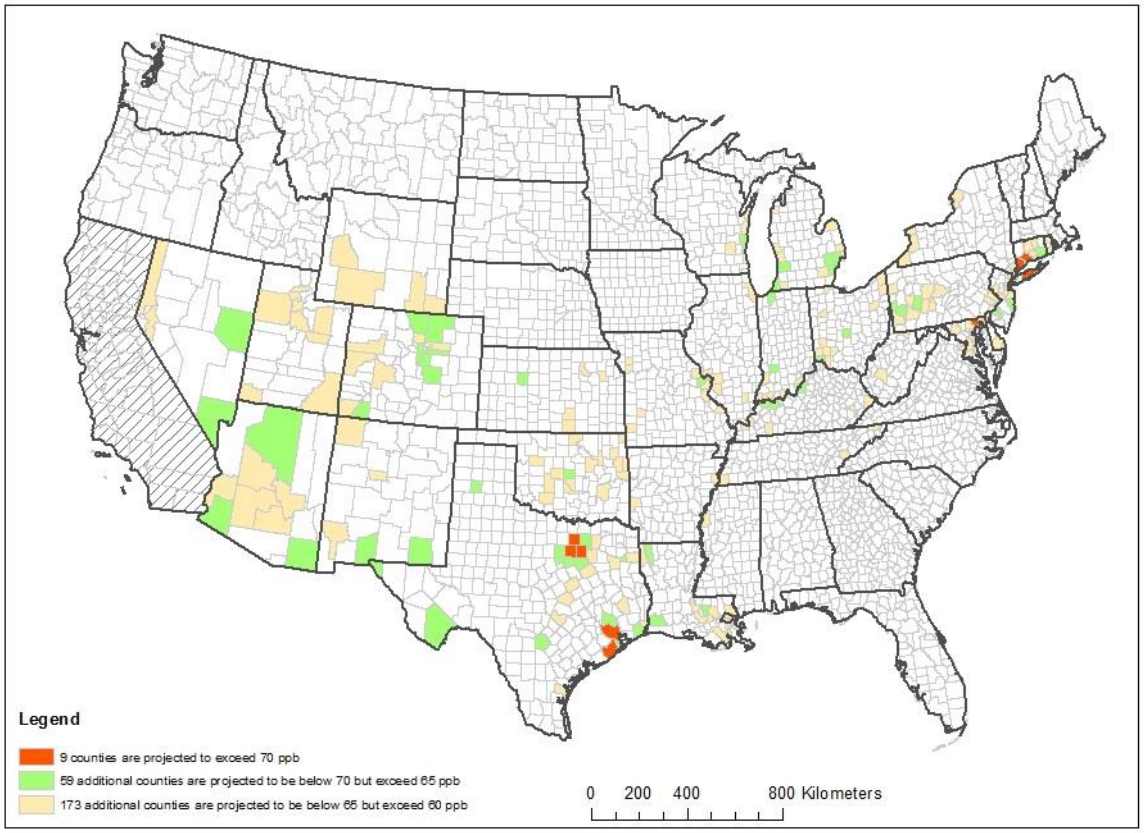
Projected Ozone Design Values in the 2025 Baseline Scenario



Source: Figure ES-2, EPA Ozone RIA

- Starting with a 2025 Base Case forecast of emissions, EPA performed national scale air quality modeling using CAMx
- EPA also did air quality modeling of 12 sensitivities to develop ozone sensitivity factors based on the modeled response of monitors to changes in emissions
- Sensitivity factors were used to estimate the quantity of reductions necessary for attainment

The Important Role of Background Ozone Levels

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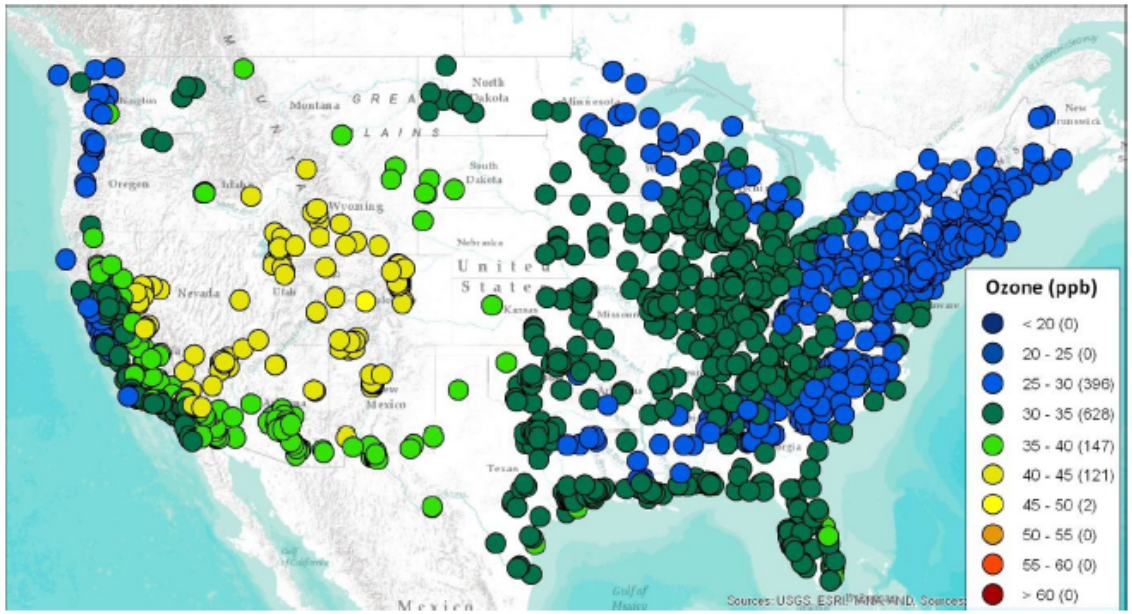
2007 Seasonal Mean of 8-Hour Daily Max Ozone from N. American Background (ppb)



Source: Figure 2-7, EPA Ozone RIA (based on zero-out modeling, CMAQ estimate

- "The definition of background ozone can vary depending upon context, but it generally refers to ozone that is formed by sources or processes that cannot be influenced by actions within the jurisdiction of concern." (RIA, p. 2-11)
  - This includes natural background ozone and anthropogenic emissions from outside the U.S.
  - Background ozone is a relatively higher % of total in intermountain West and along U.S. borders

EPA Identified Potential "Known" and "Unknown" Controls

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EPA identifies reductions as coming from either "Known Controls" or "Unknown Controls"

Known Controls	Unknown Controls
Based on existing, known technologies, include primarily end-of-pipe control technologies	Applied when Known Controls were not sufficient for attainment
Identified using the EPA's Control Strategy Tool (CoST), IPM Model, and NONROAD Model	
EGU, non-EGU point, area, and nonroad mobile sources (no onroad)	Not specified by sector, presumably distributed across sectors
Applied in any location within the multi-state region	Applied generally by region
Costs are based on engineering estimates (only include if cost was < $14,000/ton for non-EGUs)	$15,000/ton

EPA's Support for a Constant $15,000/ton Cost for "Unknown Controls"

- 96% of EPA's full set of Known Controls cost less than $15,000/ton
- Average cost of Known Controls in EPA's dataset was $3,400/ton
- EPA's Known Controls focus on a "limited set of emissions inventory sectors"; "Unknown Controls" could include currently-available controls in other sectors
- Historically, EPA has sometimes overestimated the cost of Unknown Controls
- Baseline emissions could be lower because of co-benefits from other regulations (*e.g.*, MATS, CPP and Tier 3 lowered the 2025 baseline)
- $/ton for other NO_X rules had costs between $2,200 and $11,300/ton
- Annualized NO_X offset prices in several areas in nonattainment with the current ozone NAAQS (75 ppb) are still less than $15,000 per ton
- Costs could be lower because of technological innovation and diffusion
- Environmental policy can create incentives for technological change
- Because cost changes from technological change will be available nationally, a single cost is used across regions

EPA Estimated 2025 Compliance NO_X Emissions and U.S. Costs

Only Includes States with Reductions

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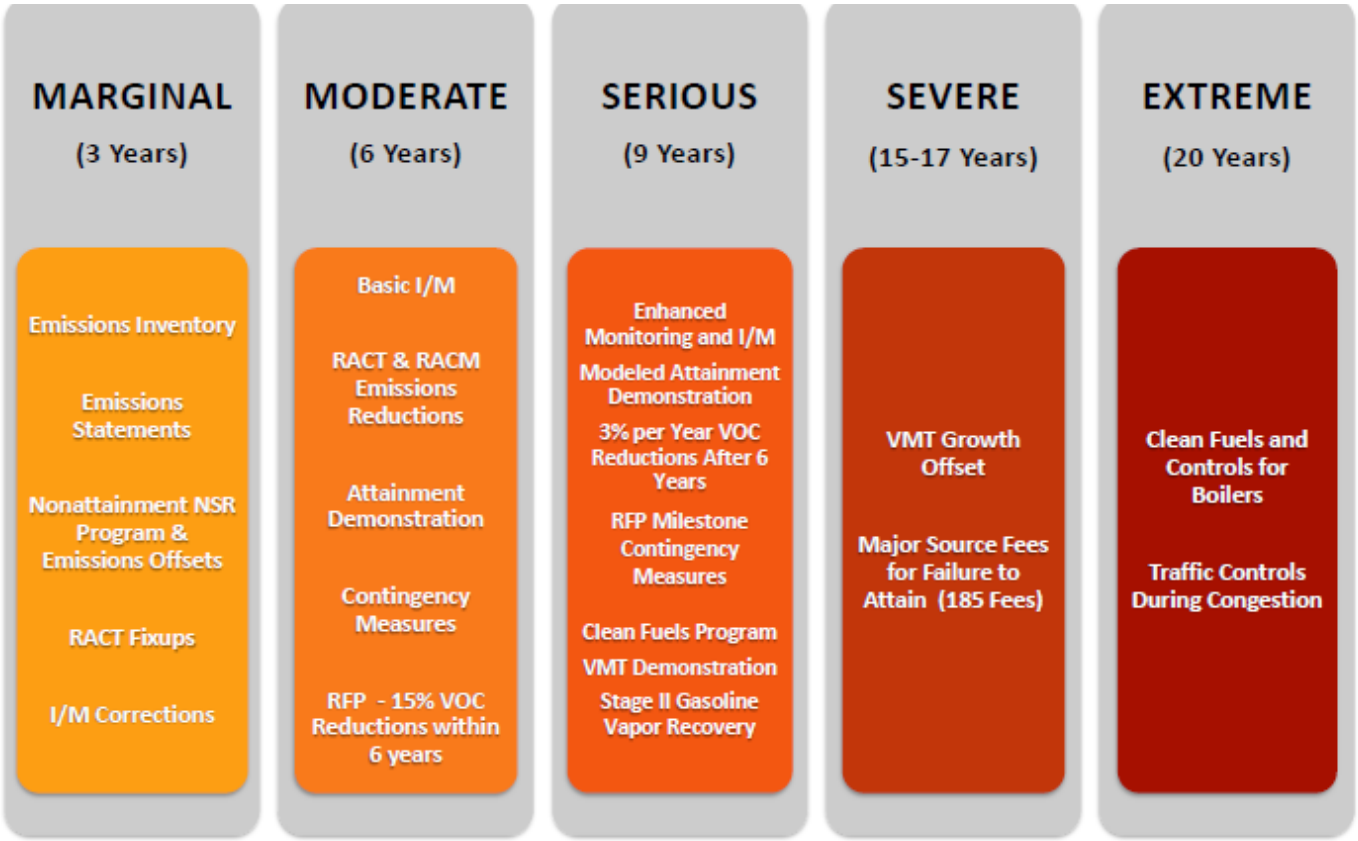
	NO_X (MM tons)	Annualized Cost (2011$, Billions)
Base Case	6.3	
CPP/75 ppb compliance	(0.6)	Not Applicable
Baseline	5.7	
Known Controls	(0.9)	$1.6
EGU SCR Controls	(0.2)	$1.7
Unknown Controls	(0.9)	$13
Compliance Emissions	3.7	
Total Reductions from Baseline	**2.0**	**$16**

Including only reductions from the Baseline, there are 2.0 million tons of NO_X reductions at an annualized cost of approximately $16 billion, or an average cost of $8,000/ton

Texas' share of these costs are approximately $4 billion

SIP Requirements for Ozone Nonattainment Areas



- Additionally, major source thresholds decline from 100 tons per year for Marginal/Moderate to 50 for Serious, 25 for Severe and 10 for Extreme
- Nonattainment NSR ratios also increase from 1.1:1 for Marginal to 1.5:1 for Extreme

Source: SIP 101, Kristin Jacobsen, TCEQ. Available at: https://www.tceq.texas.gov/assets/public/implementation/air/sip/miscdocs/2014_SIP101.pdf

Alternate Uncertainties in EPA's Approach

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Uncertainty	Consequences
1. Baseline emissions should not include reductions from proposed CPP, which is highly uncertain	Additional reductions would be required, likely from Unknown Controls
2. Compliance emissions are required in 2022 (for most states), not 2025 based on Marginal or Moderate classification	Additional reductions would be required, likely from Unknown Controls
3. Costs for Unknown Controls should not be constant (should increase with greater reductions)	Higher compliance costs and variance across areas
4. EPA assumed SIPs will put controls well outside nonattainment areas (sometimes in other states)	Higher compliance costs in nonattainment areas; lower compliance costs in attainment areas

Uncertainty 1: CPP Reductions are Uncertain and Do Not Belong in the Baseline

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- The CPP is only a proposed policy and is expected to be finalized by EPA this summer – once finalized it faces an uncertain future based on expected litigation that would likely either delay the implementation period or strike down the rule in its entirety
- Removing EPA's estimated CPP reductions increases the required reductions to be achieved by the proposed ozone NAAQS by about 300,000 tons (80,000 tons in TX)
- Adding back CPP reductions would likely require about 300,000 tons of additional "Unknown Controls"
- Using EPA's costs of "Unknown Controls," this would increase annualized costs by $4.5 billion in the U.S. ($1.2 billion in TX)

Uncertainty 2: Required Emission Reductions Are Understated by Looking Only at 2025 Compliance

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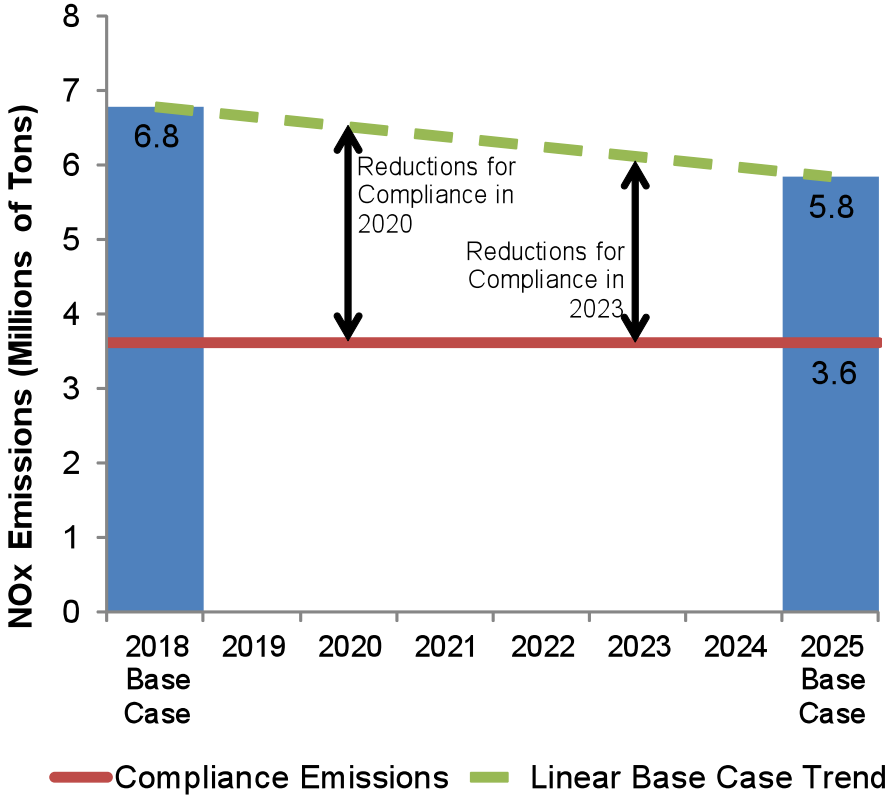
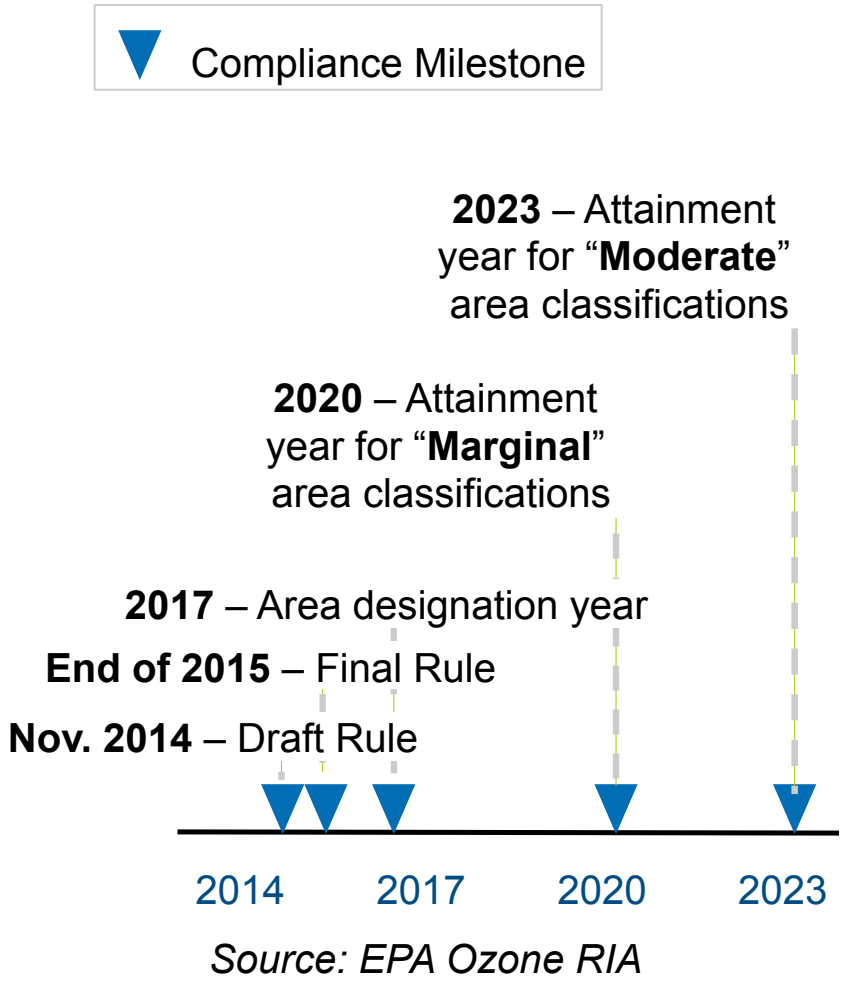
- EPA focuses its analysis on 2025, but attainment for Marginal and Moderate would be required by 2020 or 2023
  - EPA projects very large reductions in Onroad and Nonroad NO_X emissions through 2025
  - If compliance is required by 2023, 270,000 additional tons of reductions could be required (25,000 in TX)
  - Using EPA's "Unknown Control" costs, this could increase annualized costs by $4 billion in the U.S. ($0.4 billion in TX)

Emissions in States Requiring Reductions in EPA's Analysis (Excluding CA)



Estimated Timing



Source: EPA Ozone RIA

- Designations in 2017 would likely rely on 2016 design values
- NERA estimates that almost all areas designated as nonattainment will be classified as either Marginal or Moderate
- Marginal areas that do not achieve attainment by 2020 could be re-designated as Moderate
- Nonattainment areas would need to implement their controls at least 1 year prior to their attainment date to demonstrate compliance on schedule
- Moderate areas could get two 1-year extensions to demonstrate attainment if monitors in 2022 are at or below 65 ppb

Uncertainty 3: "Unknown Controls" Could Cost Significantly More than $15,000/ton

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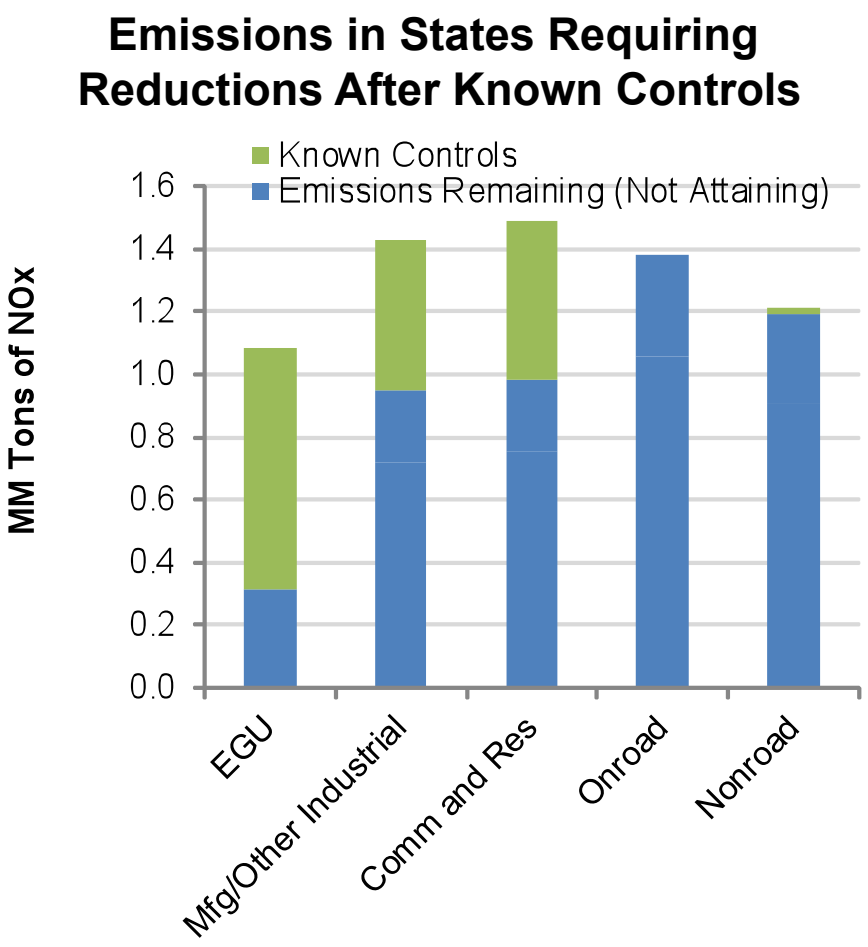
- EPA's arguments for a constant cost of "unknown controls" (see earlier slide) rely heavily on technological progress and "learning by doing," both of which are highly uncertain
  - These new/improved technologies that EPA has not identified would need to be implemented approximately 3 years after areas are designated for Marginal areas and 6 years after for Moderate areas (and less than that to be included in a SIP)
- Argument represents a shift from the 2008 and 2010 reviews, that included estimates of 'Unknown Control' costs based on a 'hybrid' approach with increasing marginal cost of control
  - This approach involved an upward-sloping extrapolation from the Known Control cost curve where the slope of the extrapolation was dependent on the ratio of Unknown to Known Control reductions
  - Areas needing a higher share of emission reductions from Unknown Controls had more rapidly increasing costs per ton for Unknown Controls
- If reductions in other sectors not evaluated by EPA are available for $15,000/ton or less, why haven't they been identified?

Where will Unknown Controls Come From?



- EGU – coal plants are fully controlled and many are projected to shut down
- Mfg/Other Industrial – large point sources have already been subject to significant control
- Commercial/Residential – there are many sources and the existing stock is difficult to regulate
- Onroad – Tier 3 in baseline, trucking hard to regulate at the state level
- Nonroad – 1/3 of emissions remaining are from freight rail, which is difficult to regulate at the state level; other sources like construction equipment and marine vessels are also hard to regulate at state level

A Hypothetical Allocation of Unknown Controls

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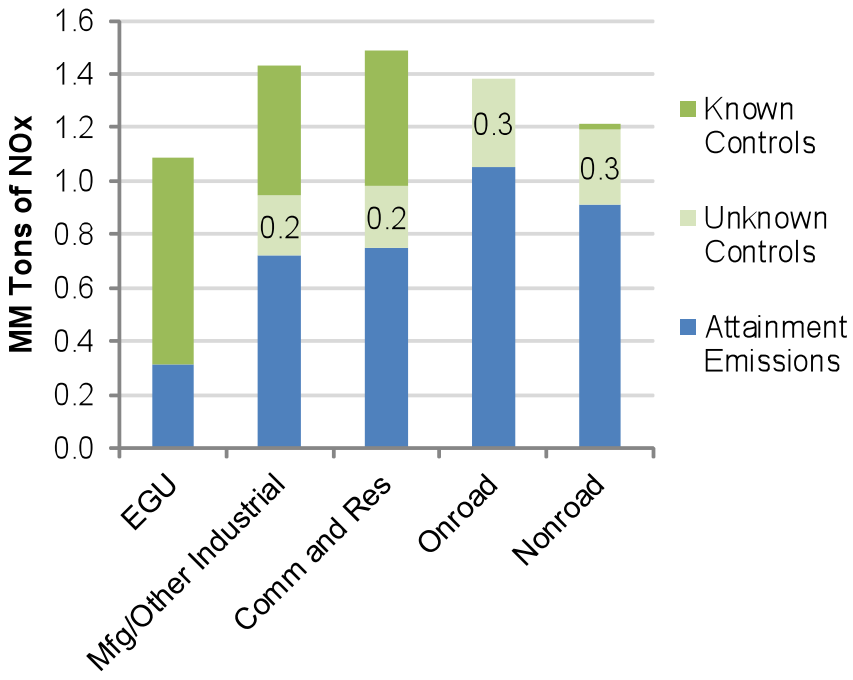
Potential Attainment Emissions Based on Allocation of Unknown Controls to Sectors



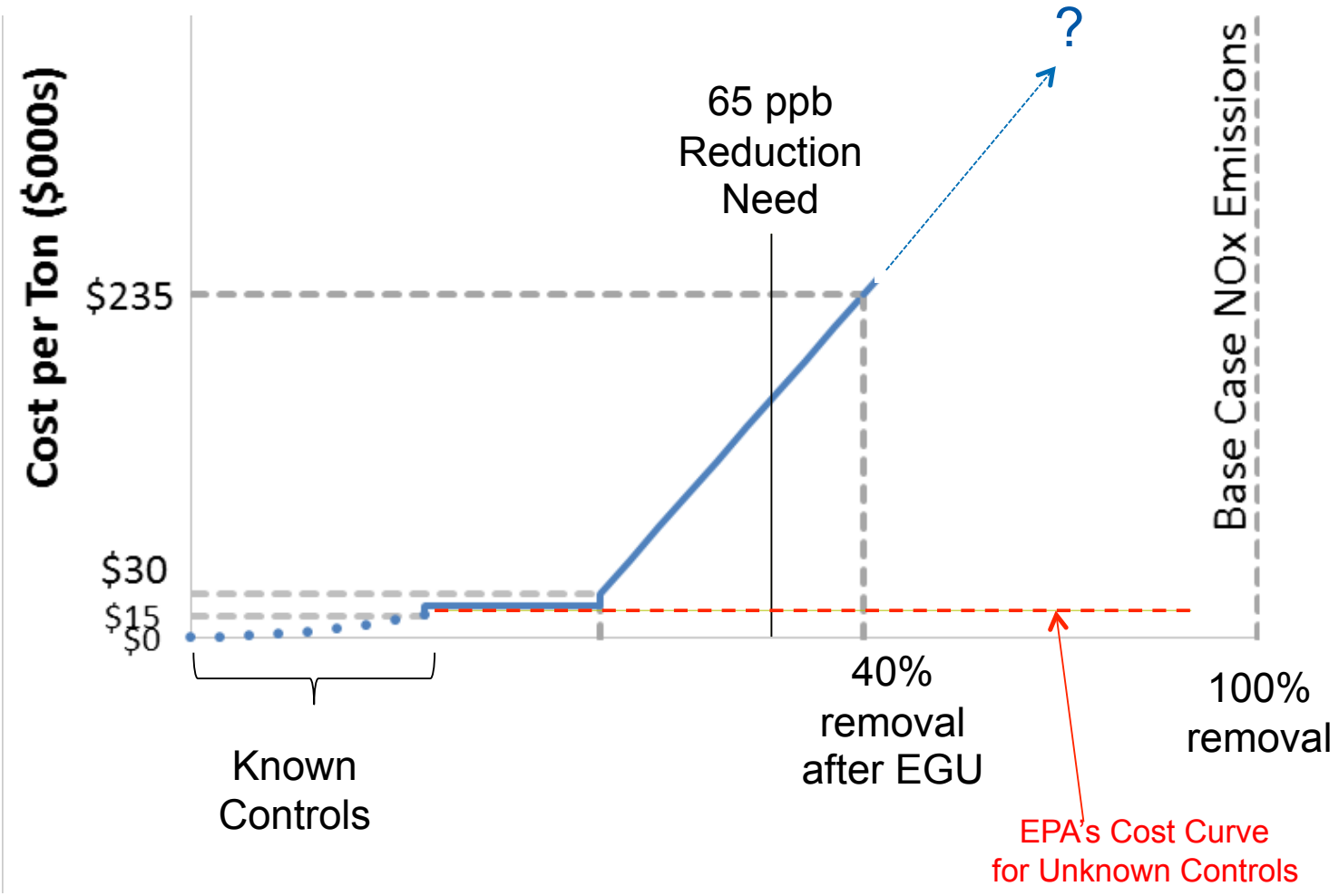
- How can states collectively:
  - Reduce NO_X emissions by more than 200,000 tons from the manufacturing and industrial sectors?
  - Reduce NO_X emissions by more than 200,000 tons from the commercial and residential sectors?
  - Reduce NO_X emissions by more than 300,000 tons from the onroad vehicles?
  - Reduce NO_X emissions by almost 300,000 tons from the nonroad vehicles?

Do states even have the statutory authority to make reductions in some of these areas?

1 Million Tons of Unknown Controls Must Come from Small Sources

- NERA did an analysis of the cost of scrapping vehicles from fleet that will be on the road in 2022:
  - Costs are based on replacing pre-Tier 2 cars with Tier 3 or electric vehicles
  - Up to 40% of remaining car/light duty truck emissions could be reduced by scrapping these vintages
  - Costs accelerate dramatically after those vehicles
- Marginal cost of the first 10% of vehicle emissions removal exceeded $50,000/ton
- Marginal cost of removing all 40% of the emissions was $235,000/ ton
- We assumed all other mobile and small sources would follow a similar cost curve, proportionately

Illustrative Cost Curve for Unknown Controls



Uncertainty 4: EPA's Regional Approach Is Inconsistent with State SIP Preparation

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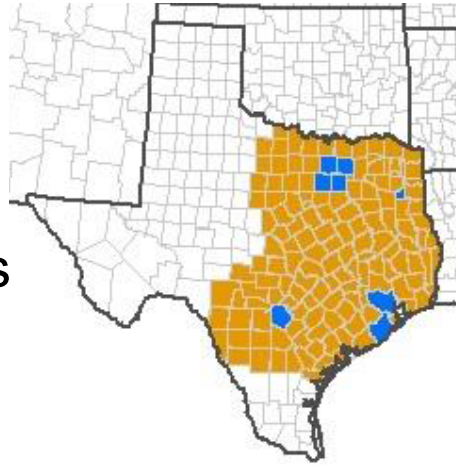
- As part of a preliminary, refined estimate for TCEQ, NERA applied a state-specific approach for TX
  - Split state into East and West, where East TX counties within 200 km of monitors above 70 ppb in 2025 EPA Base Case (orange/blue)
  - Included additional controls on engines/boilers in Houston area
  - Refinements to EGU reductions
    - Shutdown of all East TX coal units by 2022
  - Converted Unknown Tonnage Reductions in AR and MS to Unknown in East TX
    - AR and MS are in compliance with 65 ppb in Base Case and should not have any controls

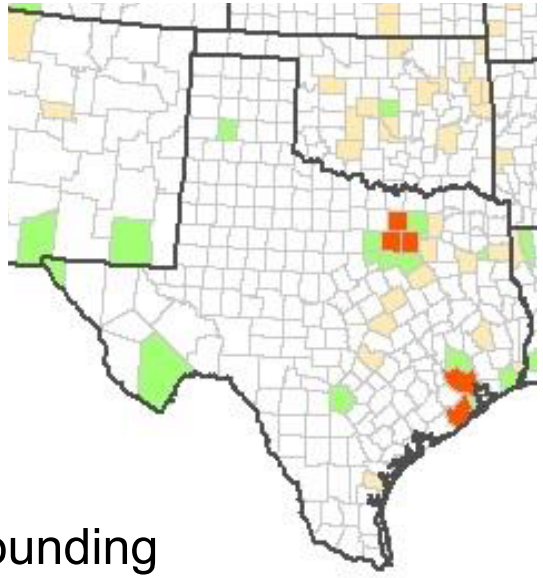


EPA had Known and Unknown Control costs in all TX counties

Reductions Have to Extend Beyond Nonattainment Counties

EPA data indicates a need for TX to make 559,000 tons of reductions to reach attainment with 65 ppb

	NO_X (tons)	# of Counties
Total TX	899,000	254
Monitored Counties in TX above 65 ppb in 2025	258,000	20



Reductions necessarily must come from counties surrounding those counties that are projected to be in nonattainment in TX. The estimated tons of reductions exceeds all of the estimated 2022 Base Case NO_X emissions for counties with a projected design value in excess of 65 ppb in the EPA Base Case.

A key question is how far away from nonattainment areas will a state require reductions to be made?

Compliance Costs and $/Ton Removed by County

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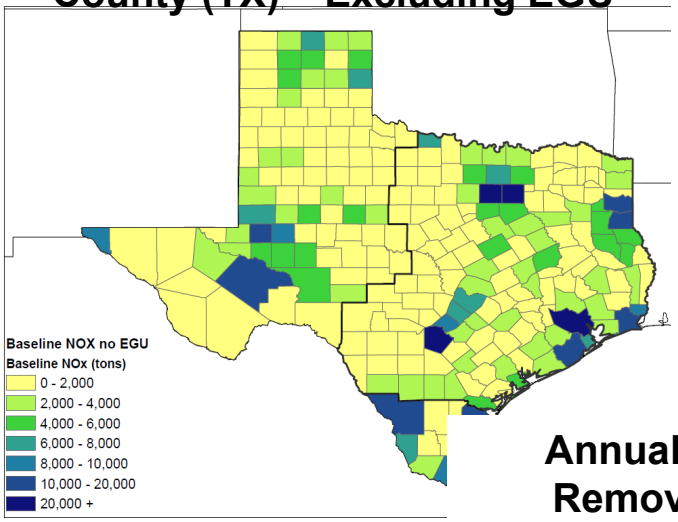
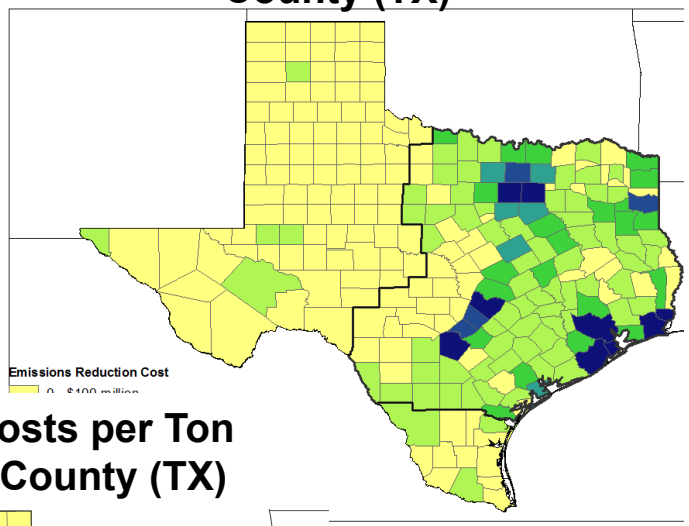
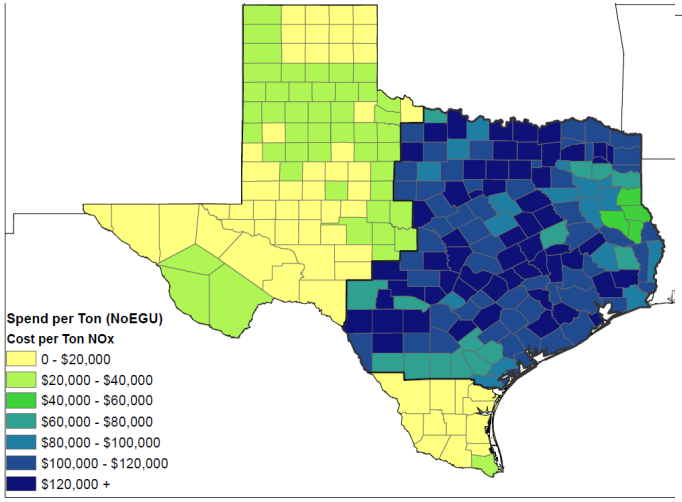
NERA 2022 Baseline NO_X by County (TX) – Excluding EGU



Annualized Compliance Costs by County (TX)



Annualized Costs per Ton Removed by County (TX)



Texas Emissions Reductions - State-Specific Compliance

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NERA's preliminary summary emissions for East and West TX to achieve compliance with 65 ppb in 2022

2022 NO_X Emissions (Thousand Tons)	East TX	West TX	Total TX
NERA Baseline	**607**	**291**	**899**
EPA "Known" Reductions	109	88	197
EGU Net Reductions (22 GW of coal retirements)	70	0	70
Add'l Houston Engine/Boiler Reductions	8	0	8
"Unknown" Reductions	237	46	283
Total Reductions	424	134	559
Estimated Compliance Emissions	**183**	**157**	**340**

Note: EPA "Known" reductions include reductions to reach 75 ppb

- *Total Reductions are 70% of East TX Baseline NO_X (46% of West TX, and 62% of Total TX)*
- *Unknown Reductions are 56% of total reductions in East TX (23% in West TX and 45% in Total TX)*

Alternate Estimated Compliance NO_X Emissions for U.S.

Only Includes States with Reductions

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	NO_X (MM tons)	Annualized Cost (2011$, Billions)
NERA Base Case	6.6	
75 ppb Compliance	(0.3)	Not Applicable
NERA Baseline	6.3	
Known Controls	(0.8)	$1.6
EGU Controls (SCR/retirements)	(0.8)	In Model
Unknown Controls	(1.0)	$153
Compliance Emissions	3.7	
Total Reductions from NERA Baseline	2.6	$155

Source: NERA calculations.

* The NERA Baseline reflects 2022 conditions in each state requiring reductions, with two exceptions: The Base Case for UT and CA reflect conditions in 2031 and 2036, respectively, based on higher likely severity classifications in those two states.

Texas' compliance costs (excluding EGU costs) are about $54 billion ($96,000/ton), based upon preliminary, refined estimates from an April 2015 analysis for TCEQ

Conclusions

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- Many uncertainties are involved in estimating the potential costs of complying with a 65 ppb ozone NAAQS and these can result in very different cost estimates
- Uncertainties about baseline emission projections and timing for reductions result in a range of required NO_X reductions of 2.0 and 2.6 million tons
- Uncertainties about costs of Unknown Controls result in a range of U.S. annualized compliance costs of $16 billion and $155 billion (excluding EGU costs)
- Uncertainties about costs of Unknown Controls and geographic location of controls results in a range of Texas compliance costs of $4 billion and $54 billion (excluding EGU costs)

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Back-up Slides

EPA Performed 12 Emissions Sensitivity Runs

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Table 3-2. List of Emissions Sensitivity Cases that Were Modeled in CAMx to Determine Ozone Response Factors

Emissions Sensitivity Case	Region	Pollutant	Emissions Change
1	National	All	111(d) option 1 state
2	National	VOC	50% VOC cut
3	California	NOx	CA explicit emissions control case
4	California	NOx	CA explicit emissions control case + 50% NOx cut
5	California	NOx	CA explicit emissions control case + 90% NOx cut
6	Southwest	NOx	50% NOx cut
7	Texas	NOx	TX explicit emissions control case
8	Central	NOx	TX explicit emissions control case + 50% NOx cut (central)
9	Midwest	NOx	50% NOx cut
10	Northeast	NOx	Northeast explicit emissions control case
11	Northeast	NOx	Northeast explicit emissions control case + 50% NOx cut
12	Northeast	NOx	Northeast explicit emissions control case + 90% NOx cut

Sensitivity runs were conducted to determine ozone response to emissions reductions of NO_X and VOC in different locations

Baseline 2025 Design Values in Texas

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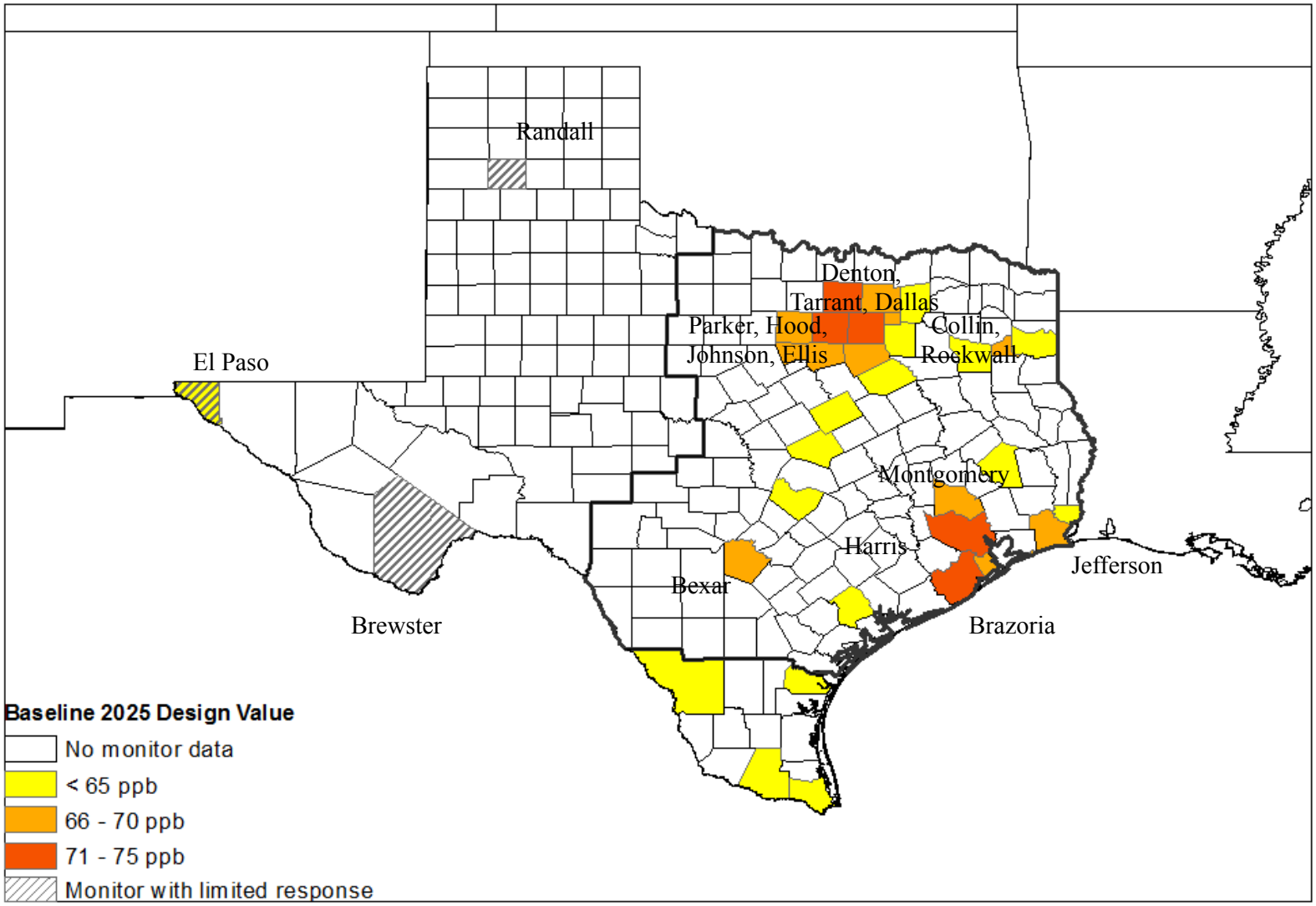

Highest Baseline Design Values for States in EPA's Central Region

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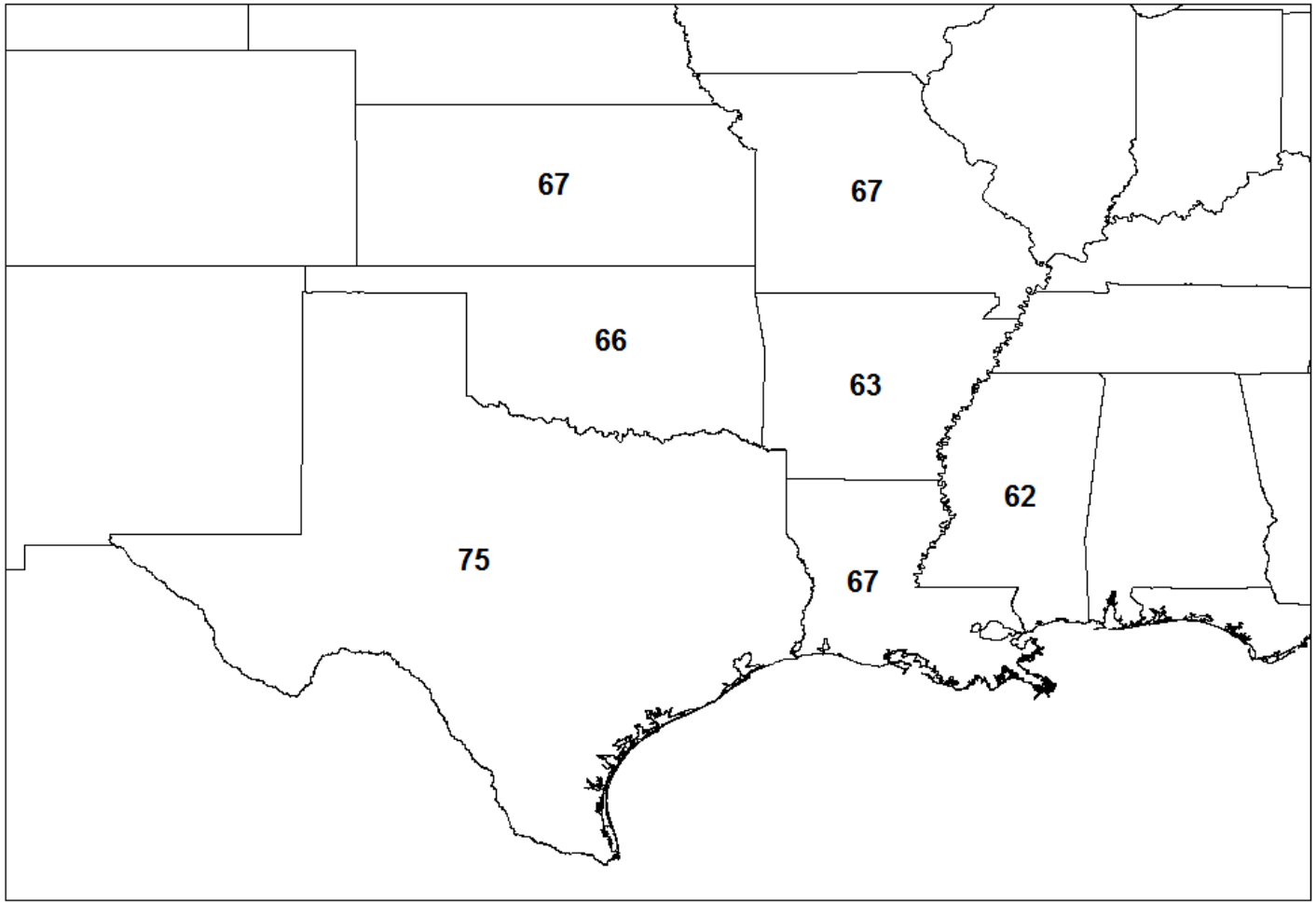

Additional Controls on Engines and Boilers in Houston Area

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- The 2010 Houston RACM analysis identified the potential to reduce an additional 32 tons/day (11,680 tons/year) at a cost of approximately $142 million by requiring additional controls on engines and boilers in the Houston area
  - The reductions would be achieved by requiring controls down to 50 hp engines in 8 counties east and northeast of the HGB area, and also including controls on ICI boilers in 3 counties to the east of HGB
  - EPA's Known Controls included 3,725 tons of reductions in the relevant counties related to rich and lean burn compressor engines down to 50 hp
  - We included as an additional Known Control the residual (11,680 less 3,725 tons, or 7,955 tons) at a cost of $12,158/ton (2010$) based on the original TCEQ estimate of $142 million for 11,680 tons

Consideration of Tightening the MECT Cap

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- The 2010 Houston RACM analysis identified the potential to reduce the MECT cap by 53 tons/day (19,345 tons/year)
  - EPA Known Controls included 27,182 tons of reductions in the counties subject to the MECT cap, more than the potential tightening considered by TCEQ
  - Thus, we did not include a tightening of the MECT cap as part of this analysis (could be considered as already being part of EPA Known Controls)

Nonattainment Status Imposes Additional Unspecified Costs

Depending on an area's classification (*e.g.*, Marginal, Moderate) there are additional requirements that get imposed

Some of these additional requirements have direct costs associated with them (*e.g.*, vehicle inspection and maintenance), but many do not

- Nonattainment New Source Review (NSR) requires the following for new sources and major modifications to existing sources:
  - Install controls to achieve the lowest achievable emission rate (LAER)
  - Purchase emission offsets
  - Allow for public involvement
- Transportation conformity could slow or limit an area's access to Federal Highway funds

Nonattainment status could lead to higher indirect costs and a slowing of economic growth (these costs are not part of the compliance costs presented here)

NERA's Analyses of the Proposed Ozone Standard

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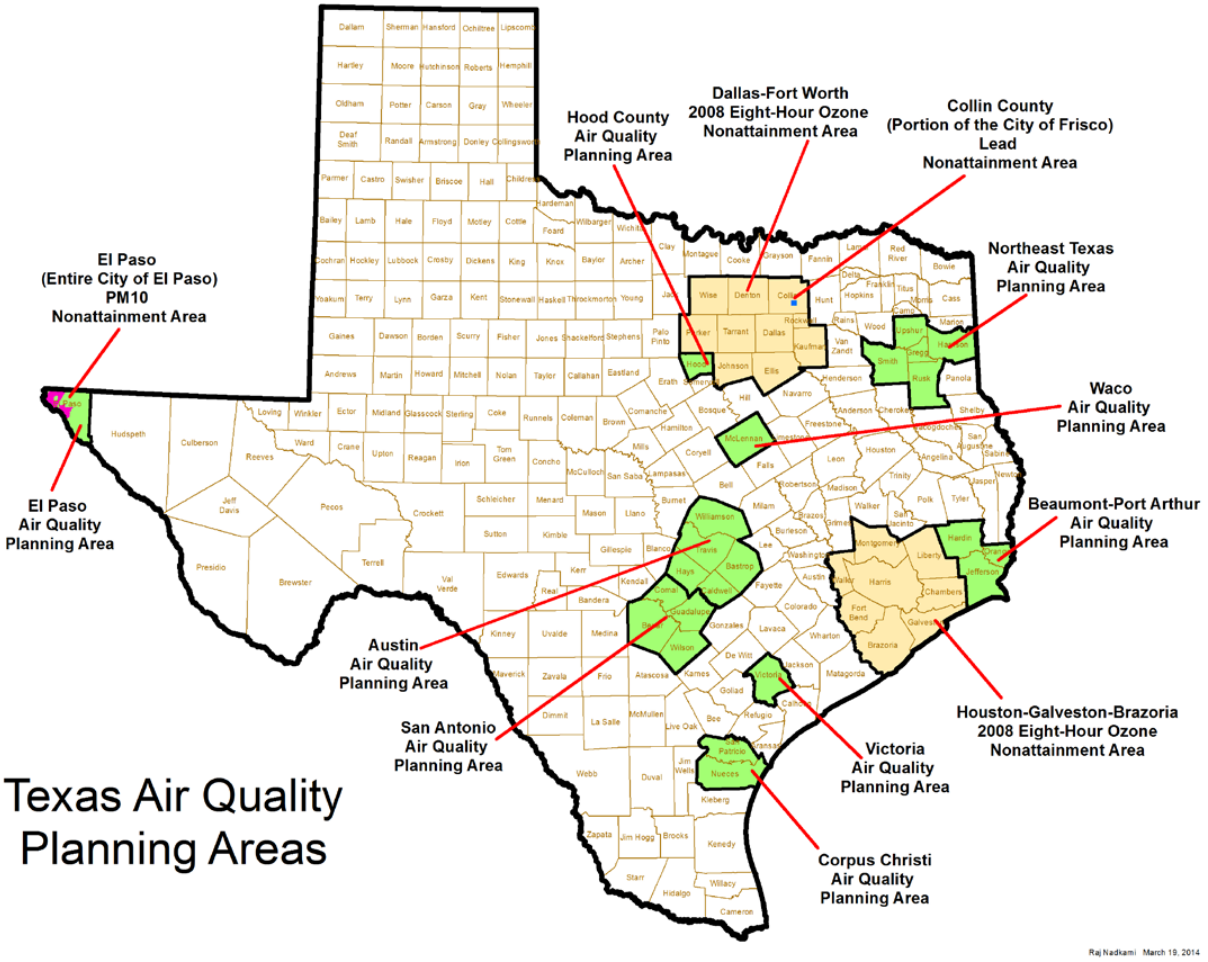
- On February 26, 2015, NERA released a report evaluating compliance with a proposed 65 ppb ozone standard for the National Association of Manufacturers (NAM)

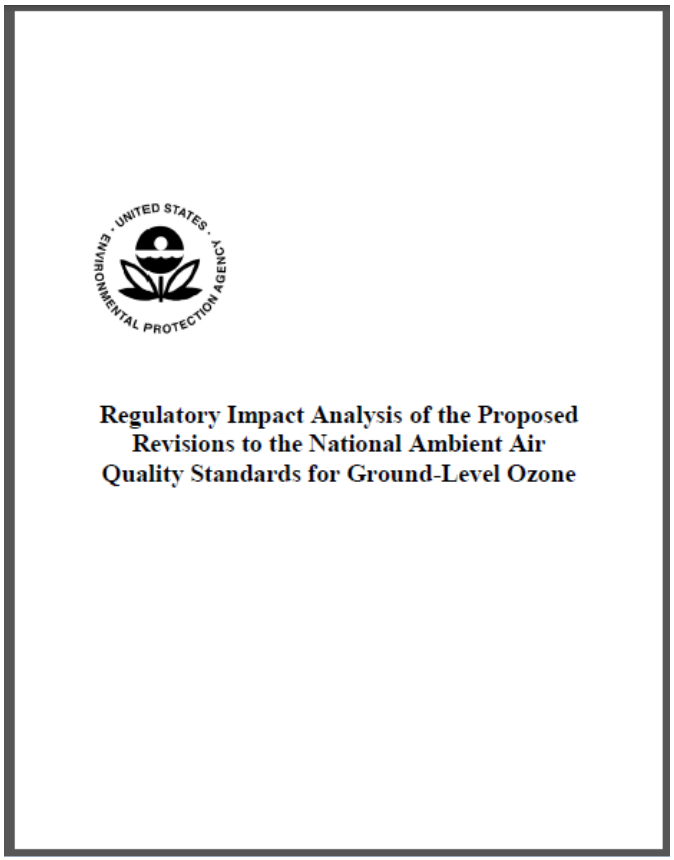
- On March 17, 2015, NERA also released a report that reviews the data and methodology the EPA used to develop estimates of the compliance costs

Texas Air Quality Planning Areas



Source: SIP 101, Kristin Jacobsen, TCEQ. Available at: https://www.tceq.texas.gov/assets/public/implementation/air/sip/miscdocs/2014_SIP101.pdf

Regulatory Impact Analysis (RIA)



Complete RIA available at:
http://www.epa.gov/ttnecas1/regdata/RIAs/20141125ria.pdf

- The RIA includes EPA's analysis of an implementation strategy to achieve full attainment of proposed standards of 65 ppb and 70 ppb
- Includes EPA approach to estimating possible compliance strategies
  - Air quality modeling
  - Base Case, Baseline, 70 ppb, 65 ppb
  - NO_X emissions
  - "Known" and "Unknown" controls
  - Costs

EPA Focused its Analysis on 2025 Attainment

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- EPA's analysis focuses on the year 2025
  - EPA "assumed that potential nonattainment areas everywhere in the U.S., excluding California, will be designated such that they are required to reach attainment by 2025"

EPA Estimated a Geographic Distribution of Emission Reductions

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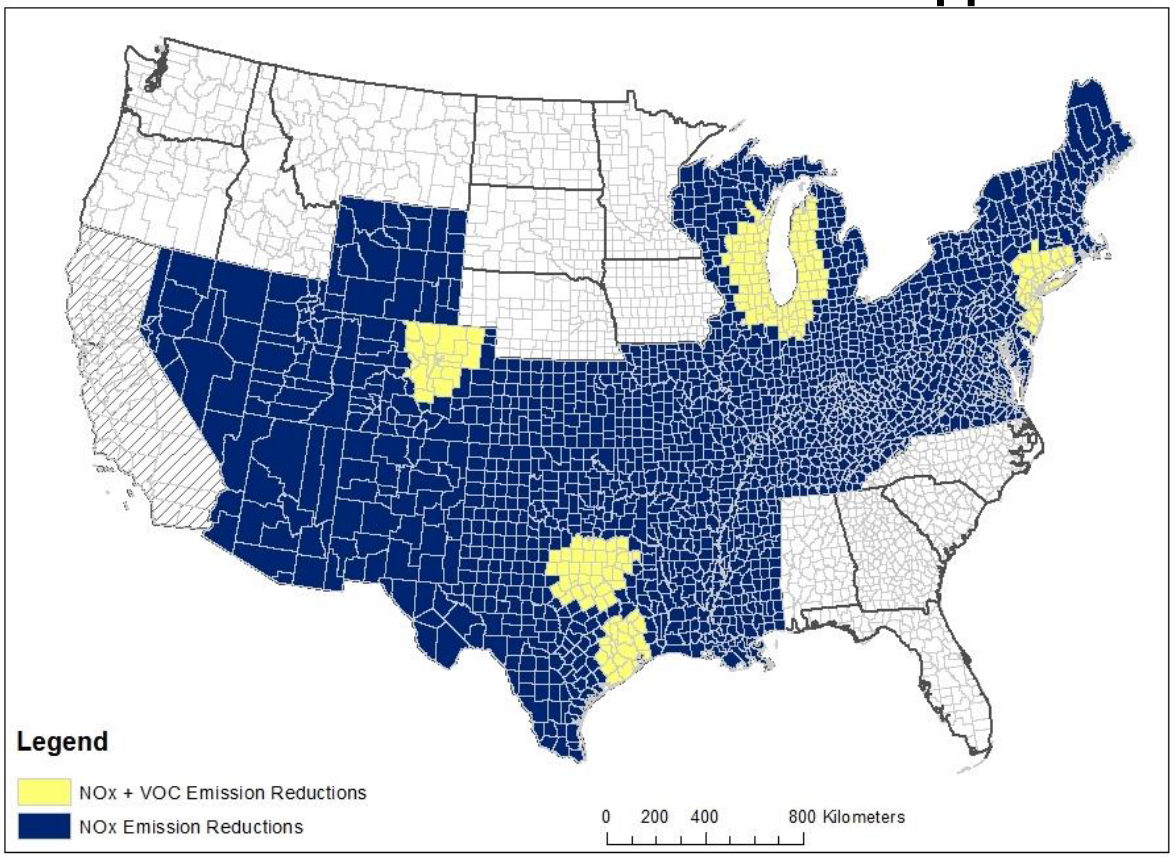
Counties With Emissions Reductions to Demonstrate Attainment with 65 ppb



Source: Figure 4-6, EPA Ozone RIA

- EPA's compliance strategy is only illustrative, actual compliance will be determine by states as part of SIPs
- EPA's emission reductions are widely distributed, including in states/areas with no nonattainment issues

EPA Known Controls for 65 ppb

Incremental to EPA Baseline

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NO_X		VOC	
Control Technology	Emission Reductions (tons)	Control Technology	Emission Reductions (tons)
Total	**1,123,514**	**Total**	**105,766**
EGU	**204,616**	**EGU**	**0**
SCR	204,616		
Point	**444,034**	**Point**	**4,118**
Low Emission Combustion	126,959	Permanent Total Enclosure (PTE)	1,554
SCR	94,970	Solvent Recovery System	842
LNB and SCR	66,610	Add-on controls, work practices & materials	564
LNB	37,383	Other	1,157
NSCR	33,553		
OXY-Firing	29,546		
Adjust Air to Fuel Ratio & Ignition Retard	27,057		
Other	27,956		
Area	**462,026**	**Area**	**101,649**
NSCR	291,136	Reformulation	55,990
LNB (1997 AQMD)	57,351	Incineration	26,164
Water heater + LNB Space Heaters	57,314	LPV Relief Valve	7,317
Low Emission Combustion	47,074	RACT	5,988
Other	9,151	Other	6,189
Onroad	**0**	**Onroad**	**0**
Nonroad	**12,837**	**Nonroad**	**0**
Diesel SCR and Engine Rebuild/Upgrade	12,837		

Source: Figure 5, NERA Report (March 2015)

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