MARYLAND

Department of the Environment

Power Plant Controls in Maryland

Tad Aburn, Air Director

AQCAC Meeting - August 5, 2015

MDE

Topics Covered

- Status of New NOx Regulations
- Background on power plant controls
- Progress in cleaning the air
- The current process to adopt additional power plant controls
- The proposed regulation

How Did We Get to Today?

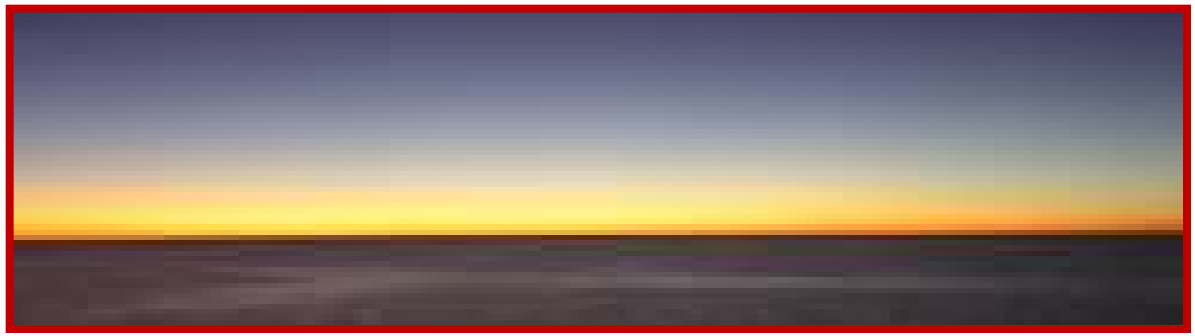
- This is not a new issue
- Discussions with stakeholders for over 3 years
  - Almost every piece of the new regulation being discussed today has been discussed in multiple stakeholder meetings in the past
- In January of 2015, AQCAC actually approved an earlier version of the regulation being discussed today
  - At that meeting, AQCAC heard from stakeholders …
    - Full support for 2015 requirements of the rule
    - Some pushed for more flexibility related to the 2020 requirements designed to drive peak day emissions down

Current Status

- MDE has moved ahead with the 2015 requirements to insure that the immediate public health protections from the 2015 reductions are achieved
  - Adopted through an emergency regulation that became effective on May 1, 2015
  - Working quite well
- MDE has taken a second look at the 2020 requirements
  - Proposing a fourth option to meet the 2020 requirements that will provide equal or greater public health protection
    - While also protecting jobs and supporting a healthy and sustainable economy
- This new "Option 4" for the 2020 requirements is the focus of the new regulatory language being proposed by MDE today

The Maryland Ozone Plan

- Maryland has a comprehensive strategy to address ozone based upon two decades of research and progress
- The regulation being discussed today is part of that strategy
  - The new regulation protects public health and promotes a healthy and sustainable economy
- The new regulation provides equal or greater public health protection compared to the earlier proposal
  - The first three options for compliance are identical to the earlier proposal
  - Choosing the new Option 4 comes with increased responsibility for earlier pollution reductions
  - Choosing Option 4 also insures lower ozone in 2020
    - An additional 120 tons of NOx reductions in the ozone season




Twenty Years of Power
Plant Controls

Power Plant Controls

Moving on to Round 8

- A long History of Power Plant regulation in Maryland
  - 1995 - Reasonably Available Control Technology for Nitrogen Oxides (NOx RACT)
  - 1996 - Acid Rain Program
  - 1999 - Ozone Transport Commission (OTC) NOx Budget Program
  - 2004 - EPA NOx SIP Call
  - 2005 - Updated NOx RACT
  - 2006 to 2012 - Healthy Air Act
  - 2015 - New daily NOx minimization rule
  - Today's requested action - Deeper reductions from 2016 to 2020

1996 Acid Rain Requirements

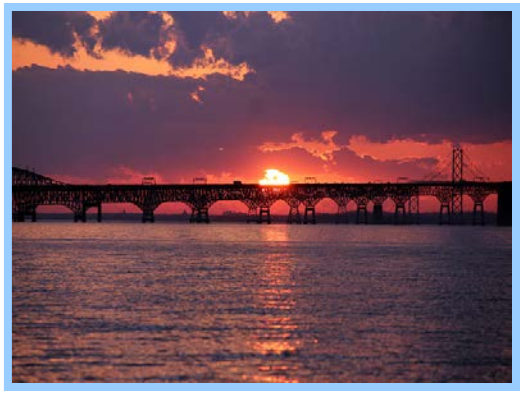
- Established under Title IV of Clean Air Act amendments of 1990
- Cap and trade program to address acid rain
- Controlled sulfur dioxide (SO2) and nitrogen oxide (NOx)
- SO2
  - 41% reduction by 2002
- NOx
  - 33% reduction by 2002

Reasonably Available Control Technology

- … or RACT
- 1995 and 2006 update
- Drove investment in a host of combustion related modifications
  - Low NOx Burners
  - Separated Overfire Air
  - More
- Did not drive post combustion controls like
  - Selective Catalytic Reduction (SCR) technology
  - Selective Non-Catalytic Reduction (SNCR) technology
- Resulted in small but meaningful NOx reductions in Maryland

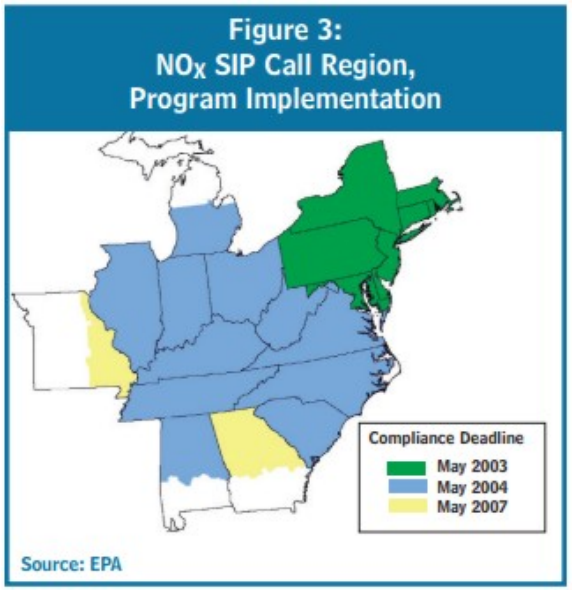
OTC NOx Budget Program

- Regional cap and trade effort between 13 states in the OTC – 1999 to 2003
- Established annual & ozone season caps
  - Market based concepts
    - Allowed banking and trading
- Regional summertime NOx caps for OTC states:
  - 2003 caps drove an approximate 60% to 70% regional NOx reduction during the ozone season from 1990 levels
- Replaced by the NOx SIP Call (a larger NOx Budget Trading Program) in 2003/2004



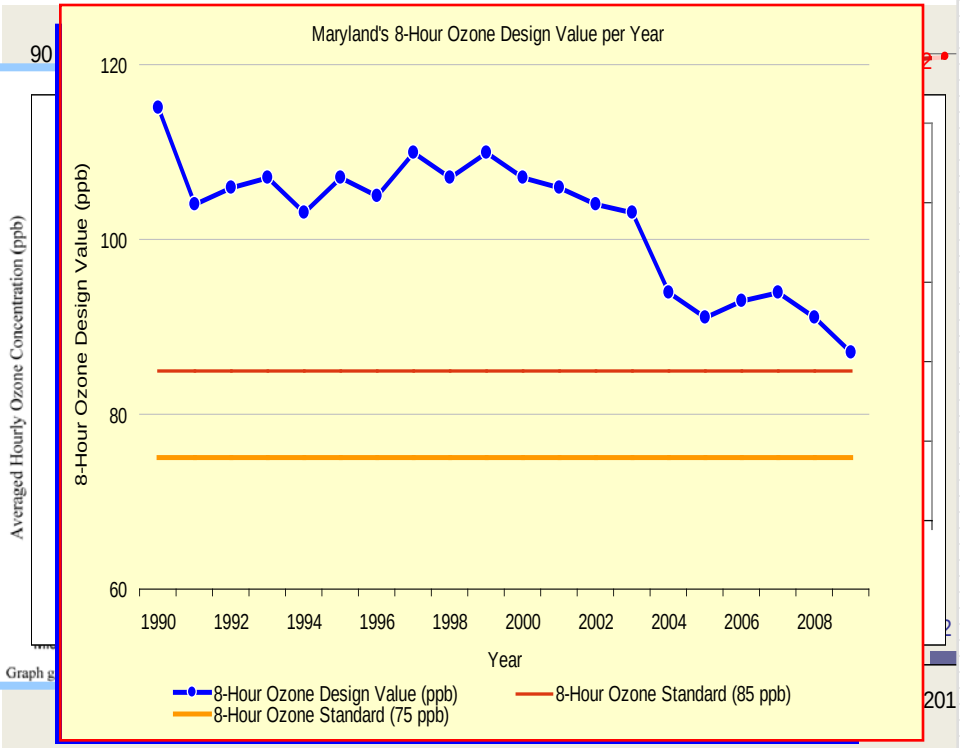
NOx SIP Call

- 20-State cap and trade program to reduce NOx
- 1998 … EPA final rule
- Implemented by EPA "calling in" SIPs (State Implementation Plans) for 20 states and requiring NOx reductions
  - Had a model rule that states could opt into
- Patterned after OTC NOx Budget Program
- Designed to reduce regional NOx 28% from 1996 emissions levels by 2007
- A major success story for reducing transport
- Still allowed unconstrained trading



Why the NOx SIP Call Worked?

Ground Level Ozone Drops Dramatically in the Same Time Frame



The classic ozone transport story

- Incoming ozone levels (as high as 80 ppb) collect in an elevated reservoir over night
- Real world programs like the NOx SIP call have shown that
  - Adding regional controls
  - Results in regional NOx emission reductions …
  - Which lead to reduced ozone in the elevated reservoir …
  - Which lead to lower ozone at ground level and public health protection!

Maryland Healthy Air Act (HAA) of 2006

- Most significant control program ever implemented in Maryland
- Partially a response to the problems with unlimited trading
  - Location does matter for ozone
- To implement the NOx SIP Call some Maryland power plants opted to purchase allowances instead of investing into controls

The Healthy Air Act

- Again, most significant emission reducing program ever adopted in Maryland
- Widely applauded by the environmental community
- Environmental community and utilities worked with MDE as partners to design and implement the law
- Almost $2.6 Billion investment for clean air by Maryland utilities
- Helped to dramatically clean the air
  - Fine particle levels dropped dramatically
  - Ozone levels dropped dramatically
  - Mercury emissions dropped dramatically

A Multi-Pollutant Approach

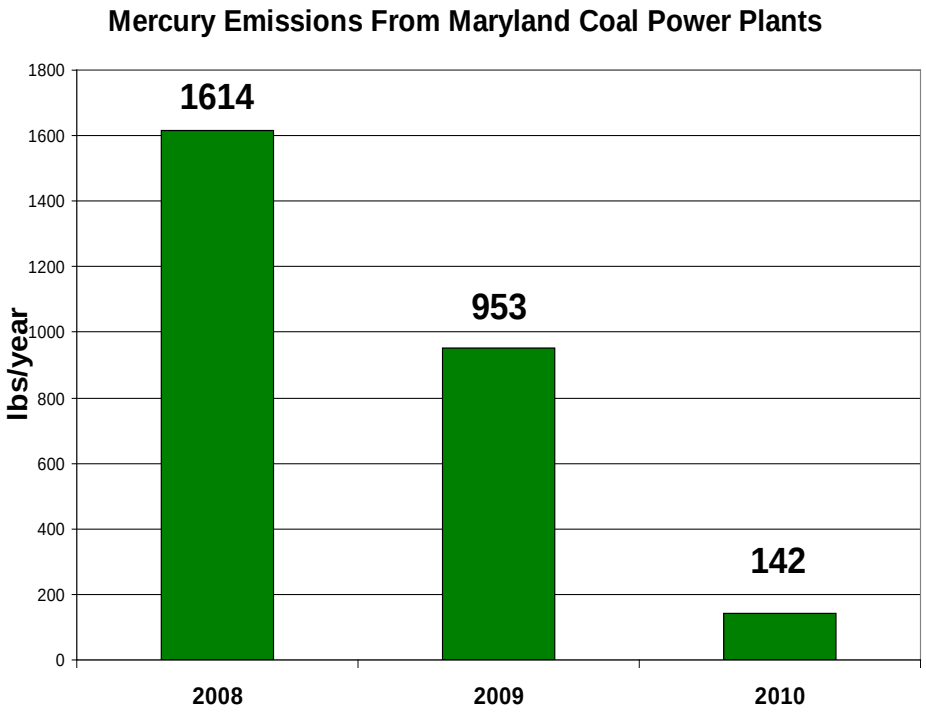
- HAA driven by multiple pollutants
  - HAA required reductions in 4 key pollutants at the States largest power plants
    - Mercury
    - Sulfur dioxide (SO2)
    - Nitrogen oxide (NOx)
    - Greenhouse gases
    - Also drove reductions in direct particulate, hydrogen chloride and other air toxics

So … What Controls Were Installed?

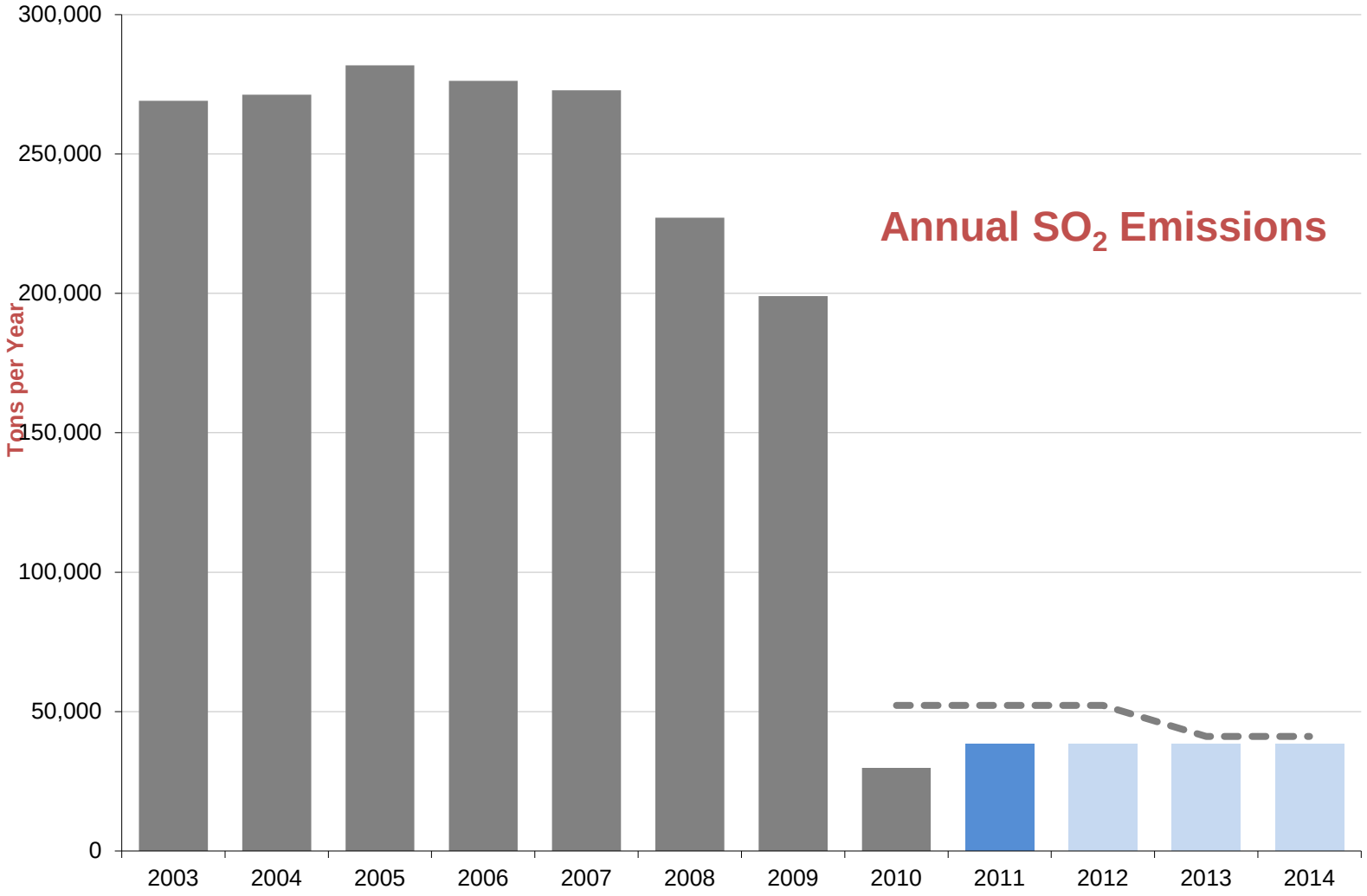
- 6 Flue Gas Desulfurizers (FGDs)
- 2 Baghouses
- 2 Hydrated Limestone injection systems
- 7 SCRs*
- 6 SNCRs
- 6 PAC (Powdered Activation Carbon) injection systems
- These controls were installed on coal units ranging in size from 125-700 MW.
  - All in a 2 to 3 year window

The Results – Mercury & Other Air Toxics

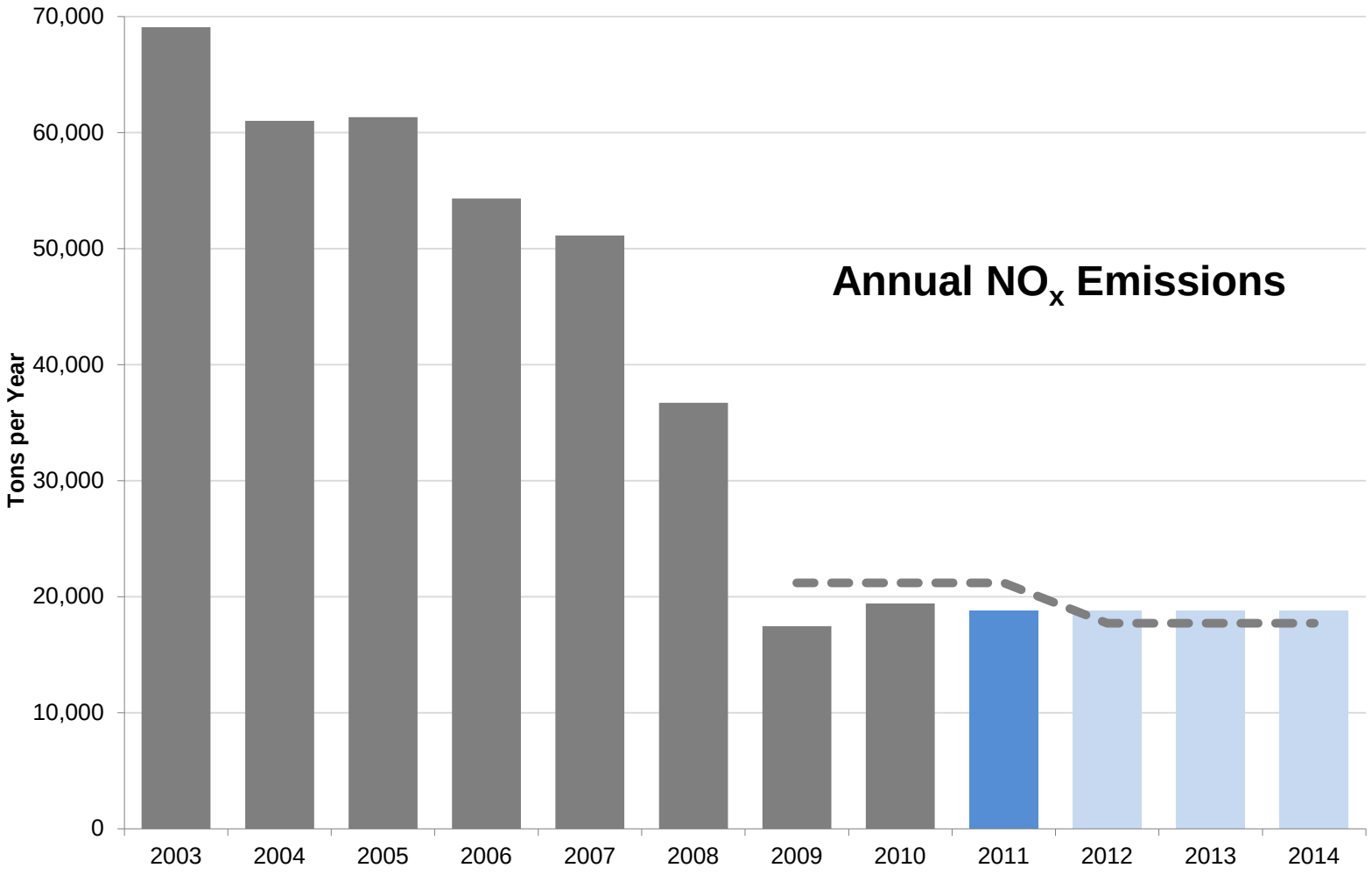
- Mercury
  - Exceeded 2012 90% reduction requirement in 2010
- Hydrogen Chloride (HCl) reduced 83%
- Direct particulate matter reduced 60%



The Results – SO2



The Results – NOx



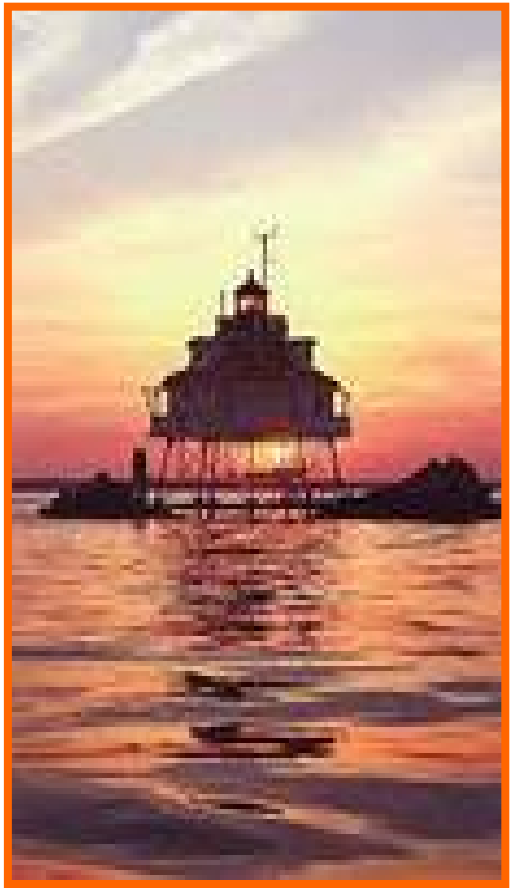
Others on Maryland's Healthy Air Act

- Constellation Energy
  - "We recently completed the installation of a major air quality control system, including scrubbers, a baghouse, and other equipment at one of our major coal facilities in Maryland," said Paul Allen, senior vice president and chief environmental officer of Constellation Energy.
  - "These systems work effectively and result in dramatically lower emissions of mercury, sulfur dioxide, particulate matter, and acid gases. We know from experience that constructing this technology can be done in a reasonable time frame, especially with good advance planning; and there is meaningful job creation associated with the projects."
    - March 16, 2011 press release

- The National Wildlife Federation
  - Maryland's Healthy Air Act would save 96 lives each year in 2010 compared to 27 lives saved under existing federal air rules
  - The Healthy Air Act's curbs on air pollution will save 17,350 workdays each year in 2010, compared to 4,925 workdays saved under federal air rules.

Summary

- Maryland has already implemented aggressive pollution controls on Maryland power plants
- The controls generated very deep reductions …
  - For the year and for the summer ozone season
    - Not for each day
- These controls have been very effective and did what they were supposed to do
  - Maryland is measuring attainment for fine particulates
  - 8-hour ozone levels have dropped dramatically under the 85 and 75 ppb ozone standard
- The current ozone standard (75 ppb) requires us to refocus on:
  - The worst ozone days where not only is ozone most likely to form, but high electricity demand drives higher than normal emissions
  - Daily emission reductions - not ozone season average reductions



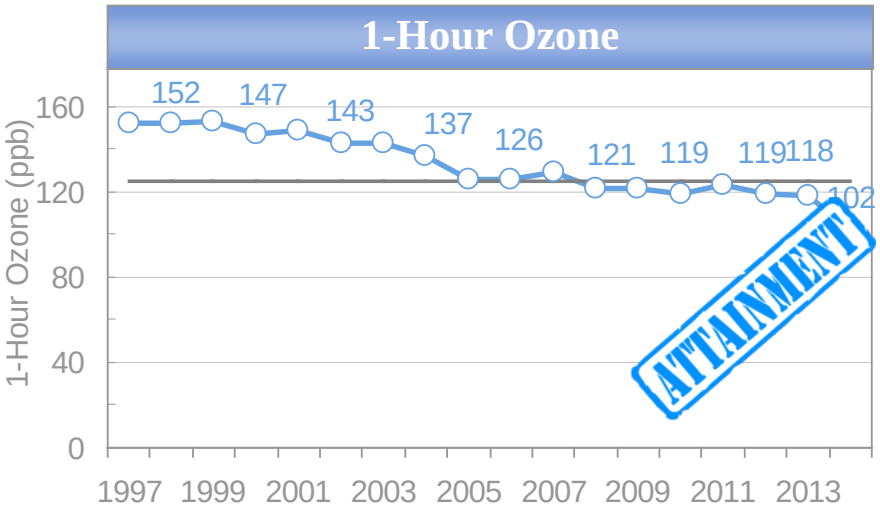
Cleaning the Air

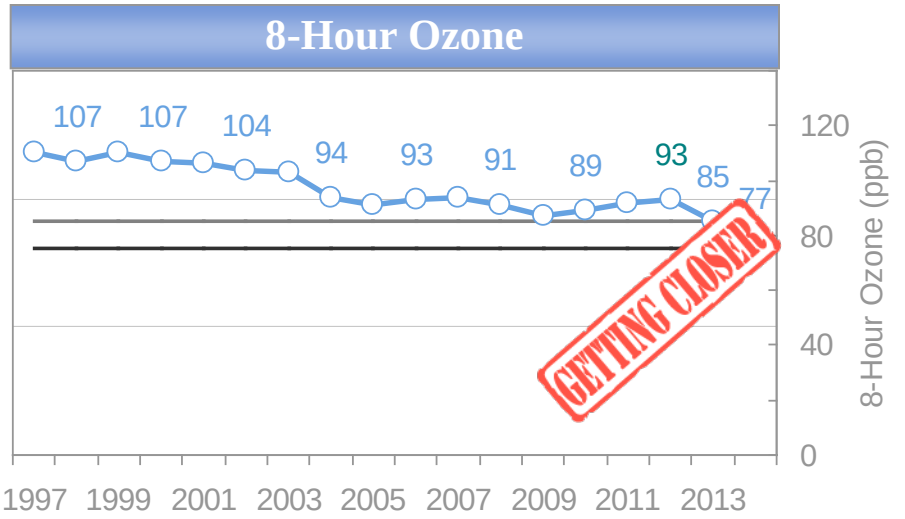
Dramatic Progress Over the Past 10 Years

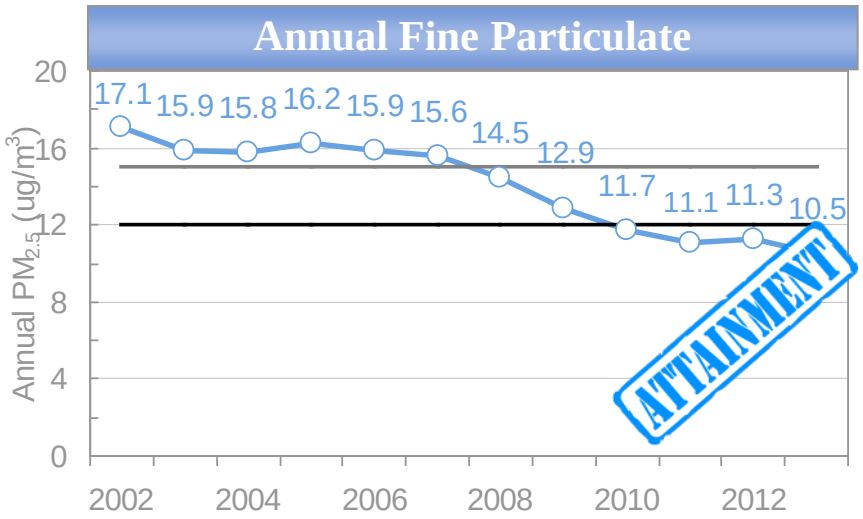
Maryland's Air Quality Challenges

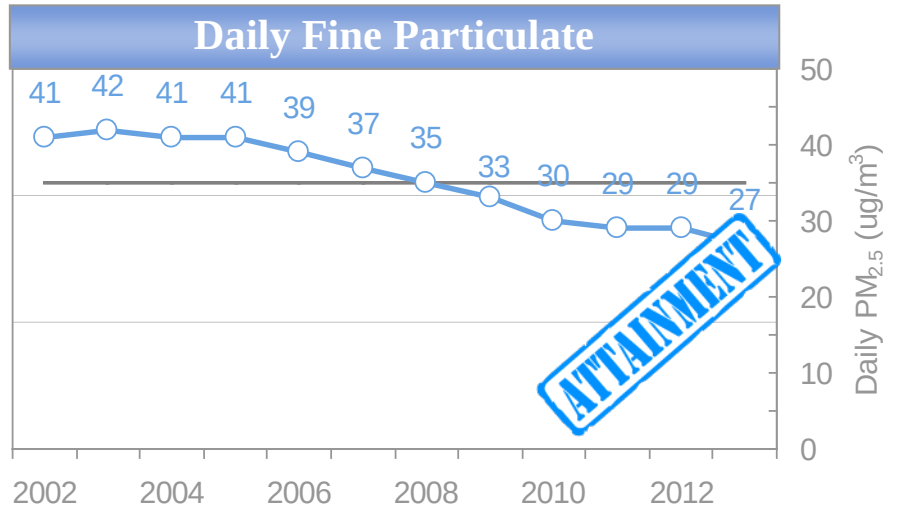
- Ground level ozone has improved dramatically but we still monitor levels above the health based standard
  - New ozone standard expected by the end of 2015
  - Will continue to push Maryland to seek more emission reductions
- Fine particle levels are currently meeting all standards
  - Continue to trend down
- Maryland is the fourth most vulnerable state to sea level rise
  - One of the major impacts from climate change
- Mercury and other air toxics are a priority
- Contribution of air pollution sources to nitrogen deposition in the Chesapeake Bay is a major issue

Progress in Cleaning Maryland's Air







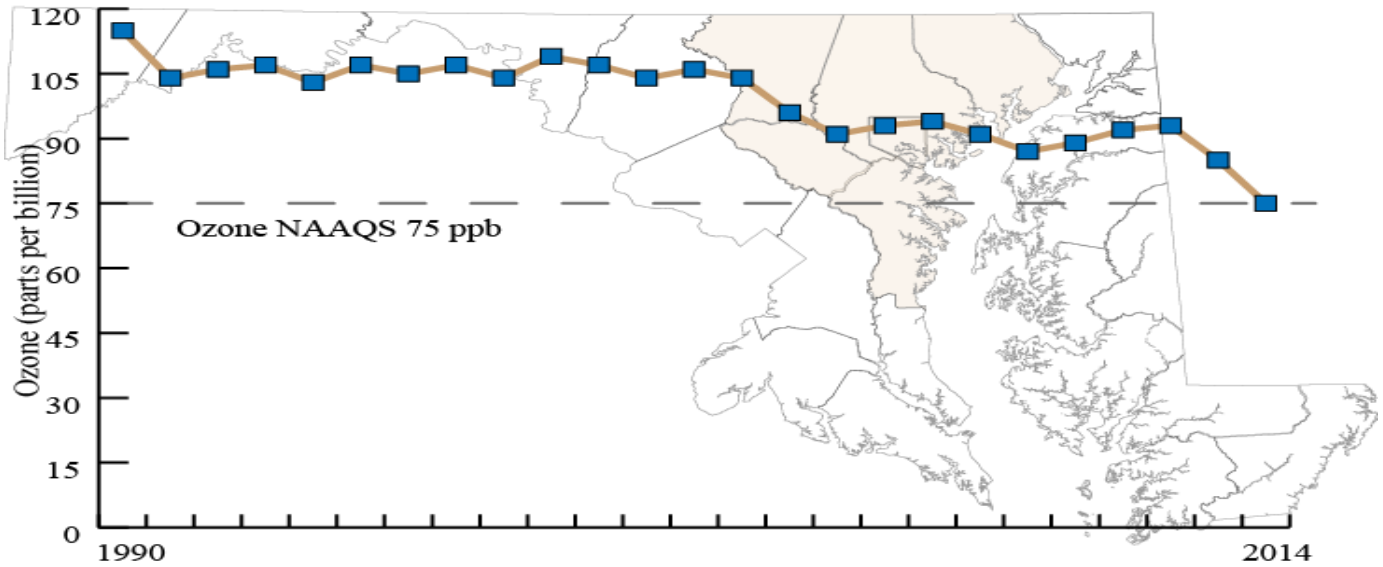


Don't forget ... We do expect EPA to adopt a new tougher 8-Hr ozone standard in the 65 to 70 ppb range by the end of the year

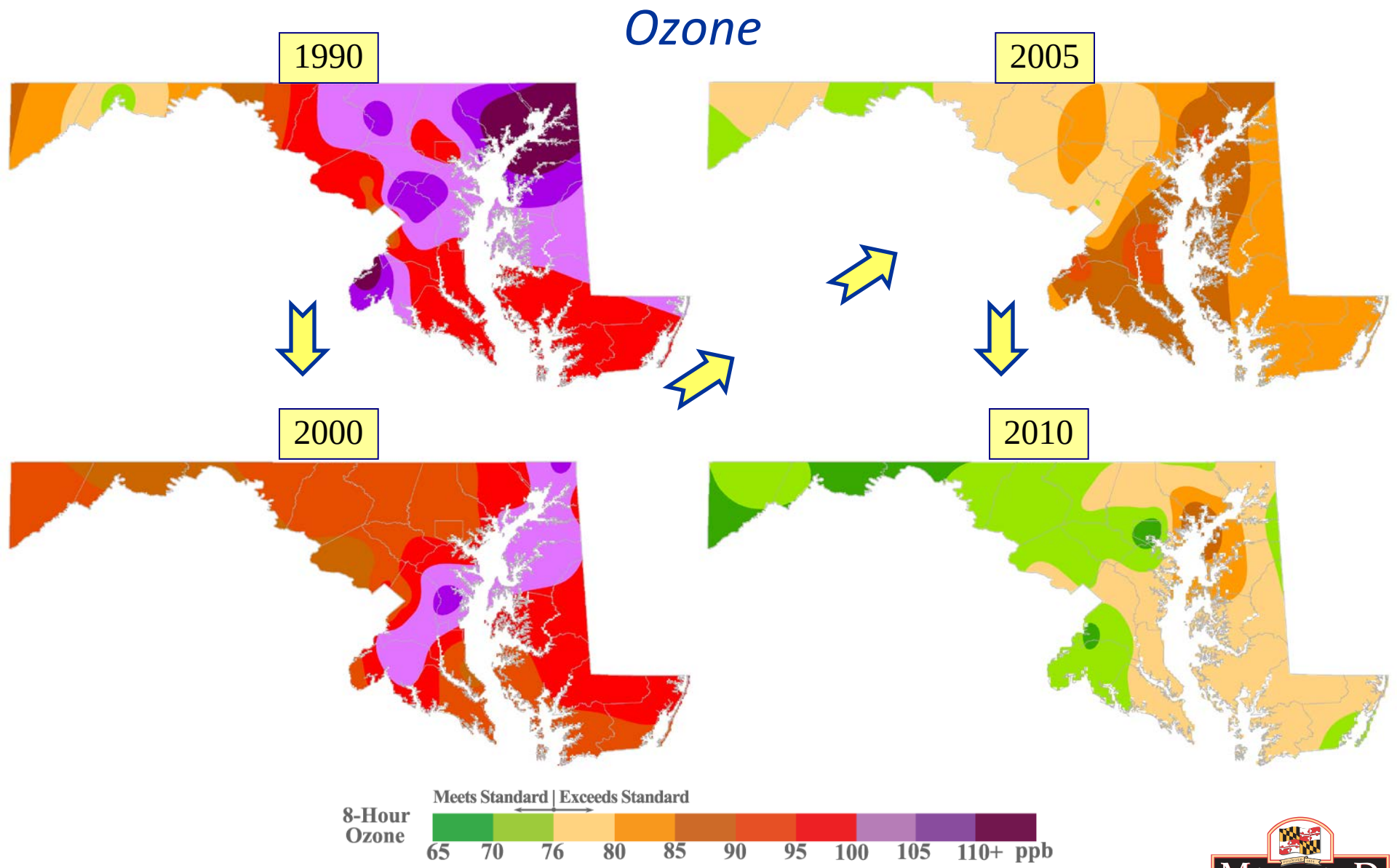
MARYLAND DEPARTMENT OF THE ENVIRONMENT

Clean Air Progress in Baltimore

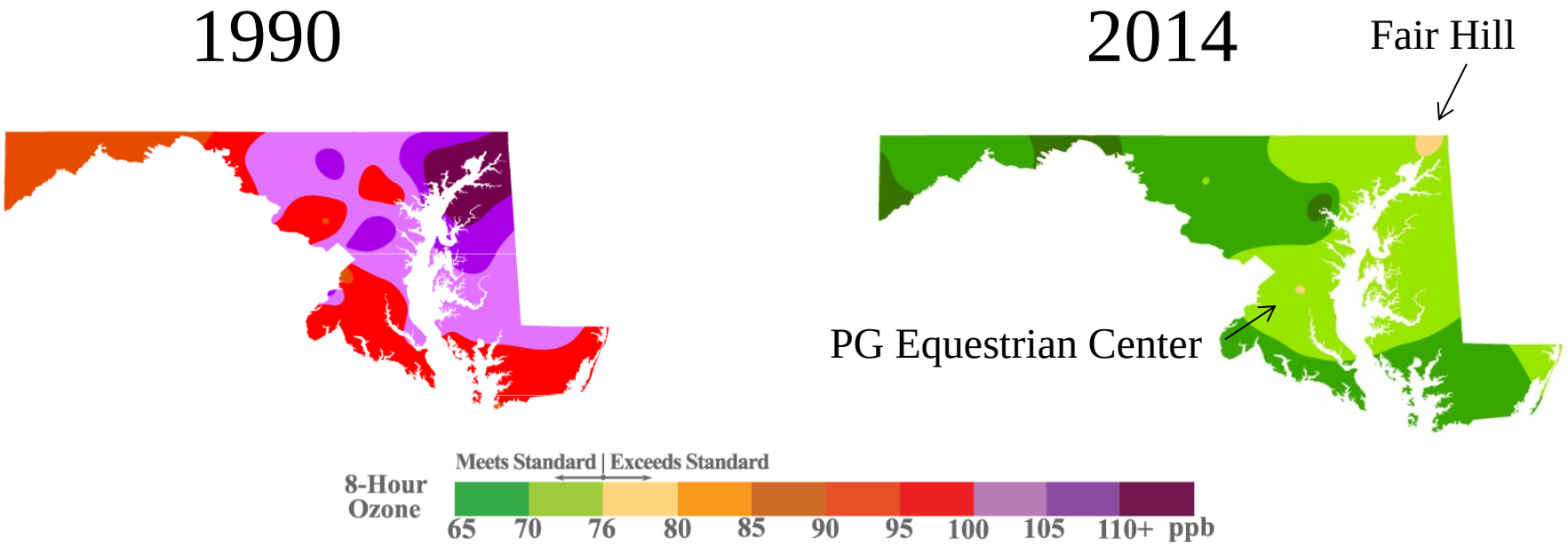
- Baltimore has historically measured some of the highest ozone in the East
- In 2014, The Baltimore area did not exceed the current ozone standard
  - First time in 30 years … weather did play a role
- EPA has now finalized a "Clean Data Determination"
- With hotter, less ozone friendly weather, Baltimore may see higher ozone
- Summer 2015 - Pretty clean so far. Only 1 day of levels above 75 ppb in Baltimore and statewide. Progress appears to be continuing.



Lower Concentrations & Smaller Problem Areas

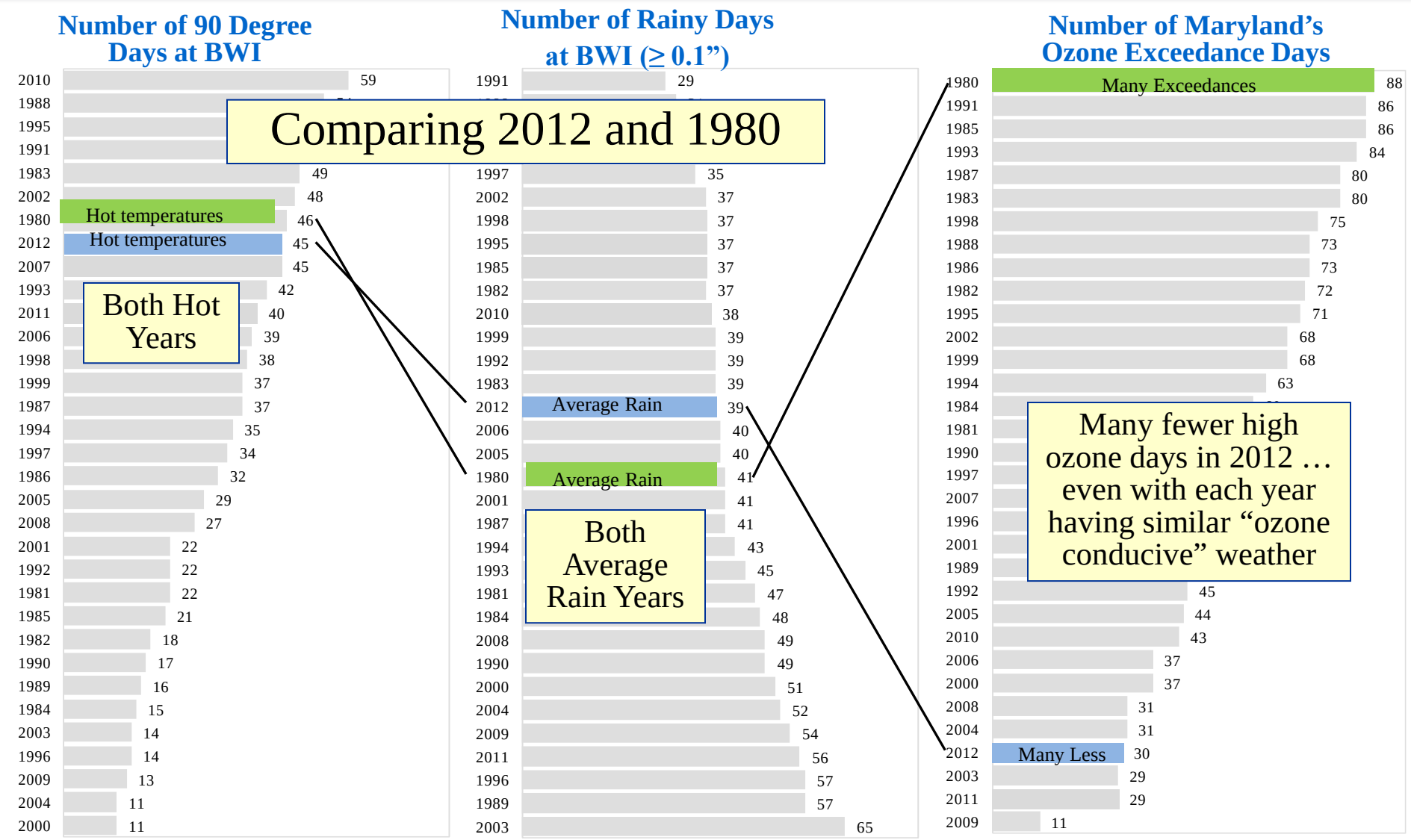


The Shrinking Ozone Problem

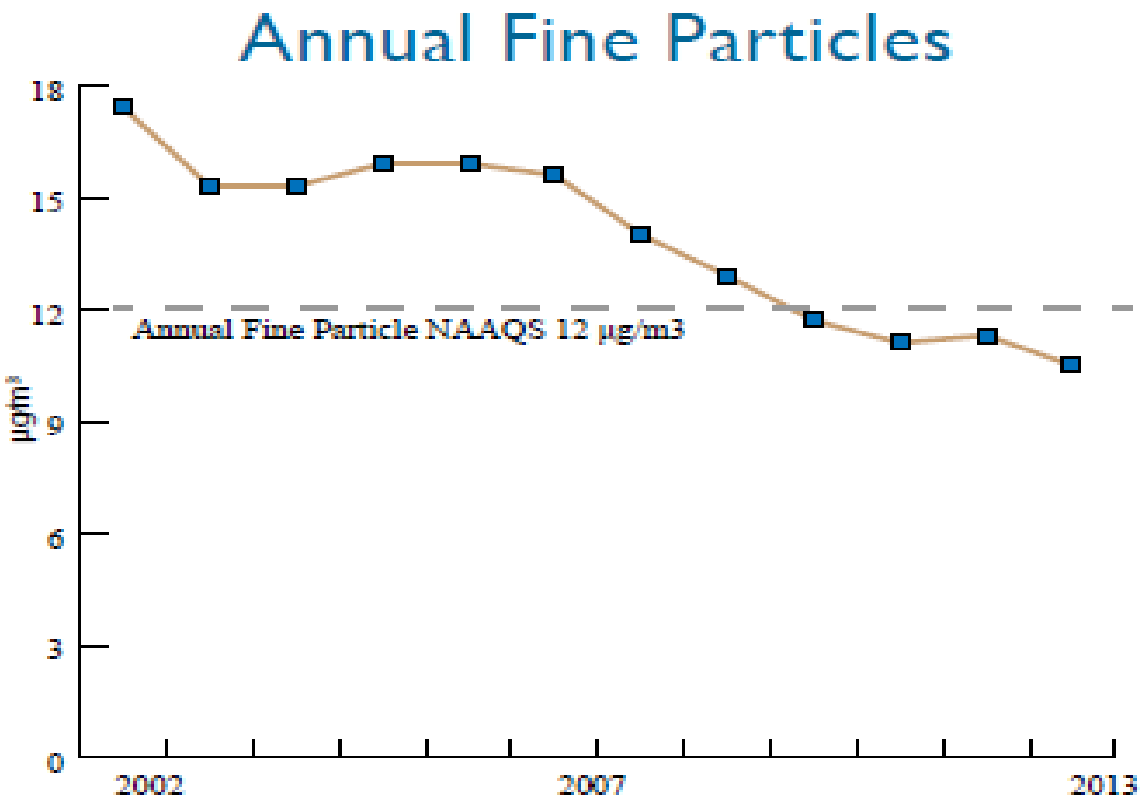


- Presently only Cecil and Prince George's Counties have single monitors that are above the standard.
- Previously approximately 86% of Marylanders were exposed to ozone levels above the standard, now that number is 9%.

Progress - Normalizing the Weather

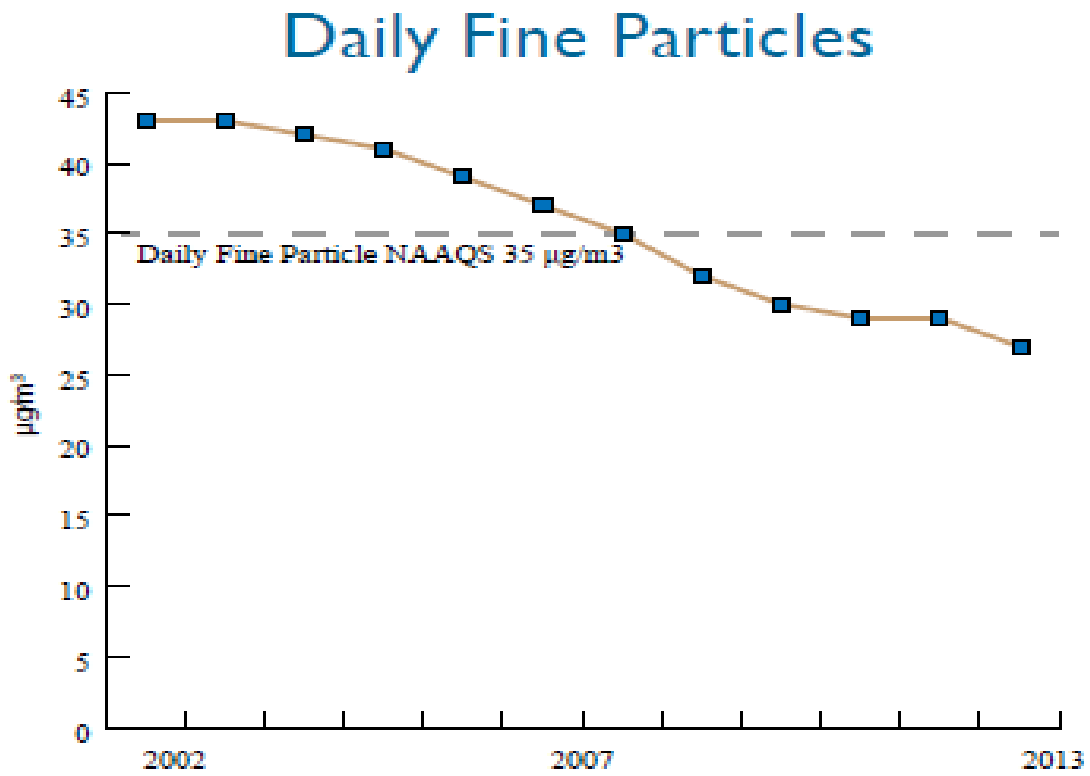


Maryland Annual Fine Particles



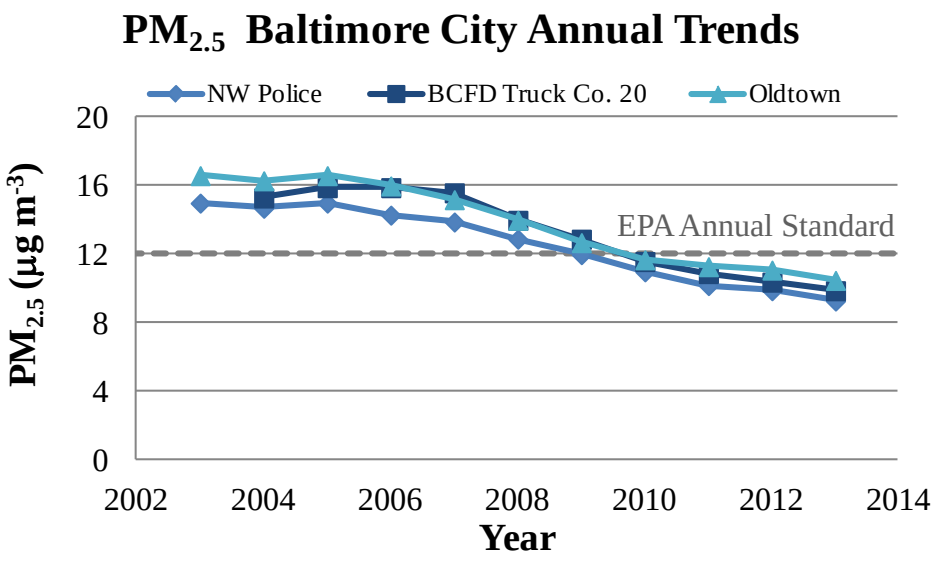
- Maryland is currently attaining the annual fine particle standard across the state
  - The annual standard is 12 µg/m^3
- Fine particulate levels continue to trend down
- This is a major success story as the health risks associated with fine particulate are very significant

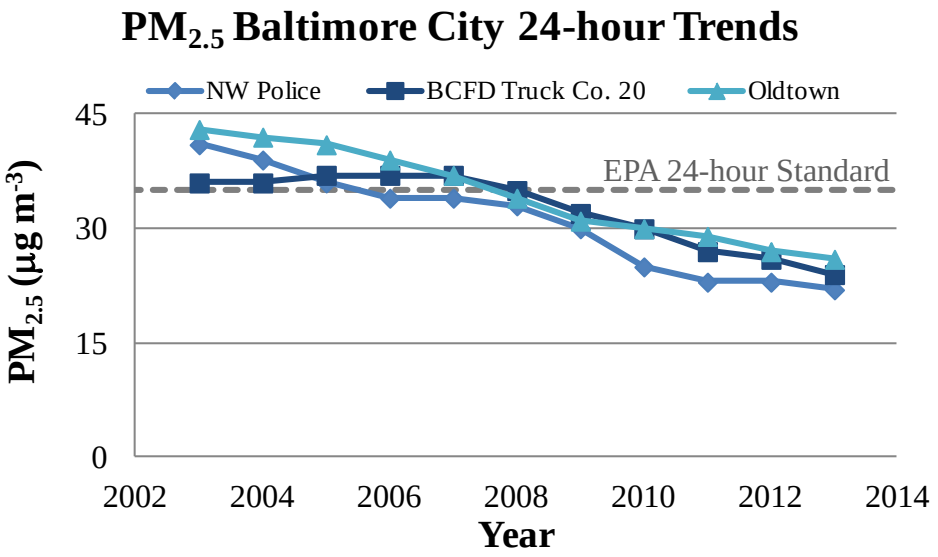
Maryland Daily Fine Particles

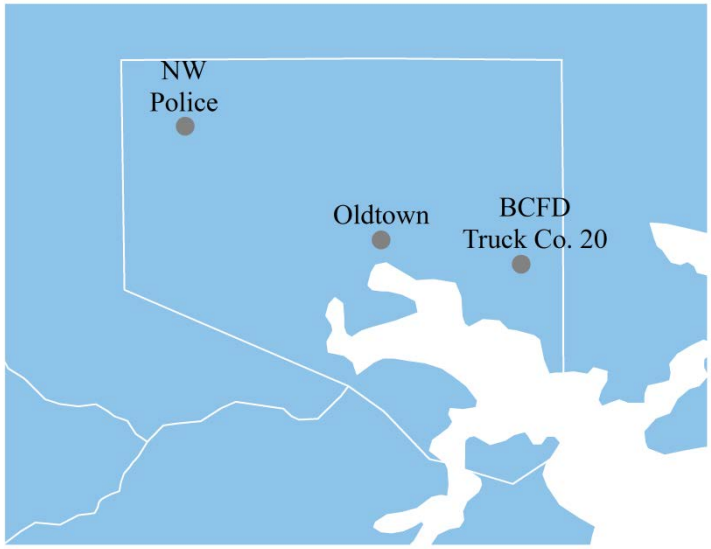


- Maryland is currently attaining the daily fine particle standard across the state.
- The annual standard is 35 µg/m^3

Fine Particulate - Baltimore City Trends

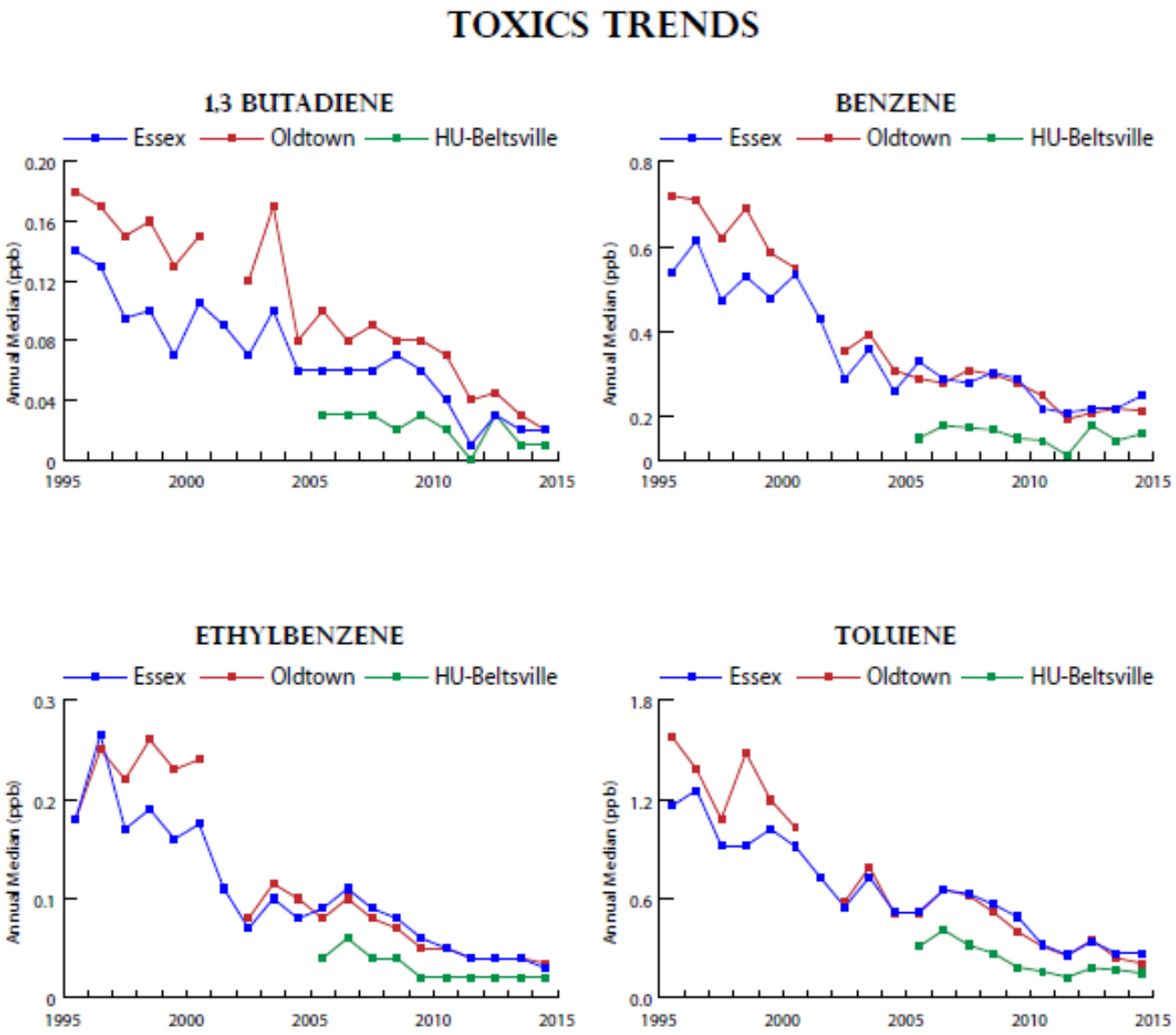






* Trends are made with annual and 24-hour design values.

Maryland Air Toxics Trends




The New Regulations

New NOx Reduction Requirements

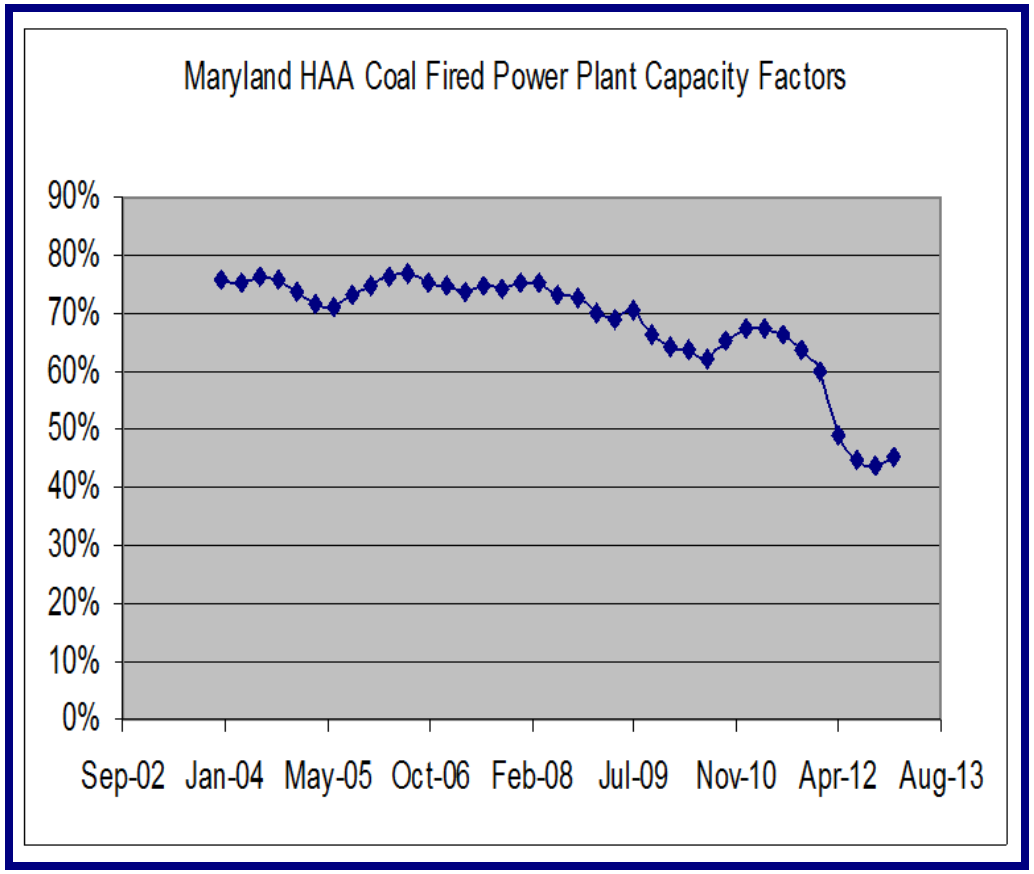
- In 2015, MDE must adopt additional NOx reduction requirements for power plants and other sectors to insure continuing progress in reducing ozone levels in the State
- For power plants:
  - Updated NOx RACT (Reasonably Available Control Technology) for power plants
  - NOx reductions for the Maryland SIP (State Implementation Plan) scheduled for late 2015
  - NOx reductions to insure public health protection (the new standard)
- Many other NOx (and volatile organic compound or VOC) strategies for mobile, area and other stationary sources in the works

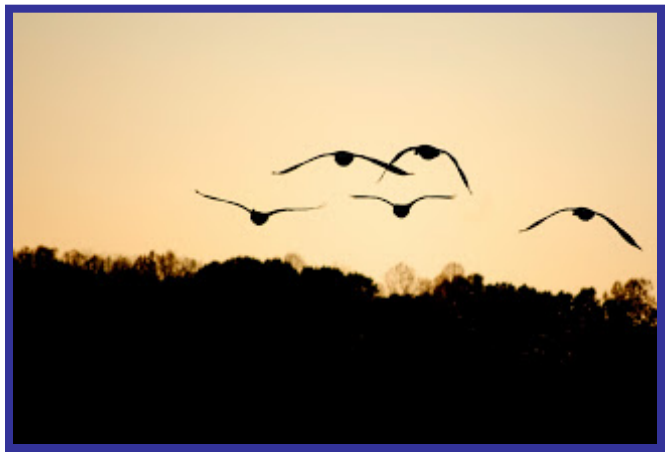
Issues With NOx Emissions

- The current ozone standard requires us to focus on peak day NOx emissions
- Healthy Air Act (HAA) annual and “ozone season” caps have not forced units to always run emissions controls when they are needed most
- Linked to lower capacity factors at many units
  - Coal units are simply not being asked to run as often as they used to run and allowance prices are very low
- Some units were not always running their control equipment optimally to insure maximize emission reductions

Decreasing Capacity Factors

- Capacity factor HAA Coal Fired Units

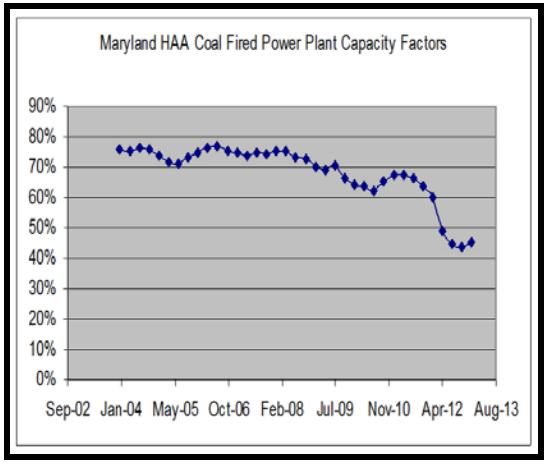




Capacity Factors of Maryland Coal plants have almost been reduced by 50%

Compliance with the HAA

- All of Maryland's power generators fully comply with the Maryland HAA of 2006
- The HAA used a regulatory scheme that allowed companies to choose where to control within their "system" to most cost-effectively meet the NOx and SO2 caps set in the Act.
  - Some units controlled more – some less
- The HAA set annual caps for SO2 and annual and ozone season caps for NOx
  - Short-term limits (hourly or daily) were not part of the HAA
  - Caps were set assuming that Maryland coal plants would continue to operate at pre-2006 levels



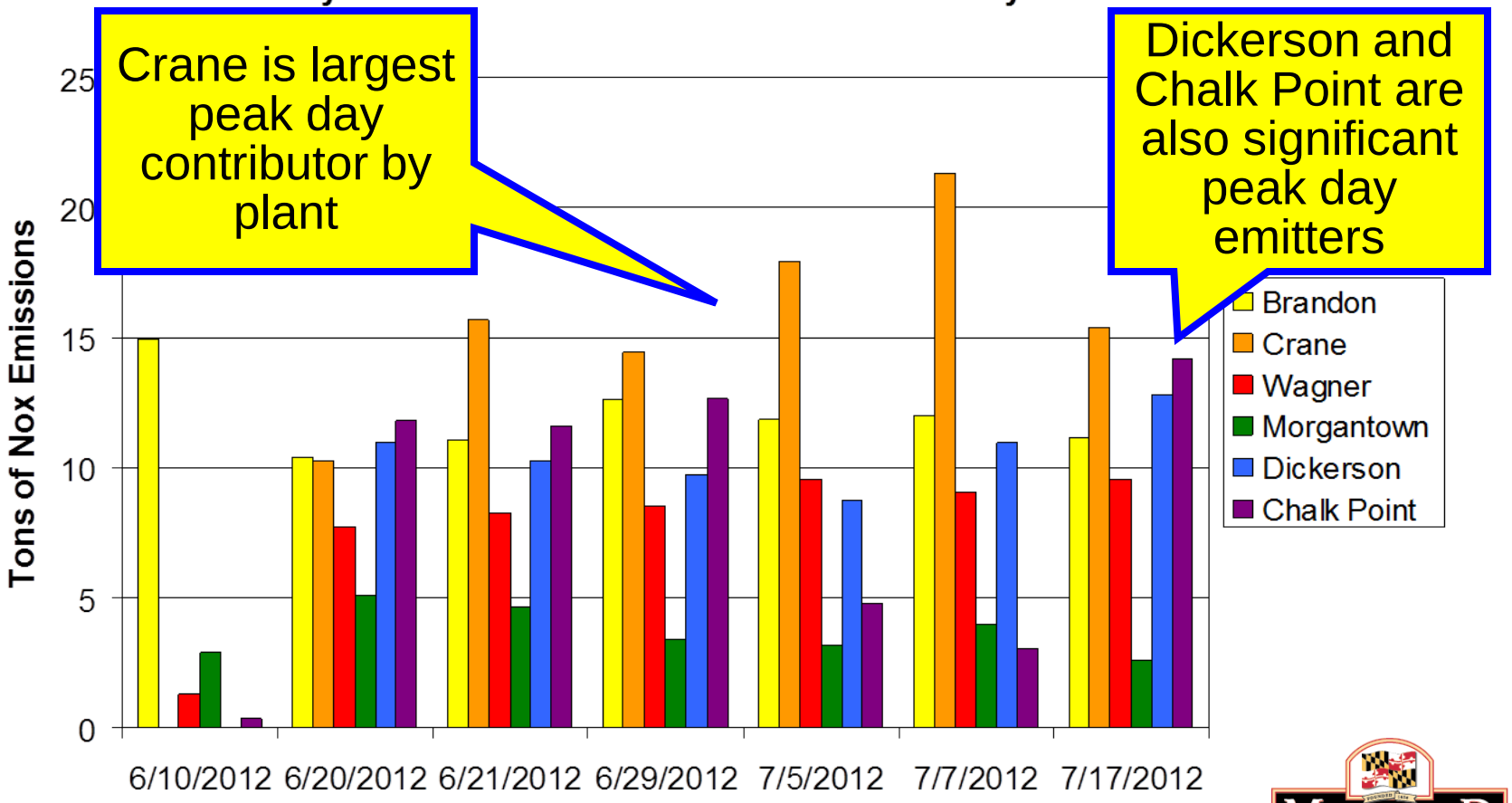
The HAA Worked Well

- The regulatory scheme in the HAA worked very well
  - System wide averaging and ozone season and annual caps did their job
    - Ozone levels are much lower
    - Helped bring Maryland into attainment for both the fine particulate standard and helped Maryland get very close to meeting the current ozone standard
- The remaining ozone problem is very focused:
  - What is happening on the worst days of the summer
  - Requires an enhanced regulatory scheme that focuses on shorter term, daily emission limits

NOx Emissions on Peak Ozone Days

Daily NOx Emissions By Plant

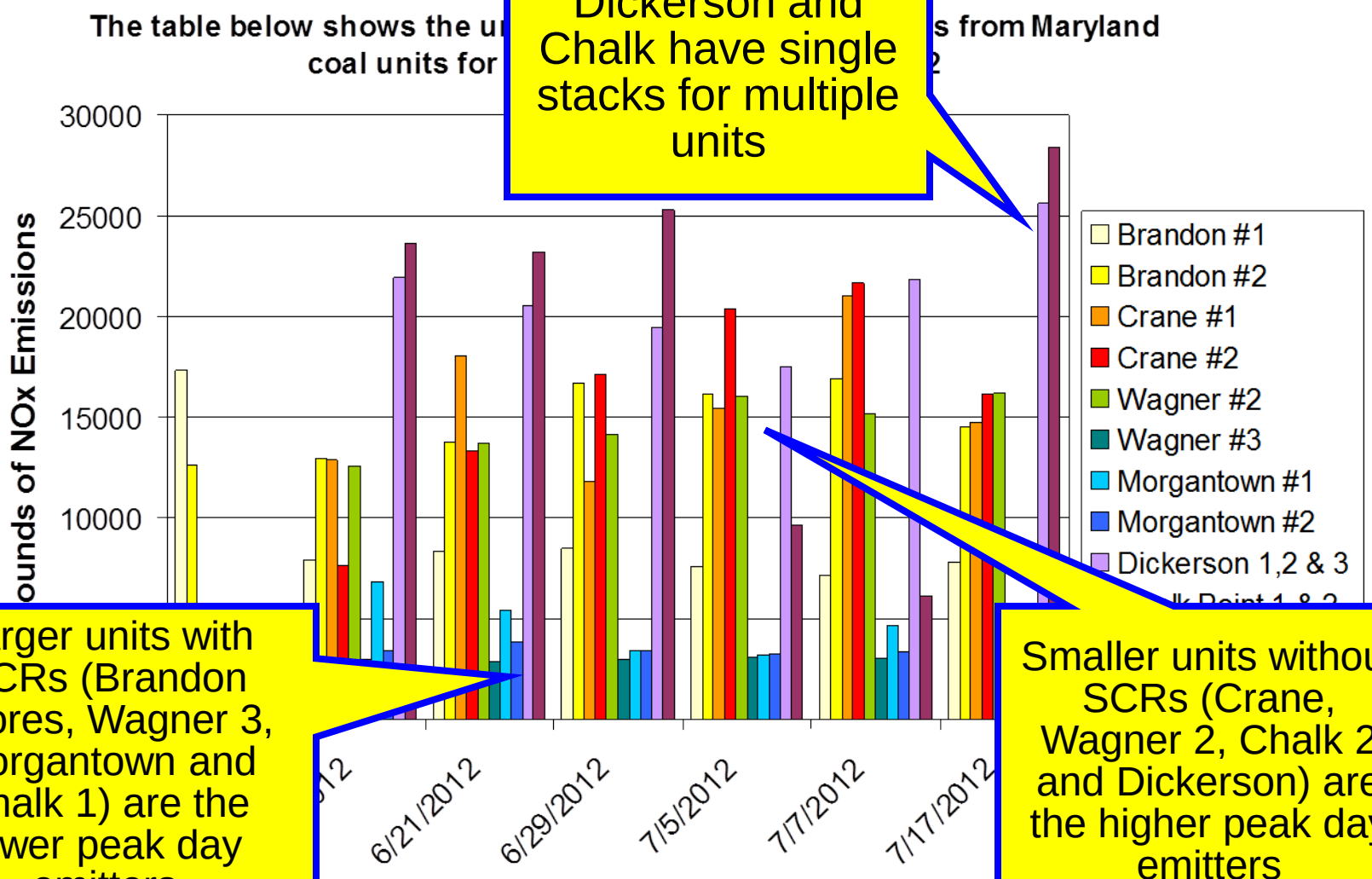
The table below shows the plant-by-plant, daily NOx emissions from Maryland coal units for the 7 worst ozone days in 2012



Seven Worst Ozone Days - 2012

NOx Emissions on Peak Ozone Days

Daily NOx Emissions By Unit



Dickerson and Chalk have single stacks for multiple units

Larger units with SCRs (Brandon Shores, Wagner 3, Morgantown and Chalk 1) are the lower peak day emitters

Smaller units without SCRs (Crane, Wagner 2, Chalk 2 and Dickerson) are the higher peak day emitters

Implementing The New Regulatory Scheme

Daily limits to reduce peak day emissions

- MDE has already moved ahead with the first step of this process:
  - Emergency rule for 2015 requirements became effective on May 1, 2015
  - Requires each unit at each plant to minimize NOx emissions each day of the summer by optimizing the use of existing control equipment
  - Significant immediate NOx reductions (about 9 tons/day) that will provide immediate additional public health protection
- Today's requested action will implement the second step of this new regulatory scheme:
  - Even deeper daily reductions by 2020

A Reminder

… What is already in place

Highlights:

Text with white background is text that is already adopted and in effect because of the emergency regulation that became effective on May 1, 2015. The emergency regulation adopted all of the 2015 requirements to provide immediate public health protection.

The text with the teal blue background is text that is identical to the text in the earlier regulation to implement additional requirements in 2020.

The text with the yellow background is new text to implement a new option to meet the 2020 requirements.

The text with the yellow background that also includes red underlining is the primary new substantive text to implement the new option to meet the 2020 requirements.

The New Regulatory Language

- This is the new substantive language in the regulation
- Adds a fourth option for 2020
  - If selected, the fourth option also drives deeper reductions in 2016, 2018 and 2020, while insuring equal or greater public health protection in 2020

.04 Additional NO_x Emission Control Requirements.

A. This regulation applies to C.P. Crane units 1 and 2, Chalk Point unit 2, Dickerson units 1, 2, and 3 and H.A. Wagner unit 2.

B. General Requirements. The owner or operator of the affected electric generating units subject to this regulation shall choose from the following:

(1) Not later than June 1, 2020:

(a) Install and operate a selective catalytic reduction (SCR) control system; and

(b) Meet a NO_x emission rate of 0.09 lbs/MMBtu, as determined on a 30-day rolling average during the ozon season;

(2) Not later than June 1, 2020, permanently retire the unit;

(3) Not later than June 1, 2020, permanently switch fuel from coal to natural gas for the unit;

(4) Not later than June 1, 2020, meet either a NO_x emission rate of 0.13 lbs/MMBtu as determined on a 24-hour systemwide block average or a systemwide NO_x tonnage cap of 21 tons per day during the ozone season.

C. When option B(4)of this regulation is selected:

(1) Not later than May 1, 2016, the owner or operator of an affected electric generating unit shall not exceed a NO_x 30-day systemwide rolling average emission rate of 0.13 lbs/MMBtu during the ozone season.

(2) Not later than May 1, 2018, the owner or operator of an affected electric generating unit shall not exceed a NO_x 30-day systemwide rolling average emission rate of 0.11 lbs/MMBtu during the ozone season.

(3) Not later than May 1, 2020, the owner or operator of an affected electric generating unit shall not exceed a NO_x 30-day systemwide rolling average emission rate of 0.09 lbs/MMBtu during the ozone season.

Highlighted Regulation - Pages 2 and 3

The New Regulatory Language

New Option 4

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Highlighted Regulation - Pages 2 and 3

0.13 lb/MMBTU - 24 Hour Average

- Where did this come from?
  - Based upon recommendations from the Ozone Transport Commission (OTC) and the two toughest similar regulations in the East (NJ and DE)
    - OTC recommends 0.125 to 0.15 lb/MMBTU for coal-fired EGUs like those in Maryland as a 24-hour average
    - Delaware's limit for coal-fired EGUs like those in Maryland is 0.125 lb/MMBTU as a 24-hour average
    - New Jersey's limit for coal-fired EGUs like those in Maryland is 0.15 lb/MMBTU as a 24-hour average
  - OTC recommendations and the DE and NJ limits are unit specific, but allow higher rates when units are starting up or shutting down or operating at low capacity
    - The Maryland limit is a system-wide limit that allows no exemptions

The 21 Tons Per Day Cap

How the cap was determined

.04 Additional NO_x Emission Control Requirements.

A. This regulation applies to C.P. Crane units 1 and 2, Chalk Point unit 2, Dickerson units 1, 2, and 3 and H.A. Wagner unit 2.

B. General Requirements. The owner or operator of the affected electric generating units subject to this regulation shall choose from the following:

(1) Not later than June 1, 2020:

(a) Install and operate a selective catalytic reduction (SCR) control system; and

(b) Meet a NO_x emission rate of 0.09 lbs/MMBtu, as determined on a 30-day rolling average during the ozon season;

(2) Not later than June 1, 2020, permanently retire the unit;

(3) Not later than June 1, 2020, permanently switch fuel from coal to natural gas for the unit;

(4) Not later than June 1, 2020, meet either a NO_x emission rate of 0.13 lbs/MMBtu as determined on a 24-hour systemwide block average or a systemwide NO_x tonnage cap of 21 tons per day during the ozone season.

C. When option B(4)of this regulation is selected:

(1) Not later than May 1, 2016, the owner or operator of an affected electric generating unit shall not exceed a NO_x 30-day systemwide rolling average emission rate of 0.13 lbs/MMBtu during the ozone season.

(2) Not later than May 1, 2018, the owner or operator of an affected electric generating unit shall not exceed a NO_x 30-day systemwide rolling average emission rate of 0.11 lbs/MMBtu during the ozone season.

(3) Not later than May 1, 2020, the owner or operator of an affected electric generating unit shall not exceed a NO_x 30-day systemwide rolling average emission rate of 0.09 lbs/MMBtu during the ozone season.

Highlighted Regulation - Pages 2 and 3

Daily Caps - If SCR Based - High End

- Assumes all units within each system controlled with SCRs
  - High performing SCRs at 0.09 lbs/mmbtu
    - 0.09 lbs/mmbtu is the rate connected to “2020 option 1” … installing an SCR
      - 04B(1)
- Full operation
- NRG system would be at 26.06 tons/day
- Raven system would be at 27.81 tons/day

NRG Units	MAX Heat Rate mmbtu/hr	NOx Rate (lbs/mmbtu)	Daily tons
Chalk Point 1	3130	0.09	3.38
Chalk Point	3130	0.09	3.38
Dickerson 1	1646	0.09	1.78
Dickerson 2	1646	0.09	1.78
Dickerson 3	1646	0.09	1.78
Morgantown 1	6465	0.09	6.98
Morgantown 2	6465	0.09	6.98
Total	24128	**NRG 24 hr tons**	**26.06**

Raven Units	MAX Heat Rate mmbtu/hr	NOx Rate (lbs/mmbtu)	Daily Tons
Brandon1	8000	0.09	6.72
Brandon2	8000	0.09	6.72
Wagner 2	2013	0.09	1.69
Wagner3	2740	0.09	2.30
Crane 1	2500	0.09	2.10
Crane2	2500	0.09	2.10
Total	25753	**Raven 24 hr tons**	**27.81**

Daily Caps - If SCR Based - Low End

- Assumes all units within each system controlled with SCRs
  - Very high performing SCRs at 0.07 lbs/mmbtu
- Full operation
- NRG system would be at 20.27 tons/day
- Raven system would be at 21.63 tons/day

NRG Units	MAX Heat Rate mmbtu/hr	NOx Rate (lbs/mmbtu)	Daily tons
Chalk Point 1	3130	0.07	2.63
Chalk Point	3130	0.07	2.63
Dickerson 1	1646	0.07	1.38
Dickerson 2	1646	0.07	1.38
Dickerson 3	1646	0.07	1.38
Morgantown 1	6465	0.07	5.43
Morgantown 2	6465	0.07	5.43
Total	24128	**NRG 24 hr tons**	**20.27**

Raven Units	MAX Heat Rate mmbtu/hr	NOx Rate (lbs/mmbtu)	Daily Tons
Brandon1	8000	0.07	6.72
Brandon2	8000	0.07	6.72
Wagner 2	2013	0.07	1.69
Wagner3	2740	0.07	2.30
Crane 1	2500	0.07	2.10
Crane2	2500	0.07	2.10
Total	25753	**Raven 24 hr tons**	**21.63**

Daily Caps - If Natural Gas Based - High End

- Assumes all non-SCR units within each system convert to natural gas
  - Consistent with .04B(3)
  - Better performing retrofit level … 0.15 lbs/mmbtu
- Full operation
- SCR units at 0.09 lbs/mmbtu
- NRG system would be at 31.87 tons/day
- Raven system would be at 32.86 tons/day

HRG Units	MAX Heat Rate mmbtu/hr	NOx Rate (lbs/mmbtu)	Daily tons
Chalk Point 1	3130	0.09	3.38
Chalk Point 2	3130	0.15	5.63
Dickerson 1	1646	0.15	2.96
Dickerson 2	1646	0.15	2.96
Dickerson 3	1646	0.15	2.96
Morgantown 1	6465	0.09	6.98
Morgantown 2	6465	0.09	6.98
Total	24128	**NRG 24 hr tons**	**31.87**

Raven Units	MAX Heat Rate mmbtu/hr	NOx Rate (lbs/mmbtu)	Daily tons
Brandon1	8000	0.09	8.64
Brandon2	8000	0.09	8.64
Wagner 2	2013	0.15	3.62
Wagner3	2740	0.09	2.96
Crane 1	2500	0.15	4.50
Crane2	2500	0.15	4.50
Total	25753	**Raven 24 hr tons**	**32.86**

Daily Caps - If Natural Gas Based - Low End

- Assumes all non-SCR units within each system convert to natural gas
  - Better performing retrofit level … 0.15 lbs/mmbtu
  - NG units operate at 75%
- SCR units at 0.09 lbs/mmbtu (100% capacity)
- NRG system would be at 28.24 tons/day
- Raven system would be at 29.71

NRG Units	MAX Heat Rate mmbtu/hr	Daily NOx Rate (lbs/mmbtu)	Capacity Factor	Daily tons
Chalk Point 1	3130	0.09	1.00	3.38
Chalk Point 2*	3130	0.15	0.75	4.23
Dickerson 1	1646	0.15	0.75	2.22
Dickerson 2	1646	0.15	0.75	2.22
Dickerson 3	1646	0.15	0.75	2.22
Morgantown 1	6465	0.09	1.00	6.98
Morgantown 2	6465	0.09	1.00	6.98
Total	24128	**NRG 24 hr tons**		**28.24**

Raven Units	MAX Heat Rate mmbtu/hr	Daily NOx Rate (lbs/mmbtu)	Capacity Factor	Daily tons
Brandon1	8000	0.09	1.00	8.64
Brandon2	8000	0.09	1.00	8.64
Wagner 2	2013	0.15	0.75	2.72
Wagner3	2740	0.09	1.00	2.96
Crane 1	2500	0.15	0.75	3.38
Crane2	2500	0.15	0.75	3.38
Total	25753	**Raven 24 hr tons**		**29.71**

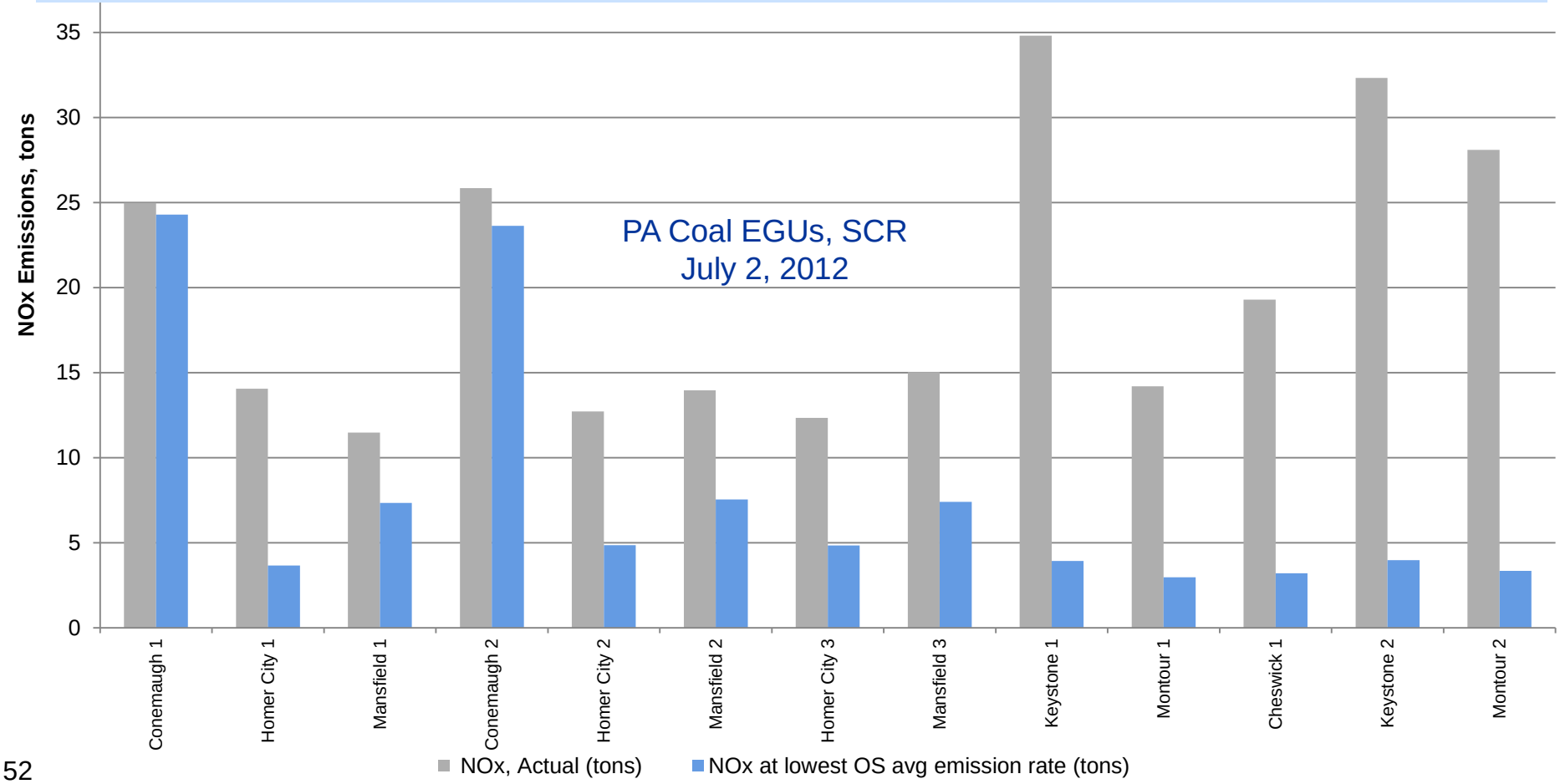
Daily Caps - Summary

Daily Caps	NRG	Raven
SCR - High	26.06	27.81
SCR - Low	20.27	21.63
NG - High	31.87	32.86
NG - Low	28.24	29.71

The proposed regulation sets 21 tons per day as the maximum daily emissions of NOx allowed from either companies “system”

Is 21 Tons per Day a Tough Cap?

- It is a very tough cap
- There are numerous individual units in PA that by themselves routinely emit more than 21 tons of NOx in a single day
- Our researchers tell us that because of winds and ozone chemistry, reductions in PA may be as … or more important … to solving Maryland's ozone problem than "in-State" reductions

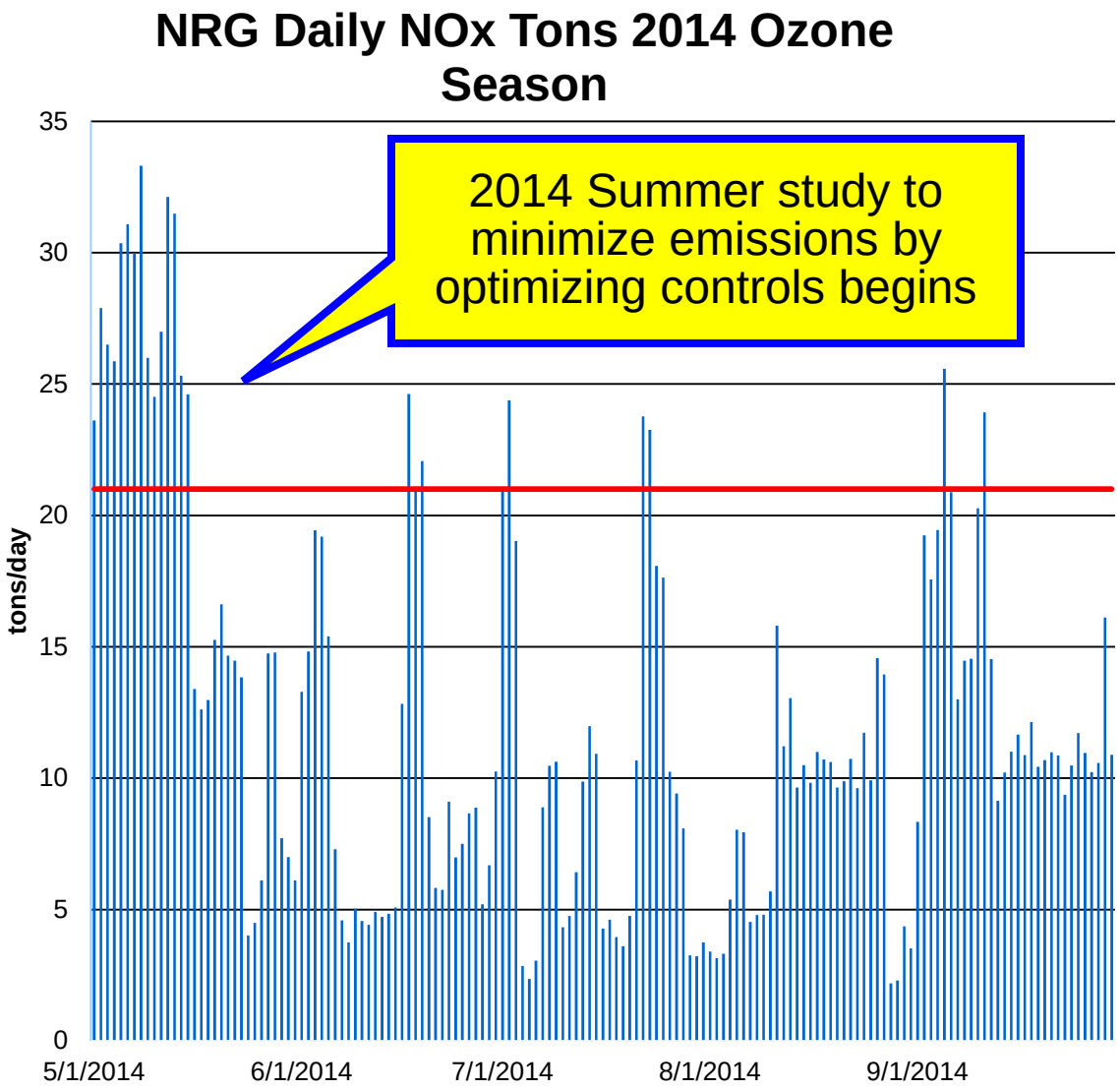


Caps and Historical Data

What does measured data tell us?

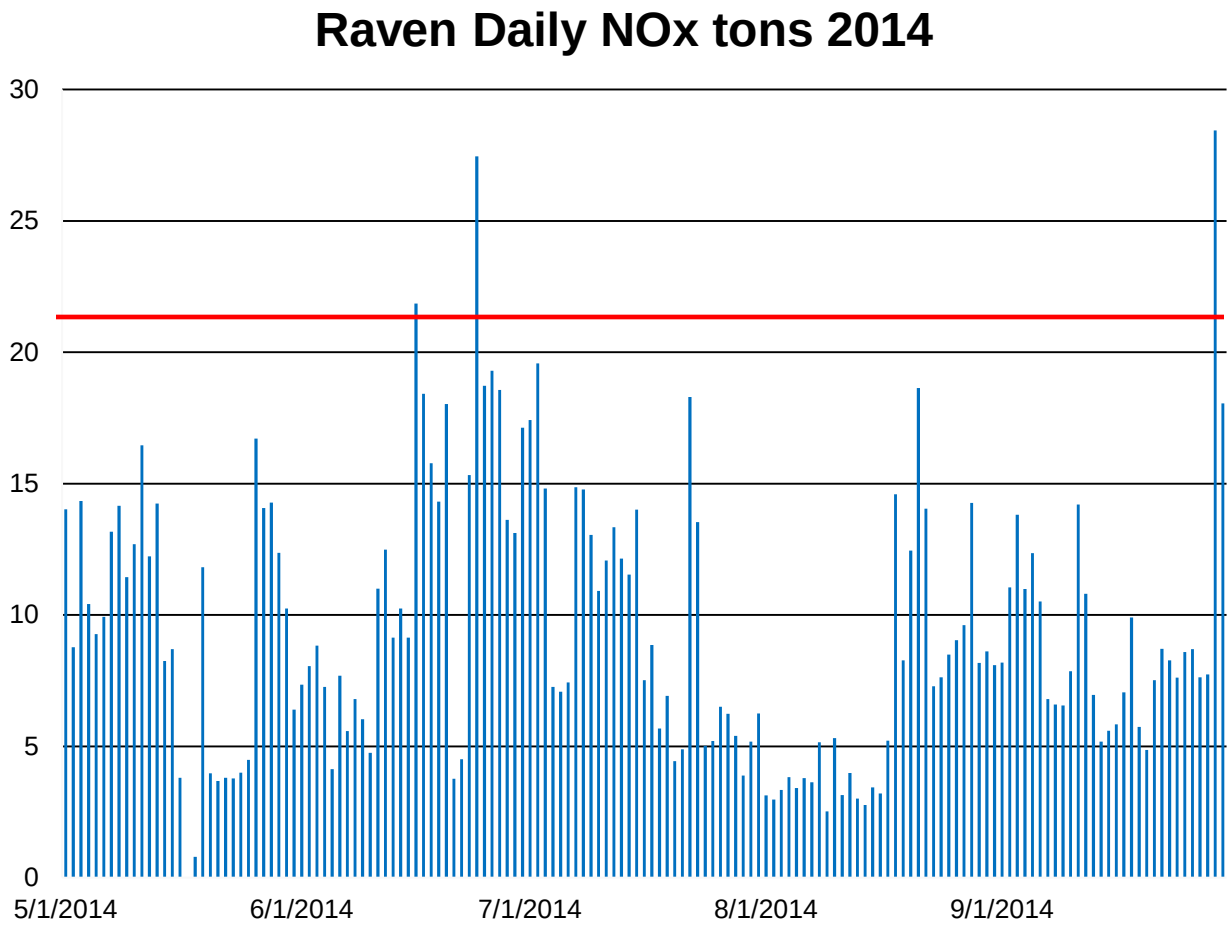
- The caps must have meaning …
  - Must be lower than high peak day emissions in the past
- We've looked at measured data in 2011, 2012, 2013 and 2014
  - 2012 was a hotter than normal summer
  - 2014 was cooler
  - 2014 was the first year where both companies minimized daily emissions by optimizing the use of existing control technology
    - The 2014 summer study

NRG Daily Emission 2014 Ozone Season



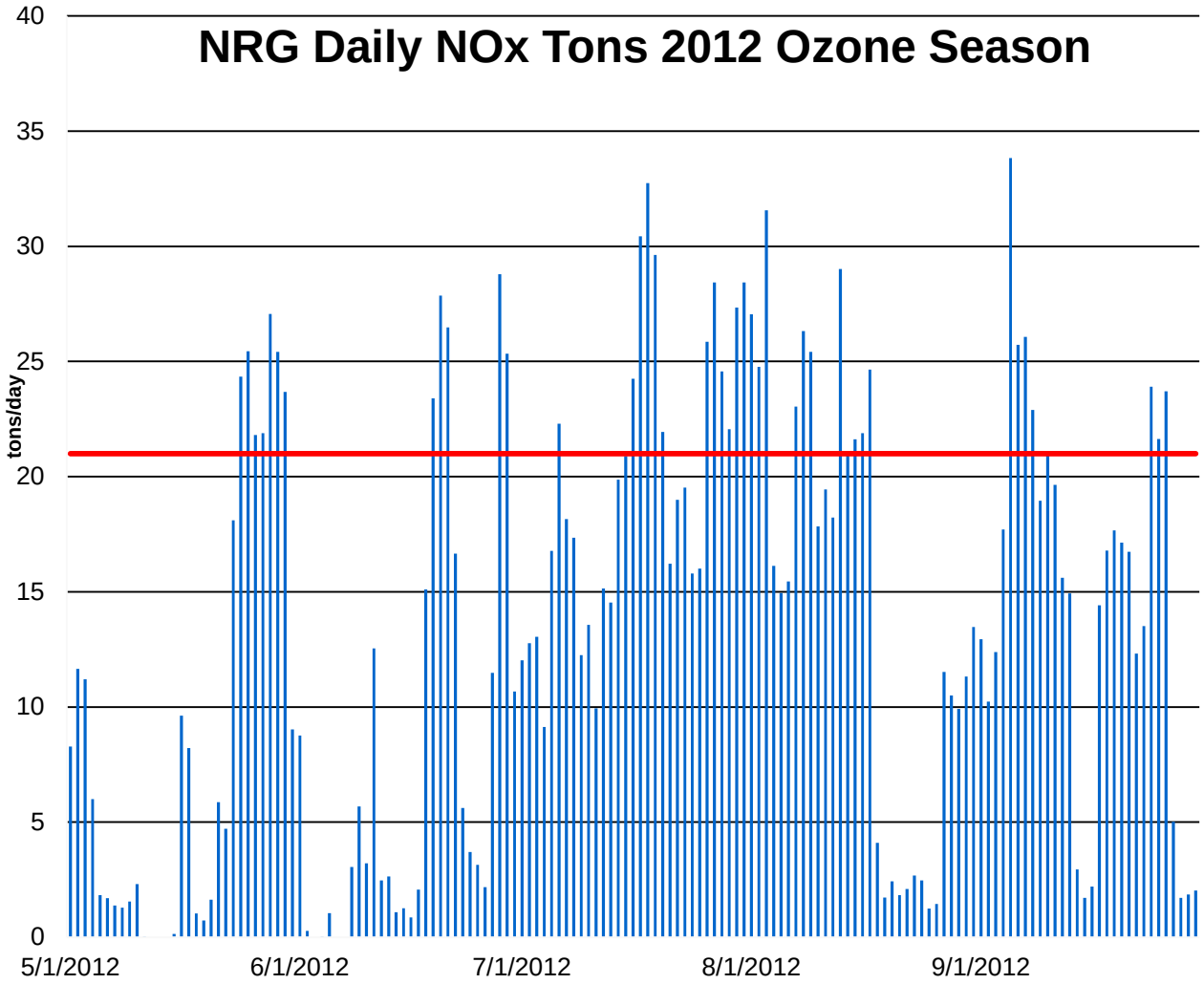
- 153 days total
- 23 days(15%) over 21 tons
- 130 days (85%) under 21 tons
- Max 33.30 tons

Raven Daily Emission 2014 Ozone Season



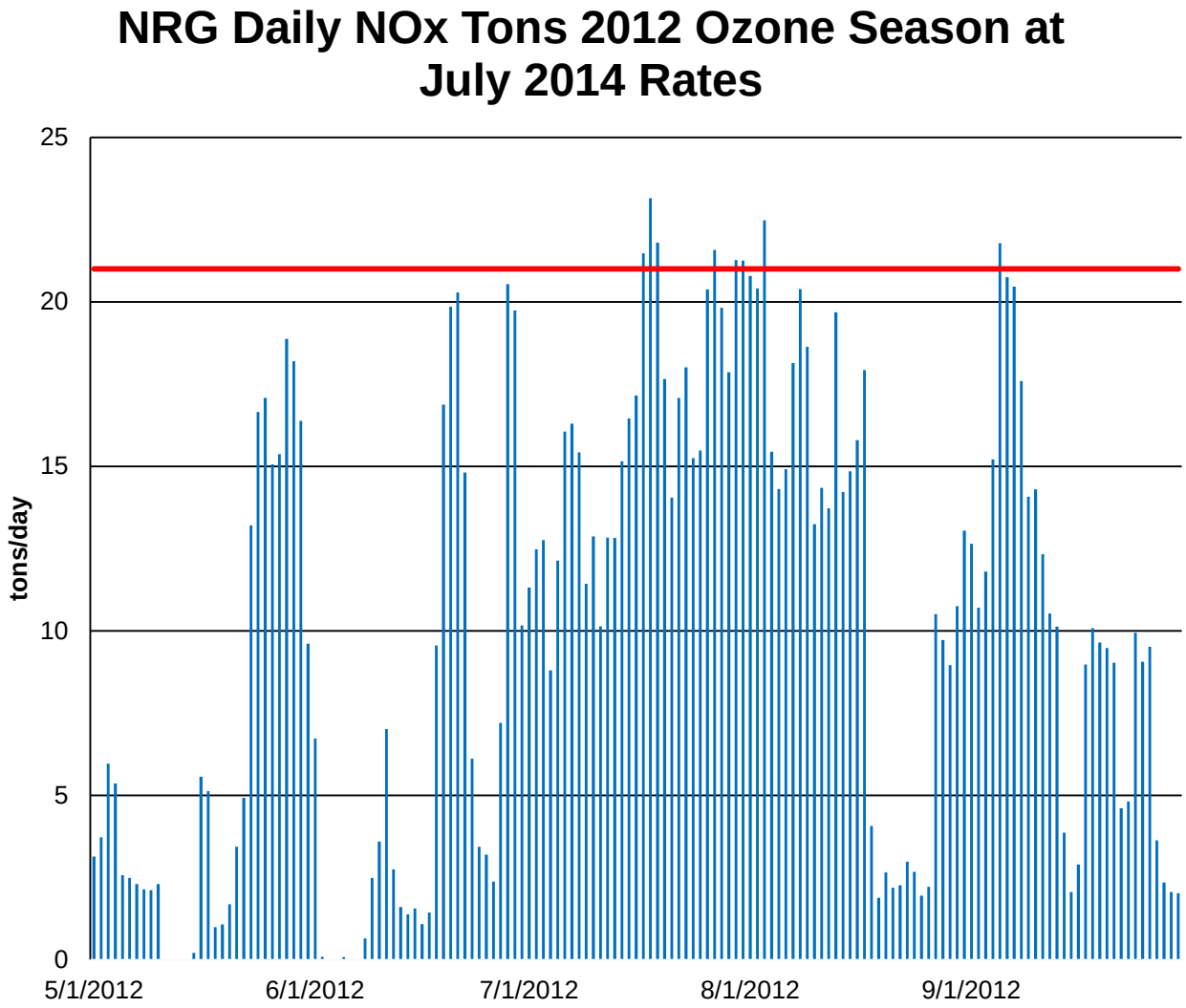
- 153 days total
- 2 days (1%) over 21 tons
- 151 days (99%) under 21 tons
- Highest day 27 tons June 24th 2014

NRG Daily Emission 2012 Ozone Season



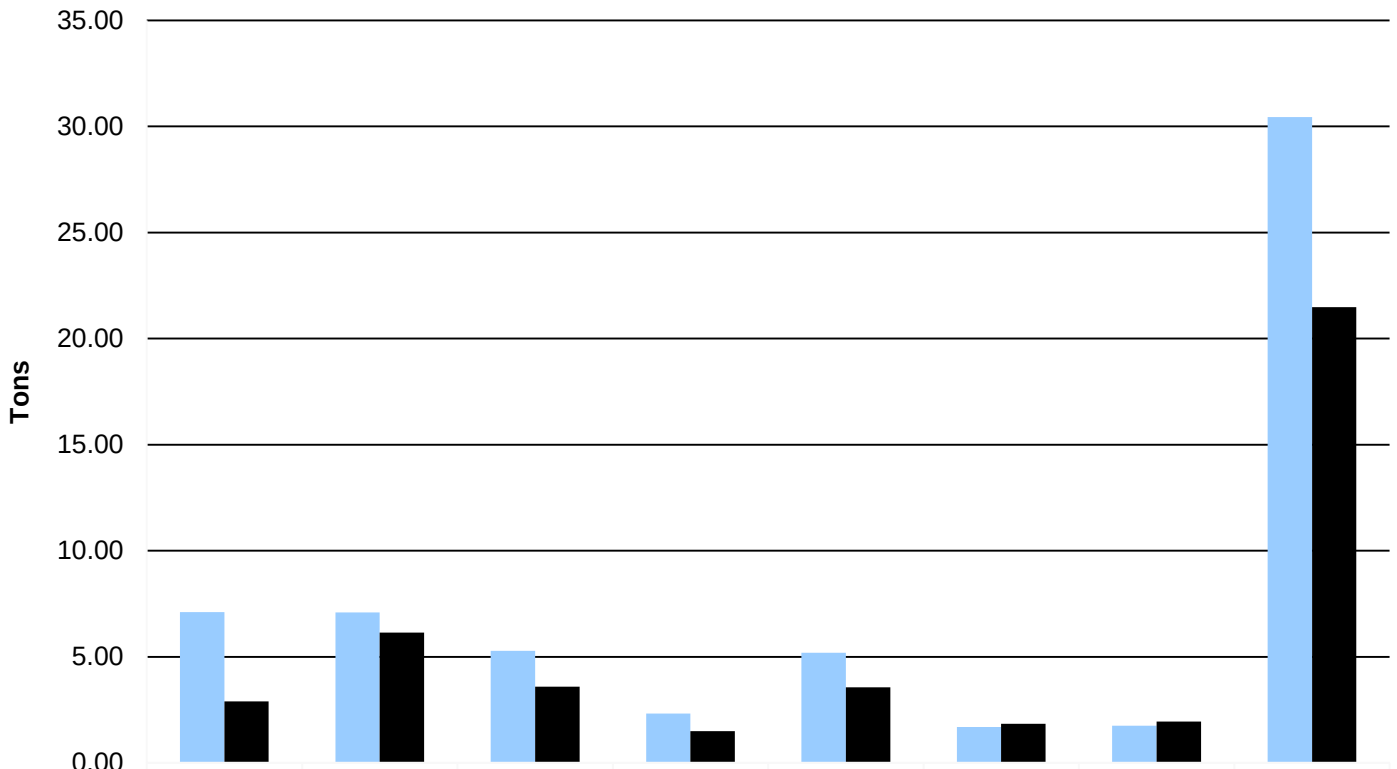
- 153 days total
- 42 days (27%) over 21 tons
- 111 days (73%) under 21 tons
- Highest day 33.8

NRG - 2012 - Optimization Assumed



- 153 days total
- 8 days (5%) over 21 tons
- 145 days (95%) under 21 tons
- Highest days
  - July 17 - 21.47 tons
  - July 18 - 23.15 tons

July 17, 2012 at July 2014 Rates



	Chalk Point 1 NOx Tons	Chalk Point 2 NOx Tons	Dickerson 1 NOx Tons	Dickerson 2 NOx Tons	Dickerson 3 NOx tons	Morgantown 1 NOx tons	Morgantown 2 NOx Tons	NRG Daily Total NOx tons
Actual tons	7.11	7.09	5.28	2.32	5.20	1.69	1.75	30.43
Tons at July 14 rates	2.90	6.14	3.60	1.49	3.56	1.84	1.95	21.48

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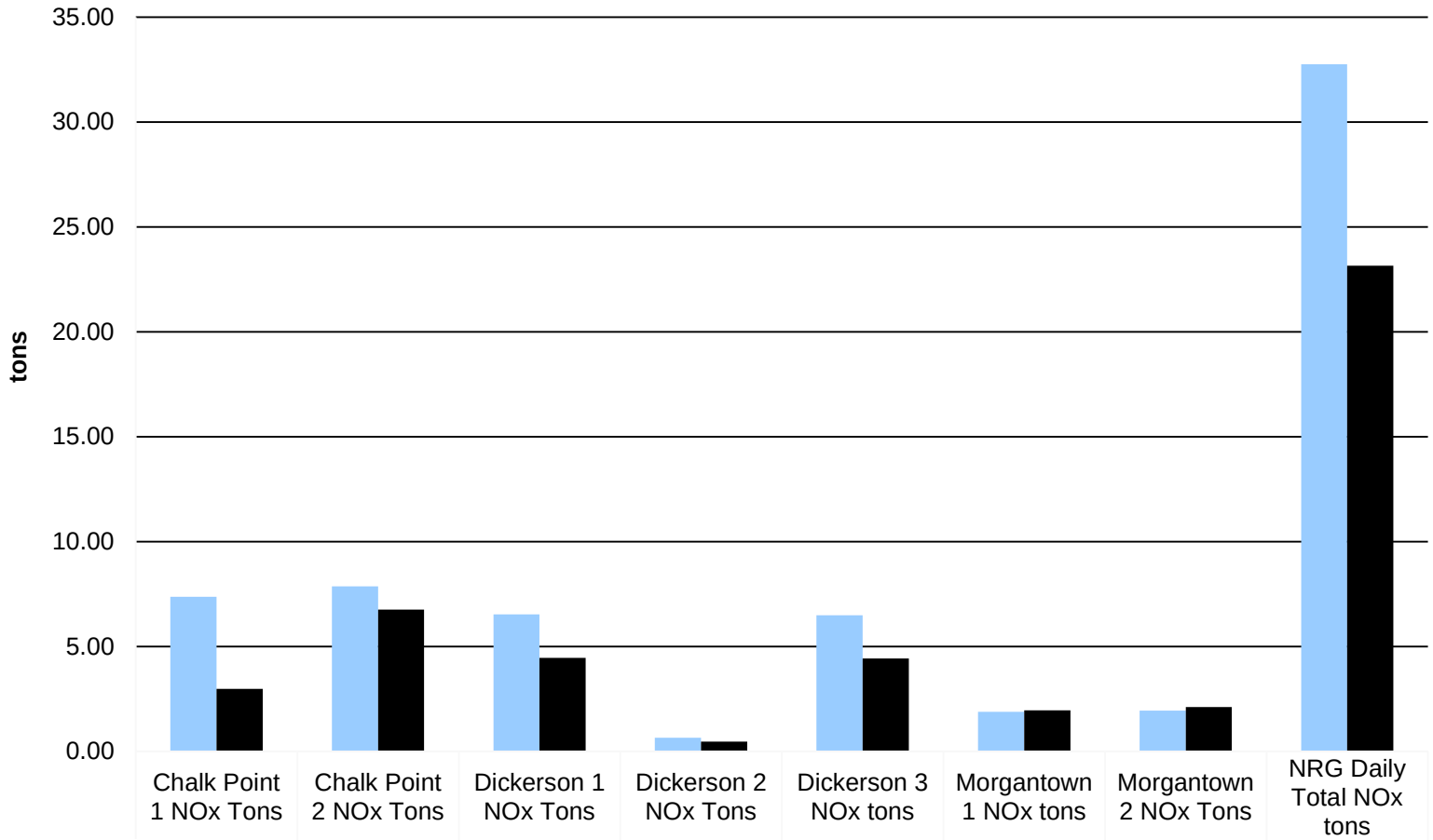
July 18, 2012 at July 2014 Rates



	Chalk Point 1 NOx Tons	Chalk Point 2 NOx Tons	Dickerson 1 NOx Tons	Dickerson 2 NOx Tons	Dickerson 3 NOx tons	Morgantown 1 NOx tons	Morgantown 2 NOx Tons	NRG Daily Total NOx tons
Actual tons	7.37	7.87	6.54	0.66	6.49	1.88	1.94	32.75
Tons at July 14 rates	2.98	6.76	4.46	0.46	4.43	1.95	2.11	23.15

Earlier Public Health Protection

… and benefits to the Bay, when new option 4 is chosen

.04 Additional NO_x Emission Control Requirements.

A. This regulation applies to C.P. Crane units 1 and 2, Chalk Point unit 2, Dickerson units 1, 2, and 3 and H.A. Wagner unit 2.

B. General Requirements. The owner or operator of the affected electric generating units subject to this regulation shall choose from the following:

(1) Not later than June 1, 2020:

(a) Install and operate a selective catalytic reduction (SCR) control system; and

(b) Meet a NO_x emission rate of 0.09 lbs/MMBtu, as determined on a 30-day rolling average during the ozon season;

(2) Not later than June 1, 2020, permanently retire the unit;

(3) Not later than June 1, 2020, permanently switch fuel from coal to natural gas for the unit;

(4) Not later than June 1, 2020, meet either a NO_x emission rate of 0.13 lbs/MMBtu as determined on a 24-hour systemwide block average or a systemwide NO_x tonnage cap of 21 tons per day during the ozone season.

C. When option B(4)of this regulation is selected:

(1) Not later than May 1, 2016, the owner or operator of an affected electric generating unit shall not exceed a NO_x 30-day systemwide rolling average emission rate of 0.13 lbs/MMBtu during the ozone season.

(2) Not later than May 1, 2018, the owner or operator of an affected electric generating unit shall not exceed a NO_x 30-day systemwide rolling average emission rate of 0.11 lbs/MMBtu during the ozone season.

(3) Not later than May 1, 2020, the owner or operator of an affected electric generating unit shall not exceed a NO_x 30-day systemwide rolling average emission rate of 0.09 lbs/MMBtu during the ozone season.

Highlighted Regulation - Pages 2 and 3

Choosing Option 4 …

… also requires phased in deeper reductions in 2016, 2018 and 2020

- Opting into option 4 also requires system-wide, phased in, additional NOx reductions:
  - 0.13 lb/mmbtu in 2016
  - 0.11 lb/mmbtu in 2018
  - 0.09 lb/mmbtu in 2020
  - All 30-day rolling averages

Other New Regulatory Language

Reliability Safety Valve Linked to New Option 4

New regulation .07 - Pages 4 and 5

.07 Electric System Reliability During Ozone Seasons.

A. In the event of emergency operations, a maximum of 12 hours of operations per system per ozone season may be removed from the calculation of the NO_x limitations in Regulation .04B(4) of this chapter from the unit(s) responding to the emergency operations provided that:

(1) Within one business day following the emergency operation, the owner or operator of the affected electric generating unit(s) notifies the Manager of the Air Quality Compliance Program of the emergency operations taken by PJM Interconnection; and

(2) Within five business days following the emergency operation, the owner or operator of the affected electric generating unit(s) provides the Department with the following information:

(a) PJM documentation of the emergency event called and the unit(s) requested to operate;

(b) Unit(s) dispatched for the emergency operation;

(c) Number of hours that the unit(s) responded to the emergency operation and the consecutive hours that will be used towards the calculation of the NO_x limitations in §.04B(4) of this chapter; and

(d) Other information regarding efforts the owner or operator took to minimize NO_x emissions in accordance with Regulation .03A(1) of this chapter on the day that the emergency operation was called.

B. Any partial hour in which a unit operated in response to emergency operations under §A of this regulation shall constitute a full hour of operations.

Supporting definition in regulation .01 - Page 1

(2) "Emergency operations" means an event called when PJM Interconnection, LLC or a successor independent system operator, acts to invoke one or more of the Warning or Action procedures in accordance with PJM Manual 13, Revision 57, as amended, to avoid potential interruption in electric service and maintain electric system reliability.

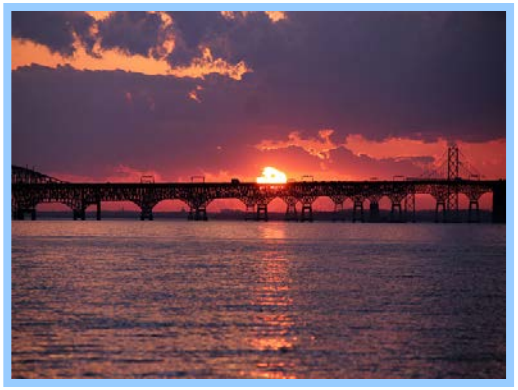
PJM Warnings and Actions

- The electricity grid in Maryland is well supported and includes adequate backup generation for high energy demand days
- In rare instances, PJM needs more reserves and issues emergency warnings and actions needed for reliability
- The regulation would allow for half a day or 12 hours of emissions to be excluded only from the calculation of daily limits

Year	Summer Events	Event Details					
		Date	Hrs	Units	Date	Hrs	Units
2015	0		0			0	
2014	0		0			0	
2013	2	7/18	4	CP1&2, D1,2&3, M1&2	9/11	5	CP1&2, D1,2&3, M1&2
2012	2	7/17	5	CP1&2, D1,2&3, M1&2, BS1&2, W2&3, C1&2	7/18	4	CP1&2, D1&3, M1&2
2011	2	6/9	4	CP2, M1&2, W2&3, BS1&2,C1&2	7/22	7	CP1&2, D1,2&3, M1&2, BS1&2, W2&3, C1&2

The Ozone Standard and Excursions

- When EPA finalizes a standard it is designed to insure public health and environmental protection with an adequate margin of safety
- EPA weighs both elements of the standard when determining protection with an adequate margin of safety
  - The level of the standard … and
  - The form of the standard
- So … the ozone standard is …
  - The fourth highest level measured at individual monitors averaged for three consecutive years
- The standard allows an occasional excursion above 75 ppb and still protects public health and the environment with an adequate margin of safety



Reliability in 2020

- The reliability safety valve does not come in to play until 2020
- MDE and the Maryland Public Service Commission (PSC) expect many fewer issues with reliability in 2020
- Four new natural gas units scheduled for construction and operation before 2020
- New systems being put into place by PJM also appear to set the stage for a very stable, reliable energy system in the 2020 time frame

Other New Language

… needed to implement option 4

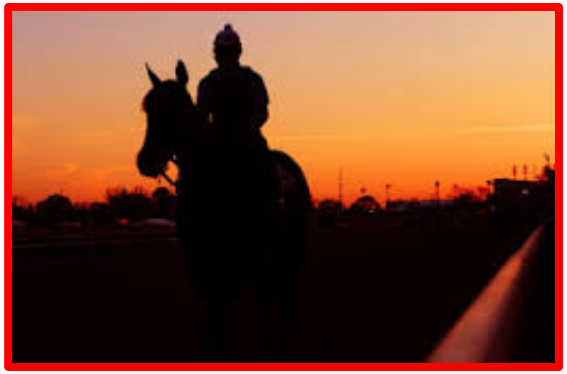
- In definitions - page 1 … highlighted regulation

(10) "24-hour systemwide block average emission rate" means a value in lbs/MMBtu calculated by:

(a) Summing the total pounds of pollutant emitted from the system during 24 hours between midnight of one day and ending the following midnight;

(b) Summing the total heat input to the system in MMBtu during 24 hours between midnight of one day and ending the following midnight; and

(c) Dividing the total number of pounds of pollutant emitted during 24 system hours between midnight of one day and ending the following midnight by the total heat input during 24 system hours between midnight of one day and ending the following midnight.



Other New Language - Continued

… linked to option 4

- Clarifying natural gas and ownership issues
- Page 3 … highlighted regulation

D. In order to calculate the 24-hour systemwide block average emission rate and systemwide NO_x tonnage cap under §B(4) of this regulation and the systemwide rolling average emission rates under §C of this regulation:

(1) The owner or operator shall use all affected electric generating units within their system as those terms are defined in Regulation .01B of this chapter; and

(2) The unit(s) NOx emissions from all operations during the entire operating day shall be used where the unit(s) burn coal at any time during that operating day.

E. Beginning June 1, 2020, if the unit(s) included in a system, as that system existed on May 1, 2015, is no longer directly or indirectly owned, operated, or controlled by the owner, operator, or controller of the system:

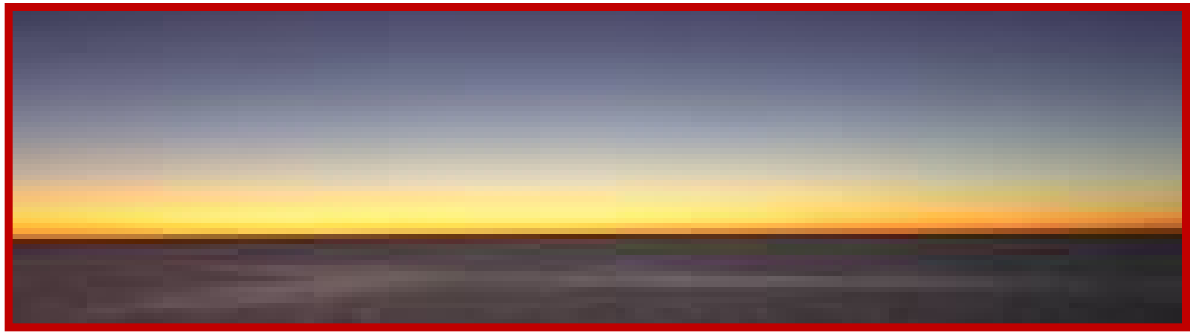
(1) The remaining units within the system shall meet either:

(a) The requirements of §B(1)—(3) of this regulation; or

(b) A NOx emission rate of 0.13 lbs/MMBtu as determined on a 24-hour systemwide block average and the requirements of §C(3) of this regulation.

(2) The unit(s) no longer included in the system shall meet requirements of §B(1)—(3) of this regulation.

F. For the purposes of this regulation, the owner includes parent companies, affiliates, and subsidiaries of the owner.



Other New Language - Continued

… driven by the need to implement option 4

- Building option 4 into reporting and compliance requirements
- Page 4 … highlighted regulation

(5) For an affected electric generating unit which has selected the compliance option of Regulation .04B(4) of this chapter, beginning June 1, 2016, the 30-day rolling average emission rate and 30-day systemwide rolling average emission rate calculated in lbs/MMBtu;

(6) For an affected electric generating unit which has selected the compliance option of Regulation .04B(4) of this chapter, beginning June 1, 2020, data, information, and calculations which demonstrate the systemwide NO_x emission rate as determined on a 24-hour block average or the actual systemwide daily NO_x emissions in tons for each day during the month; and

(7) For an affected electric generating unit which has selected the compliance option of Regulation .04E(2) of this chapter, beginning June 1, 2020, data, information, and calculations which demonstrate the systemwide NO_x emission rate as determined on a 24-hour block average for each day during the month.

Ozone, Public Health and Environmental Benefits From the New Regulations

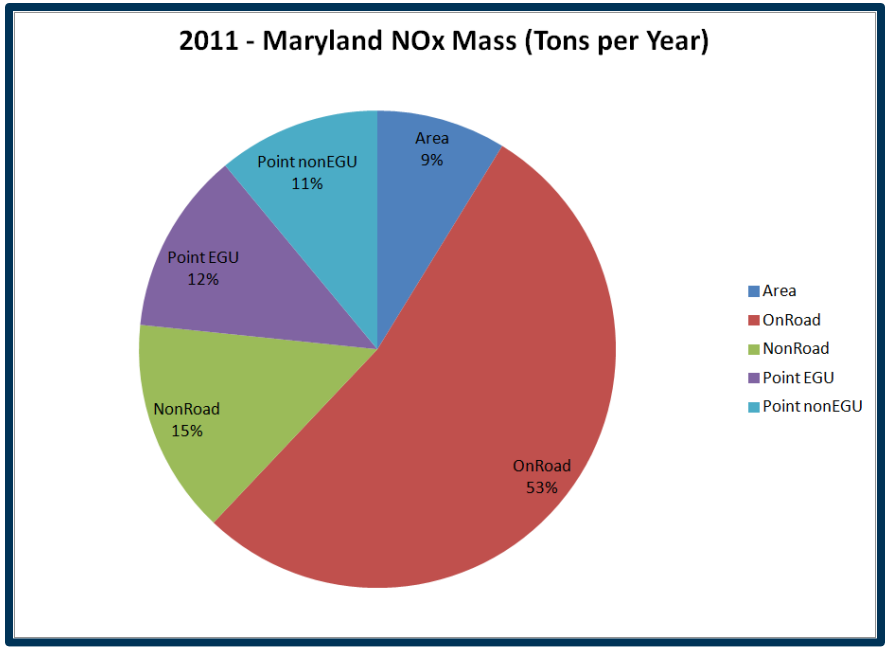
How Much Will the New Regulation

… help Maryland with it's ozone problem?

- Maryland has historically had one of the toughest ozone problems in the Country
  - Recent progress in reducing ozone has been remarkable
  - Only state East of the Mississippi designated as a "Moderate" nonattainment area by EPA
    - Baltimore is the only nonattainment area in the East required to submit an "Attainment" SIP in 2015
    - This SIP must be supported by photochemical modeling and an "Attainment Demonstration"
  - We believe we have enough modeling completed to have a very clear picture of what Maryland needs in it's plan to bring the State into attainment

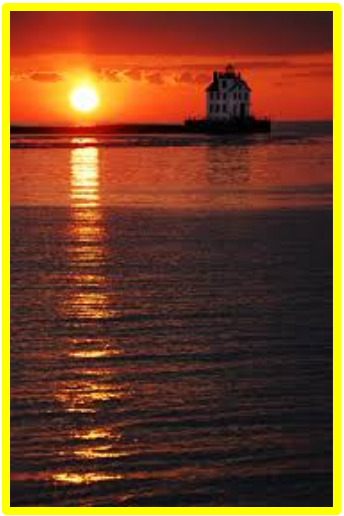
The New Regulation - How Much Help?

- It is a small, but very important part of the “Maryland Plan”
- The Maryland Plan looks at Power plants, cars, many other source categories
- We know the States ozone problem is dominated by ozone pollution floating in from upwind states (called ozone transport)
- But we also know that on many days between 30% and 50% of the States problem is home grown



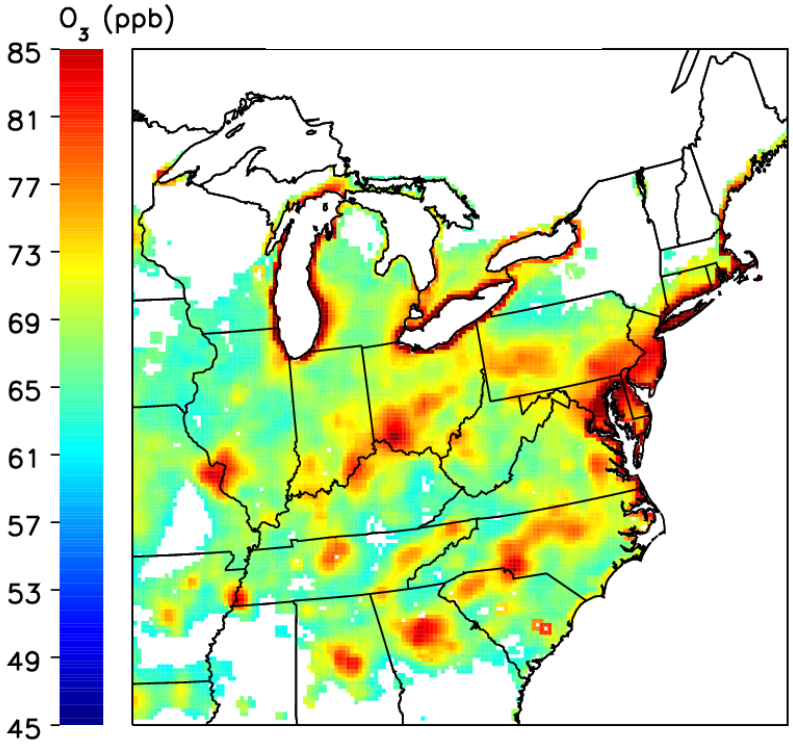
Control Measures in the MD Plan

- The Maryland Plan focuses on 3 basic packages of new control measures
- Widespread regional emission reduction programs that are “on the books” or “on the way” (OTB/OTW):
- Reductions in upwind states to reduce ozone transport
  - On some days, our research balloons and airplanes measure incoming ozone already above the 75 ppb standard
  - Power plants, cars and trucks and multiple other sources
- New reduction measures in Maryland
  - This regulatory effort on power plants
  - Other efforts on mobile and smaller “area” source

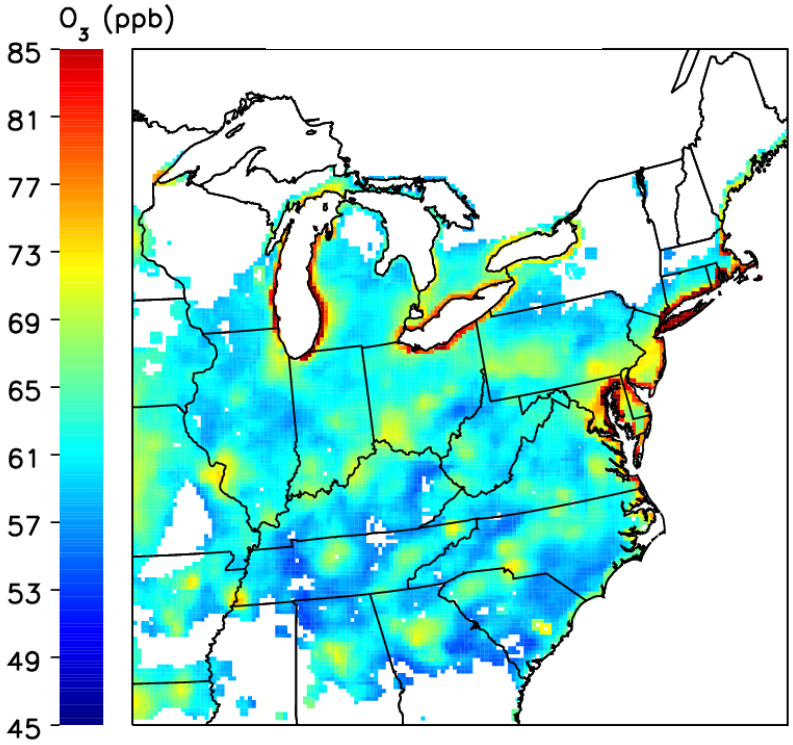


The Bottom Line

… Projected ozone improvements 2011 to 2018 from the Maryland Plan



2011 Measured Ozone

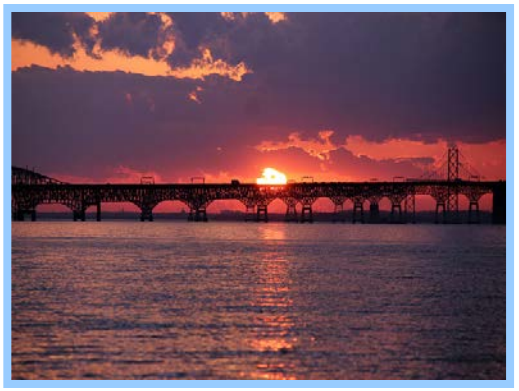


2018 - After the Maryland Plan

More later …

OTB/OTW Reductions - Some Background

- There are over 40 control programs in this piece of our Plan
  - Generally older control programs that continue to generate deeper reductions as they are phased in or as fleets turn over
- By far, the largest contributors to NOx reductions in the OTB/OTW category are mobile sources
  - Tier 2 Vehicle Standards
  - Federal fuel economy (CAFÉ) standards
  - Heavy Duty Diesel Standards
  - Marine Diesel Engine Standards
  - Emission Control Area (ECA) requirements
  - Many more …
- VOC reductions from the OTB/OTW category come from programs like
  - Federal consumer product and paint regulations
  - Tier 2 Vehicle Standards
  - VOC RACT … Many more …



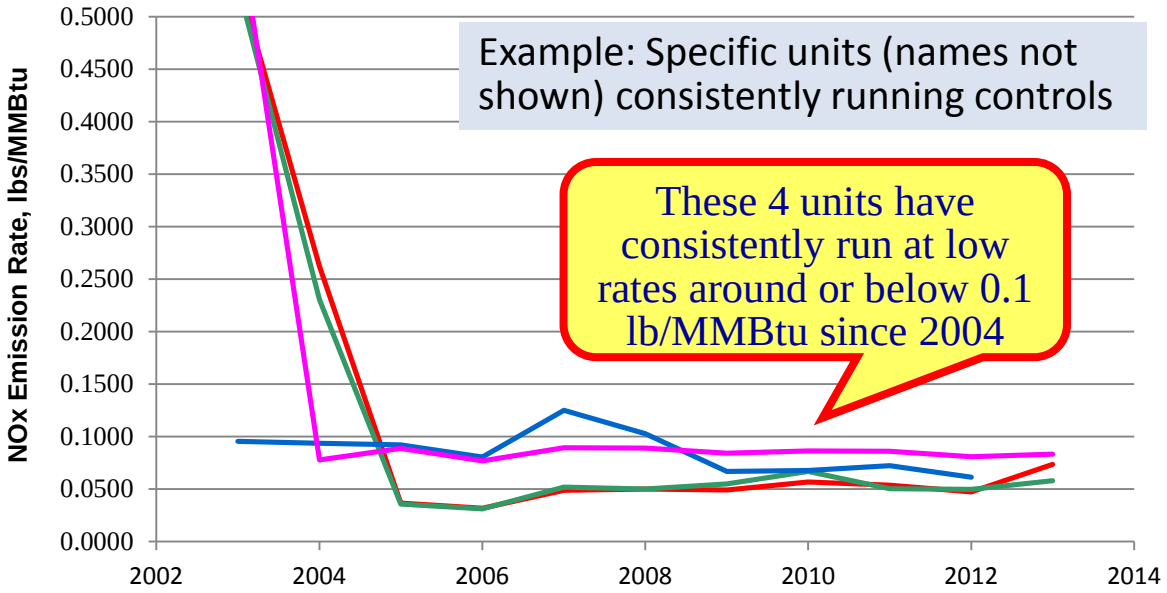
New Reductions in Transport Included?

- Three significant new transport strategies are included in the Maryland Plan
- The Federal Tier 3 Vehicle and Fuel Standards may be the most significant new transport strategy
- New OTC Regional Measures
- “Good Neighbor “ controls that address coal-fired power plants in 10 states upwind of MD are also included in the modeling
  - Focuses primarily on the large potential reductions from insuring that currently installed technologies are run well
    - Also includes significant reductions from units scheduled for retirement (or other major changes) by 2018

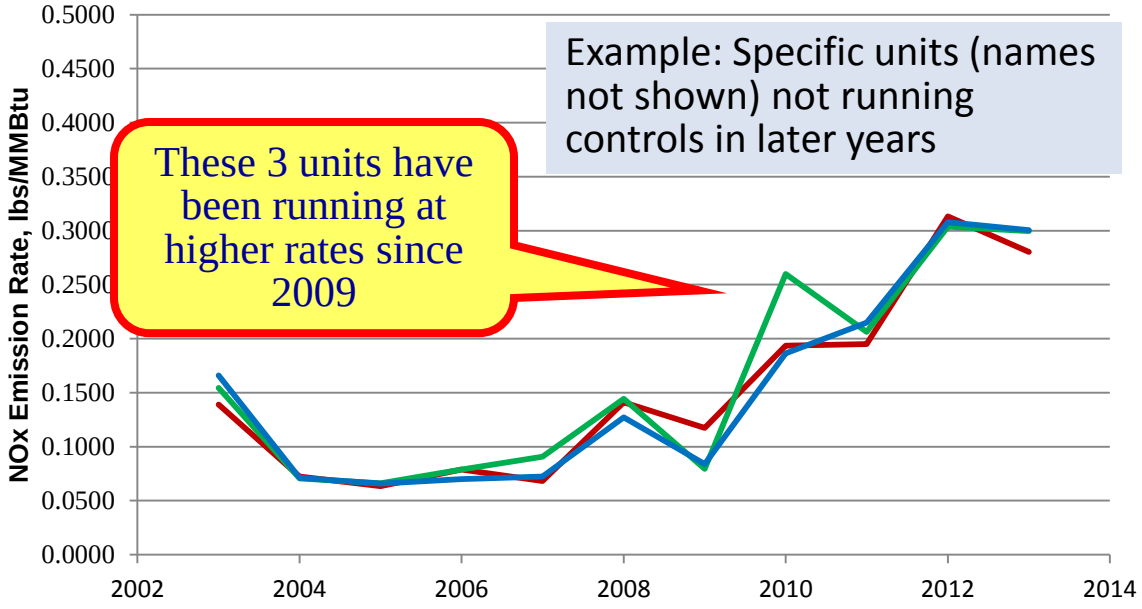
Running Power Plant Controls Well?

Average Ozone Season Emission Rates at Specific Units by Year

Many Sources Run Controls Well →

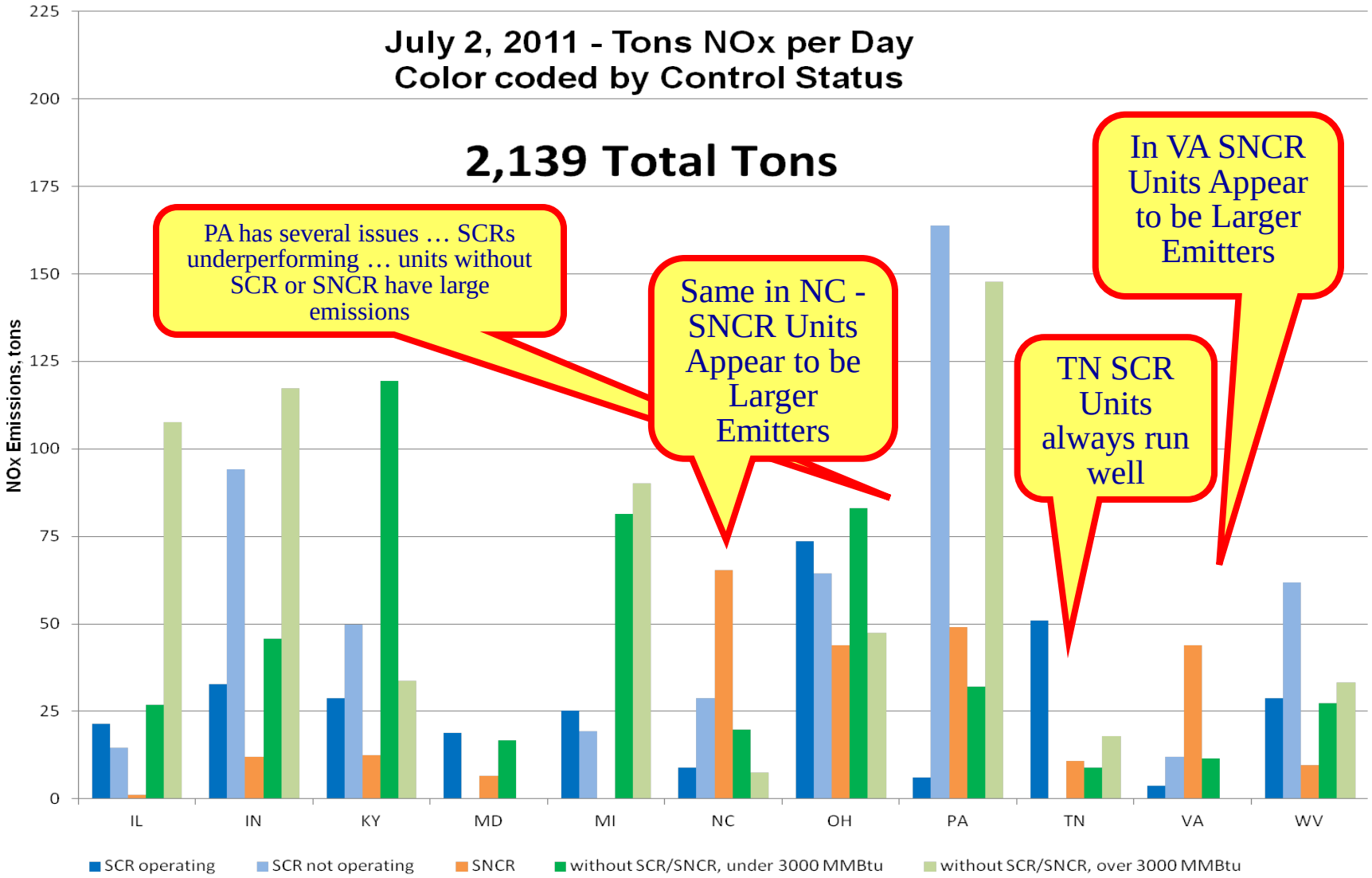


Some Units Are Not Running Controls as Well →



MDE has conducted this kind of analysis for every coal-fired unit in states that contribute to Maryland's ozone problem

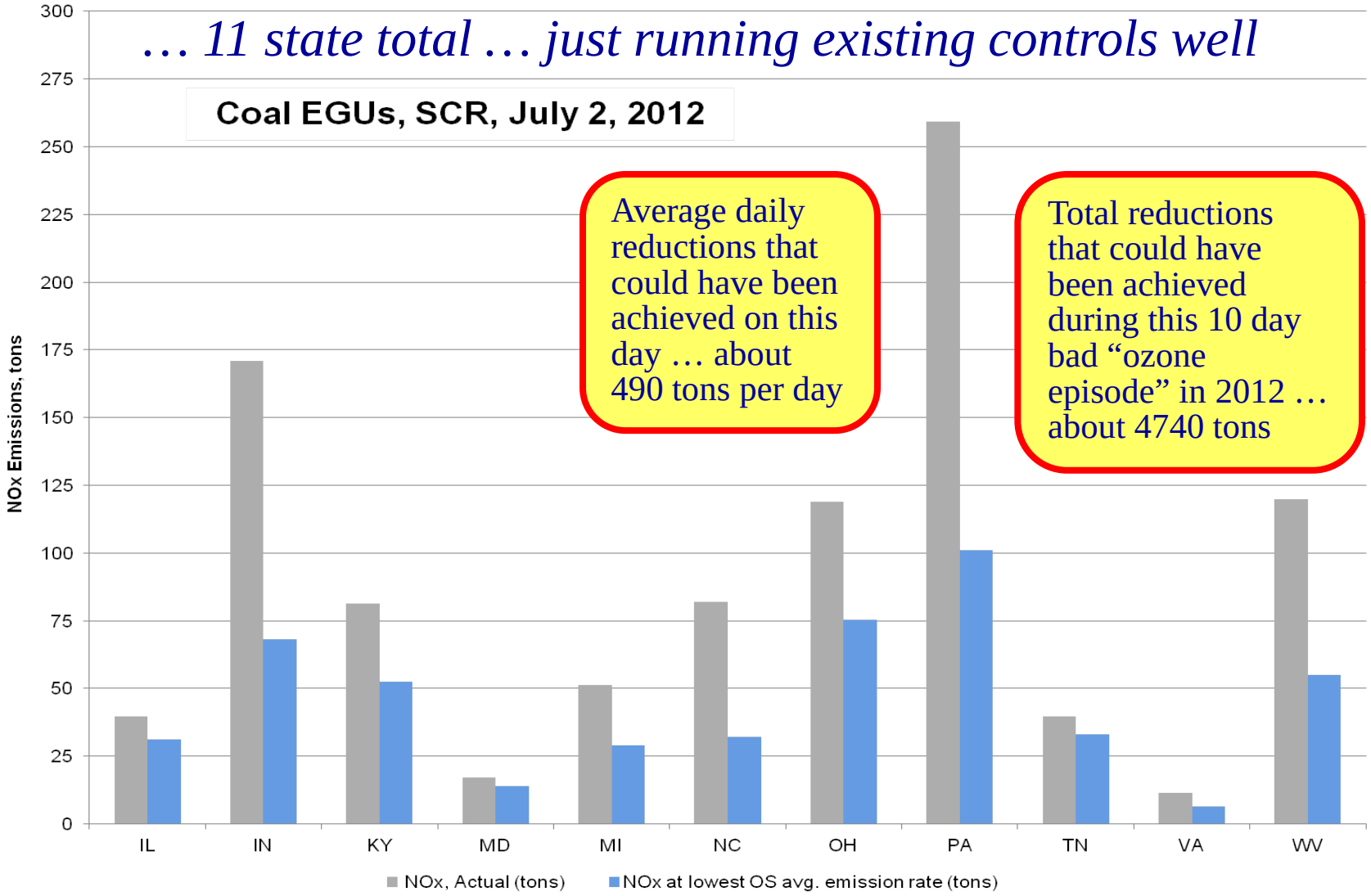
So What Has MDE Found?



The MDE research has shown that many, many sources across the East are not using their control technologies the way they were designed to be used

Reductions Could be Very Large

… 11 state total … just running existing controls well



Average daily reductions that could have been achieved on this day … about 490 tons per day

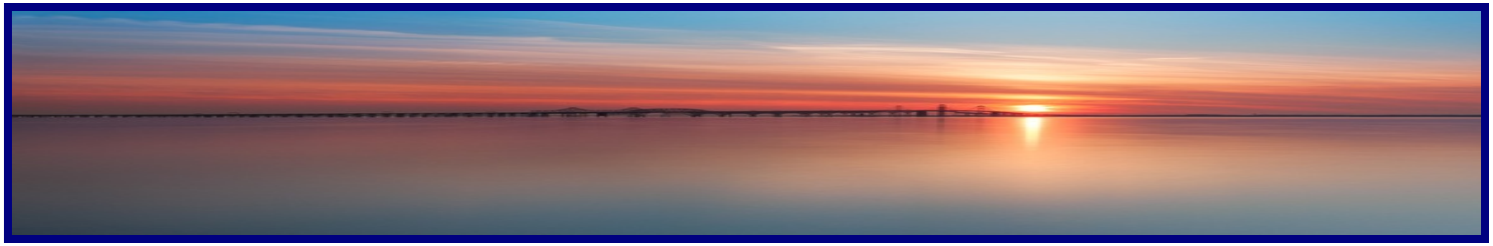
Total reductions that could have been achieved during this 10 day bad "ozone episode" in 2012 … about 4740 tons

MARYLAND DEPARTMENT OF THE ENVIRONMENT

What Inside the OTC Measures are Included?

- Mobile Source Initiatives
  - Aftermarket Catalyst effort
  - ZEV/CALEV state programs
  - Onroad and offroad idling
  - Heavy Duty I&M
  - Smartways
- NOx and VOC reductions
- New potential initiatives like Ports are not included

- Stationary and Area Source Efforts
  - Third Generation OTC/SAS Initiatives
    - Consumer products
    - Architectural and Industrial Maintenance (AIM) Coatings
    - Auto coatings
    - Ultra Low NOx burners
- NOx and VOC reductions



Reductions from OTC Measures

OTC Model Control Measures	Regional Reductions (tons per year)	Regional Reductions (tons per day)
Aftermarket Catalysts	14,983 (NOx) 3,390 (VOC)	41 (NOx) 9 (VOC)
On-Road Idling	19,716 (NOx) 4,067 (VOC)	54 (NOx) 11 (VOC)
Nonroad Idling	16,892 (NOx) 2,460 (VOC)	46 (NOx) 7 (VOC)
Heavy Duty I & M	9,326 (NOx)	25 (NOx)
Enhanced SMARTWAY	2.5%	
Ultra Low NOx Burners	3.669 (NOx)	10 (NOx)
Consumer Products	9,729 (VOC)	26 (VOC)
AIM	26,506 (VOC)	72 (VOC)
Auto Coatings	7,711 (VOC)	21 (VOC)

- Just in the OTC states
- Thanks to OTC Stationary and Area Source … and Mobile Source Committees
- Reductions from newest OTC initiatives not yet included in this chart

What "Inside MD" Reductions are Included?

- New OTC measures
- New EGU regulation for NOx
  - Required for RACT and Attainment
- Maryland efforts on mobile sources
  - Electric vehicle initiatives
  - CALEV/ZEV efforts
  - "Beyond Conformity" partnerships
- Primarily NOx reductions from EGU regulation

MDE Ozone Modeling

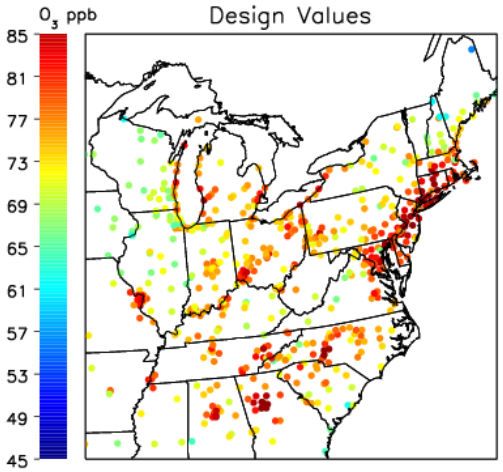
- MDE works with the University of Maryland, the OTC Modeling Committee, EPA and other states to conduct significant amounts of photochemical modeling
  - One of the premiere modeling centers in U.S.
- Current MDE/UMD/OTC Modeling Platform
  - CMAQv5.0.2 (Community Multiscale Air Quality Model)
    - Complemented by CAMX v6.10 (Comprehensive Air Quality Model with Extensions)
  - 2011 WRF (Weather Research & Forecasting) meteorological data.
  - 2011, 2017 and 2018 MARAMA/OTC/EPA inventories
  - Constantly working to improve the model
- Model performance is generally very good
- Modeling being shown today is not final …
  - But it is very high quality and future improvements will not alter the basic information presented today

Who Contributes to MDs Ozone?

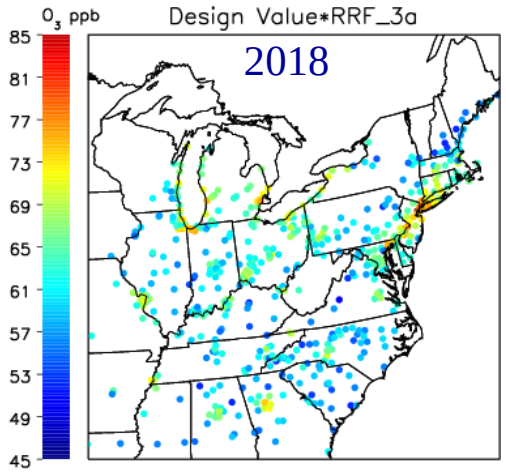
- The CAMX model has a source apportionment tool called OSAT (Ozone Source Apportionment Tool) that allows the model to work backwards and ask questions like “what states” or “what source sectors” sent the ozone to Edgewood MD – or Sheboygan WI – or Atlanta GA?
- The following samples of OSAT runs from the University of Maryland (UMCP) and the Lake Michigan Air Directors (LADCO) provide a quick snapshot of which states and which sources contribute most to Maryland’s ozone problem

Building the Maryland Plan

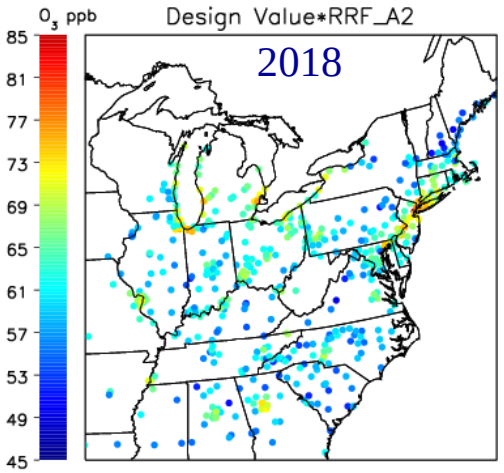
The 2011 Base



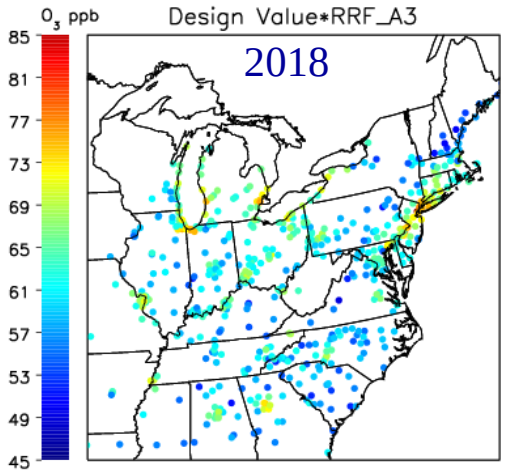
Add regional controls across the East (OTB/OTW, Tier 3, regional EGU controls)



Add the "OTR" controls along I-95 corridor



Add new controls just in MD

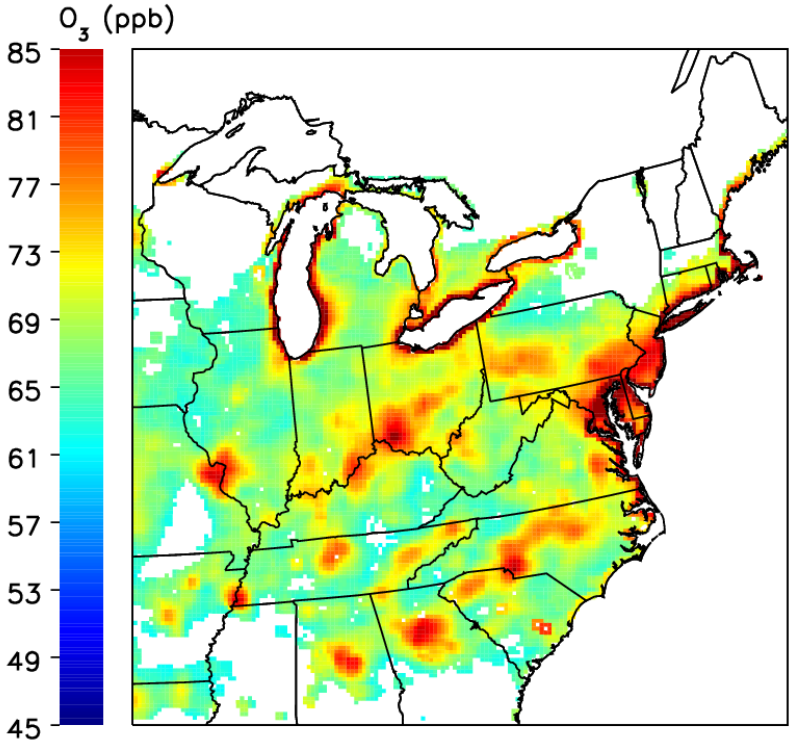


Acronym Reminder

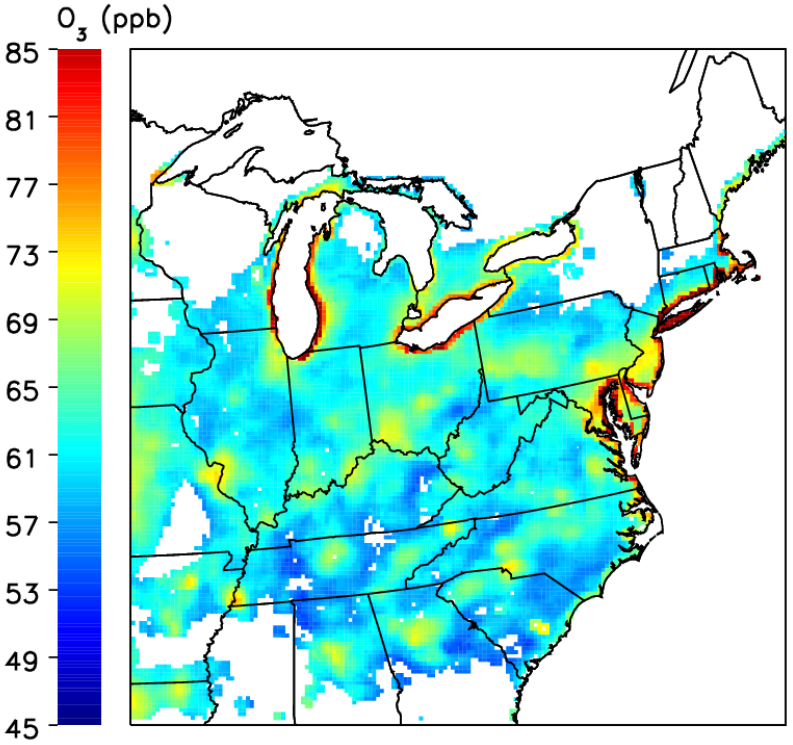
- OTB/OTW stands for emission reductions that are "on-the-books" or "on-the-way"
- Tier 3 is the new federal tailpipe and fuel standards that achieve large NOx reductions
- EGUs are "electric generating units" or power plants
- The OTR is the Ozone Transport Region which includes 13 states from VA to ME along the I-95 corridor

Total Ozone Improvement 2011 to 2018

… the Maryland Plan without MD NOx regulation



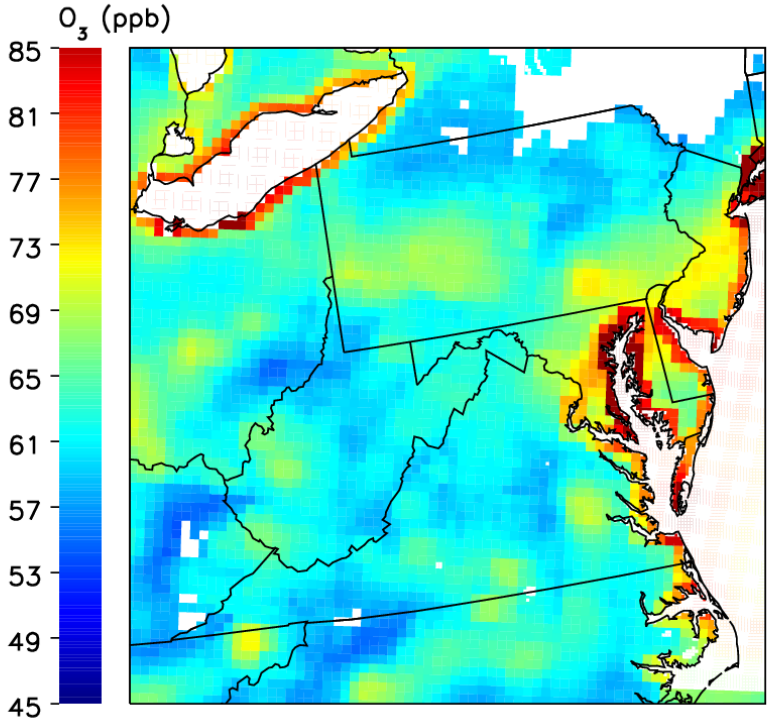
2011 Measured Ozone



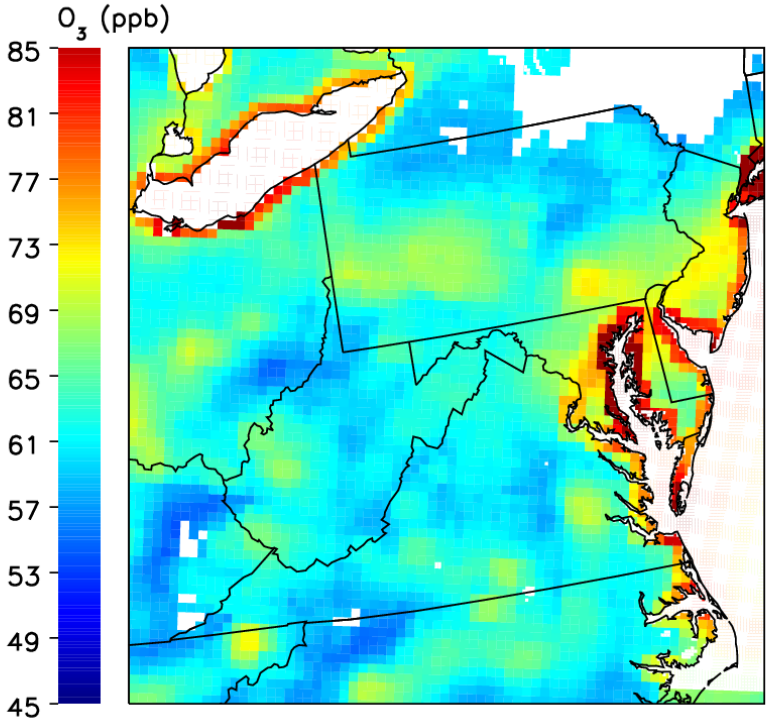
2018 - MD Plan Without NOx Reg

Ozone in 2018 - New NOx Reg

… Adding the maximum reductions from the 2020 requirements from the new regulation



2018 - MD Plan
Without NOx Reg

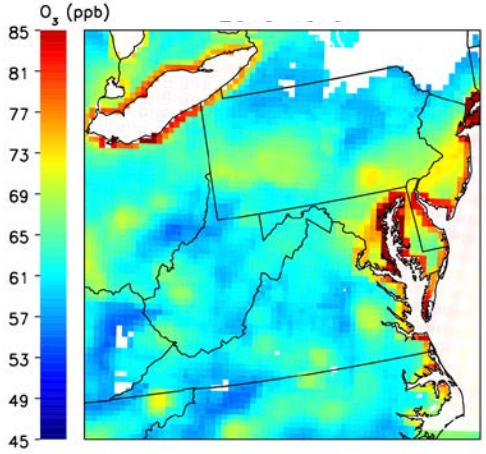


2018 - MD Plan
With NOx Reg

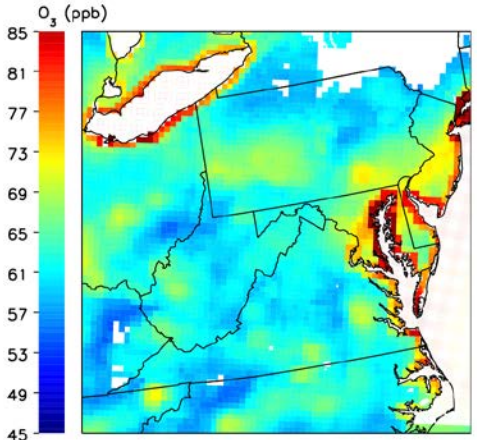
Comparing Ozone Benefits

… 2018 ozone levels after the new regulation

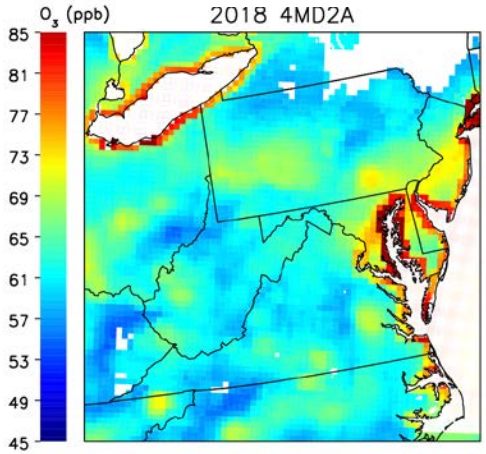
2018 - MD Plan Without NOx Reg



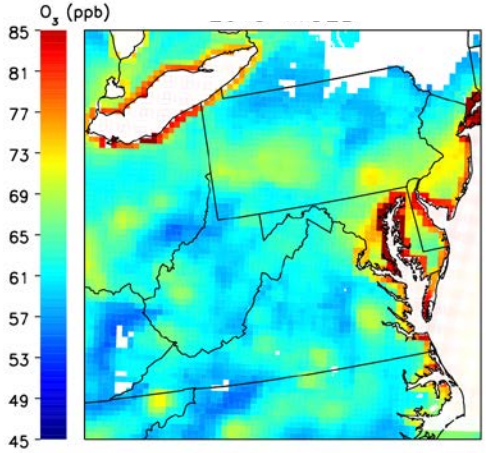
2018 - MD Reg Phase 1



2020 - MD Reg - Old Phase 2

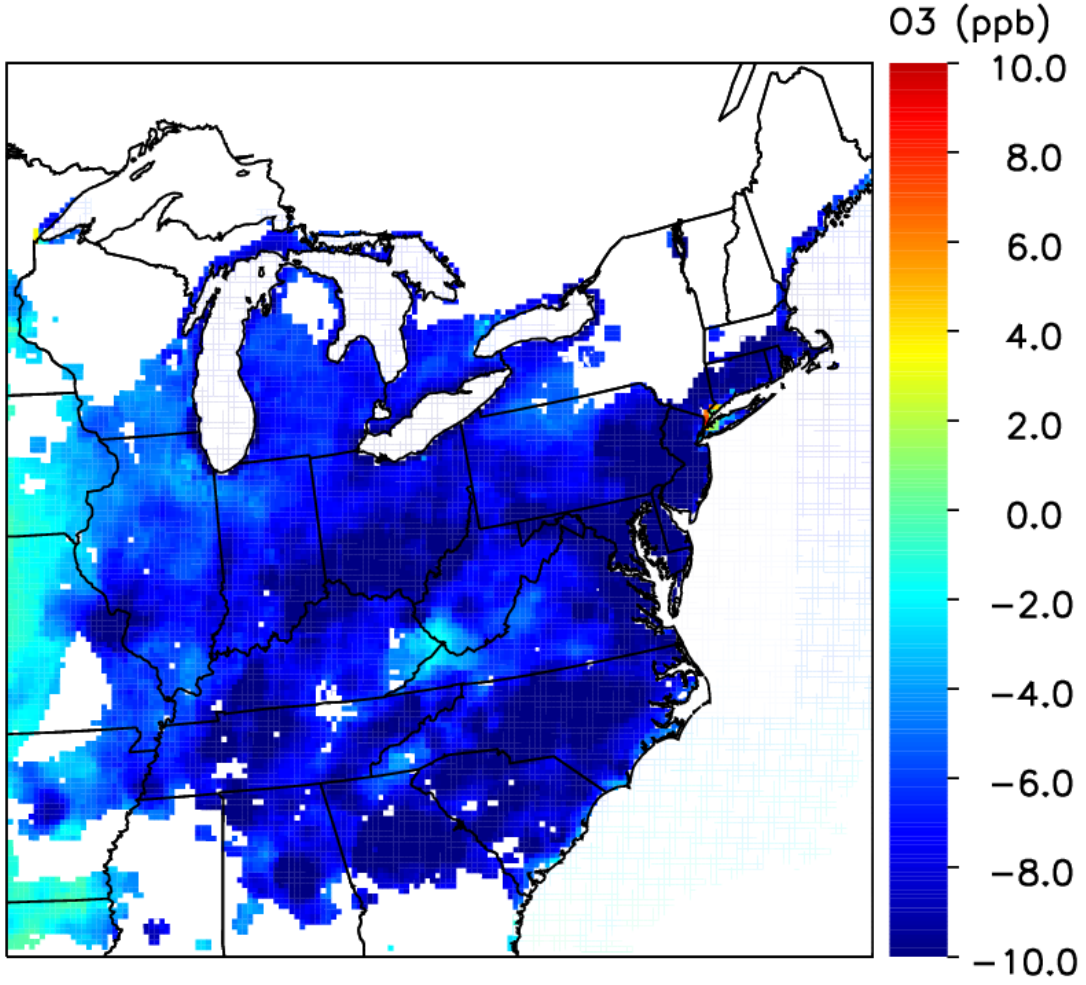


2020 - MD Reg - New Phase 2



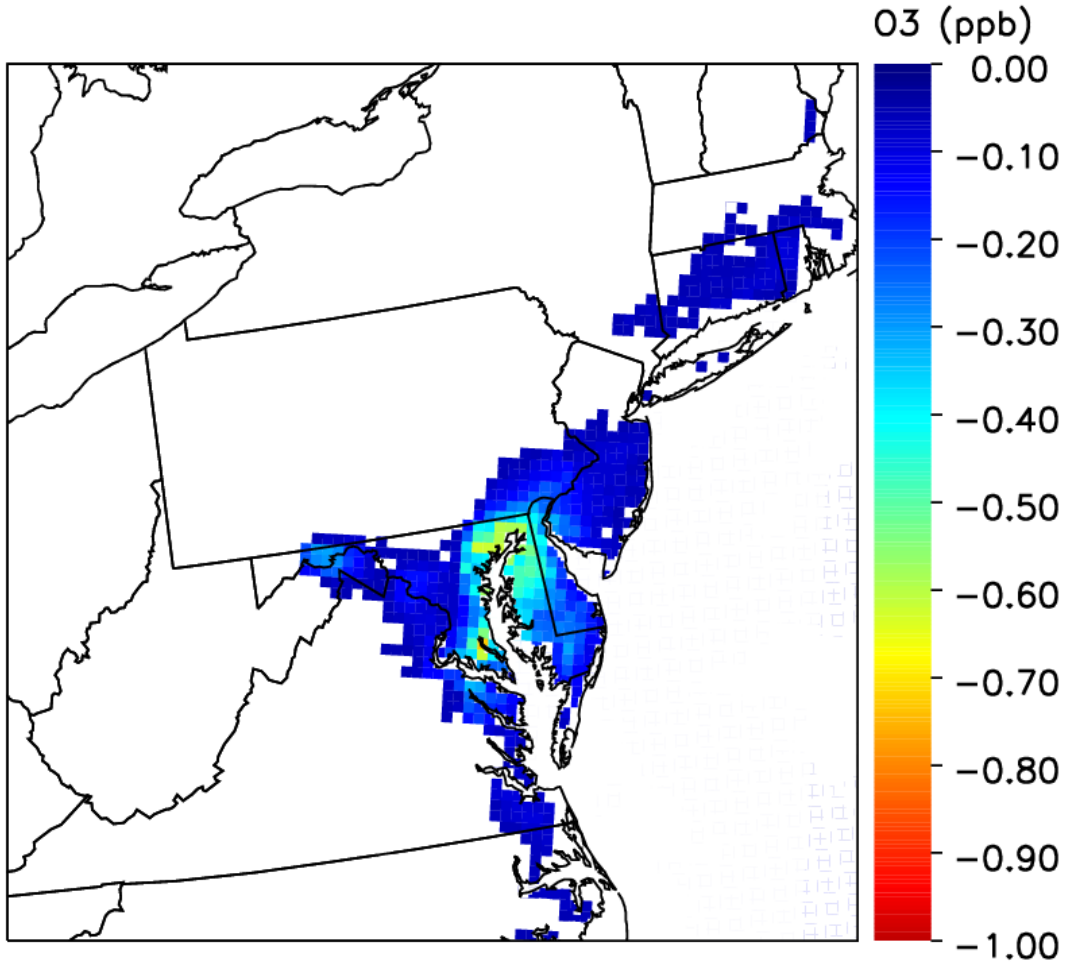
Total Ozone Benefits

… Total ozone reductions from the Maryland Plan including the new Phase 2 (2020) NOx reductions



Ozone Benefits from the NOx Reg

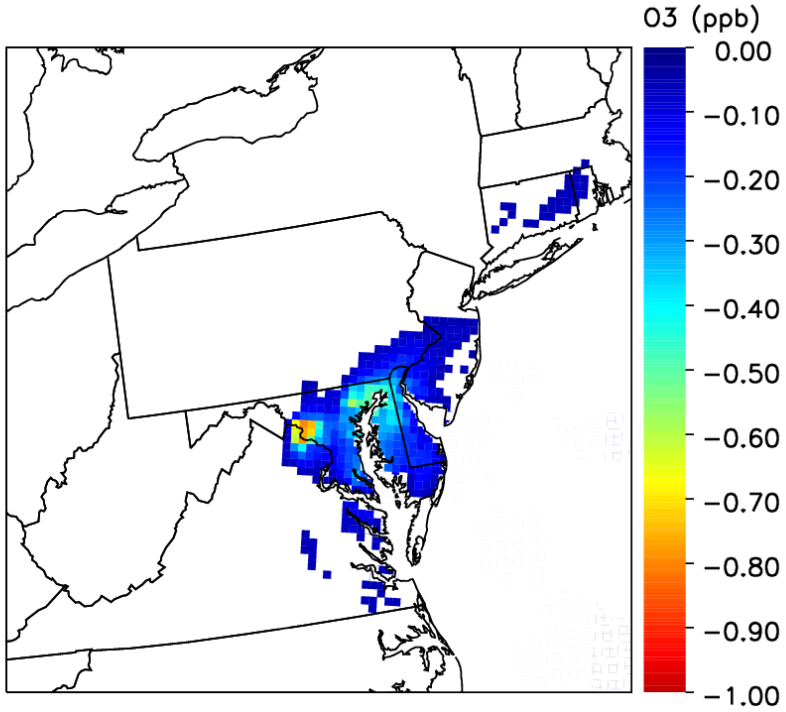
… Reduced ozone from the 2015 requirements of the new regulation



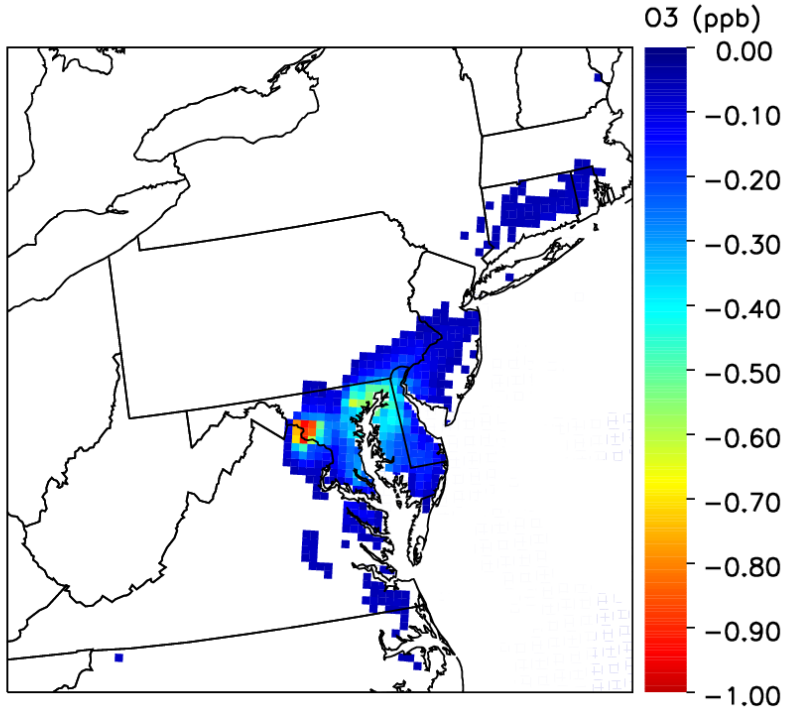
Note scale change

Ozone Reductions in 2020

… From the earlier regulation and the new option 4 requirements in 2020



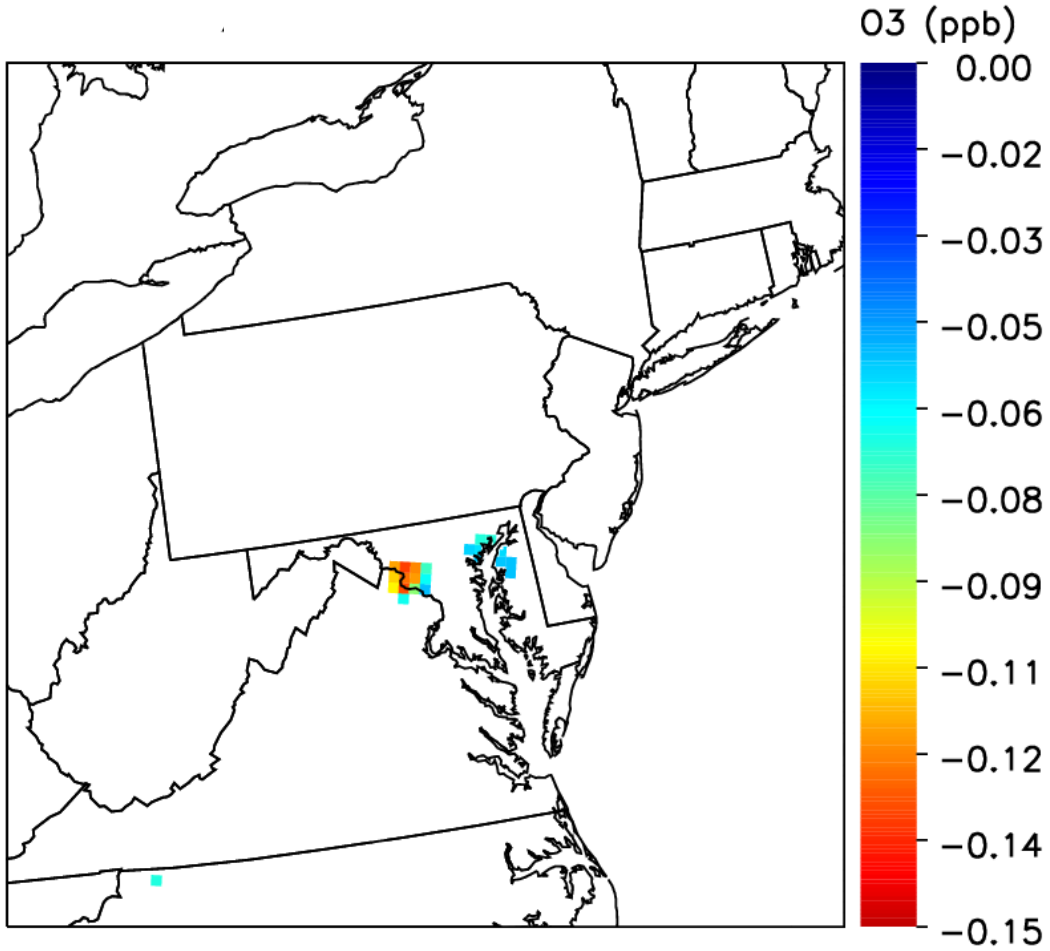
Additional 2020 reductions from 2020 requirements in the earlier proposal



Additional 2020 reductions from 2020 requirements in the new regulation - Option 4 -

Small Additional Benefits …

… from the new option 4 requirements for 2020 reductions

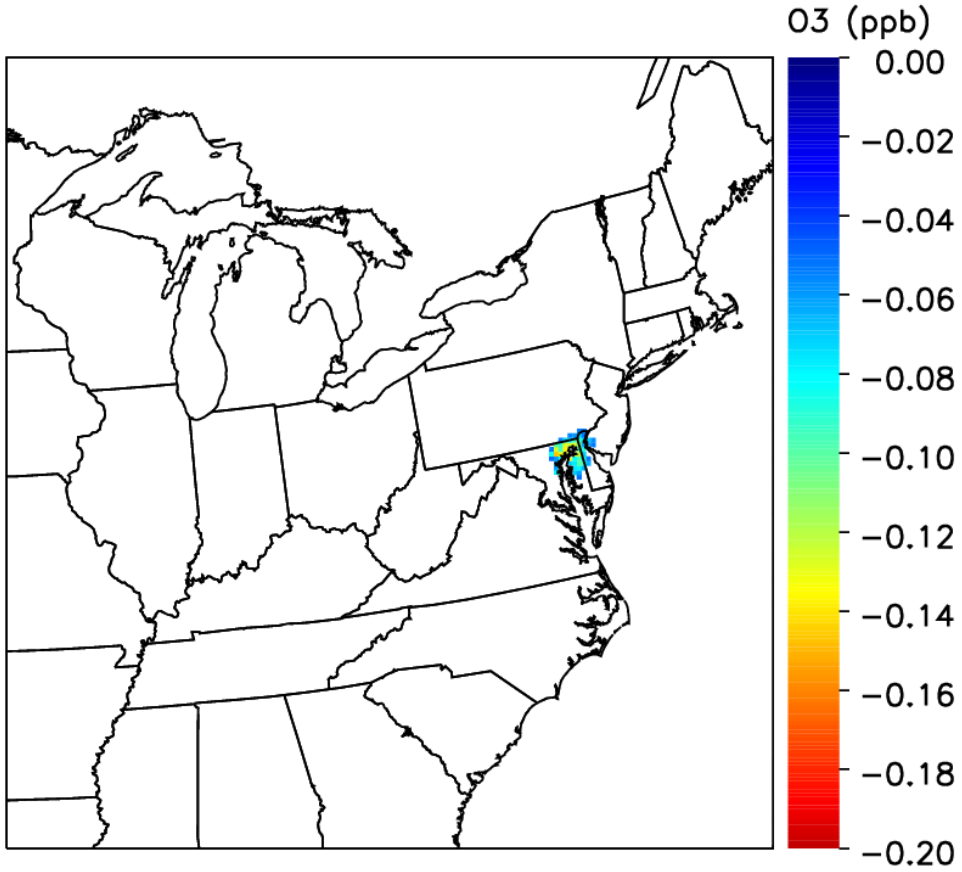


Note scale change

Additional Benefits in 2018

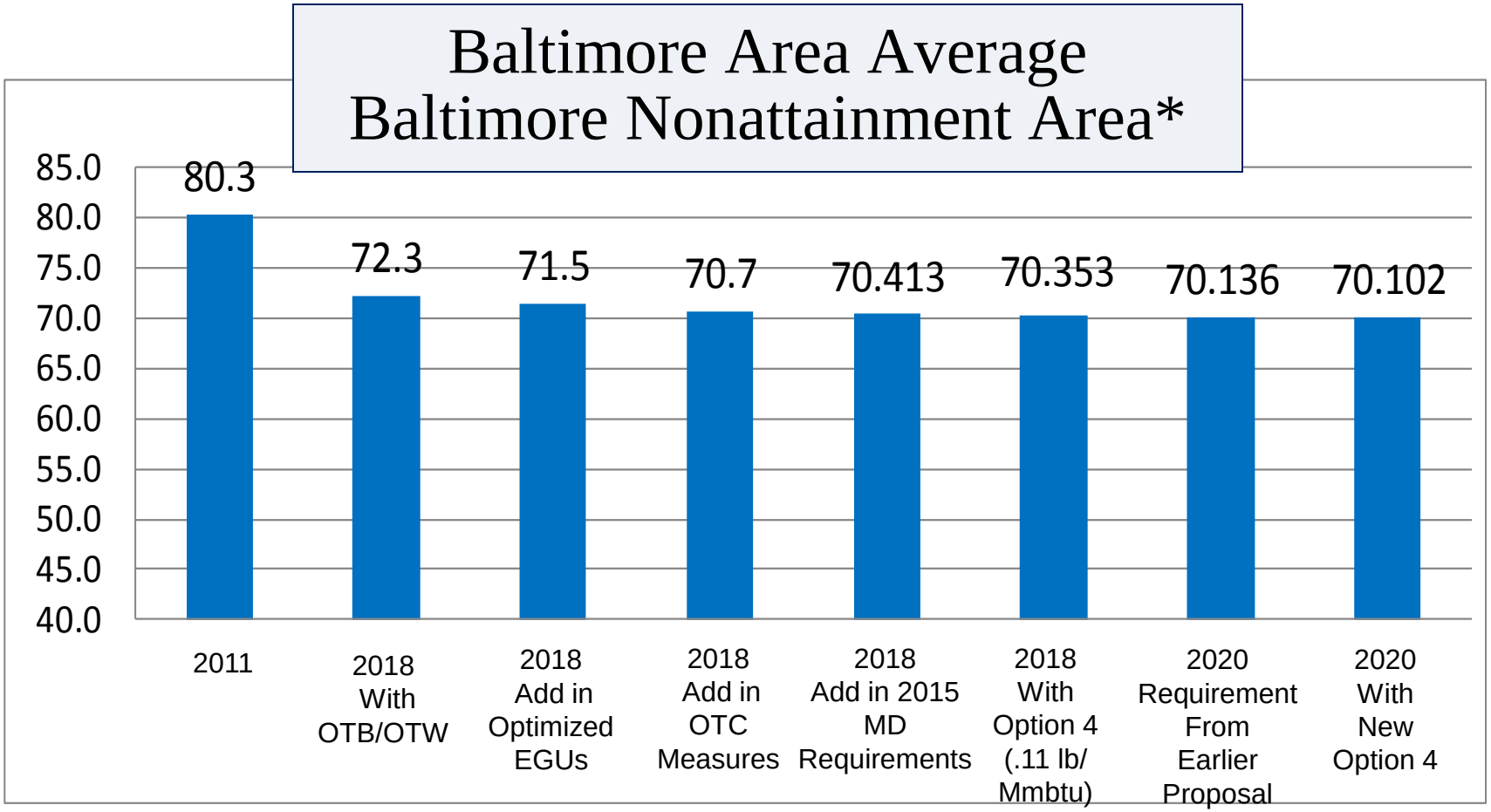
… Earlier reduced ozone with Option 4

Small additional reductions from the 0.11 lb/MMBTU limit required in 2018 when Option 4 is selected



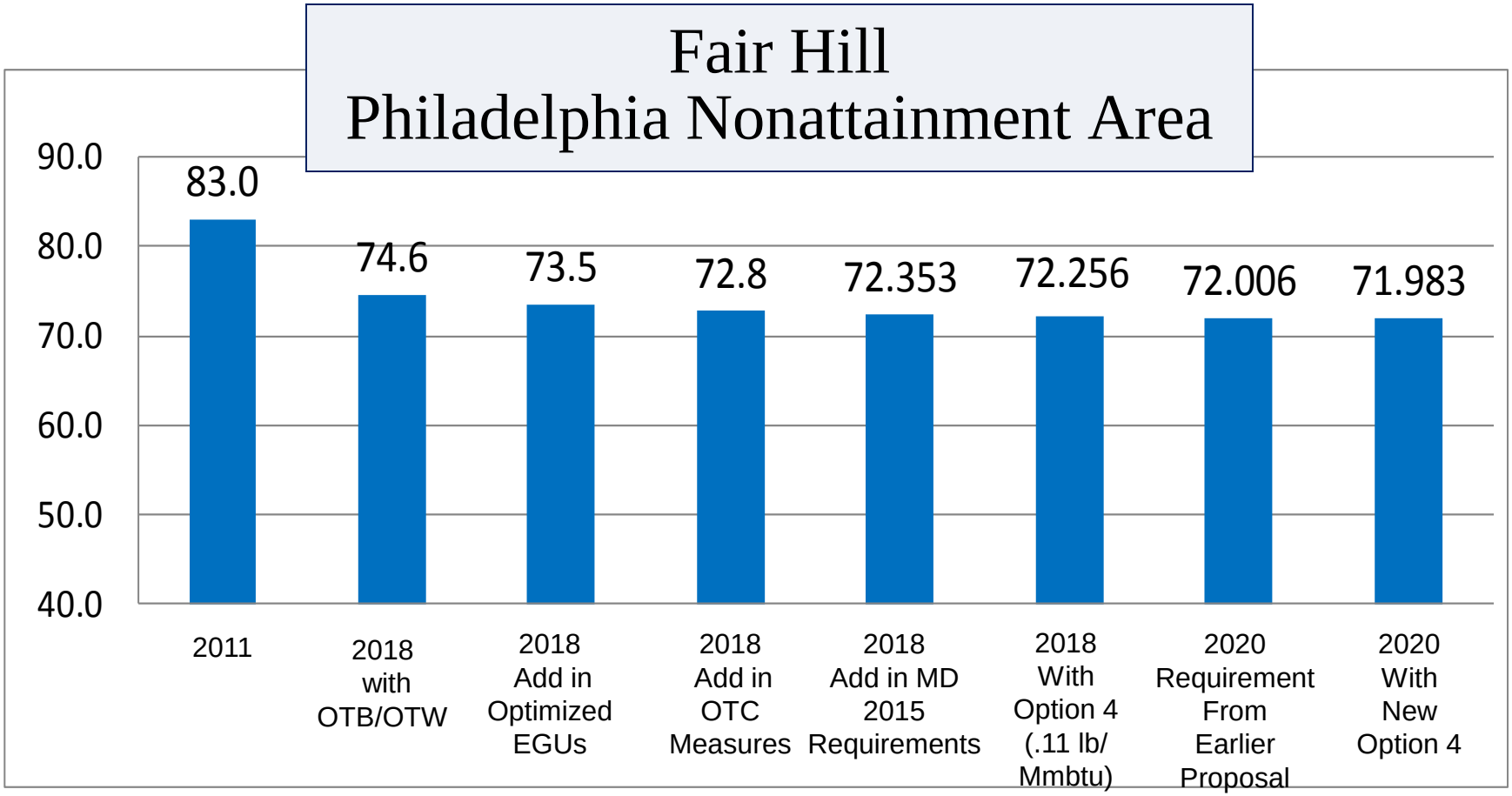
Note scale change

A Snapshot of Ozone Reductions

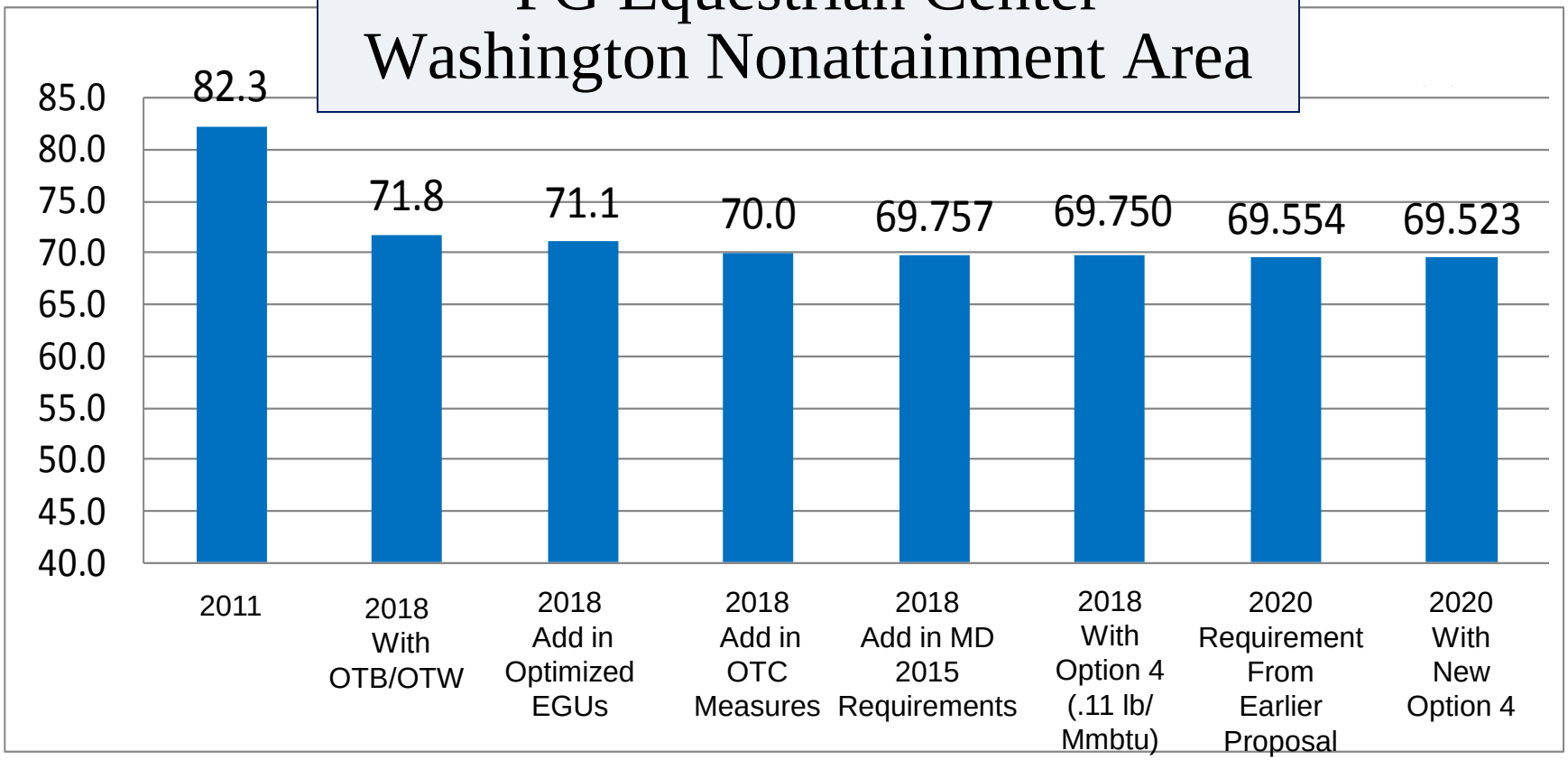


* The Baltimore nonattainment area is currently measuring attainment for the 75 ppb ozone standard at all monitors

A Snapshot - Current Worst Monitor



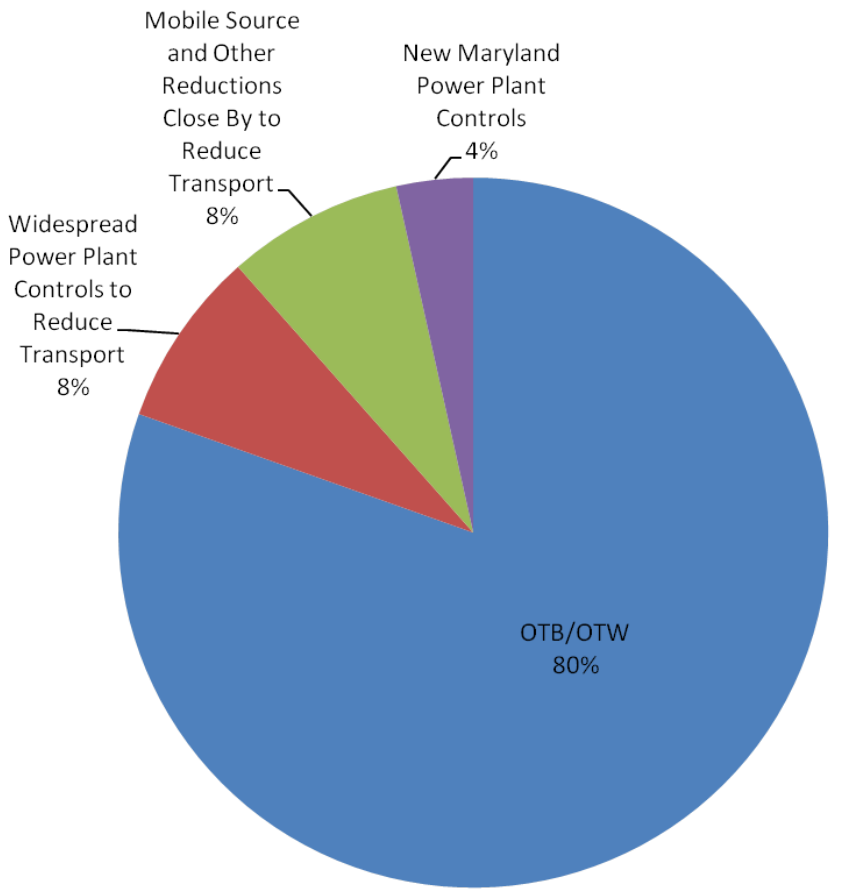
A Snapshot - Current Second Worst



Getting to Clean Air

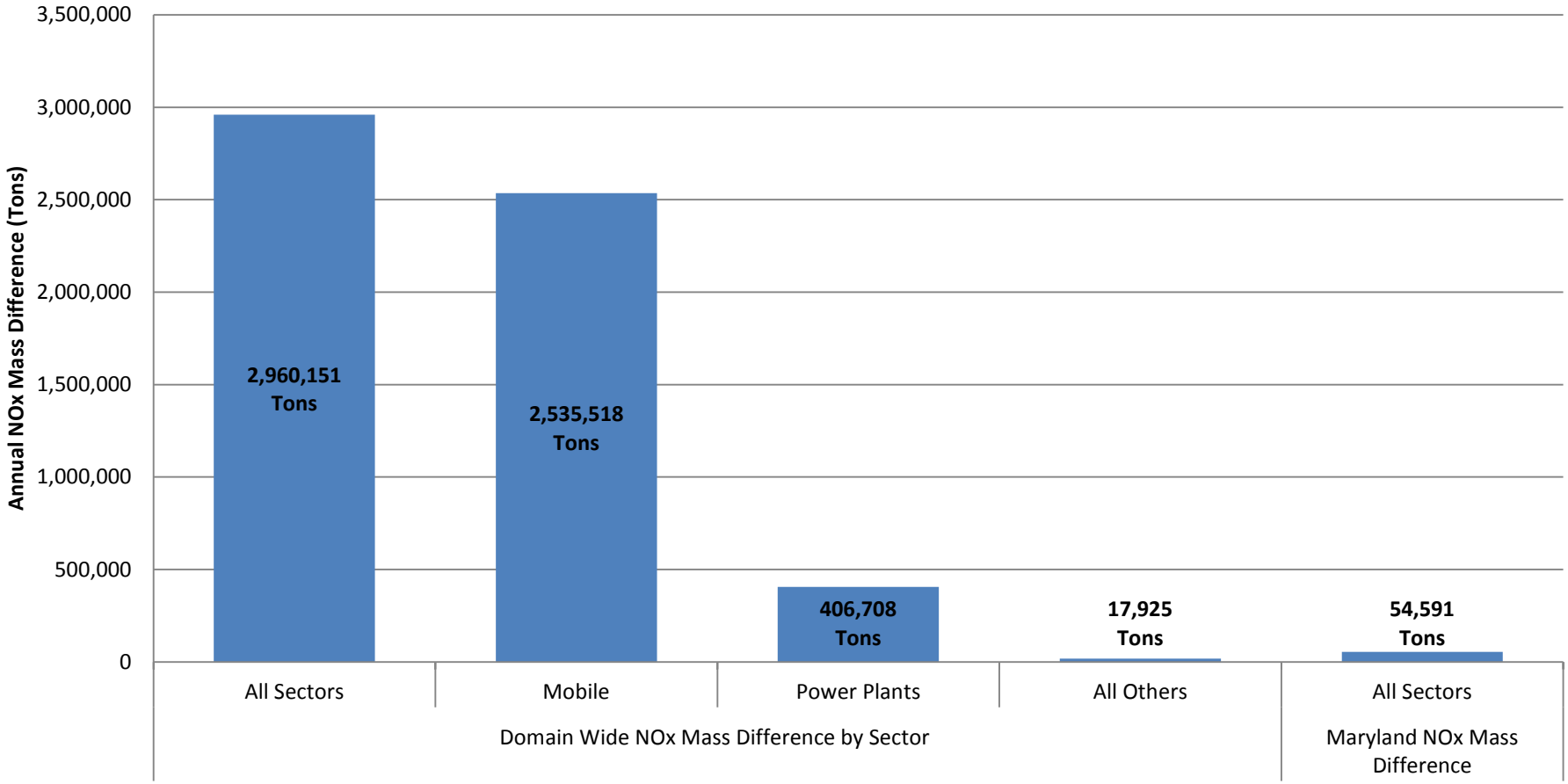
- The MDE modeling shows that Maryland has a plan that will bring the State into permanent attainment with the 75 ppb ozone standard …
  - Even when the weather is much hotter and more likely to create high ozone
- Current data in Baltimore already shows attainment
- The new NOx regulations provide small, but important ozone benefits
- The vast majority of the ozone benefits in Maryland come from OTB/OTW measures and other measures to reduce transport into Maryland

2011 to 2018 Reduction in Ozone- Baltimore



An Emissions Reductions Snapshot

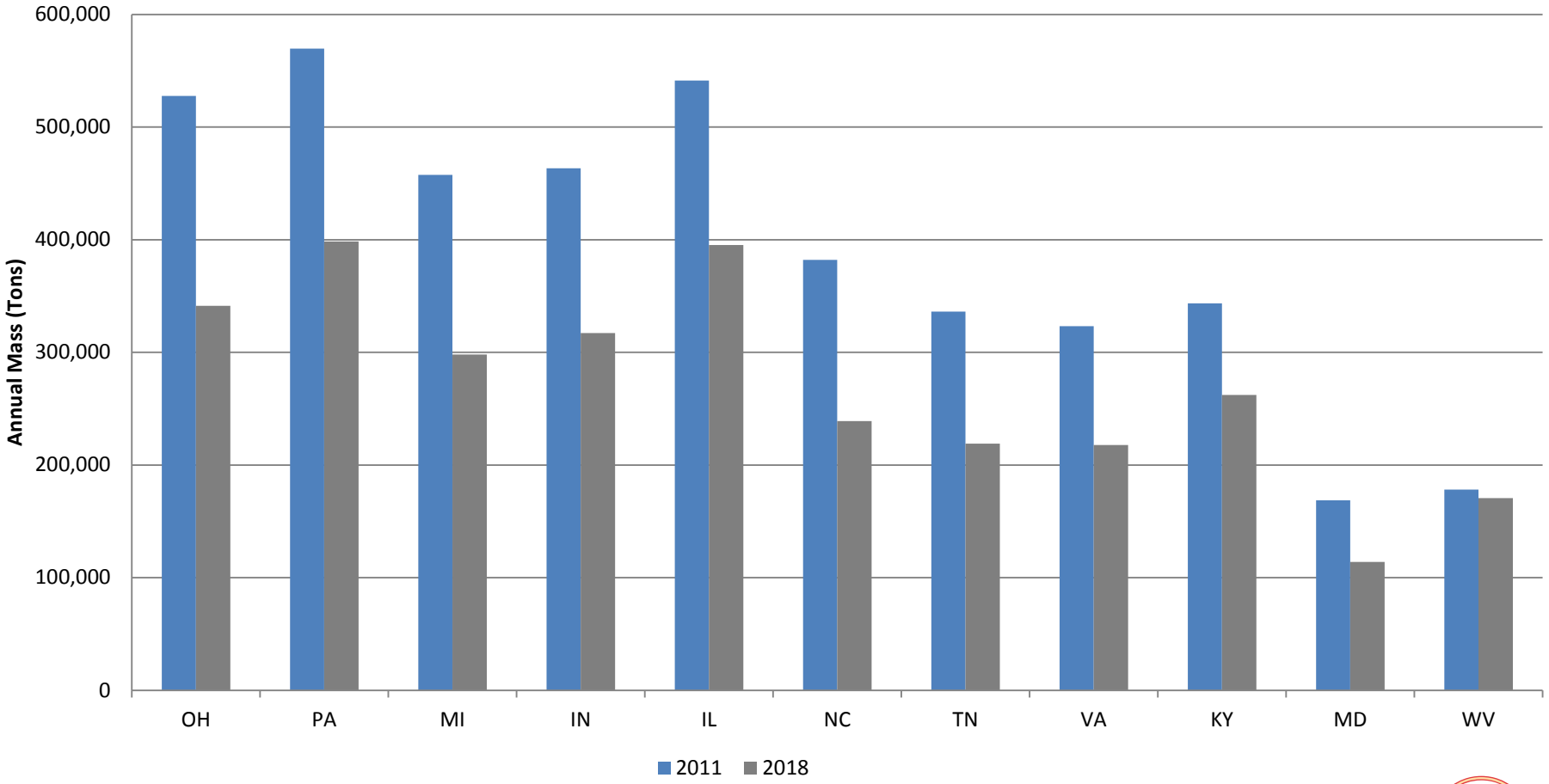
… NOx emission reductions across the East Maryland Plan - 2011 to 2018



NOx Reductions by State

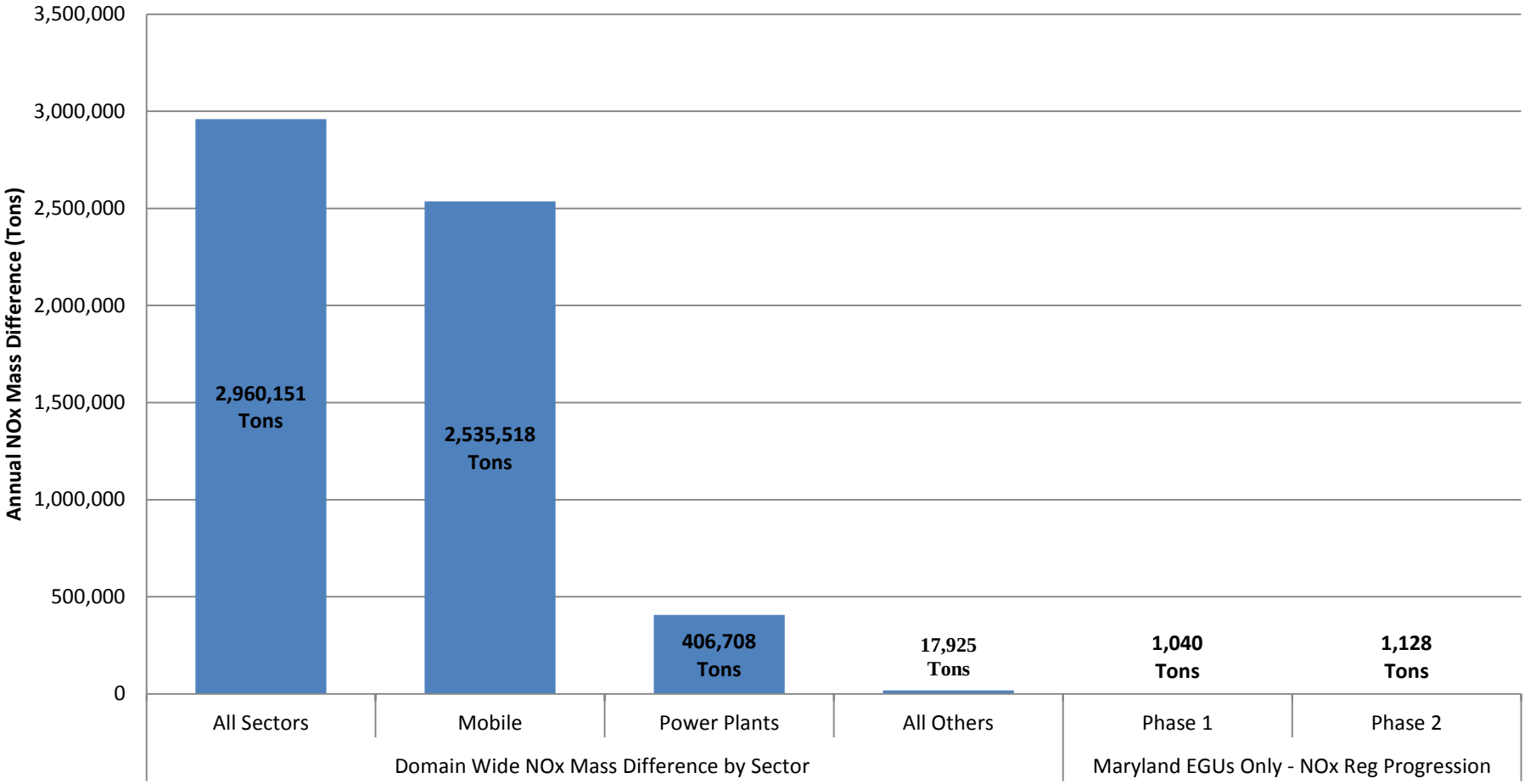
… states contributing to ozone in Maryland

Maryland Plan - 2011 to 2018



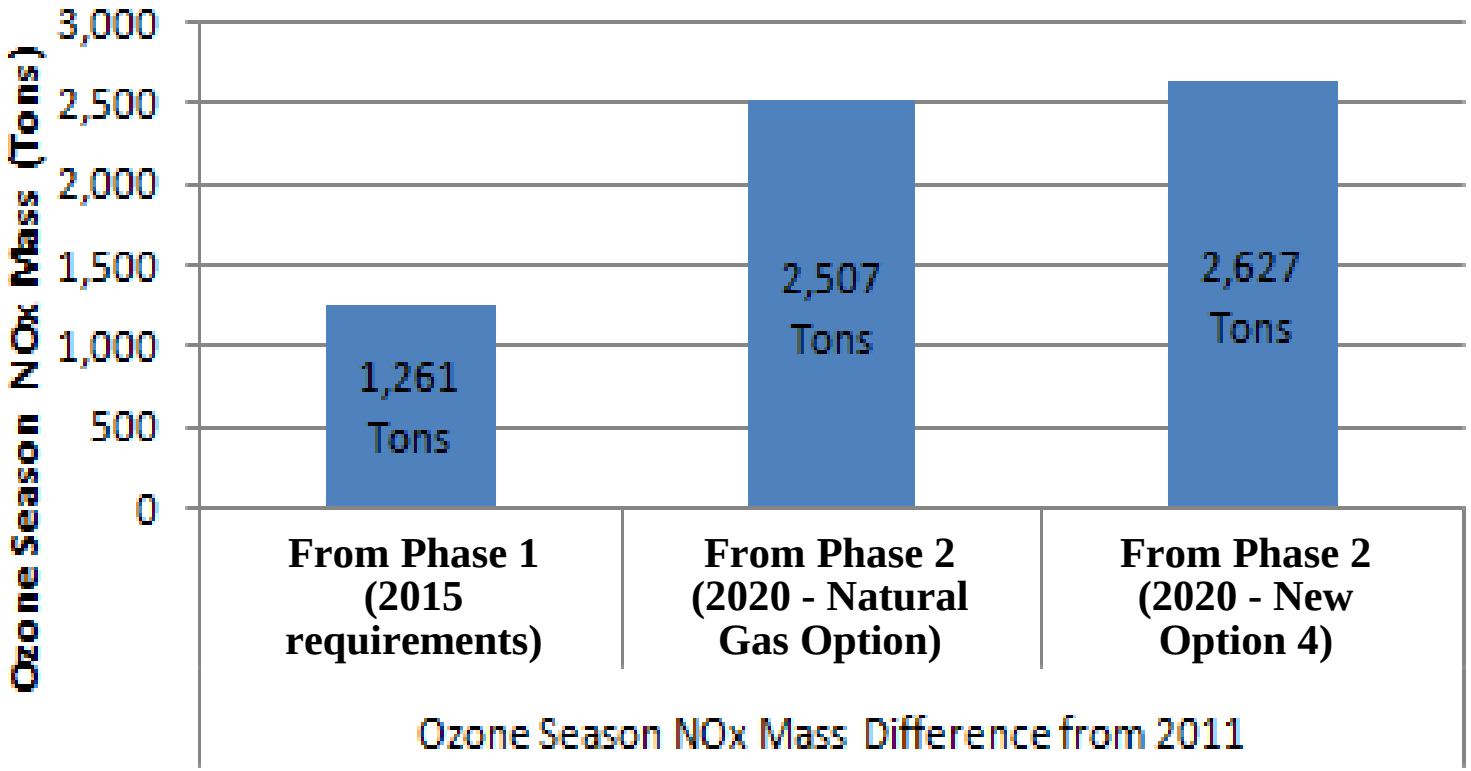
NOx Tons From New Regulation

… 2011 to 2018 annual reductions



NOx Reductions - New Regulation

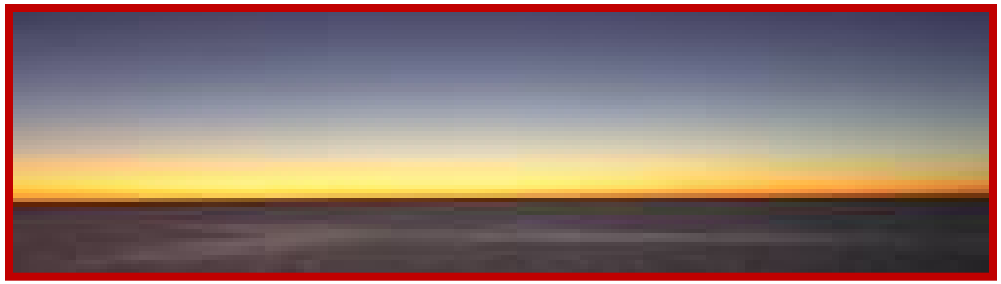
… additional ozone season NOx reductions from the new regulation



Wrap-Up

The Maryland Ozone Plan

- Maryland has a comprehensive strategy to address ozone based upon two decades of research and progress
- The regulation being discussed today is part of that strategy
  - The new regulation protects public health and promotes a healthy and sustainable economy
- The new regulation provides equal or greater public health protection compared to the earlier proposal
  - The first three options for compliance are identical to the earlier proposal
  - Choosing the new Option 4 comes with increased responsibility for earlier pollution reductions
  - Choosing Option 4 also insures lower ozone in 2020
    - An additional 120 tons of NOx reductions in the ozone season



Questions?