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Memorandum

To: The Honorable William J. Seitz
Chairman
Ohio House of Representatives Public Utilities Committee

From: Chris Zeigler
Executive Director
API Ohio

Date: March 21, 2017

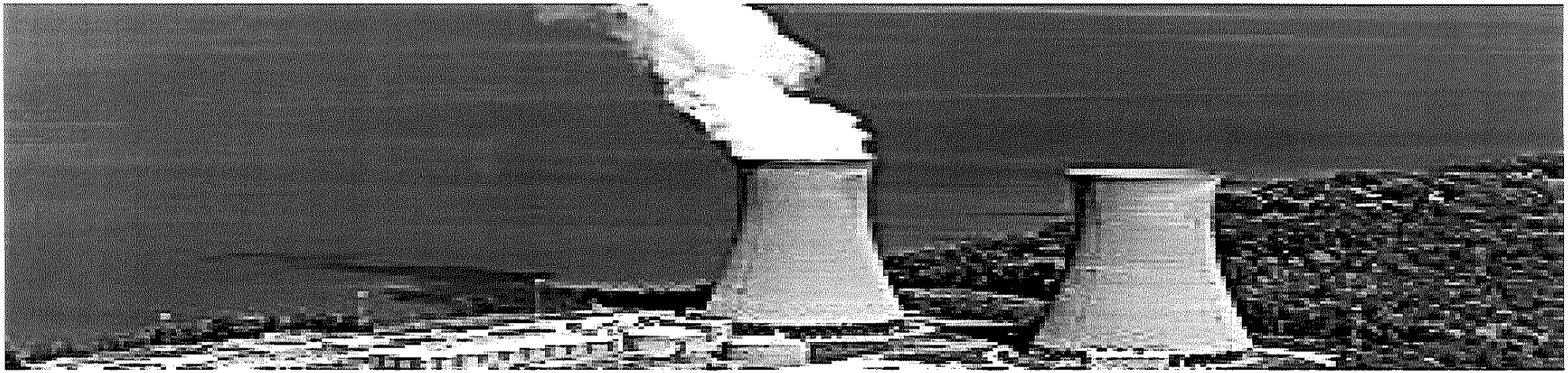
RE: Nuclear Power Generation Replacement Analysis

The attached PowerPoint supports the following key takeaways:

(1) Even if both nuclear plants were shut down tomorrow, attainment status in Ohio counties will not change under the more stringent, yet to be implemented, 2015 ozone standard of 70 ppb.

(2) If both nuclear plants "retire" and the nuclear generation was replaced completely with coal generation, the attainment status under the 2015 ozone standard STILL does not change.

(3) In both the 2017 impact assessment and the 2023 impact assessment, if you shut down the nuclear plants and replace generation with natural gas combined cycles (like those being constructed now) the design values (measures of ozone concentration by location) actually do not change because the emission increases are so small, none of them even round up to 1 ppb.



Effects of Shut Down of Two Ohio Nuclear Power Plants on Ozone Concentrations using Available Information

Ralph Morris And Ross Beardsley
Ramboll Environ

RAMBOLL

March 13, 2017

BACKGROUND

- Two nuclear power plants in Ohio may be shut down:
  - 1,240 MW Perry plant in Lake County
  - 890 MW David-Besse plant in Ottawa County
- This would require the replacement of ~2,100 MW of electricity, some of which would likely come from fossil-fueled electrical generating units (EGUs)
- Concerns have been raised that the increases in NOx emissions from the replacement fossil-fueled EGUs would contribute to ozone formation and cause or contribute to violations of the ozone standard in Ohio
- Ozone is formed in the atmosphere through a complex set of photochemical reactions involving NOx and VOC in the presence of sunlight
  - Photochemical grid models (PGMs) are typically used to simulate ozone concentrations
  - PGMs require some expertise and computational requirements to use

PURPOSE

- The purpose of this work is to use available information (e.g., no new modeling) to estimate the ozone increases due to the additional NOx emissions from fossil-fueled EGUs used to replace the electricity from the two shutdown nuclear power plants
  - Ideally would conduct explicit photochemical grid model (PGM) modeling of the new NOx emissions to estimate effects on ozone concentrations
    - Would require more time and resources
    - Also would be more dependent on the locations and types of generation used to replace the nuclear supplied electricity, which is uncertain

APPROACH

- Use EPA CSAPR modeling results to estimate the effect increased NOx emissions in Ohio would have on future year ozone Design Values in Ohio
- EPA used the CAMx PGM ozone source apportionment to calculate the contributions of state's anthropogenic NOx emissions to future year ozone Design Values
  - CSAPR Update rule in Sep 2016 to address the 2008 ozone NAAQS with a 2017 future year
    - https://www.epa.gov/airmarkets/final-cross-state-air-pollution-rule-update
  - Preliminary NODA information in Dec 2016 to address 2015 NAAQS with 2023 future year
    - https://www.epa.gov/airmarkets/notice-data-availability-preliminary-interstate-ozone-transport-modeling-data-2015-ozone
- Use CSAPR Update/NODA results to estimate what additional OH NOx emissions would have on ozone Design Values in 2017 and 2023
  - For example, if 100 TPY Ohio NOx contributes 10 ppb ozone and NOx is increased by 10 TPY that would increase ozone DV by 1.0 ppb (1.0 ppb = [10 ppb / 100 TPY] x 10 TPY)
- Two NOx increase emission scenarios analyzed:
  - Scenario#1: Assume most of replacement electricity comes from existing coal-fired EGUs
  - Scenario#2: Assume most of the replacement electricity comes from new natural gas EGUs

REPLACE NUCLEAR POWER GENERATION (15,899,764 MW/HRS):
Scenario#1 using existing coal-fired EGUs
Scenario#2 use new natural gas EGUs

- Analyze 2015 power generation in Ohio
  - 15,899,764 MW/hrs of generation from nuclear power plants
    - Davis Besse = 6,656,724 MW/hrs (Ottawa County)
    - Perry = 9,233,040 MW/hrs (Lake County)
  - Scenario#1: Coal Replacement Scenario
    - Identify existing Ohio coal-fired EGUs that had excess capacity in 2015 (< 80%)
    - Increase generation at coal EGUs with the least cost to dispatch up to 80% capacity utilization until all retired nuclear generation is replaced
    - Calculate annual NOx emissions increase (TPY) to match lost nuclear generation
  - Scenario#2: New Natural Gas Replacement Scenario
    - Identify under construction natural gas combined cycles (NGCC) EGUs
    - Increase generation from these new NGCCs to replace retired nuclear generation
    - Calculate NOx emissions increase (TPY) to match lost nuclear generation

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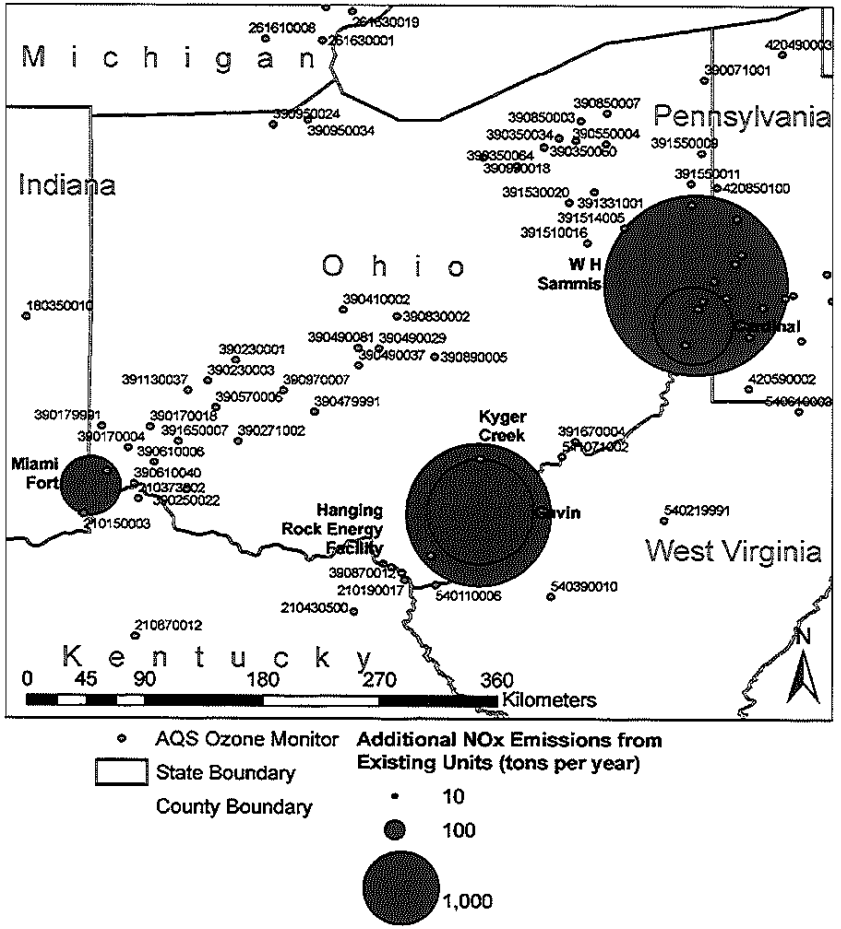
SCENARIO#1 COAL REPLACEMENT GENERATION

NOx Emission Increase = 11,405.8 TPY

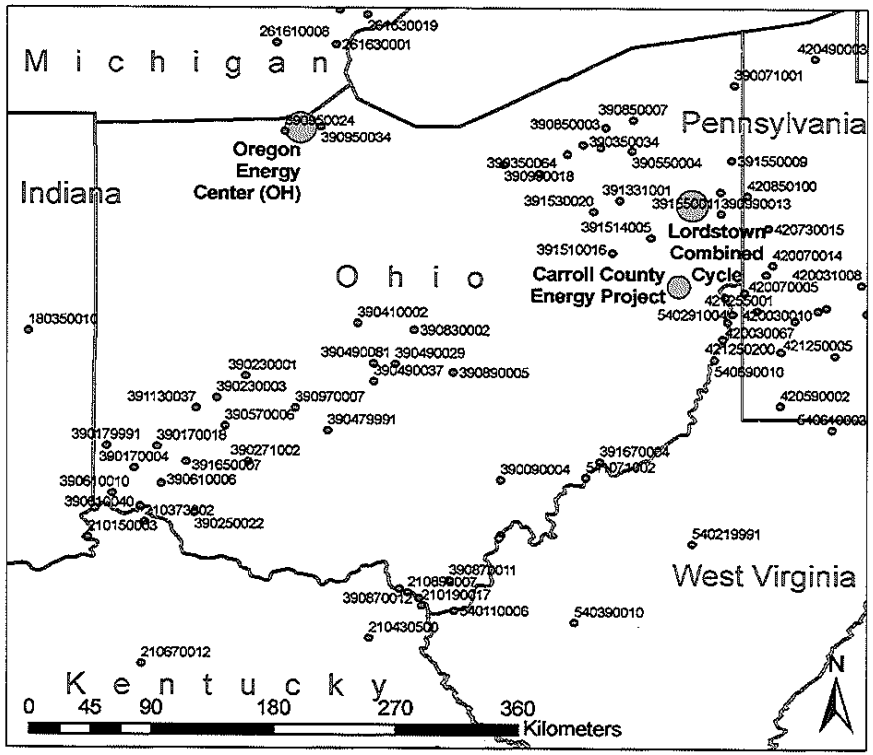
Plant Name	Unit	Sum Net Summer Capacity MW	Max Possible Generation Based on 80% Coal / 85% Gas Capacity Factor	Room to Increase from 2015 Level	Increased Generation	Incremental NOx Emissions (short tons per year)
Miami Fort	8	510	3,574,080	95,228	95,228	66.94
Gavin	2	1299	9,103,392	2,798,788	2,798,788	1,816.43
Kyger Creek	4	192.2	1,346,938	781,263	781,263	969.83
Kyger Creek	5	192.2	1,346,938	440,494	440,494	554.25
Kyger Creek	3	192.2	1,346,938	475,751	475,751	481.20
Kyger Creek	1	194	1,359,552	534,739	534,739	476.49
Kyger Creek	2	192.2	1,346,938	644,895	644,895	655.09
Cardinal	2	590	4,134,720	1,093,314	1,093,314	394.16
W H Sammis	7	600	4,204,800	1,118,383	1,118,383	542.62
W H Sammis	6	600	4,204,800	1,543,615	1,543,615	778.56
Cardinal	1	580	4,064,640	948,776	948,776	345.22
Miami Fort	7	510	3,574,080	594,413	594,413	606.49
W H Sammis	3	180	1,261,440	552,771	552,771	602.83
W H Sammis	1	180	1,261,440	531,690	531,690	585.20
W H Sammis	4	180	1,261,440	692,609	692,609	760.13
W H Sammis	5	290	2,032,320	1,247,001	1,247,001	763.82
W H Sammis	2	180	1,261,440	599,107	599,107	659.54
Cardinal	3	630	4,415,040	1,637,210	836,312	332.48
Hanging Rock Energy	CC2	626	4,661,196	360,615	360,615	14.53
Davis Besse	1	894	6,656,724	0	0	0.00
Perry (OH)	1	1240	9,233,040	0	0	0.00
Total						11,405.8



SCENARIO#2 NEW NATURAL GAS EGU REPLACEMENT GENERATION

NOx Emissions Increase = 540.3 TPY

Plant Name	Unit	Net Summer Capacity MW	Increased Generation	Incremental Nox Emissions (short tons per year)
Carroll County Energy Project	CC1	682.6	3,249,435	110
Lordstown Combined Cycle	CC	850	6,329,100	215
Oregon Energy Center (OH)	CC1	847.6	6,311,230	215
Middletown Energy Center	CC1	475		
Trumbull Energy Center	CC	940		
Harrison Power Project	CC1	1000		
Oregon Energy Center (OH)	CC2	400		
Oregon Energy Center (OH)	CC3	400		
Pickaway Energy Center	CC1	1000		
Rolling Hills Generating LLC	CC1	621		
Rolling Hills Generating LLC	CC2	621		
South Field Energy Facility	CC1	1060		
Guernsey Power Station	CC1	1650		
Total				540.3



CSAPR 2009-2013 AVG/MAX OZONE DESIGN VALUES (PPB)

- CSAPR Update/NODA start with observed 2009-2013 average (Avg) and maximum (Max) ozone Design Values (DV):
  - Ozone DV = 3-Year Average of the 4th high MDA8 ozone concentration
  - 2009-2013 Avg DV = average of 3 ozone DVs from 2009-11, 2010-12 and 2011-13
  - 2009-2013 Max DV = maximum of 3 ozone DVs from 2009-11, 2010-12 and 2011-13
- CAMx PGM modeling results using 2011 platform used to project observed Avg and Max DV to future year (FY) following EPA guidance (2014):
  - If FY Avg DV ≥ NAAQS → monitoring site is FY nonattainment monitor
  - If FY Avg DV < NAAQS and FY Max DV ≥ NAAQS → monitoring site is FY maintenance monitor
- CSAPR Update addresses 2008 ozone NAAQS (75 ppb) with 2017 FY
- Preliminary NODA addresses 2015 ozone NAAQS (70 ppb) with 2023 FY

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OHIO 2009-2013 AVG/MAX DVS THAT EXCEED THE 2008 (75 PPB, LEFT) NAAQS AND ADDITIONAL SITES THAT ALSO EXCEED THE 2015 (70 PPB, RIGHT) NAAQS)

Monitor ID	State	County	2009-2013 Avg DV	2009 - 2013 Max DV
390610006	Ohio	Hamilton	82.0	85.0
390490029	Ohio	Franklin	80.3	82.0
390850003	Ohio	Lake	80.0	83.0
390170018	Ohio	Butler	79.7	82.0
390250022	Ohio	Clermont	78.7	82.0
390271002	Ohio	Clinton	78.7	82.0
390610040	Ohio	Hamilton	78.7	80.0
390350034	Ohio	Cuyahoga	77.7	80.0
391650007	Ohio	Warren	77.7	79.0
390071001	Ohio	Ashtabula	77.3	79.0
390170004	Ohio	Butler	77.0	79.0
390179991	Ohio	Butler	77.0	77.0
390355002	Ohio	Cuyahoga	76.7	80.0
391130037	Ohio	Montgomery	76.7	78.0
391510016	Ohio	Stark	76.7	79.0
390610010	Ohio	Hamilton	76.3	80.0
391550011	Ohio	Trumbull	76.3	79.0
390230001	Ohio	Clark	75.0	76.0
390490037	Ohio	Franklin	75.0	76.0
390550004	Ohio	Geauga	74.7	78.0
390890005	Ohio	Licking	74.3	76.0
390970007	Ohio	Madison	74.3	76.0
390230003	Ohio	Clark	74.0	75.0
390830002	Ohio	Knox	73.7	75.0
390950034	Ohio	Lucas	73.7	76.0

Monitor ID	State	County	2009-2013 Avg DV	2009 - 2013 Max DV
391090005	Ohio	Miami	73.3	74.0
390030009	Ohio	Allen	73.0	74.0
390410002	Ohio	Delaware	73.0	74.0
390570006	Ohio	Greene	73.0	74.0
391351001	Ohio	Preble	72.3	74.0
391514005	Ohio	Stark	72.3	75.0
390479991	Ohio	Fayette	72.0	72.0
391510022	Ohio	Stark	72.0	73.0
391530020	Ohio	Summit	72.0	74.0
390850007	Ohio	Lake	71.7	73.0
390930018	Ohio	Lorain	71.7	75.0
391670004	Ohio	Washington	71.3	74.0
391730003	Ohio	Wood	71.3	73.0
390490081	Ohio	Franklin	71.0	73.0
391550009	Ohio	Trumbull	71.0	73.0
390990013	Ohio	Mahoning	70.7	73.0
390810017	Ohio	Jefferson	70.3	72.0
390350064	Ohio	Cuyahoga	70.0	73.0
390870012	Ohio	Lawrence	70.0	72.0

CSAPR UPDATE 2017 AVG AND MAX OZONE DVS

Monitor ID	State	County	2009-2013 Avg DV	2009-2013 Max DV	2017 Avg DV	2017 Max DV
390610006	Ohio	Hamilton	82.0	85.0	74.6	77.4
390490029	Ohio	Franklin	80.3	82.0	72.3	73.8
390850003	Ohio	Lake	80.0	83.0	65.2	67.6
390170018	Ohio	Butler	79.7	82.0	71.6	73.7
390250022	Ohio	Clermont	78.7	82.0	68.8	71.6
390271002	Ohio	Clinton	78.7	82.0	68.2	71.1
390610040	Ohio	Hamilton	78.7	80.0	71.1	72.3
390350034	Ohio	Cuyahoga	77.7	80.0	63.5	65.4
391650007	Ohio	Warren	77.7	79.0	68.5	69.6
390071001	Ohio	Ashtabula	77.3	79.0	67.0	68.5
390170004	Ohio	Butler	77.0	79.0	70.4	72.2
390179991	Ohio	Butler	77.0	77.0	68.8	68.8
390355002	Ohio	Cuyahoga	76.7	80.0	63.1	65.9
391130037	Ohio	Montgomery	76.7	78.0	68.0	69.1
391510016	Ohio	Stark	76.7	79.0	66.8	68.8
390610010	Ohio	Hamilton	76.3	80.0	69.2	72.6
391550011	Ohio	Trumbull	76.3	79.0	66.9	69.3
390230001	Ohio	Clark	75.0	76.0	66.0	66.9
390490037	Ohio	Franklin	75.0	76.0	67.5	68.4
390550004	Ohio	Geauga	74.7	78.0	64.9	67.8
390890005	Ohio	Licking	74.3	76.0	64.7	66.2
390970007	Ohio	Madison	74.3	76.0	64.3	65.8
390230003	Ohio	Clark	74.0	75.0	65.8	66.7

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- All OH 2017 Avg DVs attain the 2008 ozone NAAQS
  - No 2017 nonattainment monitors in OH
- One OH 2017 Max DV exceeds the 2008 NAAQS
  - One OH 2017 maintenance monitor
  - Hamilton County (Cincinnati)
  - 2017 Max DV = 77.4 ppb

PRELIMINARY NODA 2023 AVG AND MAX OZONE DV

Monitor ID	State	County	2009-2013 Avg DV	2009-2013 Max DV	2023 Avg DV	2023 Max DV
390610006	Ohio	Hamilton	82.0	85.0	66.6	69.1
390490029	Ohio	Franklin	80.3	82.0	65.7	67.1
390850003	Ohio	Lake	80.0	83.0	58.0	60.2
390170018	Ohio	Butler	79.7	82.0	63.8	65.6
390250022	Ohio	Clermont	78.7	82.0	61.1	63.6
390271002	Ohio	Clinton	78.7	82.0	60.6	63.2
390610040	Ohio	Hamilton	78.7	80.0	64.7	65.8
390350034	Ohio	Cuyahoga	77.7	80.0	56.9	58.5
391650007	Ohio	Warren	77.7	79.0	60.5	61.5
390071001	Ohio	Ashtabula	77.3	79.0	60.6	61.9
390170004	Ohio	Butler	77.0	79.0	63.6	65.2
390179991	Ohio	Butler	77.0	77.0	61.6	61.6
390355002	Ohio	Cuyahoga	76.7	80.0	56.8	59.3
391130037	Ohio	Montgomery	76.7	78.0	61.2	62.2
391510016	Ohio	Stark	76.7	79.0	60.4	62.2
390610010	Ohio	Hamilton	76.3	80.0	62.0	65.0
391550011	Ohio	Trumbull	76.3	79.0	60.7	62.8
390230001	Ohio	Clark	75.0	76.0	59.3	60.1

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- All OH monitors Avg DV and Max DV are below the 2015 70 ppb ozone NAAQS
  - No OH 2023 nonattainment or maintenance monitors
  - Highest at Hamilton County
    - 2023 Max DV = 69.1 ppb
  - Next highest 2023 Max DV
    - 67.1 ppb (Franklin)
    - 65.8 and 65.0 ppb (Hamilton)
    - 65.6 & 65.2 ppb (Butler)

2017 RESULTS SC#1 (COAL) & SC#2 (NATGAS)

Monitor ID	State	County	2017 Avg DV	2017 Max Dv	Sc#1 2017 Increment	Sc#2 2017 Increment	2017 Sc#1 Avg. DV	2017 Sc#2 Avg. DV	2017 Sc#1 Max DV	2017 Sc#2 Max DV
390610006	Ohio	Hamilton	74.6	77.4	0.50	0.02	75.1	74.6	77.9	77.4
390490029	Ohio	Franklin	72.3	73.8	0.75	0.04	73.0	72.3	74.5	73.8
390170018	Ohio	Butler	71.6	73.7	0.53	0.03	72.1	71.6	74.2	73.7
390610040	Ohio	Hamilton	71.1	72.3	0.41	0.02	71.5	71.1	72.7	72.3
390170004	Ohio	Butler	70.4	72.2	0.52	0.02	70.9	70.4	72.7	72.2
390610010	Ohio	Hamilton	69.2	72.6	0.26	0.01	69.5	69.2	72.9	72.6
390250022	Ohio	Clermont	68.8	71.6	0.50	0.02	69.3	68.8	72.1	71.6
390179991	Ohio	Butler	68.8	68.8	0.42	0.02	69.2	68.8	69.2	68.8
391650007	Ohio	Warren	68.5	69.6	0.55	0.03	69.1	68.5	70.2	69.6
390271002	Ohio	Clinton	68.2	71.1	0.43	0.02	68.6	68.2	71.5	71.1
391130037	Ohio	Montgomery	68.0	69.1	0.63	0.03	68.6	68.0	69.7	69.1
390490037	Ohio	Franklin	67.5	68.4	0.72	0.03	68.2	67.5	69.1	68.4
390071001	Ohio	Ashtabula	67.0	68.5	0.55	0.03	67.6	67.0	69.1	68.5
391510016	Ohio	Stark	66.8	68.8	0.65	0.03	67.4	66.8	69.4	68.8
391550011	Ohio	Trumbull	66.9	69.3	0.51	0.02	67.4	66.9	69.8	69.3
390230001	Ohio	Clark	66.0	66.9	0.51	0.02	66.5	66.0	67.4	66.9
390230003	Ohio	Clark	65.8	66.7	0.59	0.03	66.4	65.8	67.3	66.7
390850003	Ohio	Lake	65.2	67.6	0.78	0.04	66.0	65.2	68.4	67.6
390410002	Ohio	Delaware	65.2	66.1	0.47	0.02	65.7	65.2	66.6	66.1
390830002	Ohio	Knox	65.0	66.1	0.60	0.03	65.6	65.0	66.7	66.1
390550004	Ohio	Geauga	64.9	67.8	0.59	0.03	65.5	64.9	68.4	67.8
390030009	Ohio	Allen	65.0	65.9	0.39	0.02	65.4	65.0	66.3	65.9
390890005	Ohio	Licking	64.7	66.2	0.69	0.03	65.4	64.7	66.9	66.2
390950034	Ohio	Lucas	64.7	66.7	0.57	0.03	65.3	64.7	67.3	66.7

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- Maximum increase 0.78 ppb Sc#1 and 0.04 ppb (Sc#2) at Lake Cty (Max DV = 67.6 ppb)
- Hamilton has highest Avg DV (74.6 ppb) and Max DV (77.4 ppb) with 0.50 ppb (Sc#1) and 0.02 ppb (Sc#2) increases:
  - Avg DV still below 2008 NAAQS
  - Max DV still above 2008 NAAQS
- For both Sc#1 and Sc#2 additional NOx emissions do not cause any 2017 DV that was below 2008 or 2015 NAAQS to exceed it

2023 RESULTS SC#1 (COAL) & SC#2 (NATGAS)

Monitor ID	County	2023 Avg DV	2023 Max Dv	Sc#1 2023 Increment	Sc#2 2023 Increment	2023 Sc#1 Avg. DV	2023 Sc#2 Avg. DV	2023 Sc#1 Max DV	2023 Sc#2 Max DV
390610006	Hamilton	66.6	69.1	0.71	0.03	67.3	66.6	69.8	69.1
390490029	Franklin	65.7	67.1	0.89	0.04	66.6	65.7	68.0	67.1
390610040	Hamilton	64.7	65.8	0.52	0.02	65.2	64.7	66.3	65.8
390170018	Butler	63.8	65.6	0.65	0.03	64.5	63.8	66.3	65.6
390170004	Butler	63.6	65.2	0.66	0.03	64.3	63.6	65.9	65.2
390610010	Hamilton	62.0	65.0	0.45	0.02	62.4	62.0	65.4	65.0
390179991	Butler	61.6	61.6	0.46	0.02	62.1	61.6	62.1	61.6
391130037	Montgomery	61.2	62.2	0.71	0.03	61.9	61.2	62.9	62.2
390250022	Clermont	61.1	63.6	0.54	0.03	61.6	61.1	64.1	63.6
390490037	Franklin	61.0	61.8	0.90	0.04	61.9	61.0	62.7	61.8
391550011	Trumbull	60.7	62.8	0.60	0.03	61.3	60.7	63.4	62.8
390271002	Clinton	60.6	63.2	0.45	0.02	61.1	60.6	63.7	63.2
390071001	Ashtabula	60.6	61.9	0.60	0.03	61.2	60.6	62.5	61.9
391650007	Warren	60.5	61.5	0.58	0.03	61.1	60.5	62.1	61.5
391510016	Stark	60.4	62.2	0.75	0.04	61.1	60.4	62.9	62.2
390950034	Lucas	60.1	62.0	0.69	0.03	60.8	60.1	62.7	62.0
390230001	Clark	59.3	60.1	0.50	0.02	59.8	59.3	60.6	60.1
390230003	Clark	59.3	60.1	0.64	0.03	59.9	59.3	60.7	60.1
390410002	Delaware	59.3	60.1	0.51	0.02	59.8	59.3	60.6	60.1
390870012	Lawrence	59.3	61.0	0.36	0.02	59.7	59.3	61.4	61.0
390550004	Geauga	59.1	61.7	0.65	0.03	59.7	59.1	62.3	61.7
391530020	Summit	58.6	60.3	0.73	0.03	59.3	58.6	61.0	60.3
390830002	Knox	58.3	59.4	0.60	0.03	58.9	58.3	60.0	59.4
390810017	Jefferson	58.2	59.6	0.45	0.02	58.7	58.2	60.1	59.6
390850003	Lake	58.0	60.2	0.98	0.05	59.0	58.0	61.2	60.2
390490081	Franklin	57.9	59.5	0.75	0.04	58.6	57.9	60.2	59.5
390890005	Licking	57.7	59.1	0.73	0.03	58.4	57.7	59.8	59.1

- No 2023 Avg DV or Max DV is above the 2015 ozone NAAQS
- Highest Avg/Max DV at Hamilton Cty (66.6/69.1 ppb) where ozone increases of 0.71 ppb (Sc#1) and 0.02 ppb (Sc#2) are estimated
- Maximum 2023 ozone DV increase occurs in Lake Cty with values of 0.98 ppb (Sc#1) and 0.05 ppb (Sc#2) when 2023 Avg/Max DVs of 58.0/60.2 ppb

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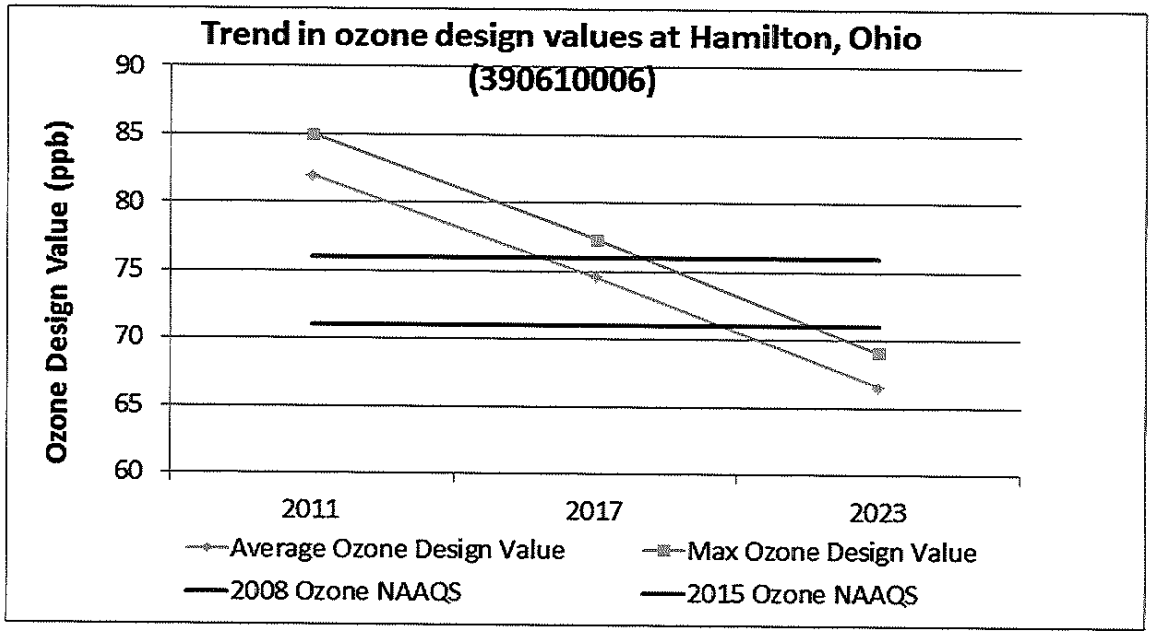
AVG AND MAX OZONE DV TRENDS AT HAMILTON 39061006
(SITE WITH HIGHEST OZONE DV)



- Ozone increases due to additional NOx emissions from replacement generation:
  - 0.50 ppb 2017 Scenario#1
  - 0.02 ppb 2017 Scenario#2
  - 0.71 ppb 2023 Scenario#1
  - 0.03 ppb 2023 Scenario#2

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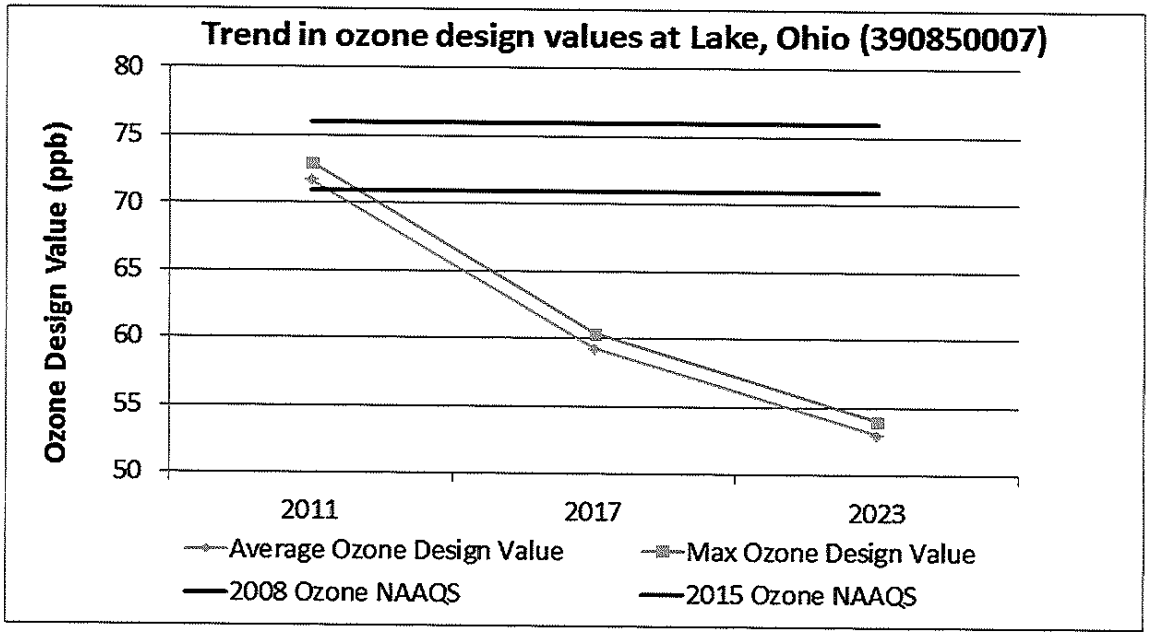
AVG AND MAX OZONE DV TRENDS AT LAKE 39085007
(SITE WITH HIGHEST OZONE INCREASE)



- Ozone increases due to additional NOx emissions from replacement generation:
  - 0.78 ppb 2017 Scenario#1
  - 0.04 ppb 2017 Scenario#2
  - 0.98 ppb 2023 Scenario#1
  - 0.05 ppb 2023 Scenario#2

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CAVEATS

- Using CSAPR whole state NOx contributions to ozone to estimate contributions of individual sources
  - Actual ozone contributions will be higher near locations of new NOx emission sources and lower than calculated away from new emission point sources
  - Using 2017/2023 distribution of OH NOx emissions to spatially allocate increased NOx emissions associated with replacement generation likely overstates ozone increases at urban monitors (e.g., Cincinnati and Cleveland) where highest ozone occurs
- Results are based on CASPR Update 2017 and NODA 2023 ozone projections and resultant future year emission projections
  - For example, 2023 NOx emission projections maybe overly optimistic (e.g., with CPP)
- Ozone formation is nonlinear -- uncertainties associated with linear scaling of ozone increases due to increased NOx emissions
  - Likely not that important since NOx emissions perturbation small (< 5%)

SUMMARY AND CONCLUSIONS

- The retirement of nuclear power plants in Ohio would lose ~15,900,000 MW/hrs in electricity
- If this electricity generation was replaced by existing coal or new natural gas EGUs that would increase Ohio NOx emissions by, respectively, ~15,400 and 540 TPY
- Using EPS's 2017 CASPR Update and 2023 Preliminary NODA modeling results the increased NOx emissions associated with replacing nuclear power would not cause any additional violations of the ozone NAAQS:
  - Only Ohio exceedance of ozone NAAQS in CSAPR/NODA occurs in Hamilton County (Cincinnati) for 2017 Max DV (77.4 ppb) where additional NOx emissions increase Max DV by 0.50 ppb (Sc#1 coal) and 0.02 ppb (Sc#2 natgas)
- Maximum increase in ozone DV due to NOx emissions increase occurs in Lake County (Cleveland, 390850003):
  - 2017 increases of 0.78 ppb (Sc#1) & 0.04 ppb (Sc#2) to Avg/Max DV 65.2/67.6 ppb
  - 2023 increases of 0.98 ppb (Sc#1) & 0.05 ppb (Sc#2) to Avg/Max DV 68.0/60.2 ppb
    - More ozone is generated in 2023 than 2017 due to same amount of NOx emissions because of lower Ohio NOx emissions in 2023 so that ozone formation is more efficient (i.e., more molecules of ozone are formed per molecule NOx emitted)