Combined National and State-level Health Benefits for the Cross-State Air Pollution Rule and Mercury and Air Toxics Standards

EPA-452/R-11-014
December 2011

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Introduction and Purpose of Analysis

This year EPA finalized two rulemakings requiring reductions of air pollutants from electric generators (EGUs)—the Cross-State Air Pollution Rule (CSAPR) and Mercury and Air Toxics Standards (MATS). Starting in 2012, the CSAPR requires 28 states in the eastern half of the United States to substantially improve air quality by reducing power plant emissions of sulfur dioxide (SO_2) and nitrogen oxides (NO_X) that cross state lines and contribute to fine particle pollution ($PM_{2.5}$) and ground-level ozone (O_3) in other states. MATS reduces emissions of toxic air pollutants including mercury (Hg), arsenic, chromium, and nickel as well as acid gases including hydrogen chloride (HCl) and hydrogen fluoride (HF) from new and existing coal- and oil-fired power plants across the U.S. starting as early as 2015. As a co-benefit, MATS also reduces SO_2 and direct $PM_{2.5}$ emissions and thereby reduces ambient $PM_{2.5}$ concentrations.

While these rules have separate and distinct goals, cover different geographic areas, and have different implementation timeframes, they are also similar in multiple respects: they affect overlapping sets of electricity producers; they were finalized within six months of each other; they will each substantially reduce exposure to air pollution and thereby improve human health and welfare; and a majority of the quantified benefits of each rule is attributable to reductions in $PM_{2.5}$ resulting from SO_2 emission reductions. Given the similarities between these rules, EPA estimated the national and state-level benefits of these rules combined, which will provide better understanding of their cumulative human health benefits.

The regulatory assessments of the CSAPR and MATS differed in several respects. For example, benefits for the CSAPR were estimated directly from air quality modeling of anticipated emission reductions for the final rule while MATS benefits were estimated using benefit per-ton (BPT) factors derived from a modeled interim policy scenario. The assessments also differed in endpoints analyzed. Due to time and resource constraints, the CSAPR assessment quantified only the health benefits of $PM_{2.5}$ and ground-level ozone reductions as well as the welfare benefits of recreational visibility improvements and climate benefits of carbon dioxide (CO_2) reductions while the MATS analysis quantified only the health benefits of $PM_{2.5}$ reductions and the climate benefits of CO_2 reductions. Additionally, the emission reductions and health benefits were assessed for differing analysis years—2014 and 2016 for the CSAPR and MATS, respectively. For more detailed information about the human health and welfare benefits of each rule, as well as the inherent limitations and uncertainties in estimating these benefits, please refer to their respective Regulatory Impact Analyses (RIAs).[1,2]

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[1] U.S. Environmental Protection Agency (U.S. EPA). 2011. Regulatory Impact Analysis (RIA) for the final Transport Rule. Office of Air and Radiation, Washington, DC. June. Available on the Internet at <http://www.epa.gov/airtransport/pdfs/FinalRIA.pdf>.

[2] U.S. Environmental Protection Agency (U.S. EPA). 2011. Regulatory Impact Analysis (RIA) for the final Mercury and Air Toxics Standard (MATS). June. Available on the Internet at <http://www.epa.gov/ttn/ecas/ria.html>.

Methods

In order to sum the benefits of the CSAPR and MATS, EPA needed to update the CSAPR benefits to reflect the same assessment year as MATS. This required re-running the benefits model (Benefits Mapping and Analysis Program (BenMAP[3])) to assess $PM_{2.5}$ and ozone benefits for a 2016 assessment year. EPA did not update the visibility benefits or climate benefits for the CSAPR.

Updating the benefits modeling affected two key parameters: population year and projected income growth. These key inputs are important to the health impacts assessment because the incidence of health impacts reduced, via reduced exposure to air pollutants, depend on population exposure and because the valuation of health impacts avoided is sensitive to income. Because EPA applies baseline incidence rates for premature mortality in 5 year increments (2010, 2015, 2020, etc.), evaluating 2016 rather than 2014 does not change in baseline incidence rates used to estimate incidences of premature mortality avoided.

While the purpose of this assessment is to evaluate benefits of the CSAPR in 2016, this analysis is based on existing air quality modeling of emissions under the CSAPR in 2014. We do not have emissions or air quality modeling to use as the basis for updating the air quality information in the benefits modeling. However, EPA does not think that this is a significant source of uncertainty because the state-level emission budgets for the CSAPR do not change after 2014. While banking of allowances in 2012 and 2013 may impact the trend of emission reductions over time, creating the potential for reductions in 2016 to be somewhat different than 2014, we expect EGU emission reductions in 2016 will likely be generally similar in aggregate level and geographic distribution to 2014.

Limitations

This analysis is a screening-level assessment of the combined benefits of the CSAPR and MATS and is limited in its inputs, methods, and results, which are fully described in the underlying RIAs. These limitations include:

- This assessment accounts for $PM_{2.5}$-related human health benefits for the CSAPR and MATS and ozone-related health benefits for the CSAPR. Time and data limitations precluded the inclusion of additional benefits that were quantified in the regulatory assessments of these rules such as visibility improvements and greenhouse gas reductions. For a full list of human health and welfare effects of pollutants affected by these rules, please refer to Table 5-2 in the CSAPR RIA[1] and Table 5-2 in the MATS RIA.[2]
- This analysis presents results at the state-level. We are confident, with respect to the availability of necessary data at the state-level, in the estimation of state-level mortality benefits. Due to the high proportion of total benefits attributable to the reduction in premature mortality, we are confident in the total monetized benefits at the state-level.

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[3] Abt Associates, Inc. 2010. Environmental Benefits and Mapping Program (Version 4.0). Bethesda, MD. Prepared for U.S. Environmental Protection Agency Office of Air Quality Planning and Standards. Research Triangle Park, NC. Available on the Internet at <http://www.epa.gov/air/benmap>.

However, we are less confident in the estimation of morbidity benefits because the assessment relies on national average baseline incidence rates. Additionally, we are more confident in the state-level results for the CSAPR than MATS because, as described in the MATS RIA, we did not perform air quality modeling for the final MATS scenario.

- As mentioned above, we used the available 2014 emissions and air quality modeling for the CSAPR to update the benefits of the CSAPR for 2016. While we do not anticipate that this is a significant source of uncertainty, we note that emission reductions in 2016 may be different than 2014.
- The $PM_{2.5}$-related benefits for MATS were derived through a BPT approach, which does not fully reflect local variability in population density, meteorology, exposure, baseline health incidence rates, or other local factors that might lead to an over-estimate or under-estimate of the actual co-benefits of reducing ambient $PM_{2.5}$.
- State-level results for MATS assume that the state distribution of health co-benefits for the final policy is equivalent to that of the modeled interim scenario.
- This assessment relies on different methods for estimating the benefits of the CSAPR (air quality modeling) and MATS (BPT). We used the BPT method to estimate MATS benefits because EPA did not develop air quality modeling for the final rule. Due to the use of the benefit per-ton method, there is more uncertainty with the state-level MATS results than for the CSAPR, and the added uncertainty in MATS contributes to the summed uncertainty. However, EPA does not anticipate that utilizing different methods will result in significant uncertainty in the summed benefits.
- We assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality. This is an important assumption because the health benefits of these rules are primarily related to reductions of SO_2, a precursor to ambient $PM_{2.5}$. $PM_{2.5}$ improvements produced via reductions in transported precursors (SO_2 and NO_X) emitted from EGUs may differ significantly from direct $PM_{2.5}$ released from diesel engines and other industrial sources, but the scientific evidence is not yet sufficient to allow differential effects estimates by particle type.
- We assume that the health impact function for fine particles is linear within the range of ambient concentrations under consideration. Thus, the estimates include health co-benefits from reducing fine particles in areas with varied concentrations of $PM_{2.5}$, including both regions that are in attainment with the fine particle standard and those that do not meet the standard, down to the lowest modeled concentrations.

Results

The results of this assessment show a very small increase in total health benefits estimated for the CSAPR in 2016 compared to 2014. This increase is due to population growth between 2014 and 2016 as well as increases in projected income. After re-calculating the CSAPR $PM_{2.5}$- and ozone-related benefits to reflect population and income growth for 2016, we summed these results with the 2016 MATS $PM_{2.5}$-related benefits to show the combined benefits of these two rules. Table 1 below depicts the total quantified and monetized human health benefits of the CSAPR and MATS as well as their combined benefits. Table 2 below presents the estimated health impacts avoided due to CSAPR and MATS in 2016 at a national level. Table 3 below displays the estimated health impacts avoided due to the CSAPR and MATS in

2016 at the state-level (3% discount rate). This table includes incidences of premature mortality avoided and the total value of all quantified and monetized mortality and morbidity benefits. The range shows estimated $PM_{2.5}$-related benefits using Pope et al. (2002)[4] and Laden et al. (2006)[5] as well as ozone-related benefits using Bell et al. (2004)[6] and Levy et al. (2005).[7] The state-level MATS results are reported in Appendix 5D of the MATS RIA.

Table 1: Total monetized human health-related benefits of CSAPR (2014 and 2016) and MATS (2007$, billions)

	CSAPR 2014	CSAPR 2016	MATS 2016	CSAPR & MATS 2016
Pope et al. (2002) & Bell et al. (2004)				
3% discount rate	$110	$120	$36	$150
7% discount rate	$100	$110	$32	$140
Laden et al. (2006) & Levy et al. (2005)				
3% discount rate	$270	$290	$89	$380
7% discount rate	$250	$260	$80	$340

[4] Pope, C.A., III, R.T. Burnett, M.J. Thun, E.E. Calle, D. Krewski, K. Ito, and G.D. Thurston. 2002. Lung Cancer, Cardiopulmonary Mortality, and Long-term Exposure to Fine Particulate Air Pollution. Journal of the American Medical Association 287:1132-1141.
[5] Laden, F., J. Schwartz, F.E. Speizer, and D.W. Dockery. 2006. Reduction in Fine Particulate Air Pollution and Mortality. American Journal of Respiratory and Critical Care Medicine 173:667-672.
[6] Bell, M.L., et al. 2004. Ozone and short-term mortality in 95 US urban communities, 1987-2000. Journal of the American Medical Association. 292(19): p. 2372-8.
[7] Levy, J.I., S.M. Chemerynski, and J.A. Sarnat. 2005. Ozone exposure and mortality: an empiric bayes metaregression analysis. Epidemiology. 16(4): p. 458-68

Table 2: Estimated health impacts avoided due to the CSAPR and MATS—incidences of avoided health effects[1] and value[1] (millions of dollars, 2007$) of mortality and morbidity impacts

		CSAPR 2014		*CSAPR 2016*		*MATS 2016*	
	Health Effect	*Incidences*	*Value*	*Incidences*	*Value*	*Incidences*	*Value*
PM-related endpoints							
Premature Mortality	Pope et al. (2002) (age > 30)	13,000		14,000		4,200	
	3% discount rate		$100		$110		$34
	7% discount rate		$94		$99		$30
	Laden at al. (2006) (age > 25)	34,000		35,000		11,000	
	3% discount rate		$270		$280		$87
	7% discount rate		$240		$250		$78
	Infant (< 1 year)	59	$0.52	60	$0.53	20	$0.20
Morbidity	Chronic Bronchitis	8,700	$4.2	8,900	$4.3	2,800	$1.40
	Non-fatal heart attacks (age > 18)	15,000		16,000		4,700	
	3% discount rate		$1.7		$1.8		$0.50
	7% discount rate		$1.3		$1.4		$0.40
	Hospital admissions—respiratory (all ages)	2,700	$0.039	2,800	$0.041	830	$0.01
	Hospital admissions—cardiovascular (age > 18)	5,800	$0.091	6,000	$0.094	1,800	$0.03
	Emergency room visits for asthma (age < 18)	9,800	<$0.01	10,000	<$0.01	3,100	<$0.01
	Acute bronchitis (age 8 - 12)	19,000	<$0.01	19,000	<$0.01	6,300	<$0.01
	Lower respiratory symptoms (age 7 - 14)	240,000	<$0.01	250,000	<$0.01	80,000	<$0.01
	Upper respiratory symptoms (asthmatics age 9 - 18)	180,000	<$0.01	190,000	<$0.01	60,000	<$0.01
	Asthma Exacerbation (asthmatics age 6 - 18)	400,000	$0.022	410,000	$0.022	130,000	<$0.01
	Lost work days (ages 18 - 65)	1,700,000	$0.21	1,700,000	$0.21	540,000	$0.10
	Minor restricted-activity days (ages 18 - 65)	10,000,000	$0.64	10,000,000	$0.65	3,200,000	$0.20
Ozone-related endpoints							
Premature Mortality	Multi-city and NMMAPS						
	Bell et al. (2004) (all ages)	27	$230	28	$240	-	-
	Schwartz et al. (2005) (all ages)	41	$360	42	$370	-	-
	Huang et al. (2005) (all ages)	37	$330	40	$360	-	-
	Meta-analyses						
	Ito et al. (2005) (all ages)	120	$1,000	120	$1,100	-	-
	Bell et al. (2005) (all ages)	87	$760	90	$800	-	-
	Levy et al. (2005) (all ages)	120	$1,100	130	$1,100	-	-
Morbidity	Hospital admissions--respiratory causes (ages > 65)	160	$4.0	170	$4.2	-	-
	Hospital admissions--respiratory causes (ages < 2)	84	$0.87	85	$0.88	-	-
	Emergency room visits for asthma (all ages)	86	$0.033	87	$0.034	-	-
	Minor restricted-activity days (ages 18 - 65)	160,000	$10	160,000	$10	-	-
	School absence days	51,000	$4.7	53,000	$4.9	-	-

[1] Rounded to two significant digits; no confidence intervals provided.

Table 3: Estimated state-level health impacts avoided[1] due to the CSAPR and MATS[2]—incidences of premature mortality[3] and value[3] (millions of dollars, 2007$) of mortality and morbidity impacts

	CSAPR	CSAPR Benefits		MATS Benefits		CSAPR Plus MATS Benefits	
	Participation	Mortality	Valuation	Mortality	Valuation	Mortality	Valuation
Alabama	$PM_{2.5}$, O_3	390–1,000	$3,400–$8,300	140–360	$1,200–$3,000	530–1,400	$4,600–$11,000
Arizona[5]				14–35	$120–$290	14–35	$120–$290
Arkansas	O_3	210–530	$1,800–$4,400	96–250	$820–$2,000	300–780	$2,600–$6,400
California[5]				6–14	$48–$120	6–14	$48–$120
Colorado[5]				53–140	$460–$1,100	53–140	$460–$1,100
Connecticut		130–340	$1,100–$2,800	35–90	$300–$750	170–430	$1,400–$3,500
Delaware		57–150	$500–$1,200	13–32	$110–$270	70–180	$600–$1,500
District of Columbia		30–77	$260–$640	6–15	$51–$120	36–92	$310–$760
Florida	O_3	630–1,600	$5,400–$13,000	280–730	$2,400–$6,000	910–2,300	$7,800–$19,000
Georgia	$PM_{2.5}$, O_3	610–1,600	$5,300–$13,000	190–490	$1,700–$4,100	800–2,000	$6,900–$17,000
Idaho[5]				3–7	$22–$54	3–7	$22–$54
Illinois	$PM_{2.5}$, O_3	610–1,600	$5,200–$13,000	220–570	$1,900–$4,700	830–2,100	$7,200–$18,000
Indiana	$PM_{2.5}$, O_3	540–1,400	$4,700–$11,000	110–290	$960–$2,400	650–1,700	$5,600–$14,000
Iowa	$PM_{2.5}$, O_3	95–240	$820–$2,000	61–160	$520–$1,300	160–400	$1,300–$3,300
Kansas	$PM_{2.5}$	84–220	$730–$1,800	60–150	$520–$1,300	140–370	$1,200–$3,100
Kentucky	$PM_{2.5}$, O_3	550–1,400	$4,700–$12,000	83–210	$710–$1,800	630–1,600	$5,400–$13,000
Louisiana	O_3	210–540	$1,800–$4,400	110–290	$970–$2,400	320–830	$2,800–$6,800
Maine		24–63	$210–$520	8–20	$68–$170	32–83	$280–$680
Maryland	$PM_{2.5}$, O_3	420–1,100	$3,700–$9,000	84–210	$720–$1,800	510–1,300	$4,400–$11,000
Massachusetts		160–400	$1,400–$3,300	52–130	$450–$1,100	210–540	$1,800–$4,400
Michigan	$PM_{2.5}$, O_3	560–1,400	$4,800–$12,000	160–410	$1,400–$3,400	720–1,800	$6,200–$15,000
Minnesota	$PM_{2.5}$	79–200	$680–$1,700	57–140	$490–$1,200	140–350	$1,200–$2,900
Mississippi	O_3	230–580	$2,000–$4,800	93–240	$800–$2,000	320–820	$2,800–$6,800
Missouri	$PM_{2.5}$, O_3	340–870	$2,900–$7,200	160–410	$1,400–$3,400	500–1,300	$4,300–$11,000
Montana[5]				3–8	$25–$62	3–8	$25–$62
Nebraska	$PM_{2.5}$	31–81	$270–$670	28–72	$240–$600	59–150	$510–$1,300
Nevada[5]				4–10	$33–$82	4–10	$33–$82
New Hampshire		32–83	$280–$690	10–25	$84–$210	42–110	$360–$890
New Jersey	$PM_{2.5}$, O_3	470–1,200	$4,000–$9,900	120–320	$1,100–$2,600	590–1,500	$5,100–$13,000
New Mexico[5]				9–24	$79–$200	9–24	$79–$200
New York	$PM_{2.5}$, O_3	800–2,000	$6,900–$17,000	170–440	$1,500–$3,700	970–2,500	$8,400–$21,000
North Carolina	$PM_{2.5}$, O_3	780–2,000	$6,700–$16,000	190–480	$1,600–$3,900	970–2,500	$8,300–$20,000
North Dakota		3–8	$28–$68	7–19	$63–$150	11–27	$90–$220
Ohio	$PM_{2.5}$, O_3	1,300–3,300	$11,000–$27,000	220–560	$1,900–$4,600	1,500–3,900	$13,000–$32,000
Oklahoma	O_3	160–410	$1,400–$3,400	120–300	$1,000–$2,500	280–720	$2,400–$5,900
Oregon[5]				5–12	$39–$97	5–12	$39–$97
Pennsylvania	$PM_{2.5}$, O_3	1,200–3,000	$10,000–$25,000	210–530	$1,800–$4,400	1,400–3,600	$12,000–$29,000
Rhode Island		32–83	$280–$680	11–29	$96–$240	44–110	$370–$920
South Carolina	$PM_{2.5}$, O_3	400–1,000	$3,400–$8,400	130–330	$1,100–$2,700	520–1,300	$4,500–$11,000
South Dakota		9–22	$75–$180	11–27	$92–$230	19–50	$170–$410
Tennessee	$PM_{2.5}$, O_3	680–1,700	$5,800–$14,000	140–370	$1,200–$3,000	820–2,100	$7,000–$17,000
Texas	$PM_{2.5}$, O_3	700–1,800	$6,100–$15,000	460–1,200	$4,000–$9,700	1,200–3,000	$10,000–$25,000
Utah[5]				8–22	$74–$180	8–22	$74–$180
Vermont		18–46	$150–$380	4–10	$34–$83	22–56	$190–$460
Virginia	$PM_{2.5}$, O_3	640–1,600	$5,500–$14,000	120–300	$1,000–$2,500	760–1,900	$6,500–$16,000
Washington[5]				12–31	$100–$250	12–31	$100–$250
West Virginia	$PM_{2.5}$, O_3	280–720	$2,400–$5,900	38–96	$320–$790	320–820	$2,700–$6,700
Wisconsin	$PM_{2.5}$, O_3	170–450	$1,500–$3,700	87–220	$750–$1,800	260–670	$2,200–$5,500
Wyoming[5]				2–6	$20–$49	2–6	$20–$49
National Total[4]		14,000—35,000	$120,000—$290,000	4,200—11,000	$36,000—$89,000	18,000—46,000	$150,000—$380,000

[1] Some states may show benefits even if emissions are not reduced within those states due to pollution transport across state boundaries.

[2] State-level MATS benefits estimates assume that the distribution of health-co-benefits for the final policy is equivalent to the modeled interim scenario. Differences in the scenarios may lead to over- or underestimates of benefits in some states.

[3] Range reflects estimates of $PM_{2.5}$-related benefits using Pope et al. (2002) and Laden et al. (2006) and ozone-related benefits using Bell et al. (2004) and Levy et al. (2005); rounded to two significant digits; no confidence intervals provided.

[4] State results do not sum to national total due to rounding.

[5] States in the Western U.S. are not expected to be significantly impacted by the CSAPR, their benefits are not presented at the state-level.

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United States Environmental Protection Agency	Office of Air Quality Planning and Standards Health and Environmental Impacts Division Research Triangle Park, NC	Publication No. EPA-452/R-11-014 December, 2011