CAPHE PHAP-RM

7.4. POINT SOURCE CONTROLS

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7.4 Emissions controls for point sources

7.4.1 What are emission controls for point sources?

Point source controls are approaches that either reduce the amount of pollutant generated by an industrial process (sometimes called pollution prevention controls) or equipment that prevents air releases of pollutants (called "end of pipe" or emissions controls). The types of controls selected for a facility depend on many factors, including the type and amount of pollutant to be controlled, the processes used at the facility, the size of the facility, available space for control equipment, and regulatory requirements.

7.4.2 What types of emissions controls can point sources use?

Controls can be classified as controls for gas phase pollutants like SO_2, NO_x and VOCs, and controls for particulate pollutants. Some controls affect both gas and particulate phase pollutants, and often gas and particulate controls can interact, so it is generally best to consider the entire process or facility when evaluating controls.

7.4.2.1 Gas phase pollutants

Gas-phase emission controls include fuel switching, burner modification, absorption, adsorption, condensation and combustion. These controls often control multiple pollutants at once, and several have very high (>90%) removal efficiencies. Tables 7.4-1A-C summarize commonly used controls for SO_2, VOCs and NO_x, respectively. Table 7.4-1A also lists several facilities in Detroit for which SO_2 controls would be technically feasible, based on Reasonable Available Control Technology (RACT) analyses performed recently.[1]

Controls described in Tables 7.4-1A-C are also considered when developing plans to reduce ground-level ozone (a secondary pollutant) since NO_x and VOCs are important precursors.

An example of one control system, a spray tower wet scrubber system used for flue gas desulfurization (FGD) is depicted in Figure 7.4-1. Typical FGD systems include a variety of chemical processes, monitoring controls, and generate liquid wastes and sludges that must be treated or disposed. These systems can be expensive to install and operate, particularly when added to an existing facility. However, costs of FGD systems have decreased significantly in the past decades. Moreover, FGD systems can remove over 90% of SO_2.[2] The installation and operation of large control systems also provides jobs.[3]

The cost estimates in Table 7.4-1 are generalized and provided by US EPA. Facility-specific factors will alter costs.

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[1] The RACT analysis was provided in appendices of: Michigan Department of Environmental Quality [MDEQ], 2015. Proposed sulfur dioxide one-hour national ambient air quality standard state implementation plan. Air Quality Division, Lansing, MI.

[2] EPA (Environmental Protection Agency). 2003. Air pollution control technology fact sheet: Flue gas desulfurization. Available: http://www3.epa.gov/ttn/catc/dir1/ffdg.pdf [accessed 18 February 2016].

[3] Construction of the very large FGD system at the DTE facility in Monroe, Michigan provided 900 temporary construction jobs and 40 full-time operator jobs DTE Energy. 2016. Emissions Controls. Based on: https://www2.dteenergy.com/wps/portal/dte/aboutus/environment/details/generation%20and%20emissions/emissions%20controls [accessed 18 February 2016].

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Figure 7.4-1. Schematic design of the absorber of a flue-gas desulfurization (FGD). From https://upload.wikimedia.org/wikipedia/commons/d/d0/Flue_gas_desulfurization_unit_EN.svg

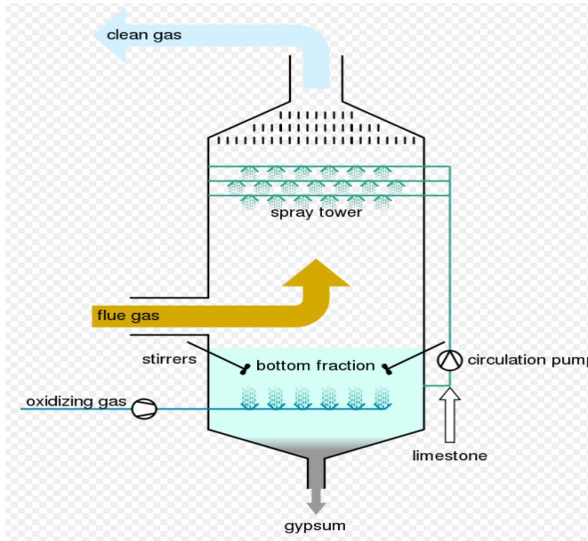

Table 7.4-1A. Control technologies for SO_2.[4,5]

Technology	Efficiency	Approach	How it works	Other pollutants removed	Facilities Where Technologically Feasible	Cost per ton removed	Disadvantages
				Sulfur Dioxide			
Sorbent Injection	10-50%	Removal from waste stream	A material is injected into the waste stream that binds to and removed the pollutant	HCl	Coal and oil combustion (US Steel, DTE River Rouge, DTE Trenton Channel)		Solid waste production
Fuel blending	20-60%	Pollution prevention	Sulfur-containing fuels are blended with low-sulfur fuels to reduce SO2 emissions		Facilities that burn coal as fuel (US Steel, DTE River Rouge)		Sulfur content in coal is variable; can lead to decreased electrical output
Fuel switching	30-90%	Pollution prevention	Sulfur-containing fuels are replaced with low-sulfur alternatives		Facilities that burn coal as fuel [Carmeuse Lime, US Steel (with retrofit), DTE River Rouge]		Not all burners can use alternative fuels
Dry Scrubbing (Flue Gas Desulfurization)	50-80%	Removal from waste stream	Solid materials (typically sodium bicarbonate) is injected into a waste stream to react with SO2	HCl	Coal and oil combustion (US Steel, DTE River Rouge, DTE Trenton Channel)	$150-300 (>2000 MMBtu/h), $500-4000 (<2000 MMBtu/h)	Solid waste production
Spray dryer absorber	80-90%	Removal from waste stream	Limestone is injected into the waste stream to react with SO2	HCl	Coal and oil combustion (US Steel)	$150-300 (>2000 MMBtu/h), $500-4000 (<2000 MMBtu/h)	Solid waste production
Wet Scrubbing (Flue Gas Desulfurization)	90-98%	Removal from waste stream	A material (e.g., soda ash) is dissolved in water and injected in the waste stream to remove acid gases	PM2.5, HCl, some water soluble VOCs	Coal and oil combustion (Carmeuse Lime, US Steel, DTE River Rouge, DTE Trenton Channel)	$200-500 (>4000 MMBtu/h), $500-5000 (<4000 MMBtu/h)	Sludge and wastewater production; increased water usage

[4] Schnelle, K.B., Brown, C.A., 2001. Air Pollution Control Technology Handbook. CRC Press.
[5] US Environmental Protection Agency [US EPA], n.d. Clean Air Technology Center Technology Transfer Network [WWW Document]. URL https://www3.epa.gov/ttncatc1/products.html#aptecfacts (accessed 5.8.16).

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Table 7.4-1B. Control technologies for VOCs.[6,7]

Technology	Efficiency	Approach	How it works	Other pollutants removed	Facilities Where Technologically Feasible	Cost per ton removed	Disadvantages
			Volatile Organic Compounds (VOCs)				
Thermal incineratio	25-99%	Removal from waste stream	VOCs in the waste stream are burned with natural gas or propane in a combustion chamber	PM (soot)	Facilities with continuous streams of mixed hydrocarbons	$440-3600	No recovery of organics; heat recovery can reduce fuel consumption; not recommended for halogen- or sulfur-containing compounds
Catalytic incineratio	25-99%	Removal from waste stream	VOCs in the waste stream are burned in the presence of a catalyst that promotes oxidation	NOx, CO, PM	Facilities with low concentrations of known VOCs in the waste stream	$105-5500	Catalysts can be "poisoned" by particulate matter
Condensation	50-95%	Removal from waste stream	VOC vapors in a waste stream are cooled, and the liquid condensate is collected	Hazardous air pollutants	Facilities with high VOC concentrations in waste streams		Limited applicability; high volatile compounds can be challenging due to high boiling points
Adsorption	50-98%	Removal from waste stream	Waste streams are passed through an absorbing liquid (either water or an organic solvent) that absorbs VOCs	Hazardous air pollutants	Facilities with large volumes of air flow with dilute pollution levels;		Selective applicability; requires specific humidity and temperature conditions
Absorption	90-98%	Removal from waste stream	Waste streams are passed through solid media (e.g., activated charcoal or silica gel) and VOCs are removed	Hazardous air pollutants	Facilities where acid gases are of concern (e.g., HCl, HF, SiF4)		Limited applicability
Flares	>98%	Removal from waste stream	VOCs are separated from the waste stream and burned in an open or closed flame		Facilities with flammable VOC streams, especially useful for sudden or unexpected concentrated flows of VOCs	$17-6500	No recovery of organics; can only be used when VOC emissions are high (unless supplemented with a fuel); does not work for halogenated compounds

[6] Schnelle, K.B., Brown, C.A., 2001. Air Pollution Control Technology Handbook. CRC Press.
[7] US Environmental Protection Agency [US EPA], n.d. Clean Air Technology Center Technology Transfer Network [WWW Document]. URL https://www3.epa.gov/ttncatc1/products.html#aptecfacts (accessed 5.8.16).

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Table 7.4-1C. Control technologies for NO_x.[8,9]

Technology	Efficiency	Approach	How it works	Other pollutants removed	Facilities Where Technologically Feasible	Cost per ton removed	Disadvantages
				Nitrogen Dioxide:			
Low excess air	0-25%	Pollution prevention	The amount of air near a burner is controlled to prevent excess NOx formation				May increase carbon monoxide emissions; flame might be longer and less stable
Selective non-catalytic reduction	30 to 50%	Removal from waste stream	Ammonia or urea is used to reduce NOx to nitrogen gas (N2)		Wide range of boiler configurations and fuels, including coal, oil, gas, biomass, and waste; thermal incinerators, solid waste combustion units, cement kilns, process heaters, glass furnaces	$400-2500	Requires a specific temperature window to be effective
Low-NOx burners	40-65%	Pollution prevention	Reduces NOx formation by burning in under "fuel rich" conditions to limit the amount of oxygen present			$250-4300	Longer flames might impinge on the walls of the combustion chamber in retrofits
Sorbent injection	60%	Removal from waste stream	A material is injected into the waste stream and reacts with the pollutant	Sulfuric acid			Creates solid waste or sludge (though some "wastes" can be resold as byproducts, e.g. ammonium nitrate)
Selective catalytic reduction	70-90%	Removal from waste stream	Ammonia is used to reduce NOx to N2 in the presence of a catalyst, which allows the reaction to take place at a lower temperature	VOCs, PM (some catalysts)	Electrical utility boilers, industrial boilers, process heaters, gas turbines, internal combustion engines, nitric acid plants	$1000-10,000	High initial costs, some ammonia emissions (ammonia "slip"); particulates can "foul" the catalyst
Water/steam injection	up to 50%	Removal from waste stream	Water is injected into a combustion chamber to lower the temperature and reduce NOx to N2				Results in a loss of efficiency
Flue gas recirculation	Up to 80%	Removal from waste stream	Flue gas is sent back through the combustion chamber and NOx is reduced by reacting with hydrocarbons				Affects heat transfer and system pressures

[8] Schnelle, K.B., Brown, C.A., 2001. Air Pollution Control Technology Handbook. CRC Press.
[9] US Environmental Protection Agency [US EPA], n.d. Clean Air Technology Center Technology Transfer Network [WWW Document]. URL https://www3.epa.gov/ttncatc1/products.html#aptecfacts (accessed 5.8.16).

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7.4.2.2 Particulate matter pollutants

Particulate matter (PM) controls focus on removing PM from the waste stream. Table 7.4-2 summarizes common PM controls. Some control technologies treat only larger particles, e.g., cyclones (Figure 7-4-2) separate out the larger particles from the waste stream, often as a "pre-treatment" step. Other control technologies, e.g., electrostatic precipitators (Figure 7.4-3) and baghouses are better suited for smaller particles like $PM_{2.5}$.

PM control costs ranged from \$0.47 to \$444 per ton removed for cyclones, and from \$77 to \$2600 for wet scrubber systems. PM controls also can remove other pollutants, e.g., metals. Preferred PM controls now mostly utilize baghouses, which have the highest efficiencies for the smaller particles.

Table 7.4-2. Control technologies for particulate matter.[10,11]

Technology	Efficiency	Approach	How it works	Other pollutants removed	Facilities Where Technologically Feasible	Cost per ton removed	Disadvantages
Cyclones	30-90%	Removal from waste stream	Larger particles are separated from the waste stream using centrifugal force		Facilities where large particles need to be collected (>10 um). Typically used as a "precleaner"	\$0.47-440	Not effective for PM less than 10 um in diameter
Wet Scrubbers	50-99%	Removal from waste stream	Water is sprayed into the waste stream to collect and remove fine particulate matter	Hazardous air pollutants (HAPs), inorganic gases, some hydrophilic VOCs	Utility, industrial and commercial boilers, chemical manufacture, mineral products, wood pulp and paper, rock products, asphalt manufacture, steel manufacturing, incinerators	\$77 to 2600 (Venturi scrubbers)	Need to reheat scrubbed effluent, sludge generation, increased wastewater
Baghouses	95-55%	Removal from waste stream	Waste streams are passed through fabric filters which remove PM	Metals (except mercury), some particulate HAPs	Utility boilers, industrial boilers, ferrous and non-ferrous metals processing, mineral products, asphalt manufacture, grain milling	\$41-372	High temperatures can require specialty fabrics, cannot be operated in moist environments
Electrostatic precipitators	90-99%	Removal from waste stream	Particles in a waste stream and charged and collected on a plate with the opposite electrical charge	Metals (except mercury), some particulate HAPs, acid mists and VOCs	Utility boilers, industrial boilers, chemical manufacture, non-ferrous metals processing, petroleum refining, mineral products, wood pulp and paper, incineration	\$38-570	Ozone is generated during gas ionization, ESPs can have large footprints, dry precipitators are not good for sticky or moist particles, wet precipitators generate sludge

[10] Schnelle, K.B., Brown, C.A., 2001. Air Pollution Control Technology Handbook. CRC Press.

[11] US Environmental Protection Agency [US EPA], n.d. Clean Air Technology Center Technology Transfer Network [WWW Document]. URL https://www3.epa.gov/ttncatc1/products.html#aptecfacts (accessed 5.8.16).

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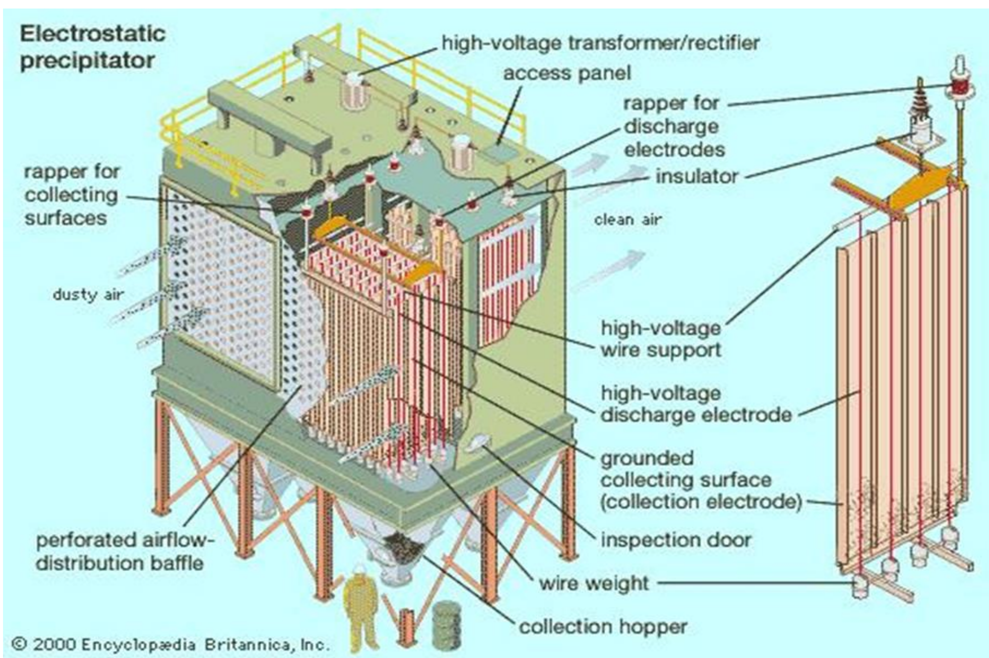
Figure 7.4-2. Diagram of a cyclone used to remove large particles from a waste stream.

Figure 7.4-3. Diagram of an electrostatic precipitator used to remove fine particles from a waste stream.



7.4.2.3 Multipollutant and preferred controls

An example of a control technology that can address multiple pollutants at once is a wet scrubber (as shown earlier in Figure 7.4-1), which uses a liquid to remove pollutants from the waste stream. Alkaline compounds can be added to the scrubber liquid to react with acid gases in the waste stream. These types of wet scrubber

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systems can be very effective in removing SO_2, acid gases, and particles. However, they create a liquid waste and have other disadvantages (pressure drop, operating and construction costs, etc.)

One current and preferred technology for SO_2 is dry powdered lime injection, possibly with carbon to remove mercury, and a baghouse to remove PM as well as the reacted lime and carbon. For PM alone, bag houses are preferred due to their very high efficiencies. Also, filter bags have become very sophisticated, and can incorporate catalysts to remove NO_x and other pollutants.

Site-specific factors, especially related to engineering and cost (see below), are always important factors in selecting appropriate controls. Emissions controls decisions must also consider, among other factors, the space available, pressure drop, operating temperature range, scalability, cost and availability of reagents, process monitoring requirements, system reliability, control efficiency, and the waste generated.

7.4.3 Air quality management and point source controls

The selection, installation, and use of emissions controls is part of air quality management (AQM), which more broadly involves designing strategies to ensure that air quality meets the National Ambient Air Quality Standards (NAAQS) and other objectives. Air quality managers have many options, e.g., elimination of sources, emissions controls, siting decisions and monitoring. However, most strategies involve point and non-point source emissions controls. Air pollution strategies can use:

- Single pollutant approaches that require controls at specific facilities to reduce concentrations at air quality monitoring and other sites for a single pollutant. Reduction targets are identified by combining information from emissions inventories, monitoring networks, and air quality models.[12] This is the approach used most often when designing state implementation plans to address NAAQS non-attainment like SO_2.
- Multi-pollutant, risk based approaches that favor controls that address multiple pollutants. This can encompass pollutants for which an area is in non-attainment as well as additional pollutants of concern. This may yield strategies that are more cost-effective and do more to reduce health disparities from ambient air pollutant exposures than single-pollutant strategies.[13,14] The use of cumulative impact assessments to consider multiple sources and pollutants is an example where multipollutant approaches can be employed.
- Uniform approaches where all sources in an area are subject to the same emissions reduction requirements to meet a reduction target, e.g., uniform 25% reduction to obtain a 25% reduction in concentrations (similar to a "rollback" approach). This simple strategy can impose higher costs per ton

[12] National Research Council [NRC]. 2004. Air quality management in the United States. National Academies Press, Washington, DC.
[13] Wesson K, Fann N, Morris M, Fox T, Hubbell B. 2010. A multi-pollutant, risk-based approach to air quality management: Case study for Detroit. Atmospheric Pollution Research 1: 296–304.
[14] Fann N, Roman HA, Fulcher CM, Gentile MA, Hubbell BJ, Wesson K, et al. 2011. Maximizing Health Benefits and Minimizing Inequality: Incorporating Local-Scale Data in the Design and Evaluation of Air Quality Policies. Risk Analysis 31:908–922; doi:10.1111/j.1539-6924.2011.01629.x.

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of pollutant removed on smaller emitters because many costs associated with pollution abatement (e.g., administrative or capital costs) are fixed, but the total amount of pollution to be removed is small.[15]

- "Largest-first" approaches where source controls are applied to the largest sources in an area first until a reduction goal is met.
- Health-based approaches where controls are applied to sources with the largest population health impacts first. This focuses on facilities that have characteristics that result in little dispersion of pollutants (e.g., stacks that are low to the ground) and/or are located near exposed populations.

There many considerations that influence the selection of controls (or combination of controls) for a facility. These are site-specific and can include: the characteristics of the pollutants, e.g., chemical composition and size distribution; characteristics of the waste stream, e.g., temperature and flow rates; how the control system might affect the performance of the industrial process, e.g., pressure drops, temperature requirements; facility characteristics, e.g., the size of the facility and whether space is available; utility needs of the control technology; generation of wastewater and solid waste; and economic considerations, e.g., capital and operating costs.

7.4.3.1 Costs and benefits

The total cost of control includes capital costs and operating costs. These costs are important as they determine what is feasible and can be imposed in a permit. Costs vary depending on the size of the facility. Typically, costs are expressed as dollars per ton of pollutant removed.

Evaluation of emissions controls should use a life cycle approach, and design, construction, operating and decommission costs can be important. There are typically economies to scale. In addition, control systems, especially end-of-pipe controls, demonstrate increasing costs to remove higher and higher fractions of pollutants, e.g., removing the first 50% of pollution may cost $500 per ton, but getting the second 50% can be far more expensive (or practically impossible).

Resources for estimating the cost of emissions controls include:

- *EPA Air Pollution Cost Control Manual*, which provides guidance to facilities and regulators on how to estimate costs for point source air pollution control devices. The current version of the manual was published in 2002; the manual is currently being updated, and is expected to be released in 2017. The manual includes guidance for estimating control costs for volatile organic compounds (VOCs), oxides of nitrogen (NO_x), sulfur dioxide (SO_2) and acid gases, and particulate matter (PM).[16]
- Air pollution abatement cost functions, which can be used to make more general estimates about the cost of reducing emissions based on factors such as industrial sector and pollutant.[17] Between 1973 and

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[15] Becker RA. 2005. Air pollution abatement costs under the Clean Air Act: evidence from the PACE survey. Journal of Environmental Economics and Management 50:144–169; doi:10.1016/j.jeem.2004.09.001.
[16] US Environmental Protection Agency [US EPA]. 2002. EPA Air Pollution Control Cost Manual: Sixth Edition.
[17] Hartman RS, Wheeler D, Singh M. 1997. The cost of air pollution abatement. Applied Economics 29:759–774; doi:10.1080/000368497326688.

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2005, the US Census Bureau collected data on the cost incurred by industry to comply with environmental regulations[18], and these data can be used to inform cost functions.

The cost-effectiveness or cost-benefit ratio for an emissions controls depends on the total cost of the control (life cycle costs) and the estimated health and other benefits (as avoided adverse health outcomes or monetized impacts). Resources for estimating the health benefits of a point source control technology include:

- Estimates of impacts per ton of pollutant, which are based on sector-specific emissions inventories, air quality modeling, and health impact functions.[19,20] These estimates are typically drawn from nation-wide studies and can be useful for screening analyses, but they do not account for location-specific factors that are important for estimating the health impacts from point sources, e.g., source location, release point characteristics, meteorology, and the distribution and sensitivity of exposed populations.[21]
- Quantitative health impact assessment tools such as *US EPA's Benefits Mapping and Analysis Program* (BenMAP)[22] or the *Framework for Rapid Emissions Scenario and Health Impact Estimation* (FRESH-EST)[23] which combine air quality data (e.g., monitoring and/or modeling results) with population and health outcome data to estimate health benefits of pollution control technologies. These types of tools can be tailored to the urban scale to better account for the location-specific factors that influence health benefit estimates.[24]

7.4.4 Why is this important?

Point sources in the Detroit area emit a significant amount of criteria and hazardous air pollutants, as described in Section 5 of this Resource Manual. Emissions controls on point sources can help eliminate air pollution before it reaches surrounding communities. This is especially important for Detroit for several reasons:

- Many point sources are old and generally do not have modern emissions controls. If newly constructed or substantially modified, these sources may be required to meet more stringent emission requirements specified under Michigan and federal law (see Section 7.6). This applies to industrial sources in Detroit using coal, diesel, and other fuels.

  No facility burning coal in Detroit has modern emission controls with the exception of DTE Monroe. These sources are responsible for nearly all SO_2 emissions since coal contains a considerable amount of

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[18] US Census Bureau. Pollution Abatement Costs and Expenditures Survey. Available: https://www.census.gov/econ/overview/mu1100.html [accessed 6 May 2016].
[19] Fann N, Baker KR, Fulcher CM. 2012. Characterizing the $PM_{2.5}$-related health benefits of emission reductions for 17 industrial, area and mobile emission sectors across the U.S. Environ Int 49:141–151; doi:10.1016/j.envint.2012.08.017.
[20] US Environmental Protection Agency [US EPA]. 2013. Technical support document: Estimating the benefit per ton of reducing PM2.5 precursors from 17 sectors.
[21] Fann N, Fulcher CM, Hubbell BJ. 2009. The influence of location, source, and emission type in estimates of the human health benefits of reducing a ton of air pollution. Air Qual Atmos Health 2:169–176; doi:10.1007/s11869-009-0044-0.
[22] US Environmental Protection Agency [US EPA]. 2016. Environmental Benefits Mapping and Analysis Program - Community Edition (BenMAP-CE). Available: https://www.epa.gov/benmap [accessed 6 May 2016].
[23] Milando CW, Martenies SE, Batterman SA. 2016. Assessing Concentrations and Health Impacts of Air Quality Management Strategies: Framework for Rapid Emissions Scenario and Health impact ESTimation (FRESH-EST). Env Int. Submitted.
[24] Hubbell BJ, Fann N, Levy JI. 2009. Methodological considerations in developing local-scale health impact assessments: balancing national, regional, and local data. Air Quality Atmosphere and Health 2:99–110; doi:10.1007/s11869-009-0037-z.

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sulfur, flue gas sulfurization is not used (all sulfur in coal is thus emitted), and these sources are large. Major coal users in Detroit include electrical generating units (DTE Trenton Channel, DTE River Rouge), other large boilers (Wyandotte Municipal Power, Guardian, JR Whiting), steel producers, coke producers, and the cement industry.

- There is a high intensity of industrial activity, especially in southwest Detroit
- Large populations live very close to many of the industrial sources
- A number of factors increase the vulnerability and susceptibility of these populations.
- Point source emissions can be very large.
- Some point sources have poor dispersion of pollutants due to source characteristics, e.g., short stack heights or large nearby structures that cause plume downwash that can cause high concentrations.

7.4.5 Which pollutants are affected by using emissions control technologies?

Point source emissions controls can be used to reduce emissions of any pollutant, but most attention has focused on the criteria pollutants (PM, NO_x, SO_2, CO, and lead), volatile organic compounds (VOCs), and metals and other hazardous air pollutants. Current emissions from point source facilities were described in Section 5 of the resource manual.

7.4.6 What health effects can be mitigated?

A number of adverse health effects could be mitigated by using point source controls to reduce pollutant emissions. The type of health effects mitigated by point source controls depends on which pollutants are reduced. These health effects range from minor outcomes, e.g., missed school or work days due to respiratory symptoms, to severe outcomes, e.g., respiratory disease, cardiovascular disease, cancer, and premature mortality. Some impacts are described below.

7.4.7 What is happening in and around Detroit?

$\underline{SO_2}$. Portions of Wayne County are out of compliance with the National Ambient Air Quality Standards (NAAQS) standards for SO_2. A number of regulatory actions have resulted, including the development of a State Implementation Plan (SIP) that was recently submitted to EPA;[25] a PTI that was recently approved for DTE Trenton Channel, and a rule change that was proposed for US Steel. These involve several aspects.

- DTE Energy will reduce SO_2 emissions from the Trenton Channel Plant. A recently approved PTI for (April, 2016) will shut-down four coal boilers, and install five smaller natural gas boilers. This will reduce SO_2 emissions by 5,392 tons/year (based on MAERS emissions data, averaged over 2010-2014). A large coal boiler without flue gas desulfurization (FGD) will remain at this facility; this boiler had emissions of 15,431 tons/year (same data source).

[25] MDEQ (Michigan Department of Environmental Quality). 2015. Proposed sulfur dioxide one-hour national ambient air quality standard state implementation plan. Available: http://www.deq.state.mi.us/aps/downloads/SIP/SO2SIP.pdf [accesses 7 March 2016].

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In the SIP, DTE identified wet or dry FGD as ways to reduce SO_2 emissions (90% was feasible), however, this option was considered too costly. Instead, DTE proposed the use of lower sulfur coal instead, which would provide smaller reductions. However, the PTI appears to supersede this.

- DTE River Rouge may use lower sulfur coal to reduce emissions, based on the SIP.
- DTE installed four FGD systems on their largest plant at Monroe, Michigan from 2009 through 2015. This is one of the largest power plant in the Midwest.[26] SO_2 emissions have decreased considerably [27] although this facility has been operating since 1968 for many decades (without SO_2 controls). SO_2 emissions (MAERS latest, 2014) were 6,286 tons, compared to 114,674 tons/year prior to the scrubbers (2005-2008 average). The installation of the new system created over 600 jobs and an estimated 300 associated jobs.
- MDEQ is negotiating with US Steel to reduce SO_2 emissions.
- MDEQ in the SIP will require Carmeuse Lime to increase their stack height from 60 to 120 feet to increase dispersion and reduce ground level concentrations. No emission reduction is proposed for this facility. This primitive control measure, a now rarely invoked "dilution is the solution to pollution" approach, will distribute SO_2 over a broader region, may not meet good engineering practice which limits stack heights, and may not be approved by US EPA.
- Marathon has requested at PTI that would increase SO_2 emissions by 22 tons in the designated non-attainment area. We have noted deficiencies in the information provided by MDEQ, the cumulative risk experienced by residents of the affected area due to multiple air pollutants, the high levels of vulnerable residents in that area of the city, and other issues in the analysis and approach.[28]

PM. MDEQ maintains enforces and encourages PM emission reductions, including a program to control fugitive dust.

O_3. If the region nearby areas are designed as non-attainment for O_3, then further emissions controls on O_3 precursors VOC and/or NO_x may be required. This may address point, non-point and mobile sources. Some impact on point sources is anticipated.

VOCs. There are many point sources with VOC emissions, including Marathon, painting and coating operations, coke facilities, etc. VOC controls include maintenance and operational controls (including leak detection and repair operations) and flaring. Marathon, an important VOC source, is the subject of a class action lawsuit that may spur additional emission reductions.[29]

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[26] Barton Malow. 2016. Building Innovative Solutions. Available: http://www.bartonmalow.com/projects/dte-monroe [accessed 7 March 2016] and DTE Energy. 2016. Emissions Controls. Available: Click Here [accessed 7 March 2016].

[27] PR Newswire. 2009. DTE Energy environmental project will create 900 jobs. Available: http://www.prnewswire.com/news-releases/dte-energy-environmental-project-will-create-900-jobs-78770632.html [accessed 18 February 2016].

[28] CAPHE. 2016. Issues regarding the proposed Permit to Install for Marathon Petroleum Company LP (A9831) Permit Number 118-15 and 122-15 Letter from CAPHE.

[29] Residents living next to the Marathon refinery in Southwest Detroit filed a class action lawsuit in U.S. District Court on 2/22/16 alleging the refinery's fumes and noise cause a perpetual nuisance harming their lives. The lawsuit seeks an excess of $5 million

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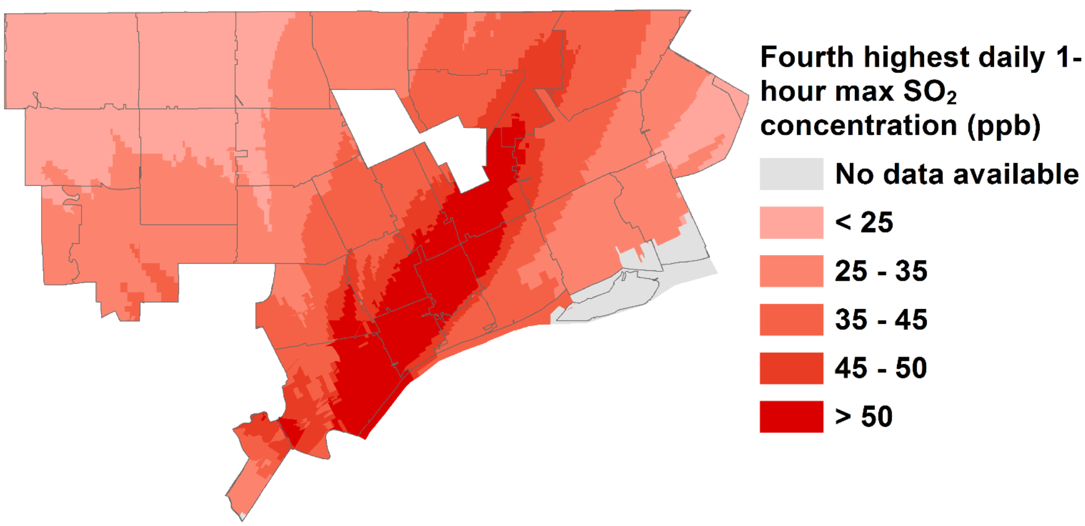
Other activity pertinent to point source emissions controls involve several large industrial facilities, including the Detroit Resource Recovery Authority's solid waste incinerator (see below) and the steel mills.

7.4.8 What are the benefits of using point source controls in Detroit

7.4.8.1 Reducing asthma-related health impacts due to point source emissions of SO_2

As described in Section 4 of this resource manual, portions of Wayne County have been designated as non-attainment of the 1-hour SO_2 NAAQS. Figure 7.4-4 shows the fourth highest daily 1-hour maximum concentrations estimated at the block level predicted from nine major point source emissions of SO_2 in the area (US Steel - Ecorse, US Steel - Zug Island, EES Coke, DTE River Rouge, DTE Trenton Channel, Carmeuse Lime, DTE Monroe, AK (formerly Severstal) Steel, Dearborn Industrial Generation, and Marathon Refinery) in 2010.[30] Concentrations are highest in southwest Detroit and extent northeast due to prevailing winds in the area. Point source controls on SO_2 emissions would decrease concentrations. As noted above, modest reductions in SO_2 emissions are called for the SO_2 State Implementation Plan that was submitted to US EPA in May 2016.

Figure 7.4-4. Peak SO_2 concentrations from major point source emissions of SO_2



dollars, as well as a court order that Marathon cease the release of all contaminants into what it calls the "class area," which includes residential neighborhoods within the blocks of the factory bounded by Pleasant Street to the north, Schaefer Highway to the south, Basset Street to the east and Edsel and South Patricia streets to the west. Information from Detroit Free Press. 2016. Refinery neighbors sue Marathon over pollution impacts. Available: http://www.freep.com/story/news/local/michigan/detroit/2016/02/22/refinery-neighbors-sue-marathon-over-pollution-impacts/80764434/ [accessed 3 March 2016].

[30] The major point sources include those discussed in the MDEQ Proposed SIP. The analysis discussed in Section 7.4.8.1 uses SO_2 emissions in 2010, which differs from (but are similar to) the 5 year filtered average used in the analysis presented in Section 4 of this manual. The following tons of SO_2 emitted by each facility in 2010 were used in the analysis (ranked lowest to highest): Marathon Refinery: 104 tons; Carmeuse Lime: 358 tons; Dearborn Industrial Generation: 464 tons; AK (Severstal) Steel: 650 tons; EES Coke: 1917 tons; US Steel (Ecorse & Zug Island): 3926 tons; DTE River Rouge: 14,421 tons; DTE Trenton Channel: 23,469 tons; DTE Monroe: 47,602 tons. DTE Trenton Channel and Monroe will have reduced emissions at present.

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As an example of the benefits of source controls, we present an analysis of a simplified source control alternative or "scenario" that would eliminate SO_2 emissions from the three largest sources: DTE Monroe, DTE Trenton Channel, and DTE River Rouge. Complete eliminating of SO_2 emissions at these facilities would require changing the fuel source from coal to natural gas, using highly effective emissions controls, shuttering the plants, or some combination of controls. While full elimination might seem unrealistic, the analysis also pertains to intermediate reductions, e.g., a 50% reduction in emissions at these facilities would confer 50% of the benefits. (Methods used are detailed in Section 5.5.1).

Figure 7.4-5A maps the annual and highest daily mean concentrations of SO_2 due to 2010 emissions at most major sources near Detroit, MI (A); Figure 7.4-5B shows the same plots with the same scale, but displays the outcome of the test scenario that eliminates emissions from the River Rouge, Trenton Channel and Monroe power plants. Concentrations are substantially reduced by excluding these sources.

Health impacts for the change in SO_2 concentrations were estimated, specifically, the number of ED visits for asthma, hospitalizations for asthma, and respiratory symptoms days (defined as a day with cough, wheeze, or shortness of breath). The impacts were estimated using the quantitative health impact assessment (HIA) methods described in Section 5.5.1, which uses predicted daily average concentrations, health impact functions from the epidemiological literature,[31] and local demographic and health data.[32]

[31] Asthma hospitalization and ED visits use ZIP code level data for Detroit and county level data outside of Detroit; asthma exacerbation rates use Detroit data Population data come from the American Community Survey. Concentration-response coefficients are drawn from the peer-reviewed literature.

References: Wasilevich, E., Lyon-Callo, S., Rafferty, A., Dombkowski, K., 2008. Detroit- the epicenter of asthma burden, Epidemiology of Asthma in Michigan

Michigan Department of Health and Human Services [MDHHS], 2016. Michigan Asthma Surveillance, Data and Reports [WWW Document]. URL http://www.michigan.gov/mdhhs/0,5885,7-339-71550_5104_5279-213824--,00.html (accessed 2.8.16)

US Census Bureau, 2015. TIGER/Line® with Selected Demographic and Economic Data [WWW Document]. URL http://www.census.gov/geo/maps-data/data/tiger-data.html (accessed 7.2.15); US Census Bureau. American Community Survey 5-year Estimates. URL https://www.census.gov/programs-surveys/acs/ (accessed 2.16.16).

Li, S., Batterman, S., Wasilevich, E., Elasaad, H., Wahl, R., Mukherjee, B., 2011. Asthma exacerbation and proximity of residence to major roads: a population-based matched case-control study among the pediatric Medicaid population in Detroit, Michigan. Environ Health 10, 34

Schildcrout, J.S., Sheppard, L., Lumley, T., Slaughter, J.C., Koenig, J.Q., Shapiro, G.G., 2006. Ambient Air Pollution and Asthma Exacerbations in Children: An Eight-City Analysis. Am. J. Epidemiol. 164, 505–517

Linn, W.S., Szlachcic, Y., Gong, H., Kinney, P.L., Berhane, K.T., 2000. Air pollution and daily hospital admissions in metropolitan Los Angeles. Environ Health Perspect 108, 427–434

[32] Asthma hospitalization and ED visits use ZIP code level data for Detroit and county level data outside of Detroit; asthma exacerbation rates use Detroit data Population data come from the American Community Survey. References:

Wasilevich, E., Lyon-Callo, S., Rafferty, A., Dombkowski, K., 2008. Detroit- the epicenter of asthma burden, Epidemiology of Asthma in Michigan

Michigan Department of Health and Human Services [MDHHS], 2016. Michigan Asthma Surveillance, Data and Reports [WWW Document]. URL http://www.michigan.gov/mdhhs/0,5885,7-339-71550_5104_5279-213824--,00.html (accessed 2.8.16)

US Census Bureau, 2015. TIGER/Line® with Selected Demographic and Economic Data [WWW Document]. URL http://www.census.gov/geo/maps-data/data/tiger-data.html (accessed 7.2.15); US Census Bureau. American Community Survey 5-year Estimates. URL https://www.census.gov/programs-surveys/acs/ (accessed 2.16.16).

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Results of the quantitative HIA are summarized in Table 7.4-4. Two cases are shown: base case with current emissions; and the alternative case (or scenario) that excluded SO_2 emissions from the three DTE facilities. The alternative case reduced asthma-related health outcomes among children and adults in Detroit due to SO_2 exposure by 28%. These results are conservative because the assessment considered only the Detroit population, while SO_2 impacts extend well beyond the city (Section 5.5.3). As noted earlier, benefits would be proportional to the degree of emissions control, e.g., installing FGD systems that remove 90% of SO_2 (rather than eliminate it completely) would achieve 90% of the listed impacts.

This analysis only considers SO_2 controls. Additional benefits would result from controls on multiple pollutants at these sources, which is discussed next.

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Figure 7.4-5A. Annual and highest daily mean SO_2 concentrations estimated at the block level for emissions at nine major sources of SO_2 near Detroit, MI in 2010

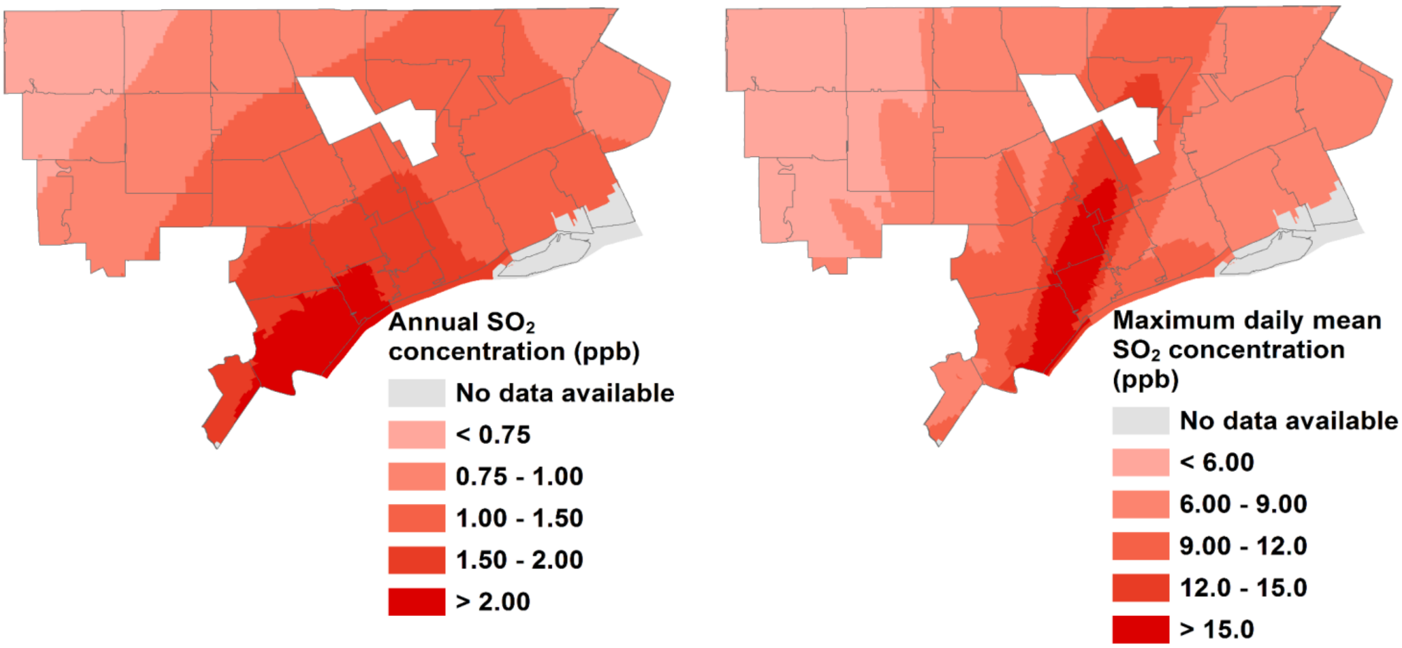

Figure 7.4-5B. Annual and highest daily mean SO_2 concentrations estimated at the block level after excluding DTE River Rouge, DTE Trenton Channel and DTE Monroe from the dispersion model.

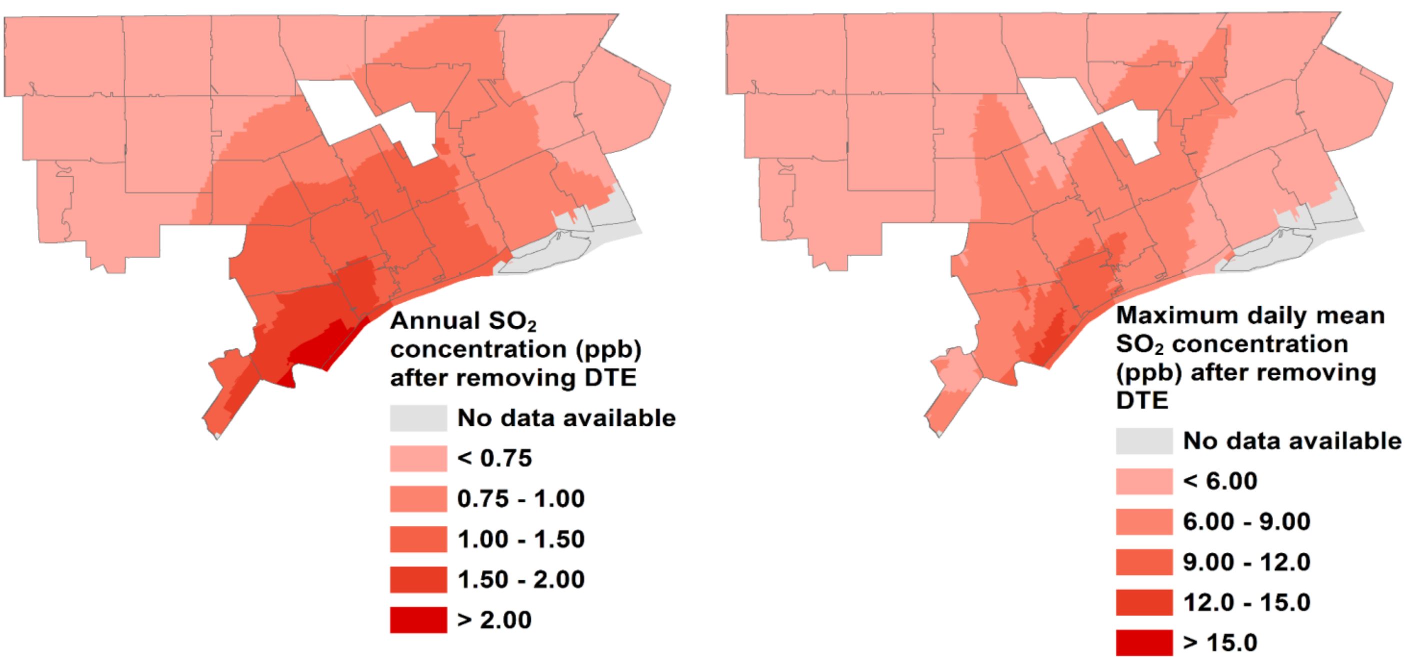

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Table 7.4-3. Health impacts attributable to SO_2 emissions from major point sources in 2010 for base and alternative cases.

	Base case: Health impacts attributable to SO_2 emissions from 9 major point sources near Detroit, MI			Alternative case: Health impacts attributable to SO_2 emissions from major sources excluding three coal-fired power plants			
Asthma-related Outcome (age group)	Attributable impacts (cases per year)	DALYs (years)	Monetized impacts ($ per year)	Attributable impacts (cases per year)	DALYs (years)	Monetized impacts ($ per year)	Percent Difference
Exacerbations (6-14 years)	3965	4.36	$229,975	2849	3.13	$165,228	-28.1
ED visits (<18 years)	65	0.09	$27,858	47	0.06	$20.056	-27.2
Hospitalization (<65 years)	7	0.04	$115,961	5	0.03	$83,255	-28.6
Total		4.49	$373,794		3.23	$268,540	-28.0

7.4.8.2 Reducing health impacts from point source emissions

As detailed in Section 5.5.2 of the Resource Manual, exposure to $PM_{2.5}$, NO_x and SO_2 from point source emissions can have significant health impacts. Table 7.4-4 summarizes the health impacts due to emissions of $PM_{2.5}$, NO_x and SO_2 from 24 facilities.[33] These facilities were selected either because they are large pollutant emitters (the first 16 sources listed in the table), or because they are in close proximity to exposed populations (last 8 sources in the table). Results for some facilities (notably St. Mary's Cement and BASF Corporation) are preliminary and may change after review of the dispersion modeling data. The results show that:

- The 24 facilities account for 75% of the total health impacts attributable to point source emissions.
- Current emissions of NO_x, SO_2 and $PM_{2.5}$ from point sources incur a total of 971 DALYs per year and $550 million per year in monetized health impacts.

Considering health impacts from all point sources and the three pollutants, reducing $PM_{2.5}$ emissions would potentially have the greatest health benefits. This is because $PM_{2.5}$ is associated with a number of severe health outcomes, including cardiovascular diseases and premature mortality.

- Exposure to $PM_{2.5}$ causes all of the mortality (including all-cause, IHD, lung cancer, and infant). In addition, $PM_{2.5}$ causes most of the hospitalizations, including all hospitalizations for CVD, pneumonia, and non-fatal heart attacks. For asthma exacerbations, $PM_{2.5}$ causes all ED visits for asthma, and all cases

[33] This table is also shown in Section 5.5.2 of this manual.

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of shortness of breath, minor restricted activity days, and work loss day. For the summary measures, $PM_{2.5}$ causes 98.4% of the total DALYs and 99.3% of the monetized impact.

- Exposure to NO_x causes 32% of hospitalizations for asthma, 38% of ED visits for asthma, 54% of hospitalizations for COPD, and 57% of asthma aggravations with one or more symptoms.
- Exposure to SO_2 causes 39% of the hospitalizations for asthma, 47% of ED visits for asthma, 100% of ED visits for asthma using the Detroit-based epidemiology study, and 45% of hospitalizations for COPD.

Table 7.4-4. Health impacts attributable to $PM_{2.5}$, NO_x, and SO_2 average emissions (2010-2014) from point sources near Detroit, MI.[34]

Health Outcome or Metric (age)	DTE Monroe	DTE Trenton Channel	DTE River Rouge	JR Whiting Co.	US Steel	EES Coke	AK Steel	Carmeuse Lime	Dearborn Industrial Generation	Guardian Industries	GM Hamtramck	Marathon Petroleum	Greater Detroit Resource Recovery	Carleton Farms Landfill	Daimler Chrysler Technology	A123 Systems	Detroit Wastewater Treatment Plant	St Mary's Cement	Beacon Heating Plant	Detroit Diesel Corporation	Jefferson North Assembly Plant	BASF Corporation	Wyandotte Dept. of Municipal Power	Ford Motor Co. Rouge Complex	Other Point Sources	**Total Point Sources**
Mortality (number of cases)																										
All Cause (>29)	0.1	0.2	0.0	0.4	3.7	0.4	2.2	0.2	0.6	1.1	0.1	0.5	0.1	0.6	0.2	1.1	0.0	4.5	0.0	0.1	0.2	4.7	0.0	0.2	7.4	**28.6**
IHD (>29)	0.1	0.2	0.0	0.4	3.1	0.4	1.8	0.2	0.5	0.9	0.0	0.4	0.1	0.5	0.2	0.9	0.0	3.7	0.0	0.1	0.2	3.6	0.0	0.2	6.1	**23.4**
Lung Cancer (>29)	0.0	0.0	0.0	0.1	0.6	0.1	0.3	0.0	0.1	0.2	0.0	0.1	0.0	0.1	0.0	0.2	0.0	0.7	0.0	0.0	0.0	0.8	0.0	0.0	1.1	**4.3**
Infant (0-1)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	**0.3**
Hospitalizations (number of cases/events)																										
Asthma (0-64)	1.7	1.0	1.1	0.4	2.6	1.0	0.9	0.8	0.6	0.5	0.2	0.4	0.6	0.2	0.1	0.2	0.1	0.8	0.0	0.1	0.1	0.8	0.1	0.1	3.4	**17.9**
COPD (>64)	10.6	6.4	6.8	2.2	12.4	5.9	3.2	5.0	3.3	2.4	1.4	2.1	4.2	1.1	0.5	0.0	1.1	0.5	0.1	0.6	0.6	0.6	0.6	0.4	14.6	**86.7**
CVD (>64)	0.0	0.0	0.0	0.1	0.8	0.1	0.5	0.1	0.1	0.3	0.0	0.1	0.0	0.1	0.1	0.3	0.0	1.0	0.0	0.0	0.0	1.2	0.0	0.0	1.7	**6.6**
Pneumonia (>64)	0.0	0.0	0.0	0.0	0.4	0.0	0.2	0.0	0.1	0.1	0.0	0.0	0.0	0.1	0.0	0.1	0.0	0.5	0.0	0.0	0.0	0.6	0.0	0.0	0.8	**3.1**
Non-fatal heart attack (>17)	0.0	0.0	0.0	0.0	0.2	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.3	0.0	0.0	0.0	0.3	0.0	0.0	0.4	**1.7**
ED visit for asthma (0-17)	20.6	11.8	13.2	4.6	26.3	11.0	8.3	8.8	7.2	4.5	2.7	3.9	6.8	2.1	1.0	1.1	1.7	4.6	0.2	1.0	1.2	4.2	1.0	0.8	31.2	**179.6**
ED visit for asthma-Detroit CR (0-17)	18.8	12.1	12.0	3.7	19.4	8.1	5.7	5.7	6.3	0.9	2.0	1.8	0.9	0.3	0.1	0.0	0.4	0.0	0.0	0.1	0.0	0.0	0.4	0.0	1.1	**99.9**
Asthma exacerbations and restricted days (number of cases, days)																										
Cough (6-14)	31	78	6	175	1,521	170	932	96	247	429	21	188	49	233	93	453	11	2,116	6	31	83	1,730	7	94	3,018	**11,818**
Shortness of breath (6-14)	3	8	1	17	149	17	91	9	24	42	2	18	5	23	9	44	1	209	1	3	8	173	1	9	298	**1,165**
Wheeze (6-14)	2	6	0	14	117	13	72	7	19	33	2	14	4	18	7	35	1	164	0	2	6	136	1	7	235	**917**
One or more symptoms (6-14)	1,496	873	973	312	1,781	855	468	754	497	332	203	311	654	149	78	0	172	64	16	93	95	56	87	69	2,459	**12,847**
One or more symptoms - Det CR (6-14)	4,375	2,842	2,816	861	4,655	1,945	1,374	1,401	1,538	219	452	447	208	67	13	0	0	0	0	0	0	0	0	0	654	**23,868**
Minor restricted activity day (18-64)	51	129	10	287	2,474	281	1,445	155	383	712	35	305	81	389	150	750	18	3,104	9	49	135	3,184	12	140	4,893	**19,181**
Work loss day (18-64)	9	22	2	50	428	49	250	27	66	123	6	53	14	67	26	130	3	538	2	8	23	555	2	24	850	**3,327**
Summary measures																										
Total DALYs (years)	4.4	7.6	1.7	15.0	127.6	15.4	73.4	8.8	19.9	36.3	2.1	16.0	5.1	19.6	7.9	37.0	1.1	153.3	0.5	2.5	7.5	149.3	0.7	7.0	251.7	**971.4**
Monetized Impact (2010 $millions)	2.0	4.1	0.6	8.5	71.3	8.4	41.7	4.7	11.1	21.0	1.1	9.0	2.6	11.3	4.4	21.6	0.6	86.0	0.3	1.4	4.0	88.7	0.4	4.0	141.8	**550.5**

[34] Note, results for the point source analysis are preliminary, and results may be updated.

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7.4.9 What are the best practices?

Air pollution controls have become very sophisticated. There are effective controls for many types of emissions at many types of sources, as well as ways to reduce the need for polluting fossil fuels. Here we mention only a few items.

Promote and enable clean energy. The low cost of natural gas, cost-competitiveness of solar and wind energy, concerns over greenhouse gases, SO_2 and other environmental concerns, policies including the President's Clean Energy Plan, and considerable activism[35] together are driving a major transition away from fossil fuels, especially coal. Clean energy sources can be used to reduce use of fossil fuels in residential, commercial and industrial sectors.

Provide incentives and remove regulatory and financial barriers regarding renewable energy. For example, community solar arrangements allow individuals and businesses to purchase shares in a renewable energy system not located on their property, however, public utilities like DTE can only offer community solar programs as pilot projects when approved by the Michigan Public Service Commission (PSC).[36]

Reform utility approaches and Public Service Commission rules to promote innovation and clean energy.[37] New York is trying to for example PSC rules to encourage solar and renewables; coal plants have already been shut down.

Get Detroit and other cities to commit to renewable energy targets. A number of smaller cities already obtain 100% of their energy from renewable sources, and other larger cities, including Grand Rapids and San Diego (population 1.4 million), have pledged to do so. San Diego's plan uses a method called community choice aggregation to determine where the electricity comes from, while utilities continue to operate the transmissions lines and manage the electrical grid.

Conduct regular inspections, evaluations and provide recommendations for emissions controls. As mentioned, many facilities are very old and have rudimentary emissions controls.

Improve flare efficiency. Flaring is a relatively primitive control technology with variable efficiency, yet is practiced widely at refineries and some other sources. In 2003, the Bay Area Air Quality Management District (BAAQMD) in California required that refineries conduct comprehensive, real-time monitoring of flare efficiency to ensure maximum combustion.[38] After implementation of the rule, the amount of flaring and emissions dropped considerably.[39]

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[35] Sierra Club. Coal is an outdated, backward and dirty 19th-century technology. Available: http://content.sierraclub.org/coal/about-the-campaign [accessed 3 March 16].

[36] Community solar: see http://www.ecocenter.org/clean-energy-programs#innovative_financing_programs (accessed 25 April 2016).

[37] New York State has a plan to use market forces to shake up the utility industry for this purpose called "Reforming the Energy Vision." New York Times, May 10, 2016/

[38] Bay Area Air Quality Management District. 2003. Flare monitoring at petroleum refineries. Available: www.baaqmd.gov/~/media/files/planning-and-research/rules-and-regs/reg-12/rg1211.pdf?la=en [accessed 18 February 2016].

[39]Bay Area Air Quality Management District. 2015. Available:http://www.baaqmd.gov/~/media/files/planning-and-research/rules-and-regs/workshops/2015/1215-1216-workshop/refinery-emissions-tracking-and-mitigation-workshops_march2015.pdf [accessed 18 February 2016].

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Reduce fugitive emissions. These may tend to require active attention to administrative and engineering controls, thus, inspection, operation and management programs need attention.

7.4.10 Applicable strategies for Detroit

Install up to date emissions control devices. Facilities should install emissions control devices that minimize the amount of pollution released into surrounding areas. This includes:

- Install FGD (flue gas desulfurization) systems at all coal-fired boilers and power plants.
- Install desulfurization systems for coke oven gas. Detroit is believed to have the only coke facility in country without such technology.
- Reduce SO_2 and PM emissions at steel facilities.
- Improve flare efficiency and monitoring at Marathon and other facilities as noted for BAAQMD in the previous section.
- Require low NO_x burners on all combustors.
- Provide incentives to modernize facilities and reduce emissions.

Utilize health impact evaluations when setting permits limits that determine controls necessary. In particular, evaluate cumulative impacts and impacts that below the NAAQS.

Install up to date emissions monitors and require verification of emissions. This is discussed in Section 7.6.

Increase process and combustion efficiency.

Eliminate open storage and material transfer processes that can result in fugitive releases

Utilize modern tools to detect and quantify VOC releases.

Shift to renewable and green fuels. A landscape with clean and renewable energy could transform the energy and physical landscape in Detroit. As noted in the previous section:

- Provide incentives for green energy. Use solar panels along buffers that also reduce noise and air pollution.
- Remove regulatory and financial barriers regarding renewable energy.
- Reform utility approaches and Public Service Commission rules
- Get Detroit and other cities to commit to renewable energy targets

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