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Energy & Air Quality: A Texas Primer

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KEY FINDINGS

- Steady advances in technology are decoupling fossil-fuel energy and air pollution.
- Air pollution continues to reach new record lows even as Americans burn increasing amounts of coal, oil, and natural gas to power their homes, vehicles, businesses, and factories.
- Texas already meets federal health standards for most air pollutants. The key remaining challenge for DFW and other Texas cities is ozone.
- DFW will attain the ozone standard regardless of whether new coal plants are built. Coal is already a small fraction of ozone-forming emissions, and EPA requires total power plant pollution to continue to decline, even if new coal plants are built.

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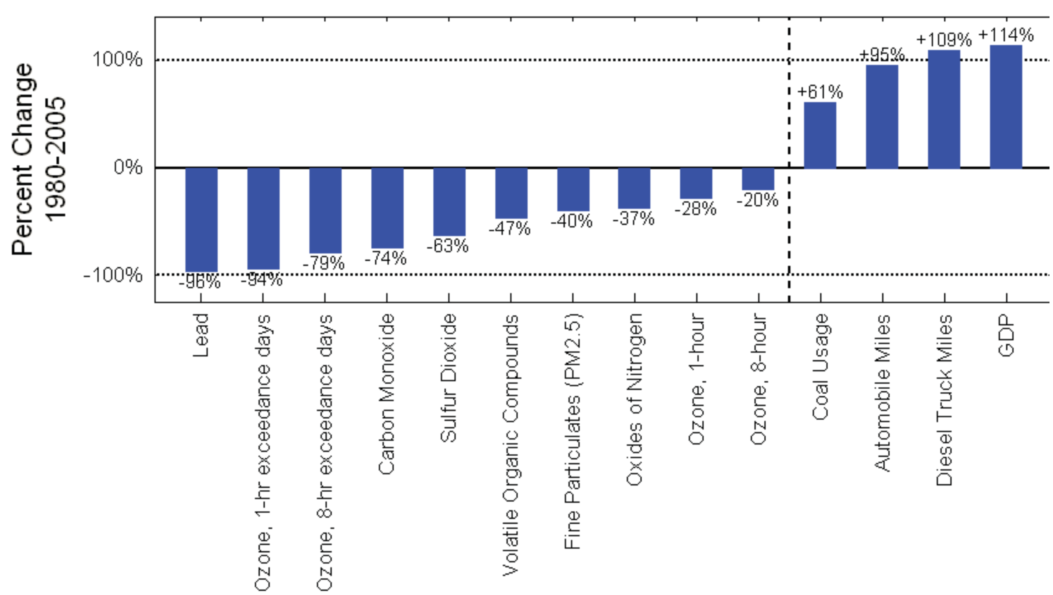
AIR QUALITY AND ELECTRICITY GENERATION

The debate over power plants in Texas is based on false premises. Much of the public has the mistaken impression that building new coal-fired power plants necessarily means more air pollution. In fact, steady advances in technology are decoupling fossil-fuel energy and air pollution. That is why air pollution continues to reach new record lows in Texas and the nation, even as Americans burn increasing amounts of coal, oil, and natural gas to power their homes, vehicles, businesses, and factories.

Figure 1 tells the story. From 1980 to 2005, even as coal consumption increased more than 60 percent and driving nearly doubled, air pollution of all kinds sharply declined.[1] Polls show most Americans are unaware of this astounding progress.[2] The likely reason is press coverage of air quality issues that consistently fails to provide a realistic picture of air pollution levels and trends.[3]

The Texas air quality debate has intensified in the battle over whether Texans should be allowed to build coal-fired power plants as one means to meet increasing demand for electricity. The outcome of this battle will significantly

Figure 1. National Trends in Miles Driven, Energy Production, and Economic Activity vs. Trends in Air Pollution Levels, 1980–2005[4]



Notes: Figure 1 shows the percentage change in each value between 1980 and 2005. The value for volatile organic compounds (VOC) represents the change in estimated emissions, since no long-term measurements of ambient levels of total VOCs are available. The trends for lead, sulfur dioxide, nitrogen dioxide, and particulates are based on average annual levels. The trends for carbon monoxide and ozone are based on peak daily levels (second highest annual value for 1-hour ozone and carbon monoxide and fourth highest annual value for 8-hour ozone). See endnote #4 for source data and further details.

continued on next page

affect whether the state can produce enough electricity to meet its citizens' needs and how much consumers will pay for their electricity.

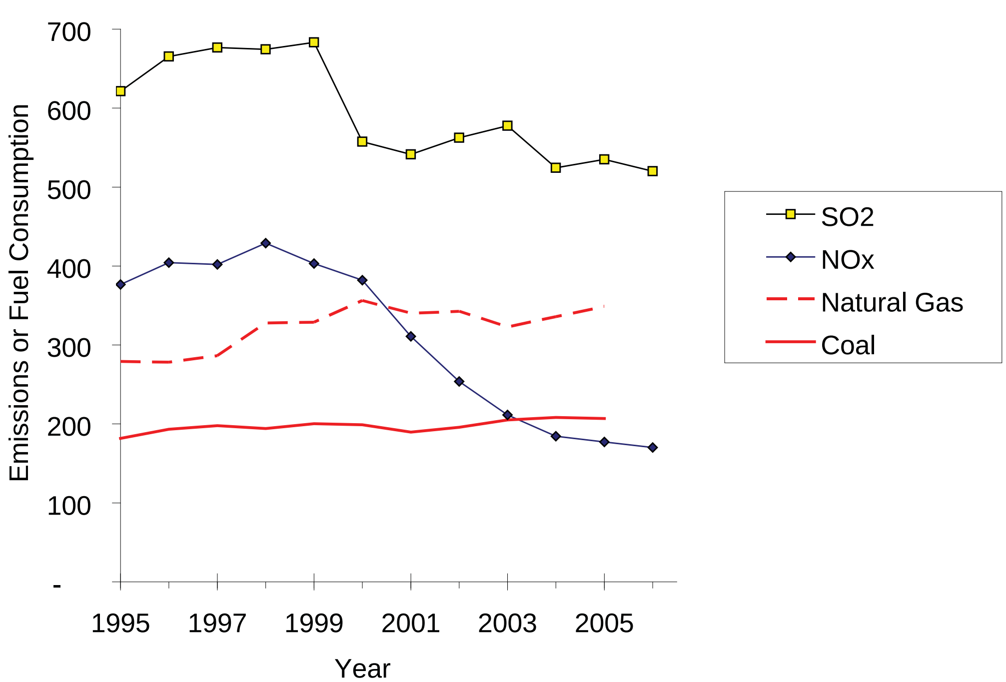
Texans can continue to meet their electricity needs by the most cost-effective means available, while continuing to reduce air pollution. When alternative energy sources or conservation measures make economic sense, consumers will adopt them voluntarily. The fact that consumers must be forced—through subsidies, generation mandates, efficiency requirements and the like—to buy energy from non-traditional sources is a sign that they don't make economic sense on their own terms.[5]

Texas already meets federal health standards for most air pollutants. The entire state meets federal standards for sulfur dioxide (SO2), nitrogen dioxide (NO2), carbon monoxide (CO), and lead, in all cases with plenty of room to spare. Dallas-Fort Worth (DFW) and nearly all of the rest of the state also complies with EPA's annual and 24-hour standards for fine particulate matter (PM2.5), including the much tougher 24-hour PM2.5 standard EPA recently adopted. Existing requirements will bring the few remaining PM2.5 non-attainment locations into compliance over the next few years. Likewise, pollutants such as benzene and 1,3-butadiene, whose emissions are regulated, but for which there are no specific federal limits on ambient levels, have also sharply declined and will continue to do so.

The key remaining air pollution challenge for DFW and other Texas cities is ozone. Ozone is not directly emitted, but is formed from chemical reactions driven by oxides of nitrogen (NOx) and volatile organic compounds (VOC) in the presence of sunlight.[6] The highest ozone levels tend to occur on sunny, warm days with low winds, because stagnant air allows ozone to build up. Texas has a number of metropolitan areas that violate the federal 8-hour ozone standard, including the DFW metropolitan area.[7]

According to computer modeling by consultants to the Texas Commission on Environmental Quality (TCEQ), about 46 percent of the ozone in the DFW area is caused by emissions within Texas and about 45 percent is either natural or the result of ozone and ozone-forming emissions transported from outside the U.S.[8] The remainder is due to transport from other states.

Figure 2 . Trends in Pollution Emissions and Fuel Consumption at Texas Power Plants[9]



Notes: SO2 and NOx emissions are in thousands of tons. Coal consumption is in millions of tons. Natural gas consumption is in tens of millions of cubic feet (that is, multiply the value in the chart by 10 million to get total cubic feet of natural gas consumed).

The tie-in with power plants is that they contribute to the NOx emissions that help form ozone. According to the modeling cited above, Texas power plants contributed an estimated 2 to 3 percent of DFW ozone on high-ozone days. The power plant contribution is small, because power plants contribute a small portion of total ozone-forming emissions. TCEQ estimates that power plants will account for less than 3 percent of total NOx emissions in the DFW area in 2007, down from about 7 percent in 2002.[10] The 3 percent is for the whole nine county nonattainment area, while the 2002 data was for the original four county area.

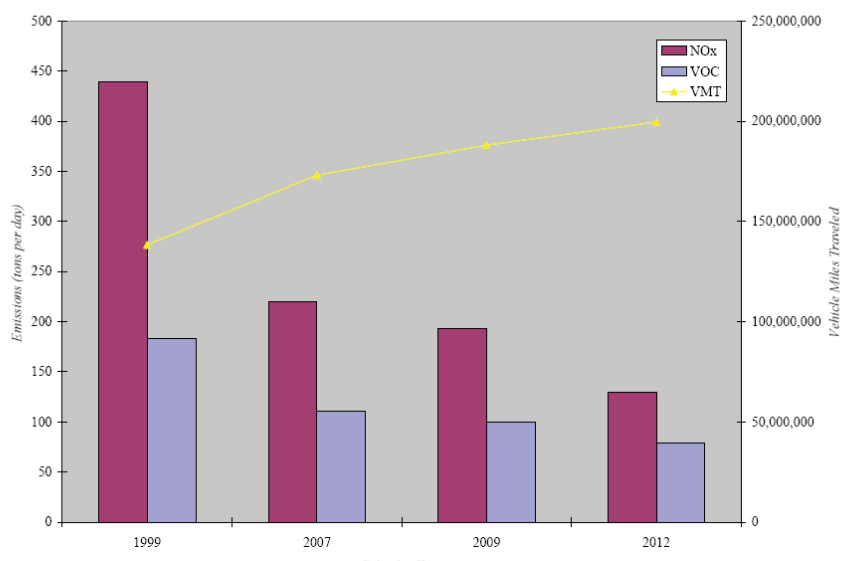
As shown in **Figure 2**, despite growing consumption of coal and natural gas for electricity, power plant emissions have rapidly declined in Texas. Since peaking in the late 1990s, annual power plant NOx emissions dropped by 60 percent and SO2 by 24 percent. NOx declined even more—64 percent—during the May-September "ozone season," when NOx emissions matter most for pollution levels. EPA's Clean Air Interstate Rule (CAIR) requires large additional NOx and SO2 reductions during the next decade that will eliminate most remaining power plant emissions.[11]

"Mobile sources"—diesel trucks, off-road diesel equipment, and automobiles—account for most NOx, contributing an estimated 81 percent of DFW NOx emissions in 2002 and 72 percent in 2007.[12] These emissions are dropping, as well. TCEQ estimates a 43 percent decline in on-road vehicle NOx from 2002 to 2007 and an 11 percent decline from non-road vehicles (e.g., construction and farm equipment). These improvements will continue. Existing federal vehicle emissions requirements will eliminate at least four-fifths of mobile source NOx emissions during the next 20 years or so, even after accounting for growth in total driving, as the fleet turns over to vehicles meeting EPA's tough 21st century standards.[13]

The proposed revision to the DFW plan to attain the federal 8-hour ozone standard includes a chart (reproduced below as **Figure 3**) that estimates NOx and VOC emissions from on-road mobile sources from 1999 to 2012. As the chart shows, on-road vehicle emissions are declining rapidly, despite steady increases in total miles of driving.

According to the proposed attainment plan, the nine-county DFW area needs to reduce NOx emissions to 400 tons per day to reach attainment of the 8-hour ozone standard—a reduction of about 44 tons per day, or 10 percent below estimated NOx emissions for 2007.[14] As Figure 3 shows, TCEQ estimates that on-road mobile source NOx will drop about 15 tons per year from 2007 to 2009 and about 20 tons per year thereafter. Declines will also continue well beyond 2012.[15] Off-road mobile source NOx has also been declining and these declines will accelerate when EPA's 90-percent NOx reduction requirement is implemented with the 2010 model year.[16]

Figure 3. Predicted Trend in On-Road Vehicle Emissions in the DFW Area, 1999-2012[17]



Notes: Emissions are in tons per day. Note that the number of years varies between each point along the horizontal axis. This makes it look like the rate of emissions decline is decreasing, when it is not.

In other words:

- DFW is currently only about 10 percent above where it needs to be on NOx emissions, in order to attain the 8-hour ozone standard.

- Power plants account for about 3 percent of NOx emissions. Power plant NOx emissions have been declining, despite increasing coal and natural gas consumption.

- Mobile sources account for 72 percent of NOx emissions. These emissions have been dropping about 8 percent per year for the last few years, and the rate of decline will accelerate in the future.[18]

Talking*Point*:

DFW will attain the 8-hour ozone standard, regardless of whether policymakers allow new coal plants to be built.

Seen in this light, the debate about power plant emissions misses the point. DFW will attain the 8-hour ozone standard, regardless of whether policymakers allow new coal plants to be built—even if we ignore the fact that earlier proposals included offsetting all of the NOx emissions from the new plants through reductions at existing plants. The hitch is that EPA requires DFW to reach attainment by 2009, a year or two before mobile source NOx emissions are guaranteed to be low enough to put DFW under the 400-ton-per-day cap.[19]

While this is not a trivial matter, it should not be used to deny Texans access to the lowest-cost sources of electricity. DFW can have affordable electricity and cleaner air. Two potential options are to, (1) allow new coal plants to be built, but require any new NOx emissions be offset by reductions elsewhere (e.g., existing power plants or other pollution sources), or (2) allow new coal plants to be built, but only if they begin operation after 2009, when additional mobile source NOx reductions will have provided a "cushion" to protect against any new NOx emissions from the coal plants.

For all intents and purposes, Texas and DFW can choose just about whatever level of power plant pollution they want, regardless of whether growing demand for electricity is met with coal or with other fuels. But there is a tradeoff to be made. Lowering pollution costs money, making electricity more expensive. Still coal plants with additional pollution controls are likely to provide cheaper electricity than the expensive alternative energy sources most often promoted by self-styled consumer advocates.

The real choice Texas policymakers face is how expensive they want to make electricity for their constituents. Given coal's cost advantage, banning new coal generation is likely to raise electricity costs, as is requiring existing plants to install the most stringent NOx controls. The way to meet air quality goals *and* keep electricity affordable is to allow utilities to build new coal plants if they wish, while requiring continued modest reductions in overall power plant NOx emissions.[20] In fact, EPA's Clean Air Interstate Rule (CAIR) already requires the elimination of most NOx (and SO2) from power plants, regardless of whether new plants are built. In any case, whatever Texas policymakers choose to do about power plants, the effect on air quality will be a small blip compared to the massive NOx and VOC reductions on tap for mobile sources. Either way, the air will be cleaner.

One final consideration is that EPA proposed a tougher ozone standard in June 2007 and expects to finalize the standard in March 2008. We don't know yet what this standard will be. Any tightening of the standard will require additional reductions in NOx and VOC beyond those necessary to attain the current 8-hour standard. However, because of the long lead times between proposal of a new standard and deadlines for attainment, it will be on the order of a decade or more before DFW and other areas must attain this new standard.[21] By then, most NOx and VOC will have been eliminated by mobile source fleet turnover and other federal requirements on NOx emissions from a range of smaller NOx sources (including power plants), while state and local policymakers will always have the option of requiring additional pollution controls. Taken together, these factors mean there is little risk in building new coal-fired power plants now.

It is also worth stressing, as will be demonstrated in detail below, that the current 8-hour ozone standard already protects public health with a large safety margin. Thus, future attainment of EPA's new ozone standard will be a legal and regulatory challenge, but not a public health issue.

The remainder of this report provides more detailed information on air pollution levels and trends, as well as on the health risks of current pollution levels for the people of Texas.

AIR POLLUTION TRENDS

Texas and Dallas-Fort Worth (DFW) already comply with most federal air pollution standards. All of Texas meets federal standards for carbon monoxide (CO), nitrogen dioxide (NO2), sulfur dioxide (SO2), and lead. Even though coal-burning is the main source of SO2 emissions, from 1996 to 2006, the highest SO2 levels in Texas didn't come within even half the level of EPA's 24-hour SO2 standard or within one-third the level of the annual standard.

The story is similar for NO2, a component of NOx. According to EPA's 2002 National Emissions Inventory, about 7 percent of NOx in the DFW area comes from power plants and about 13 percent statewide.[22] Almost all of the rest comes from diesel trucks, off-road diesel equipment, and automobiles. Nevertheless, the highest NO2 levels in Texas don't come within even half the federal standard.

Power plants do not appreciably contribute to carbon monoxide or volatile organic compound emissions. Almost all CO comes from motor vehicles, while the vast majority of VOC comes from gasoline vehicles, solvents, and coatings. However, it is worth noting that these pollutants have been declining as well. Texas, along with the rest of the nation, is achieving these reductions despite continuing increases in total miles of driving. The Appendix provides data charts with recent trends in the pollutants discussed above.

The main air quality concern with power plants is their contribution to ozone and fine particulate matter (PM2.5). Power plants contribute to PM2.5 through their SO2 emissions. SO2 is a gas, but some SO2 is converted into particulate sulfate through reactions in the atmosphere (and is therefore known as "secondary" particulate matter to distinguish it from directly emitted "primary" forms of PM, such as diesel soot or smoke from wood burning), contributing about one-third of total PM2.5 in the South-Central U.S.[23] Power plants contribute to ozone "smog" through their NOx emissions. NOx and VOC work together to form ozone.

Figures 4 and 5 display trends in PM2.5 from 2000 to 2006. Figure 4 shows the trend in annual average PM2.5 levels, while Figure 5 shows the trend in peak daily levels.[24] Each graph displays PM2.5 concentrations at the location with the highest pollution reading in either DFW or Texas as a whole, as well as the average level in Texas or DFW. The "average" trend includes only monitors that operated continuously over the given time period and, therefore, represents the general trend in PM2.5 levels. On the other hand, the "worst location" includes *all* monitoring locations that operated during a given year and thus provides information on the highest pollution levels found in a given region, but is not necessarily representative of trends.[25]

Average annual PM2.5 levels in DFW declined about 11 percent from 2000 to 2006 but have been relatively steady in the state overall. Peak PM2.5 levels have been declining more rapidly, dropping 21 percent in DFW during the last six years, with somewhat slower declines in the rest of the state. The entire DFW area and most of the rest of Texas complies with the annual PM2.5 standard. A handful of sites in the Houston and El Paso areas exceed the standard by relatively small margins. These areas will come into compliance over the next several years, as existing requirements achieve further reductions in diesel soot, SO2, and other contributors to particulate matter.

The entire state complies with the "old" daily PM2.5 standard, and nearly the entire state already complies with the much tougher daily standard that EPA will begin enforcing in 2010. Given current trends, the entire state will likely be in compliance by the time the new standard becomes effective—with the possible exception of parts of the Houston area.

Widespread PM2.5 monitoring began only a few years ago, as a result of EPA's adoption of national PM2.5 standards. However, we can also look at longer-term PM2.5 trends,

Figure 4: Fine Particulate Matter (PM2.5): Trend in Annual Average Concentration

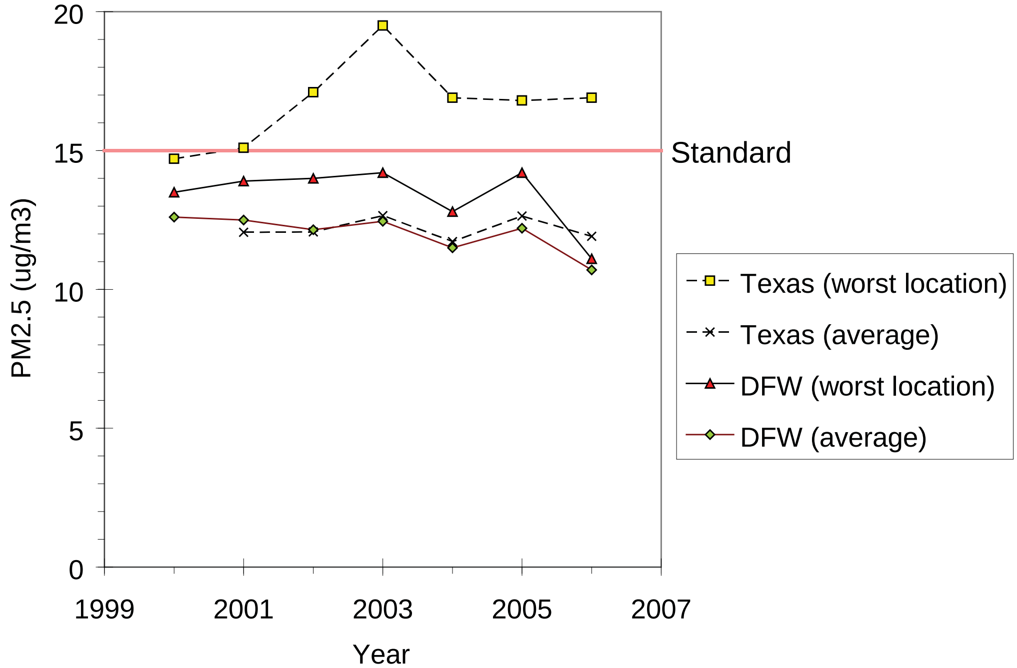
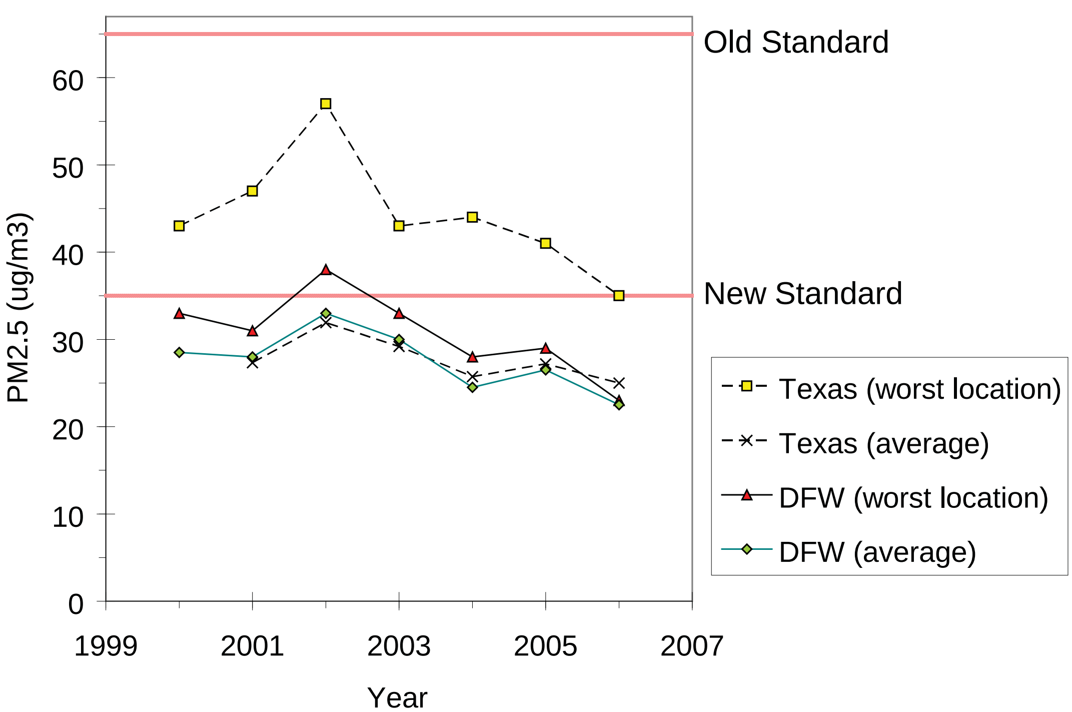


Figure 5 : Fine Particulate Matter (PM2.5): Trend in Peak Concentration



Notes: The "old" standard is the current legal standard. EPA adopted a "new" standard in 2006, which it will begin enforcing in 2010.

thanks to a special study EPA did on PM2.5 levels during the early 1980s.[26] Based on data from the study, current PM2.5 levels are more than 35 percent lower than levels during the early 1980s.

Ozone has been the most difficult air pollutant to banish. Large reductions in VOC and NOx have resulted in relatively modest reductions in ozone levels. Nevertheless, the comparatively high levels of the 1970s and 1980s are a thing of the past. Even Houston rarely exceeds the old 1-hour ozone standard. Exceedances of the tougher 8-hour standard are also relatively uncommon. And 2007 has turned out to be a record year, with ozone plunging to levels well below previous years. The relatively slow progress on ozone is not for lack of progress in reducing the NOx and VOC emissions that form ozone. As shown above, Texas has already achieved large reductions in NOx from power plants—a 64-percent reduction during the "ozone season" since emissions peaked in 1998.[27] Emissions from other NOx and VOC sources have also been dropping. TCEQ estimates that, from 2002 to 2007, total NOx and VOC emissions in DFW dropped 26 percent and 12 percent, respectively.[28]

Figure 6 displays the trend in days per year exceeding the 1-hour ozone standard (0.125 ppm, averaged over a 1-hour period) from 1996 to 2006. As the graph shows, exceedance of the 1-hour standard is rare. Even the worst location in DFW has only one or two days per year with ozone above the level of the standard. Most locations never exceed the standard. One-hour ozone-exceedance days have dropped substantially during the last decade.

In 2004, EPA replaced the 1-hour standard with the tougher 8-hour standard (0.085 ppm averaged over an 8-hour period).[29] The two standards are not directly comparable, because of the different averaging periods. However, the 1-hour standard is roughly equivalent to an 8-hour standard set at about 0.095 ppm. **Figure 7** shows the trend in exceedance days for the 8-hour standard. Because the 8-hour standard is more stringent, it is exceeded more frequently (Figures 6 and 7 have the same vertical scale, allowing easy comparison of 1-hour and 8-hour exceedance trends). Note that progress has been slower on 8-hour ozone exceedances.

Unlike the 1-hour standard, compliance with the 8-hour standard is based on the fourth-highest 8-hour ozone level each year, rather than on the number of days per year exceeding the standard.[30] Thus, **Figure 8** displays the trend in the fourth-highest 8-hour ozone level. The graph also marks the current 0.085 ppm standard. EPA recently proposed a more stringent 8-hour ozone standard.[31] Although the agency has not settled on a specific level, the new standard will probably be lowered from the current level of 0.085 ppm down to somewhere between 0.060 ppm to 0.080 ppm. EPA expects to announce its final decision in March 2008. As Figure 8 shows, fourth-highest ozone levels have been declining, on average, in Texas. This is mainly due to improvements in the Houston metro area. On the other hand, DFW's fourth-highest ozone levels were relatively steady from 1996 to 2006, before plunging to record lows in 2007.

The chemistry of ozone formation is complicated by a number of factors. Ozone formation is not a linear function of NOx and VOC emissions, but depends also on the ratio of VOC to NOx. At low VOC-to-NOx ratios, reducing NOx has no effect on ozone levels or can even increase ozone, while VOC reductions reduce ozone.[32] Recent research suggests that this is exactly the situation in cities in Texas and around the nation.[33] Other complicating factors include transport of ozone, NOx, and VOC from other areas and even from other countries. These issues of ozone control strategy are beyond the scope of this report. Regardless, existing federal requirements will eliminate most remaining NOx and VOC emissions, as well as emissions of other pollutants during the next two decades.

For example, EPA's Clean Air Interstate Rule (CAIR) will reduce power plant SO2 by more than 70 percent below 2003 emissions and NOx by nearly 60 percent.[34] The companion Clean Air Mercury Rule will eliminate most power plant mercury emissions.[35] These reductions and the subsequent permanent cap in total power plant emissions must be adhered to, regardless of how many coal-fired power plants are built or how much coal is burned. Yet the debate over coal-fired power has proceeded as if these requirements did not exist.

Existing requirements will also eliminate most emissions from mobile sources, which are the largest contributor to ozone and a major contributor to PM2.5. EPA's "Tier 2" automobile standards began phasing in with the 2004 model year and require emissions to be reduced by 77 to 95 percent below previously allowed levels for cars, SUVs, and pickup trucks.[36] New standards for heavy-duty trucks came into effect for the 2007 model year and require a 90-percent reduction in NOx and soot emissions, when compared with

Figure 6. Ozone: Trend in Days Per Year Exceeding 1-hour Ozone Standard

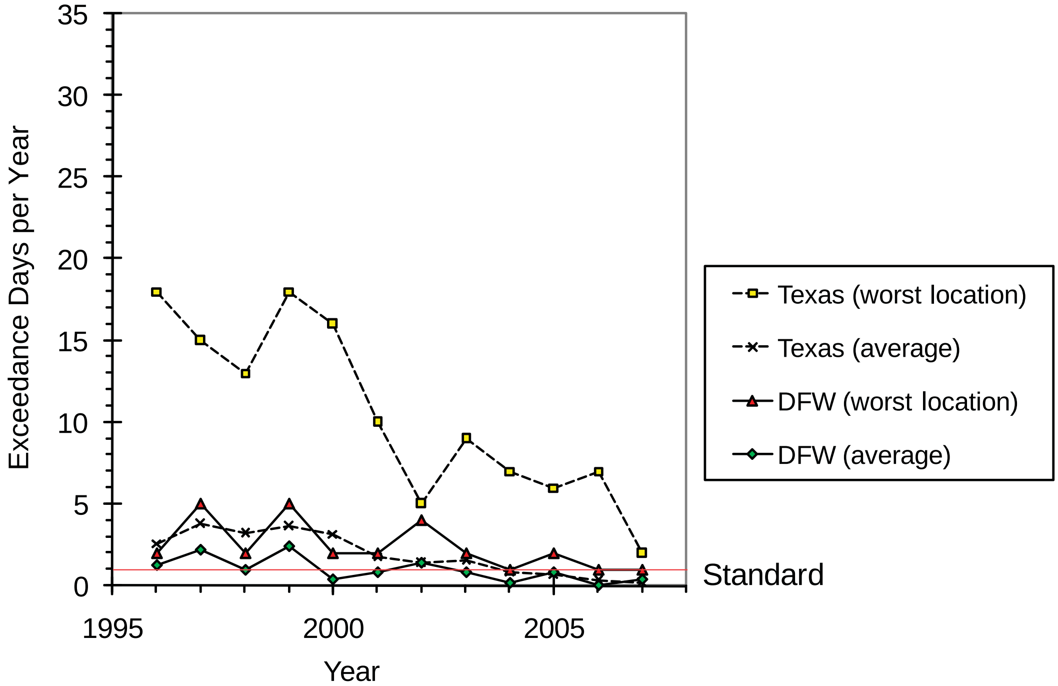


Figure 7. Ozone: Trend in Days Per Year Exceeding 8-hour Ozone Standard

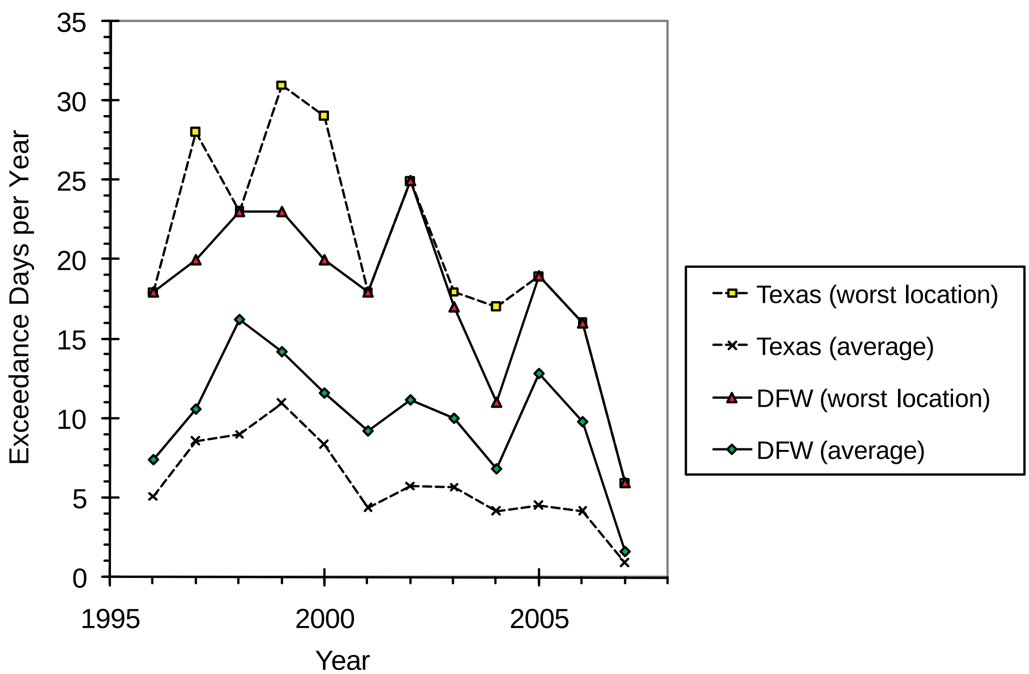
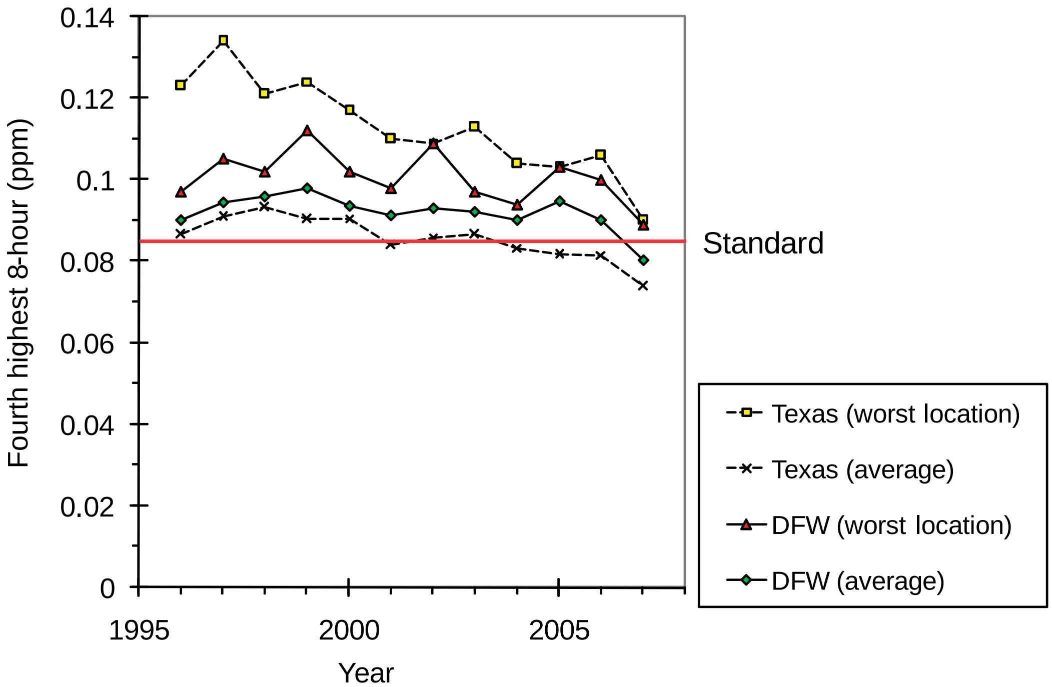


Figure 8. Ozone: Trend in Fourth-highest 8-hour Concentration Relative to 8-hour Standard



previous requirements.[37] A similar 90 percent reduction requirement comes into effect for off-road diesel vehicles in 2010.[38]

Based on these requirements, DFW regulators and planners predict that total NOx emissions from on-road vehicles will decline 80 percent between 2007 and 2025, while VOC will decline 55 percent—even after accounting for a projected 41 percent increase in total miles of driving in the region.[39] The actual VOC reduction will be substantially greater than 55 percent, because the computer model (known as MOBILE6) regulators use to predict future vehicle emissions has been shown to underestimate the real rate of automobile emissions improvement and to overstate the emissions of more recent models relative to earlier ones.[40]

The requirements above apply to the major sources of air pollution. During the next two decades, dozens of other EPA requirements will reduce emissions from just about every other source of air pollution as well.[41] When compared with the past several decades, most pollution emissions have already been eliminated. The vast majority of remaining air pollution will be eliminated during the next 20 years or so. To summarize, existing requirements will eliminate the vast majority of pollutant emissions, both within Texas and in other states. If TCEQ's modelers are correct that 54 percent of DFW ozone is due to Texas and other states' NOx and VOC emissions, most of this ozone will be gone in a decade or so, regardless of how Texas policymakers treat air pollution from existing or new coal plants. This is good news because it gives policymakers room to meet the twin goals of improved air quality and low-cost electricity.

AIR POLLUTION AND HEALTH

We've seen that pollution emissions have been dropping in Texas and the nation as a whole, resulting in steadily improving air quality. Ozone is the only remaining pollution standard that will be difficult for Texas and DFW to attain. However, the more important concern is what any given level of air pollution means for people's health. Here, the news is even better than the news on the emissions. Although press reports often create an appearance of grave harm from current levels of ozone, a wide range of evidence from health research shows that even ozone at levels as high as the old 1-hour standard have at worst a minor effect on people's health.

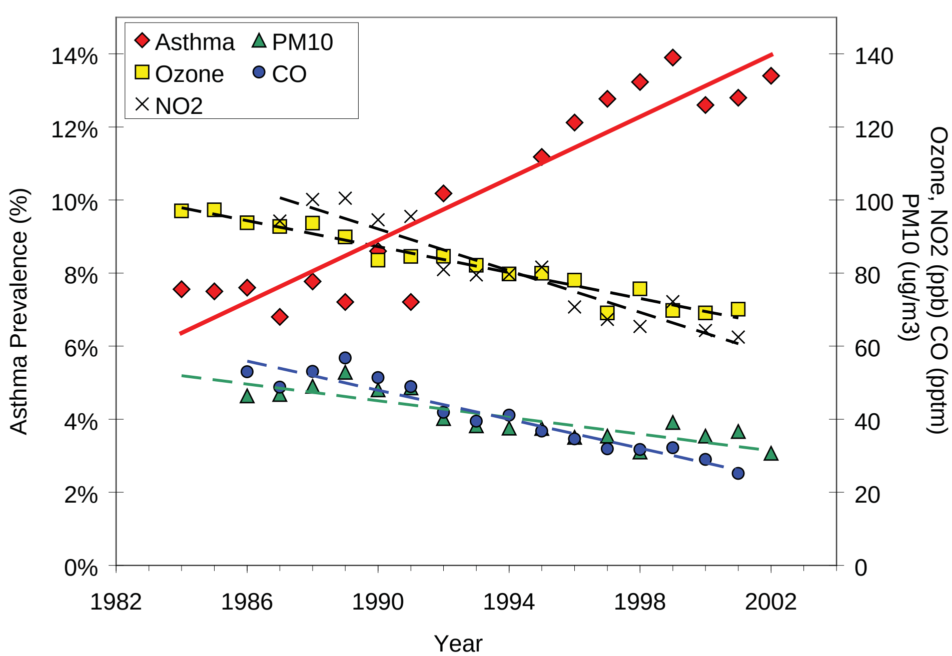
For example, the Children's Health Study (CHS) tracked thousands of California children living in communities ranging in air pollution from background levels, up to the smoggiest places in the nation. The study was funded by the California Air Resources Board (CARB) and performed by researchers from the University of Southern California (USC). After following the children for eight years, the researchers reported no association between ozone and lung capacity or lung growth, even though the communities in the study ranged from zero to 70 1-hour ozone exceedance days per year and zero to 120 8-hour ozone exceedance days.[42]

In another CHS analysis, the USC researchers reported *higher* ozone and other air pollutants were associated with a *lower* risk of developing asthma.[43] Though many claim air pollution as a cause of asthma, these claims have no real-world foundation. Around the U.S. and the Western world, asthma prevalence has been *rising* at the same time air pollution of all kinds has been *falling*. **Figure 9** shows the data for California. The pattern is similar across the U.S. —declining air pollution and rising asthma.

Cross-country data also demonstrate the implausibility of asthma-air pollution claims. Many developing countries have far higher air pollution than is ever found in the U.S., yet they have much lower rates of asthma than the U.S. or other Western countries.[44] The reunification of Germany highlighted the irrelevance of air pollution for the development of asthma. Before 1991, the former East Germany had high air pollution levels and low asthma prevalence. But after reunification, at a time when the former East Germans were adopting Western lifestyles and experiencing increases in income levels, air pollution declined, but the prevalence of asthma rose to levels comparable with those in the former West Germany.[45]

While ozone and other air pollutants are not a plausible cause of asthma, they can exacerbate pre-existing respiratory diseases. Yet once again, the effects of air pollution have been greatly overstated in popular accounts when compared with the weight of the evidence. For example, in a study published in the journal *Environmental Health Perspectives*, EPA scientists estimated that reducing nationwide ozone

Figure 9 . Declining Air Pollution, Rising Asthma[46]



Notes: All data are for California. Ozone, CO, and NO2 are the average of the top 30 daily readings for each year (ozone and CO peak 8-hour, NO2 peak 1-hour) across all monitoring sites for the given pollutant. PM10 is the average of the annual-average PM10 readings for all monitoring sites. Only sites with data in every year throughout the time period for each pollutant were included in the analysis. Number of monitoring sites for each pollutant: NO2=57, CO=47, Ozone=68, PM10=29. Pollution declined not only on average, but at nearly every individual monitoring site. The start of the time period (which ranges from 1984-1987) for each pollutant was chosen to maximize the number of monitoring sites included, while still overlapping the time period during which asthma prevalence rose. Lines through the data points are linear regression lines. CO is listed in parts per 10 million (pptm; divide by 10 in order to get parts per million) so that CO values fall within the same range as other pollutants on the graph. Ppb = parts per billion; ug/m3 = micrograms per cubic meter.

from levels during 2002, which had by far the highest ozone levels of the last six years, down to the federal 8-hour standard would reduce asthma emergency room visits by 0.04 percent and respiratory hospital admissions by 0.07 percent.[47]

CARB recently adopted an ozone standard for California that is much tougher than the federal standard, requiring ozone to be reduced to near or even below background levels across the state.[48] Nevertheless, CARB predicts these large ozone reductions would reduce emergency room visits for asthma and respiratory-related hospital admissions by only a few tenths of a percent.[49]

The seasonal pattern of asthma-related hospital visits is also an indicator of the minor risks from ozone. Data from around the U.S. show that hospital visits for asthma attacks are *lowest* in July and August—the months when ozone concentrations are at their *highest*.[50]

Despite the fact that virtually all of Texas meets EPA's toughest standards for particulate matter, activists also claim that "pollution from coal plants shortens the lives of 1,160 Texans each year."[51] The main form of particulate matter from coal-fired power plants is ammonium sulfate, as well as smaller amounts of ammonium nitrate.[52] However, laboratory studies with human volunteers, including volunteers with respiratory diseases, have shown that sulfate and nitrate are not toxic, even at levels many times the maximum levels found in ambient air.[53] In fact, ammonium sulfate is used as an inert control—that is, a compound with no health effects—in studies of the health effects of other types of particulates.[54] Furthermore, asthma inhaler medications are delivered in the form of sulfate aerosols. Because sulfates and nitrates are not toxic, activists are mistaken when they claim reducing particulate matter from power plants would have any health benefits.

Air pollution affects far fewer people, far less often, and with far less severity than advocates claim. For more detailed discussions of the evidence on air pollution's health effects, see the articles cited in the footnote.[55] The key point is that when it comes to power plants and air pollution, the public health stakes are far lower than Texans have been led to believe. Texans already have air that's safe to breathe. Nevertheless, existing requirements will continue to clean the air and will eliminate most remaining air pollution during the next two decades.

MERCURY

This paper has saved a discussion of mercury until now, because mercury is in a class by itself as an air pollutant. Although mercury is emitted into the air, the health concern is exposure to mercury through consumption of fish with elevated mercury levels—not through air inhalation or water consumption.[56] Fish at the top of the food chain—such as shark, swordfish, tuna, and the freshwater largemouth bass—tend to accumulate the highest levels.

The tie-in with coal-fired power plants is that coal contains trace amounts of mercury that are emitted into the air when the coal is burned. Coal-fired power plants are the largest source of U.S. mercury emissions, accounting for 45 percent of the estimated 112 tons of mercury emitted nationwide in 2002.[57] Texas has the largest mercury emissions of any state, and coal accounts for about half of the state's share.

Texas has been pilloried for being the nation's largest mercury emitter,[58] but this is merely a function of Texas' being one of the nation's most populous states. On a per capita basis, Texas ranks 22nd in mercury emissions, at 0.40 tons per million people, just above the national average of 0.38 tons per million. Nevada is first, by this measure, at 2.8 tons of mercury per million people.

The U.S. has reduced total mercury emissions by about 70 percent since 1989 and 80 to 90 percent since the early 1980s.[59] Coal-fired power plants have become the largest source of U.S. mercury emissions not because their emissions are particularly large or because their emissions have increased, but merely because the truly stupendous sources of mercury—incineration of mercury-containing wastes and processing of mercury-containing ores—have been virtually eliminated.

One more piece of context on mercury emissions: about two-thirds to three-fourths of mercury deposition in the U.S. comes from other countries.[60] The U.S. accounts for only about 2 percent of annual worldwide mercury emissions. However, mercury can travel long distances after it is emitted, and both natural and human-caused mercury are continually deposited and reemitted to the air.

The main issue is what mercury emissions mean for people's health. Many claim mercury emissions from coal are a serious health concern. For example, according to the

SEED Coalition, mercury "contaminates fish and leads to permanent brain damage in exposed children."[61] There is no doubt mercury is toxic when ingested in sufficient quantities. But claims such as the SEED Coalition's have literally nothing to do with reality. Americans' mercury exposures are nowhere close to levels that could cause brain damage.

There have been two major epidemiological studies of children exposed to relatively high levels of mercury through fish, one in the Seychelles Islands and the other in New Zealand.[62] Both populations were chosen because of their high fish consumption, resulting in mercury exposures about 10 times greater than those of Americans. Neither study found higher mercury exposures to be associated with lower IQs or anything else that could be construed as "brain damage," and none of the children in the studies were learning disabled or mentally retarded, despite their—by U.S. standards—enormous mercury exposures.

A third epidemiological study in the Faroe Islands assessed the effects of mercury exposure through consumption of whale meat.[63] Once again, the exposures were about 10 times greater than that of Americans. This study did not measure IQ. However, it did report that higher mercury exposures were associated with small reductions in performance on a few of the many neurological tests administered as part of the study. Once again, none of the children in the study were retarded, learning disabled, or in any way abnormal. And even the subtle effects reported in the study required much higher mercury exposures than Americans experience, and they were associated with mercury exposure through whale meat, rather than fish. It is also possible that the small mercury associations in this study were statistical artifacts, as the same study also reported that higher alcohol exposure during pregnancy was associated with *improved* performance on neurological tests.

So what does it take for mercury to cause brain damage? A key source of evidence for serious harm from mercury comes from tragic poisoning incidents in Japan and Iraq a few decades ago, where people suffered mental retardation, cerebral palsy, and seizures.[64] These incidents involved mercury exposures on the order of 100 times the levels Americans are exposed to through fish today and about 10 times the levels of children in the Seychelles, Faroe Islands, and New Zealand studies.

Texas anti-coal activists have also been claiming that mercury is causing children to become autistic.[65] The claim is based on a study that reported that each 1,000 lbs. of mercury emitted to the air in Texas is correlated with a 17 percent increase in autism.[66] The claim is implausible on its face. If mercury could cause such a large increase in autism, we should have seen a large reduction in the rate of autism in the U.S. during the last 25 years, concomitant with the elimination of most mercury emissions. But we see just the opposite—the prevalence of autism has increased. Likewise, if mercury posed a high risk of autism, the Seychelles and Faroe Islands, where children have 10 times the mercury exposures of Americans, should have unusually high rates of autism; they don't.

Regardless of the health effects of mercury, EPA's Clean Air Mercury Rule (CAMR), adopted last year, requires a 70 percent reduction in mercury from power plants over the next decade.[67] Just as for NOx and SO2 from coal-fired power plants, the overall CAMR mercury cap applies regardless of how many new coal-fired power plants are built or how much coal is burned. Total power plant mercury emissions must remain below the nationwide cap. Also, just as with NOx and SO2, Texas is essentially free to choose any level of mercury emissions it desires, subject, of course, to the tradeoff that tougher controls mean higher electricity costs.

Because of this tradeoff between emissions reductions and electricity costs, it makes sense to base regulations on actual health effects, rather than on irresponsible scare-mongering.

CONCLUSION

Once again, the debate over power plants in Texas has been based on false premises. Steady advances in technology are decoupling fossil-fuel energy use and air pollution, resulting in steady declines in pollution levels during the last few decades. Federal requirements for power plants, motor vehicles, and dozens of other sources will eliminate most remaining air pollutants during the next couple of decades. Air quality in Texas is good, getting better, and will continue to improve.

Power plants in Texas contribute only a few percent of NOx emissions and no VOC emissions. The federal Clean Air Interstate Rule puts a declining cap on even this small remaining NOx contribution—a cap that remains in place even if Texas builds more coal-fired power plants. Similar declining caps apply to power plant mercury and sulfur dioxide.

In other words, the debate about power plant emissions misses the point. The real choice Texas policymakers face is how expensive they want to make electricity for their constituents. The way to meet air quality goals and keep electricity affordable is to allow utilities to take advantage of the least costly energy sources available, including choosing to build new coal plants if they wish. Declining limits on power plant emissions ensure that air pollution from electricity generation will continue to decline, even as utilities continue to meet the increasing energy needs of Texas' citizens.

APPENDIX: ADDITIONAL DATA ON RECENT AIR POLLUTION TRENDS IN TEXAS AND DFW

This appendix presents additional data on air pollution trends in Texas and DFW specifically. Unless otherwise noted, all data were downloaded from EPA's air quality monitoring databases.

Figures 10 through 12 show levels of CO, NO2, and SO2, respectively, in Texas and the DFW metropolitan area from 1996 to 2006, relative to their respective federal health standards.[68] The graphs display the pollution concentration at the location with the highest pollution reading in the respective areas, as well as the average level.

The "average" trend includes only monitors that operated continuously over the given time period and, therefore, represents pollution trends in Texas and DFW. On the other hand, the worst location includes *all* monitoring locations that operated during a given year and, thus, provides information on the highest pollution levels in a region. Therefore, the worst location curve is not necessarily representative of trends, because pollution can vary from place to place, and monitoring sites go in and out of operation over time.

Note that, for all three pollutants, even the most polluted locations in Texas and DFW meet federal standards, with plenty of room to spare. CO declined substantially from 1996 to 2006, both on average and in the worst areas. Gasoline vehicles account for almost all CO emissions in metropolitan areas.[69] Thus, these large reductions in CO were achieved despite large increases in total driving, providing evidence that the average car is getting cleaner far faster than total driving is increasing.[70]

Even back in 1996, all of Texas already complied with the federal health standards for NO2 and SO2, and levels of both pollutants were very low, relative to the standards. Levels of both pollutants have remained low during the last decade. Automobiles, diesel trucks, and coal-fired power plants are the main sources of NO2, while coal combustion is the main source of SO2.[71] Thus, once again, increases in driving and energy production have occurred without increases in ambient NO2 levels.

Finally, **Figures 13 through 16** display trends in total and specific volatile organic compounds (VOC). Automobiles are the main source of VOC, yet VOC levels have declined, despite increases in driving.[72]

Figure 10: Carbon Monoxide (CO): Trend in Second-highest 8-hour Concentration

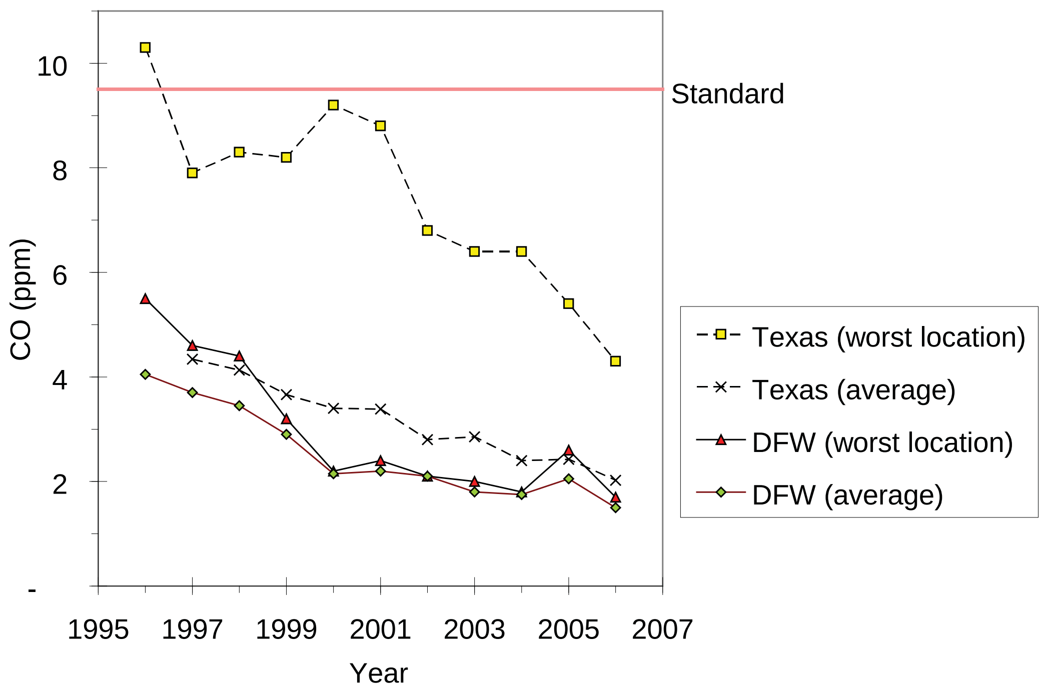


Figure 11: Nitrogen Dioxide (NO2): Trend in Average Annual Concentration

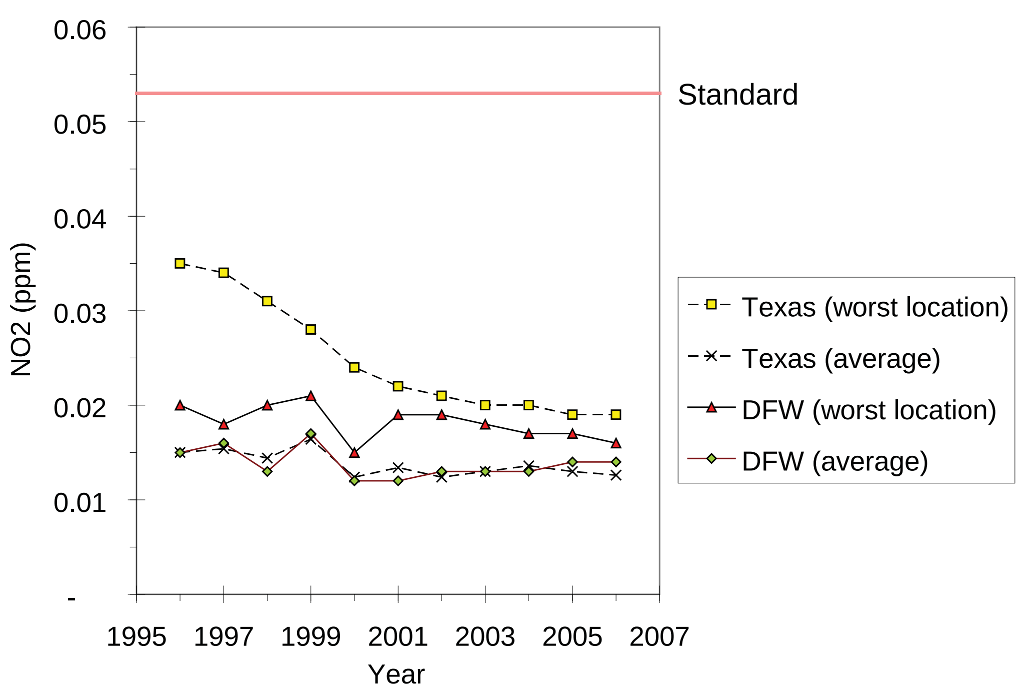


Figure 12: Sulfur Dioxide (SO2): Trend in Average Annual Concentration

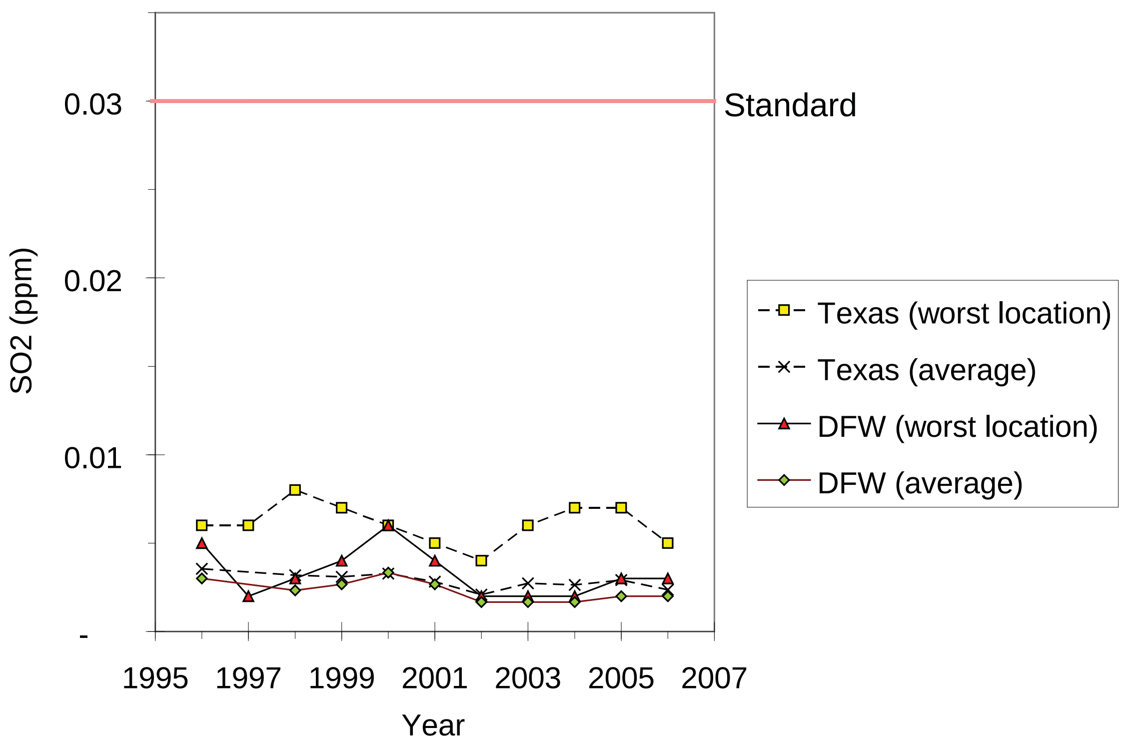


Figure 13: Volatile Organic Compounds (VOC): Trend in Average Annual Levels[73] in the Houston-Galveston-Brazoria Metropolitan Area

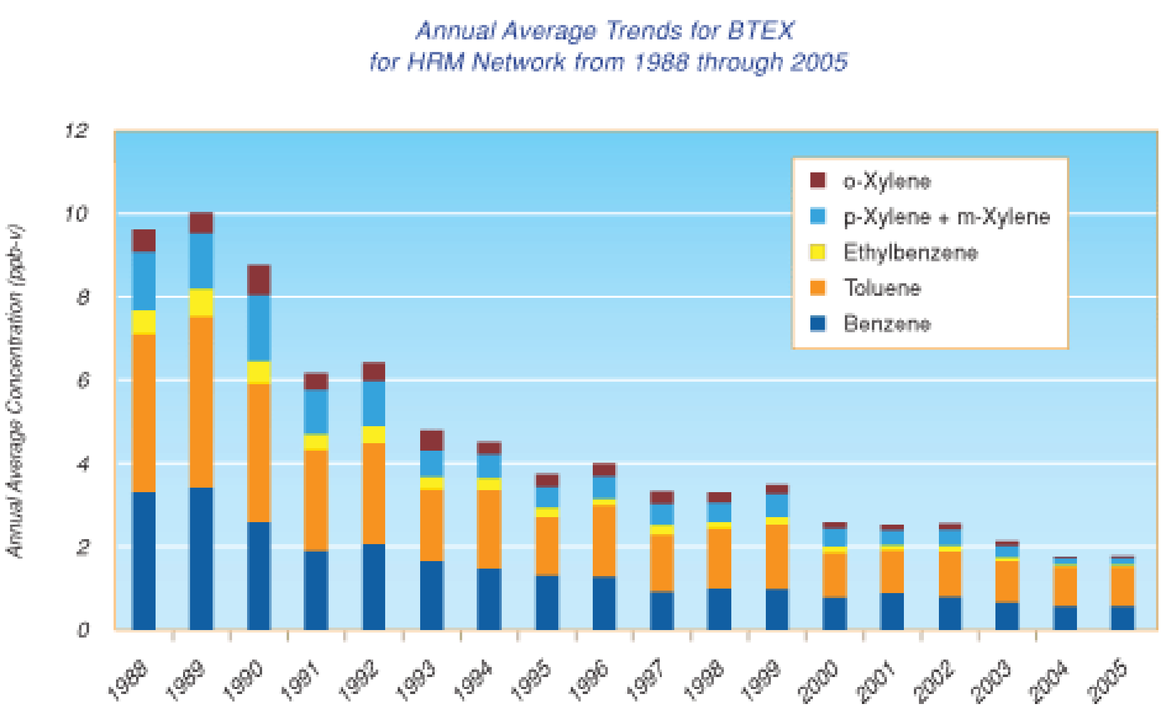


Figure 14. Volatile Organic Compounds (VOC): Trend in Average Annual Levels in Dallas[74]

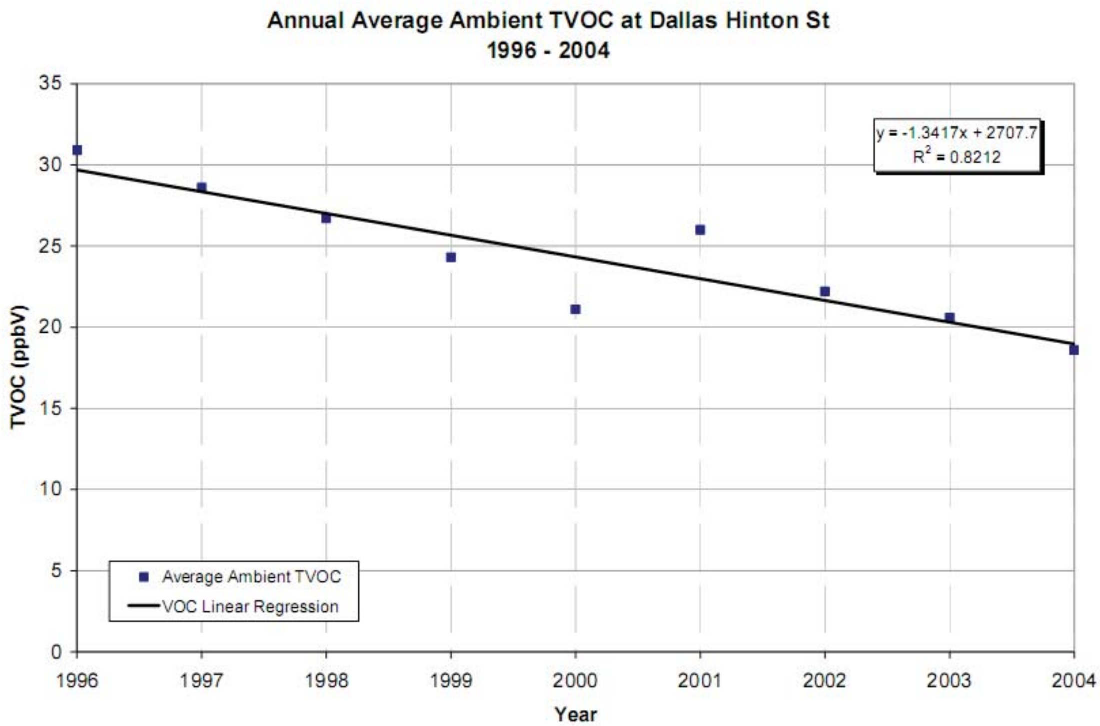


Figure 15. Benzene: Trend in Average Annual Levels

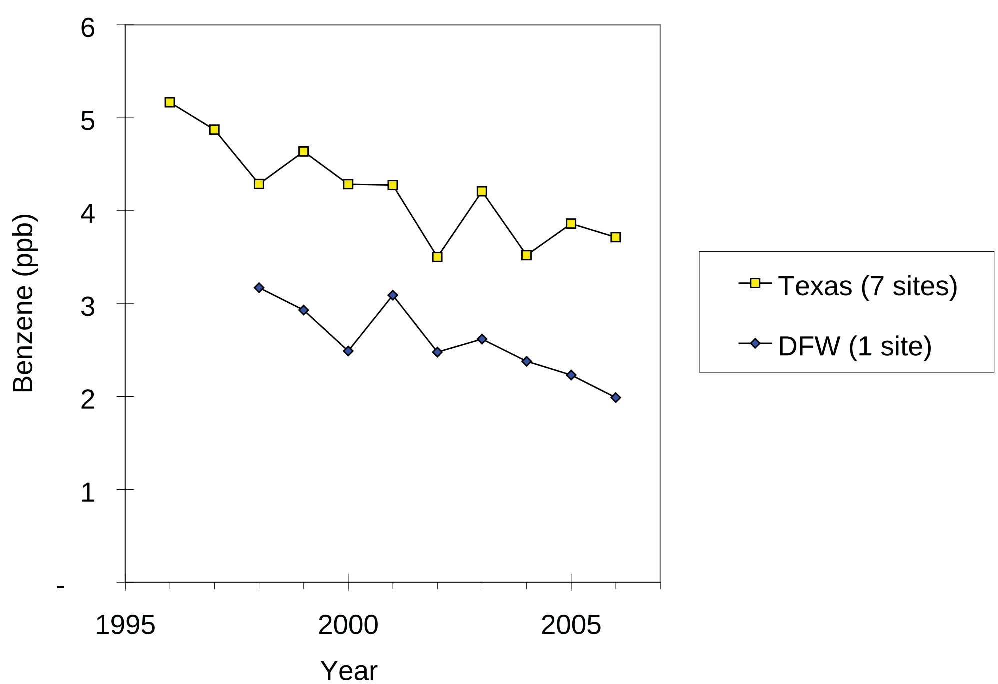
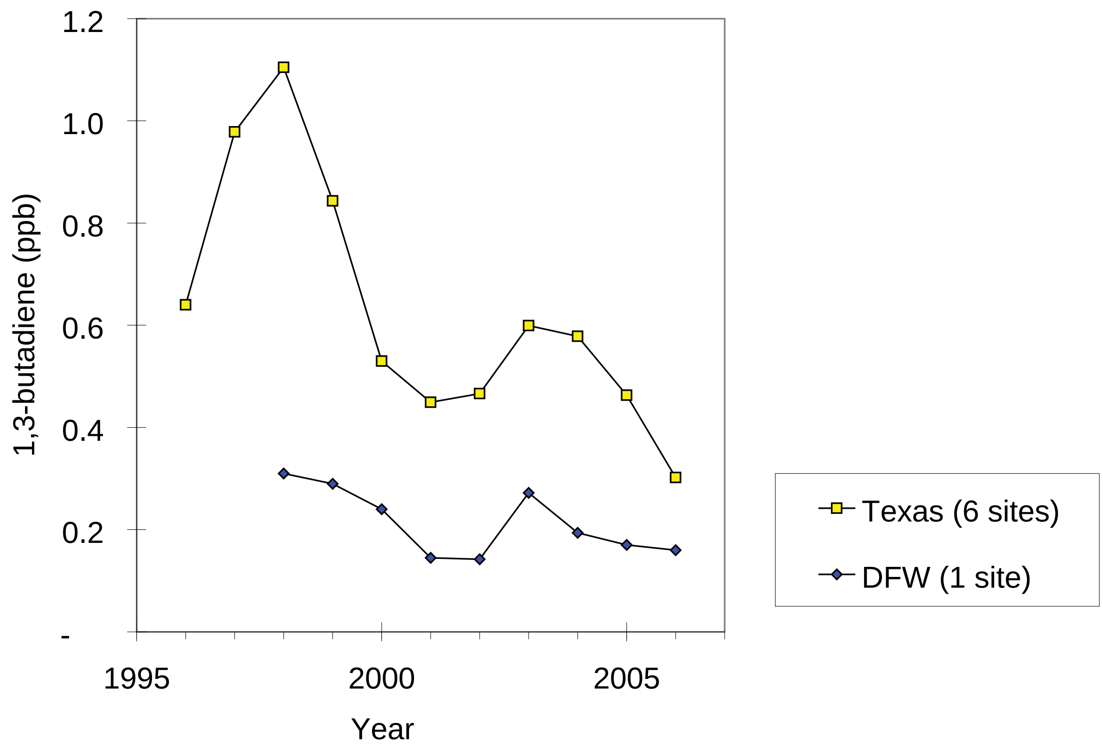


Figure 16: 1,3-butadiene: Trend in Average Annual Levels in the Houston-Galveston-Brazoria Metropolitan Area



Notes: The chart excludes one outlier site with much higher 1,3-butadiene levels. This is the Merriman St. site in Port Neches. This site averaged about 33 ppb in 1996. Levels declined substantially between 1996 and 2000. Since 2000, levels have ranged from about 4 to 6 ppb.

ENDNOTES

[1] As this paper was being written, the Environmental Protection Agency posted national air pollution data through 2006, demonstrating continued improvements. EPA's website provides charts of national, state, and local pollution monitoring data at http://www.epa.gov/airtrends/. Click on the links for each air pollutant for national and local trend data.

[2] *See* Foundation for Clean Air Progress, Clean Air National Survey Results (Wirthlin Worldwide: Aug. 2004) http://www.cleanairprogress.org/research/clean_secret_survey.asp.

[3] *See* D. Schoenbrod, "Putting the 'Law' Back into Environmental Law," Regulation 22 (1999) http://www.cato.org/pubs/regulation/regv22n1/envirolaw.pdf; J. Schwartz, "Air Quality: Much Worse on Paper Than in Reality" (Washington, DC: American Enterprise Institute, May 2005) http://www.aei.org/docLib/20050602_EPOMay_Junenewg%282%29.pdf; J. Schwartz, "Air Pollution and Health: Do Popular Portrayals Reflect the Scientific Evidence?" (Washington, DC: American Enterprise Institute, May 2006) http://www.joelschwartz.com/pdfs/AirPoll_Health_EPO_0506.pdf; J. Schwartz, "Air Pollution: Why Is Public Perception So Different from Reality?" *Environmental Progress* 25 (2006) 291-97.

[4] Sources: Bureau of Economic Analysis, National Economic Accounts, U.S. Department of Commerce, http://www.bea.doc.gov/bea/dn/nipaweb/SelectTable.asp (accessed 15 Nov. 2006); Bureau of Transportation Statistics, National Transportation Statistics, http://www.bts.gov/publications/national_transportation_statistics/ (accessed 2 Apr. 2007); D. O. Hinton, J. M. Sune, J. C. Suggs, et al., Inhalable Particulate Network Report: Operation and Data Summary (Mass Concentrations Only) Volume I, April 1979–December 1982 (Research Triangle Park, N.C.: Environmental Protection Agency, Nov. 1984); D.O. Hinton, J. M. Sune, J. C. Suggs, et al., Inhalable Particulate Network Report: Data Summary (Mass Concentrations Only), Volume III, January 1983-December 1984 (Research Triangle Park, N.C.: Environmental Protection Agency, Apr.1986); Energy Information Administration, Annual Energy Review 2005 (July 2006) http://www.eia.doe.gov/emeu/aer/pdf/aer.pdf (accessed 15 Nov. 2006); Environmental Protection Agency, Air Emission Trends, http://www.epa.gov/airtrends/econ-emissions.html (accessed 15 Nov. 2006); Environmental Protection Agency, AirTrends, http://www.epa.gov/airtrends/ (accessed 15 Nov. 2006); Environmental Protection Agency, Airdata: Reports and Maps, http://www.epa.gov/air/data/reports.html (accessed 15 Nov. 2006). The graph provides the percentage change in the average number of days per year that U.S. ozone monitoring sites exceeding the 1-hour and 8-hour ozone standards. For PM2.5, the base-year data were collected at various times during 1979-83, as part of an EPA special study (the Inhalable Particulate Monitoring Network) in about 90 metropolitan areas, rather than only during 1980.

[5] It is also possible that in some cases laws or regulations stand in the way of adoption of otherwise cost effective energy sources or efficiency measures. When this is the case, the appropriate response is to remove the artificial regulatory or legal barriers to adoption of these alternatives.

[6] NOx is the sum of nitric oxide (NO) and nitrogen dioxide (NO2), which are continually interconverted through the chemical reaction cycles that form ozone.

[7] The federal standard requires that the average of the 4th-highest 8-hour ozone levels from each of the most recent three years be less than 0.085 parts per million (ppm). The worst location in the DFW area averaged 0.096 ppm for 2004-2006.

[8] These model results are based on an estimate of what NOx and VOC emissions will be in 2009. Peter Breitenbach, DFW Modeling Update, DFW Photochemical Modeling Technical Committee Meeting (6 July 2006) http://www.tceq.state.tx.us/assets/public/implementation/air/am/committees/pmt_dfw/20060706/06.07.06-breitenbach-dfw_modeling.pdf.

[9] Sources: U.S. Environmental Protection Agency, "Clean Air Markets – Data and Maps," http://cfpub.epa.gov/gdm/index.cfm?fuseaction=emissions.wizard&EQW_datasetSelection= (accessed 18 Mar. 2007); U.S. Energy Information Administration, "Electric Power Annual 2005 – State Data Tables," Nov. 2006 (accessed 8 Apr. 2007) http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html.

[10] Power plants are not a significant source of VOC, accounting for well under 1 percent of estimated emissions. Emissions estimates by source category for 2002 and 2007 were downloaded from TCEQ at http://www.tceq.state.tx.us/implementation/air/airmod/data/dfw1.html. These emissions breakdowns include only human-caused emissions. According to TCEQ estimates for 2002, about 2 to 3 percent of NOx and nearly half of all VOC in the DFW area is the result of natural or "biogenic" emissions from vegetation and soils. The biogenic fraction has increased since 2002, due to declines in human-caused emissions. Texas Commission on Environmental Quality, Texas 2002 Periodic Emissions Inventory: Area, Nonroad Mobile, and Biogenic Sources (Austin, June 2004) ftp://ftp.tceq.state.tx.us/pub/OEPAA/TAD/Modeling/DFW/pei/2002/area_nonroad/TX_2002_Area_NonRoad_Mobile_EI_report.pdf.

[11] U.S. Environmental Protection Agency, Projected Annual SO2 and NOx Emissions, and Projected Costs of CAIR (Washington, DC: 2005) http://www.epa.gov/cair/charts_files/cair_emissions_costs.pdf.

[12] Emissions estimates by source category for 2002 and 2007 were downloaded from TCEQ at http://www.tceq.state.tx.us/implementation/air/airmod/data/dfw1.html.

[13] North Central Texas Council of Governments, Mobility 2025 (Fort Worth, Texas: April 2006) http://www.nctcog.org/trans/mtp/current/; North Central Texas Council of Governments, Mobility 2030, Transportation Improvement Program, and Associated Air Quality Conformity Analysis (Fort Worth, Texas: 14 Dec. 2006) http://www.nctcog.org/trans/mtp/2030/MTPRecommendations.pdf.

[14] TCEQ, Proposed Eight-Hour Ozone Attainment Demonstration SIP Revision for the DFW Area (Austin, 13 Dec. 2006) http://www.tceq.state.tx.us/assets/public/implementation/air/sip/dfw/dfw_ad_sip_2006/2006013SIPNR_Chap4_112106.pdf.

[15] For longer term projections, see NCTCOG Mobility 2025 and 2030 reports cited in note 10.

[16] U.S. Environmental Protection Agency, Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines (Washington, DC: May 2004) http://www.epa.gov/nonroad-diesel/2004fr/420r04007.pdf.

[17] Source: TCEQ, Proposed Eight-Hour Ozone Attainment Demonstration SIP Revision for the DFW Area (Austin, 13 Dec. 2006) http://www.tceq.state.tx.us/assets/public/implementation/air/sip/dfw/dfw_ad_sip_2006/2006013SIPNR_Chap4_112106.pdf.

[18] Recent rate of decline is based on a comparison of the 2002 and 2007 mobile source inventories discussed earlier.

[19] And also bear in mind that mobile source NOx and VOC emissions are dropping everywhere else in the U.S. as well, so the amount of ozone and ozone-forming emissions transported into the DFW area is also dropping.

[20] In fact, EPA's Clean Air Interstate Rule will require large reductions in total NOx (and SO2) from power plants, regardless of whether new plants are built.

[21] For comparison, EPA proposed the current ozone standard in 1996 and DFW's attainment deadline is 2009. Lawsuits caused a few years of delay in implementing the standard. But even without any lawsuits, there would be on the order of a decade from proposal to attainment deadline.

[22] The power plant fraction is probably a bit lower now, because power plant NOx has likely dropped more rapidly during the last few years when compared with other NOx sources. U.S. Environmental Protection Agency, "2002 National Emissions Inventory Data & Documentation," http://www.epa.gov/ttn/chief/net/2002inventory.html.

[23] NOx emissions also contribute to PM2.5 because some NOx is converted to particulate nitrate. However, this is mainly a concern in the western half of the U.S. NOx is a minor contributor to PM2.5 in the eastern half of the U.S. Environmental Protection Agency, Latest Findings on National Air Quality: 2002 Status and Trends (Washington, DC: Aug. 2003) http://www.epa.gov/air/airtrends/aqtrnd02/2002_airtrends_final.pdf.

[24] The values in Figure 5 are the 98th percentile of daily readings in a given year. If daily PM2.5 readings at a given site for a given year are ranked from highest to lowest, the 98th percentile corresponds to the 7th worst day. For daily PM2.5 levels, EPA recently lowered the standard from 65 micrograms per cubic meter (⊠g/m3) down to 35 ⊠g/m3. Both standards are marked in Figure 5. EPA will begin enforcing the new standard in 2010.

[25] The reason for this is that pollution can vary from place to place and monitoring sites go in and out of operation over time.

[26] EPA collected PM2.5 data in about 90 metropolitan areas, including Dallas, during 1979-1983 as part of a special study. D.O. Hinton, J.M. Sune, J. C. Suggs et al., Inhalable Particulate Network Report: Operation and Data Summary (Mass Concentrations Only) Volume I, April 1979–December 1982 (Research Triangle Park, NC: Environmental Protection Agency, Nov. 1984); D.O. Hinton, J.M. Sune, J. C. Suggs et al., Inhalable Particulate Network Report: Data Summary (Mass Concentrations Only) Volume III, January 1983-December 1984 (Research Triangle Park, NC: Environmental Protection Agency, Apr. 1986).

[27] U.S. Environmental Protection Agency, "Clean Air Markets – Data and Maps," http://cfpub.epa.gov/gdm/index.cfm?fuseaction=emissions.wizard&EQW_datasetSelection=.

[28] Emissions estimates by source category for 2002 and 2007 were downloaded from TCEQ at http://www.tceq.state.tx.us/implementation/air/airmod/data/dfw1.html.

[29] The 8-hour standard was adopted in 1997, but, due to legal challenges, was not implemented until 2004.

[30] That is, for each monitoring site in each year, rank daily 8-hour-average ozone levels from 1 to 365 and take the fourth-highest day. To comply, the average of the fourth-highest reading from each of the most recent three years must be less than 0.085 ppm. In contrast, the 1-hour standard requires that each monitoring site have no more than 3 exceedance days during the most recent three-year period.

[31] U.S. Environmental Protection Agency, National Ambient Air Quality Standards for Ozone, *Federal Register* (11 July 2007) 37818-37919.

[32] N. Carslaw and D. Carslaw, "The Gas-Phase Chemistry of Urban Atmospheres," *Surveys in Geophysics* 22 (2001) 31-53; J. H. Seinfeld, "Urban Air Pollution: State of the Science," *Science* 243 (1989) 745-52.

[33] B. K. Pun and C. Seigneur, "Day-of-Week Behavior of Atmospheric Ozone in Three U.S. Cities," *Journal of the Air & Waste Management Association* 53 (2003) 789-801; R. Torres-Jardon and T. C. Keener, "Evaluation of Ozone-Nitrogen Oxides-Volatile Organic Compound Sensitivity of Cincinnati, Ohio," *Journal of the Air & Waste Management Association* 56 (2006) 322-33; C. L. Blanchard and S. J. Tannenbaum, "Weekday/Weekend Differences in Ambient Air Pollutant Concentrations in Atlanta and the Southeastern United States," *Journal of the Air & Waste Management Association* 56 (2006) 271-84; C. L. Blanchard, S. Tanenbaum and D. R. Lawson, "Differences between Weekday and Weekend Air Pollutant Levels in Atlanta, Baltimore, Chicago, Dallas-Fort Worth, Denver, Houston, New York, Phoenix, Washington, DC, and Surrounding Areas," *Journal of the Air and Waste Management Association* (2008) in review; S. Reynolds, C. L. Blanchard, and S. D. Ziman, "Understanding the Effectiveness of Precursor Reductions in Lowering 8-Hr Ozone Concentrations," *Journal of the Air & Waste Management Association* 53 (2003) 195-205; S. Reynolds, C. L. Blanchard, and S. D. Ziman, "Understanding the Effectiveness of Precursor Reductions in Lowering 8-Hour Ozone Concentrations—Part II. The Eastern United States," *Journal of the Air & Waste Management Association* 54 (2004) 1452-70; E. M. Fujita, W. R. Stockwell, D. E. Campbell, et al., "Evolution of the Magnitude and Spatial Extent of the Weekend Ozone Effect in California's South Coast Air Basin 1981-2000," *Journal of the Air & Waste Management Association* 53 (2003) 864-75; D. R. Lawson, "The Weekend Effect—The Weekly Ambient Emissions Control Experiment," *Environmental Manager* (July 2003) 17-25; L. C. Marr and R. A. Harley, "Modeling the Effect of Weekday-Weekend Differences in Motor Vehicle Emissions on Photochemical Air Pollution in Central California," *Environmental Science & Technology* 36 (2002) 4099-4106; L. C. Marr and R. A. Harley, "Spectral Analysis of Weekday-Weekend Differences in Ambient Ozone, Nitrogen Oxide, and Non-Methane Hydrocarbon Time Series in California," *Atmospheric Environment* 36 (2002) 2327-35.

[34] U.S. Environmental Protection Agency, Projected Annual SO2 and NOx Emissions, and Projected Costs of CAIR.

[35] U.S. Environmental Protection Agency, "Clean Air Mercury Rule – Basic Information," http://www.epa.gov/camr/basic.htm.

[36] Environmental Protection Agency, "Control of Air Pollution from New Motor Vehicles: Tier 2 Motor Vehicle Emissions Standards and Gasoline Sulfur Control Requirements; Final Rule," Federal Register (10 Feb. 2000) 6698-870, www.epa.gov/otaq/tr2home.htm#preamble; Environmental Protection Agency, Clean Vehicles + Clean Fuel = Cleaner Air (Washington, DC: 2004) http://www.epa.gov/tier2/420f04002.pdf; Natural Resources Defense Council, EPA Touts New Cleaner Cars (26 Jan. 2004) http://www.nrdc.org/bushrecord/2004_01.asp.

[37] U.S. Environmental Protection Agency, Regulatory Impact Analysis: Heavy-Duty Engine and Vehicle Standards and Highway Diesel Fuel Sulfur Control Requirements (Washington, DC: Dec. 2000) http://www.epa.gov/otaq/diesel.htm.

[38] U.S. Environmental Protection Agency, Final Regulatory Impact Analysis: Control of Emissions from Nonroad Diesel Engines.

[39] North Central Texas Council of Governments, Mobility 2025; North Central Texas Council of Governments, Mobility 2030, Transportation Improvement Program, and Associated Air Quality Conformity Analysis.

[40] P. McClintock, "Mobile6 vs. On-Road Exhaust Emissions and Mobile6 Evaporative Credits vs. I/M Gas Cap Failures," 19th Annual Mobile Sources Clean Air Conference, Steamboat Springs, Colorado, September, 2003; P. McClintock, "Comparing Remote Sensing Emissions Measurements in St. Louis to Emissions Estimates from the Mobile6 Arterial Roadway Type," 16th Annual CRC On-road Emissions Workshop, San Diego, Coordinating Research Council, Mar. 2006.

[41] *See* U.S. Environmental Protection Agency, Regulatory Announcement: Emission Standards for New Nonroad Engines (Washington, DC: September 2002) http://www.epa.gov/otaq/regs/nonroad/2002/f02037.pdf; Environmental Protection Agency, Regulatory Announcement: Frequently Asked Questions from Facility Managers and Other Owners of Industrial Spark-Ignition Engines (Washington, DC: Sept. 2002) http://www.epa.gov/otaq/regs/nonroad/2002/f02041.pdf; Environmental Protection Agency, Regulatory Announcement: EPA Proposal for More Stringent Emissions Standards for Locomotives (Washington, DC: Mar. 2007) http://www.epa.gov/otaq/regs/nonroad/420f07015.htm; U.S. Environmental Protection Agency, "Emission Standards for Hazardous Air Pollutants," (last updated 26 Mar. 2007) http://www.epa.gov/ttn/atw/mactfnlalph.html.

[42] Exceedance days per year were determined from CHS ozone monitoring data provided by staff at the California Air Resources Board.

[43] The study did report that higher ozone was associated with a higher risk of asthma in a subset of children who played three or more team sports. However, this association was found only in the four highest-ozone communities, which averaged 89 8-hour ozone exceedance days per year—much higher ozone than ever occurs in Texas, or anywhere else outside the CHS study areas. R. McConnell, K. Berhane, F. Gilliland et al., "Asthma in Exercising Children Exposed to Ozone: A Cohort Study," *Lancet* 359 (2002) 386-91.

[44] For international data, see "Worldwide Variation in Prevalence of Symptoms of Asthma, Allergic Rhinoconjunctivitis, and Atopic Eczema: Isaac. The International Study of Asthma and Allergies in Childhood (Isaac) Steering Committee," *Lancet* 351 (1998) 1225-32.

[45] J. Heinrich, B. Hoelscher, C. Frye et al., "Trends in Prevalence of Atopic Diseases and Allergic Sensitization in Children in Eastern Germany," *European Respiratory Journal* 19 (2002) 1040-6; J. Heinrich, K. Richter, H. Magnussen et al., "Is the Prevalence of Atopic Diseases in East and West Germany Already Converging?" *European Journal of Epidemiology* 14 (1998) 239-45.

[46] Sources: Asthma prevalence: California Department of Health Services, Points of Interest—Asthma in California (Sacramento: 9 May 2003). Air pollution: California Air Resources Board, 2003 Air Pollution Data CD, http://www.arb.ca.gov/aqd/aqdcd/aqdcd.htm.

[47] This analysis assumes that there are no health benefits from additional ozone reductions once the standard is achieved. If benefits continue to accrue as pollution drops below the level of the standard, then percentage reduction in respiratory distress would be about five times greater than the values in the text, or 0.2 and 0.35 percent, respectively. B. J. Hubbell, A. Hallberg, D. R. McCubbin et al., "Health-Related Benefits of Attaining the 8-Hr Ozone Standard," *Environmental Health Perspectives* 113 (2005) 73-82; J. Schwartz, *Rethinking the California Air Resources Board's Ozone Standards* (Washington, DC: American Enterprise Institute, Sept. 2005) http://www.aei.org/doclib/20050912_Schwartzwhitepaper.pdf.

[48] California Air Resources Board, Review of the California Ambient Air Quality Standard for Ozone (Sacramento: Mar. 2005) http://www.arb.ca.gov/research/aaqs/ozone-rs/ozone-final/ozone-final.htm.

[49] Once again, the benefits would be greater—about a 1 to 2 percent reduction in respiratory hospital visits—if they continue to accrue as pollution declines below the level of the standard. Schwartz, *Rethinking the California Air Resources Board's Ozone Standards.*

[50] For data on asthma emergency room visits and hospitalizations by month, see, for example, Spokane Regional Health District, Asthma in Spokane County (Spokane, Washington: Apr. 2002) http://www.srhd.org/information/pubs/pdf/factsheets/AsthmaInSpokaneCounty.pdf; J. K. Stockman, N. Shaikh, J. von Behren et al., California County Asthma Hospitalization Chart Book, Data from 1998-2000 (Sacramento: California Department of Health Services, Sept. 2003) http://www.ehib.org/cma/papers/Hosp_Cht_Book_2003.pdf; Texas Department of Health, Asthma Prevalence, Hospitalizations and Mortality – Texas, 1999-2001 (Austin: 21 Nov. 2003) http://archive.dshs.state.tx.us/legacytdh/cphpr/asthma.htm; K. Tippy and N. Sonnenfeld, Asthma Status Report, Maine 2002 (Augusta, Maine: Maine Bureau of Health, 25 Nov. 2002); K. R. Wilcox and J. Hogan, An Analysis of Childhood Asthma Hospitalizations and Deaths in Michigan, 1989-1993 (Lansing, Michigan: Michigan Department of Community Health, undated) http://www.michigan.gov/documents/Childhood_Asthma_6549_7.pdf.

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