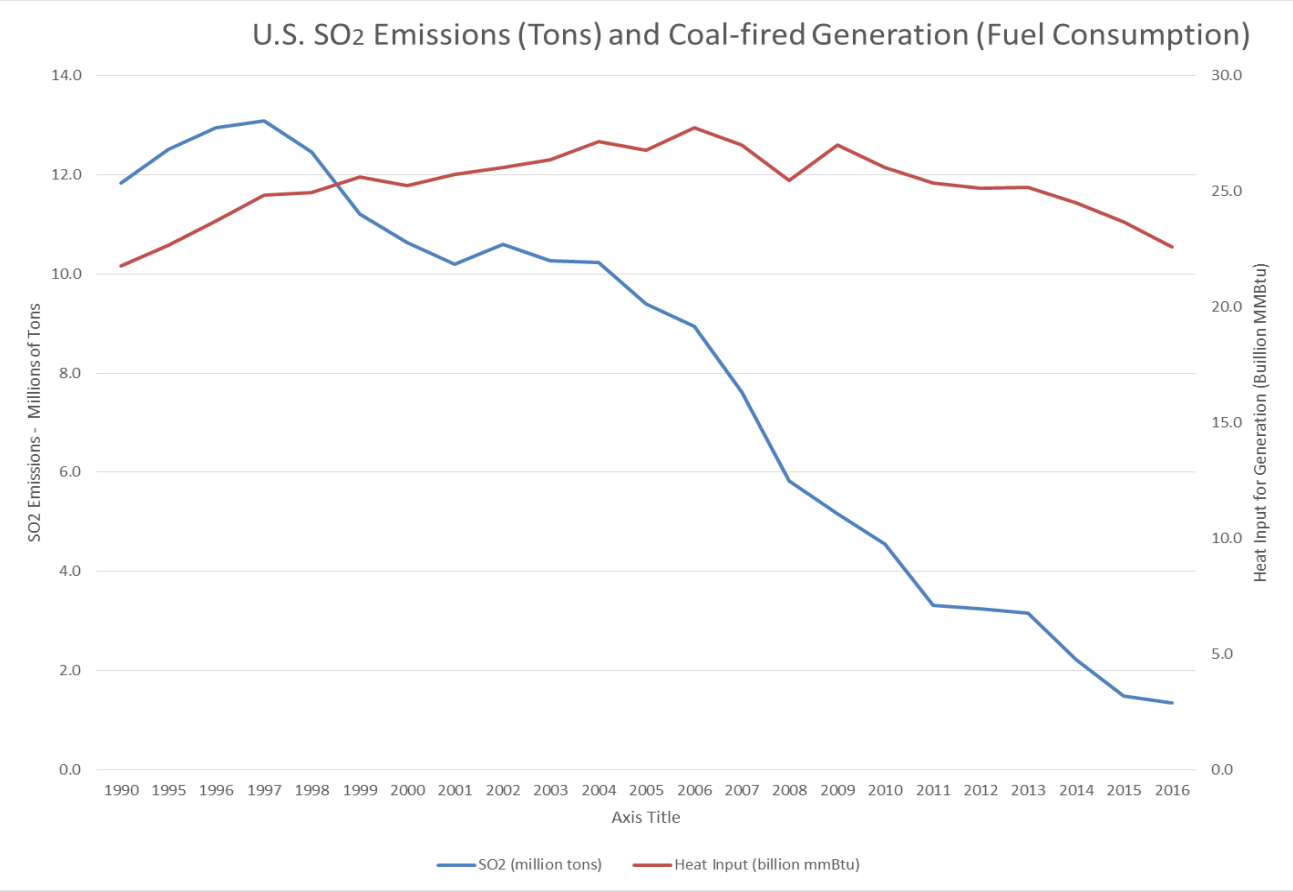
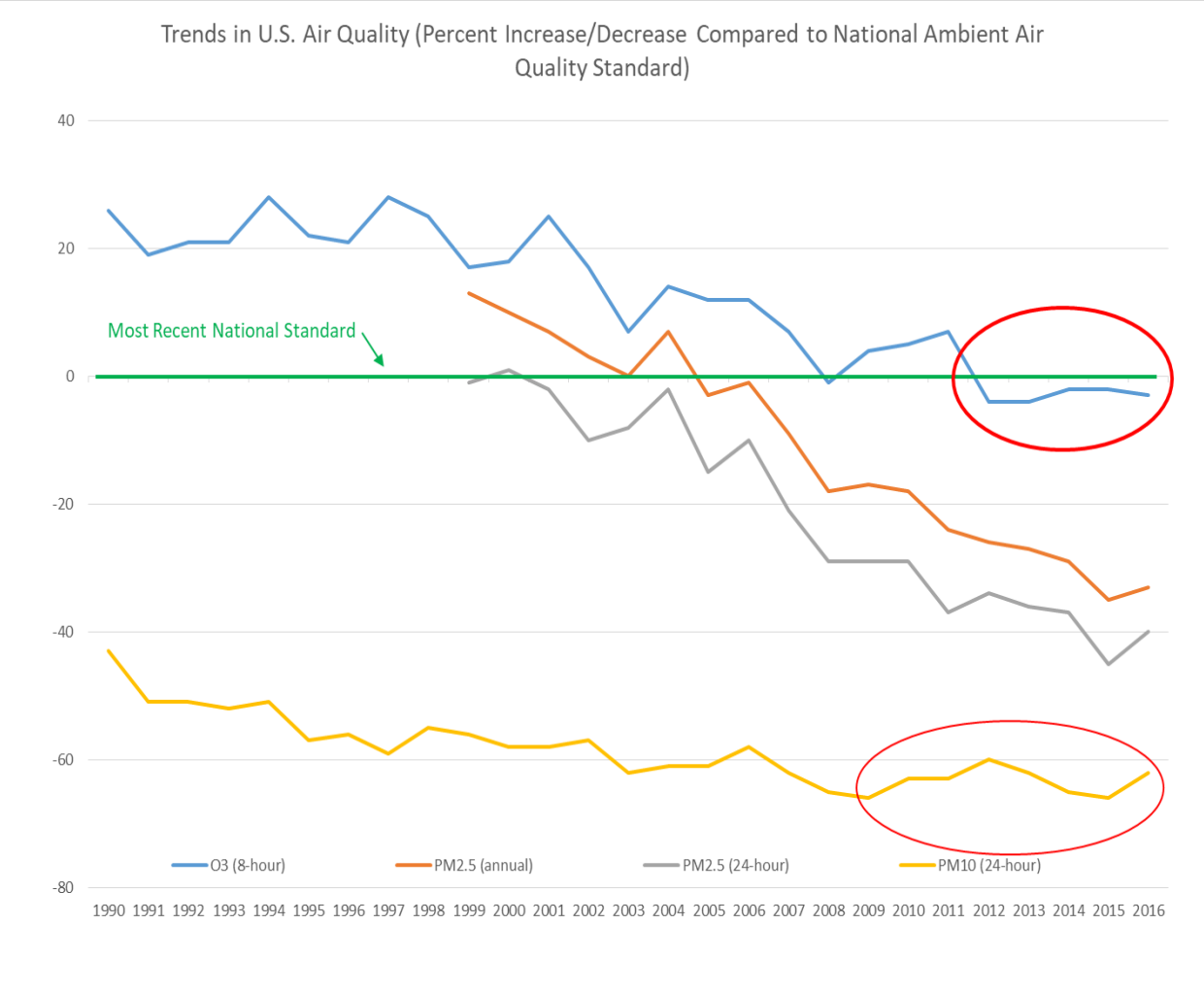
US Experience in Reducing Emissions from Coal-fired Power Plants

- 90 Percent Reduction in SO_2 Emissions Since 1990



US Air Quality Trends

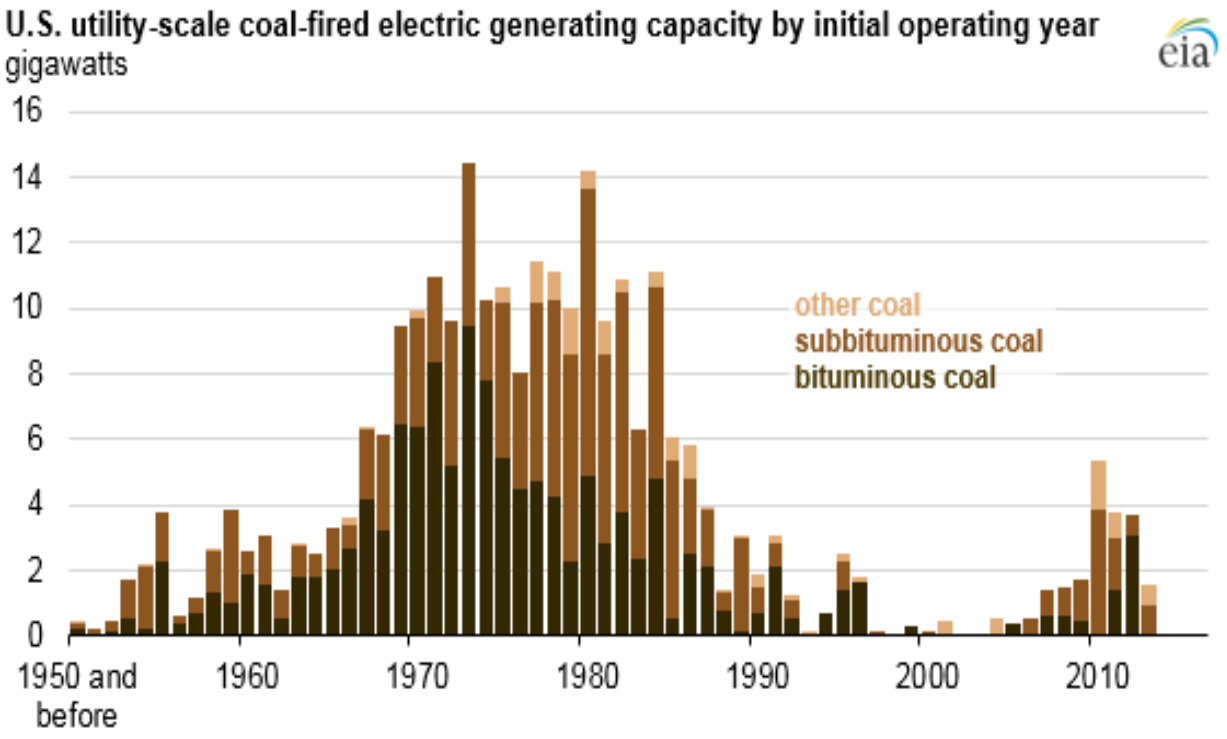


- These data are national averages.
- They show progress – not success.
- 125 million residents live in ozone non-attainment areas.
- 23 million residents live in PM2.5 non-attainment areas.
- 9 million residents live in PM10 non-attainment areas.
- Note the lack of progress in ozone and PM10 from 2012-2016 as recession ends

Most recent NAAQS:

- Ozone (8 hr) 0.070 ppm (2015)
- PM2.5 (annual) 12 ug/m3 (2012)
- PM2.5 (24 hr) 35 ug/m3 (2012)
- PM10 (24 hr) 150 ug/m3 (1987)

Characteristics of U.S. Coal-fired Power Plants



- One third of the fleet has recently retired or is retiring soon.
- 63 GW have retired since 2010;
- another 40 GW have announced retirement.
- Capacity factors decline from 73% to 53%.

- 69% of units (80% of capacity) have FGD (average U.S. SO_2 emission rate ˜375 ug/m3)
- 29% of units (54% of capacity) have SCR (average U.S. NOx emission rate ˜250 ug/m3)
- Average U.S. coal plant CO_2 emission rate = 2,243 lb/MWh (2,035 kg/MWh)

U.S. Regulatory Scheme

- Failed state programs of earlier years led to Federal “floor” for state-administered regulation
- Patchwork of more than a dozen programs
- Mix of “risk based” programs
  - *State implementation plans –*
  - *reasonable progress towards meeting National Ambient Air Quality Standards*
- and “technology based” programs
  - *New Source performance standards*
  - *Modification rules for existing sources*
  - *Performance standards for new and existing sources of highly toxic air pollutants*

U.S. Regulatory Scheme (continued)

- Acid Rain Program

- Interstate transport programs – “good neighbor provisions”
  - *Cross State Air Pollution Rule*
  - *State petitions*

- Mercury and Air Toxics for new and existing coal-fired plants

- Regional Haze (impaired visibility in U.S. national parks)
  - *“reasonable progress” toward 2064 goal*

CO_2 Regulation – Clean Power Plan (CPP)

- New source limits for coal-fired plants based on partial carbon-capture and sequestration.
- Existing source program –state targets, based on existing mix of generation, and requiring a shift of generation to cleaner sources.
- Substantial flexibility/trading.
- Framework amenable to future reductions.
- Market has already exceeded requirements – 2017 CO2 emissions less than 2026 target.

Trump Administration Response to the CPP

- A CO_2 rule is required by U.S. law.
- Challenges to the CPP (and the CPP itself) are stayed indefinitely as the Administration attempts to repeal and replace the CPP.
- No proposal for new sources yet.
- Existing sources – “ACE Proposal” - return control to states; no Federal floor.
- “Theoretical” efficiency improvements at individual plants that may be too small to measure.
- Encourages extending the life of existing power plants.
- No regulation of gas-fired plants.
- Overall, may increase CO_2 emissions from the sector.

Lessons from U.S. Experience

- Mix of “risk-based” limits coupled with emission limits on all very large emitters was a good idea.
  - *Power plants and mobile sources are the most cost-effective sources to control.*
  - *No risk of “off shoring” electricity generation.*
  - *There are limits on our ability to understand and manage risk.*
- Adopt emission limits for new sources based on the best available technology today – you may be living with the result for the next 50 years.
- Existing sources – adopt a schedule for a decision to control or shut down existing units. Almost any schedule is better than no schedule.
- Schedule for control/retirement of existing units should be based on a hard date (e.g., 30 years after commencement of operation rather than definitions (e.g., “modification”) that are susceptible of multiple interpretation and argument.
- Understand the difference between
  - *engineered useful life (35-40 years) and*
  - *economic useful life” (“cannot be expressed in terms of years”).*

Lessons from U.S. Experience (continued)

- The most cost-effective pollution control comes from maintaining and operating the pollution controls that are already installed.
- U.S. enforcement experience is that these controls, especially PM controls, are poorly maintained. Other controls are often turned off at night or on weekends.
- A, once every few years, “beauty contest’ reference test and/or occasional “visible emission” monitoring is insufficient.
- The only way to ensure that installed controls are maintained and used is to require continuous emission monitors for PM, SO2, NOx and Hg, coupled with near “real time” reporting to a publicly accessible website maintained by the regulator.
- These monitors are commercially available and relatively inexpensive.

Cost Issues

- Proponents of new fossil-fuel power plants often assume highly optimistic rates of usage to generate low estimates of the cost of electricity that appear competitive with renewables.
  - *Assuming 90% capacity factor instead of 40% cuts the $/MWh cost almost in half.*

- Proponents of new fossil-fuel fired plants also fail to include a risk premium to cover
  - *Fuel price volatility over the life of the plant*
  - *Exchange rate volatility over the life of the plant*
  - *These factors are absent or limited for renewables*

- Opponents of effective controls often raise an issue of the cost of controls.
  - *While the absolute capital cost may be large – the impact on rates is spread over many years and many customers – ("a penny a day" for the Java/Bali grid).*
  - *Pollution control costs – even FGDs at $500/kW have been determined to be highly cost-effective in the U.S. when adverse health and productivity costs are included.*
  - *The rate payers pay for these controls and benefit from the best controls.*