

**REINHOLD ENVIRONMENTAL Ltd.**



# **2016 NO<sub>x</sub>-Combustion-CCR Round Table Presentation**

**February 1 & 2, 2016, in Orlando, FL / Hosted by OUC**

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# Clean Power Plan and Ozone - How does it fit in?

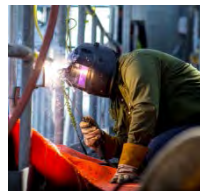
Chris Wedig, CB&I  
William Frazier, CB&I  
Dennis Ahern, CB&I

Training Class 12  
2016 NO<sub>x</sub> – Combustion – CCR Round Table  
Feb. 1, 2016  
Orlando, Florida



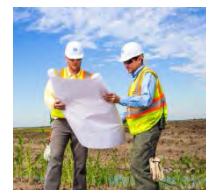
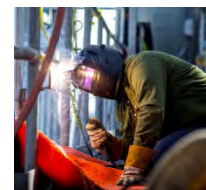
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- **Introduction**
  - Key concepts
  - Major regulatory programs affecting fossil fuel-fired power plants
- **Proposed update to the Cross State Air Pollution Rule (CSAPR)**
  - Overview
  - Potential impacts on fossil fuel-fired power plants
- **Clean Power Plan (CPP)**
  - Overview
  - Potential impacts on fossil fuel-fired power plants
- **2015 8-hour Ozone National Ambient Air Quality Standard (NAAQS)**
  - Overview
  - Potential impacts on fossil fuel-fired power plants
- **Summary**
- **Extra slides**

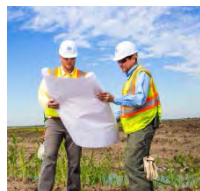
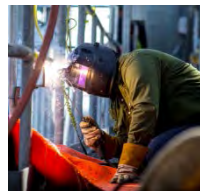


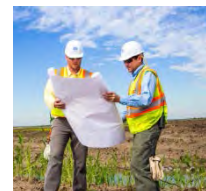
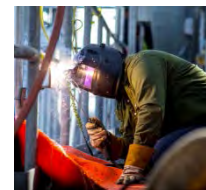
# Introduction

- There are numerous regulations and guidelines that impact fossil fuel-fired power plants.
- This workshop will provide an overview of three regulatory programs, which could impact air quality compliance planning for owners of existing fossil fuel-fired power plants
  - Proposed Update to the Cross State Air Pollution Rule (CSAPR)
  - Clean Power Plan (CPP)
  - 2015 8-hour Ozone National Ambient Air Quality Standard (NAAQS)
- The workshop will focus on how these regulatory programs may impact operations of existing air quality control systems (AQCS) as well as the potential need for retrofits of new AQCS at existing fossil fuel-fired power plants (with a primary focus on NOx emissions)



- **Air quality programs**
  - Proposed update to the Cross State Air Pollution Rule (CSAPR)
  - Mercury and Air Toxics Standards (MATS)
  - Regional Haze Rule (mainly western power plants)
  - Clean Power Plan (CPP) (existing power plants)
  - Carbon Pollution Standards (new power plants)
  - 2015 8-Hour Ozone National Ambient Air Quality Standard (NAAQS)
- **Water quality programs**
  - Clean Water Act Section 316(b) Rule
  - Steam Electric Effluent Limitation Guidelines (ELG)
- **Solid waste disposal**
  - Coal Combustion Residuals (CCR) Rule





Sources: EPA

Source: Patricio Silver, Senior Analyst, System Planning, ISO New England, [ISO New England Environmental Update](#), November 3, 2015

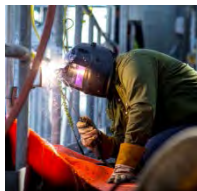
# **Proposed Update to the Cross State Air Pollution Rule (CSAPR)**

## **Overview**

## Some of the key documents available from the CSAPR include:

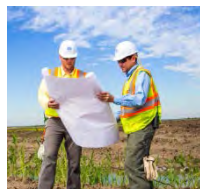
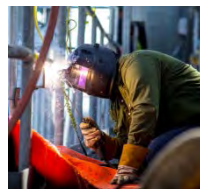
- Proposed Cross-State Air Pollution Update Rule
- Regulatory Impact Analysis (RIA)
- Air Quality Modeling Technical Support Document (TSD) for the 2008 Ozone NAAQS Cross-State Air Pollution Rule Proposal.
- Electric Utility Steam Generating Unit (EGU) NO<sub>x</sub> Mitigation Strategies Proposed Rule TSD
- Ozone Transport Policy Analysis TSD, and Appendix E - Detailed Budget Calculations
- Status of 110(a)(2)(D)(i)(I) SIPs Proposed Rule TSD
- Assessment of Non-EGU NO<sub>x</sub> Emission Controls, Cost of Controls, and Time for Compliance TSD
- Unit Level Allocations and Underlying Data for the CSAPR for the 2008 Ozone NAAQS

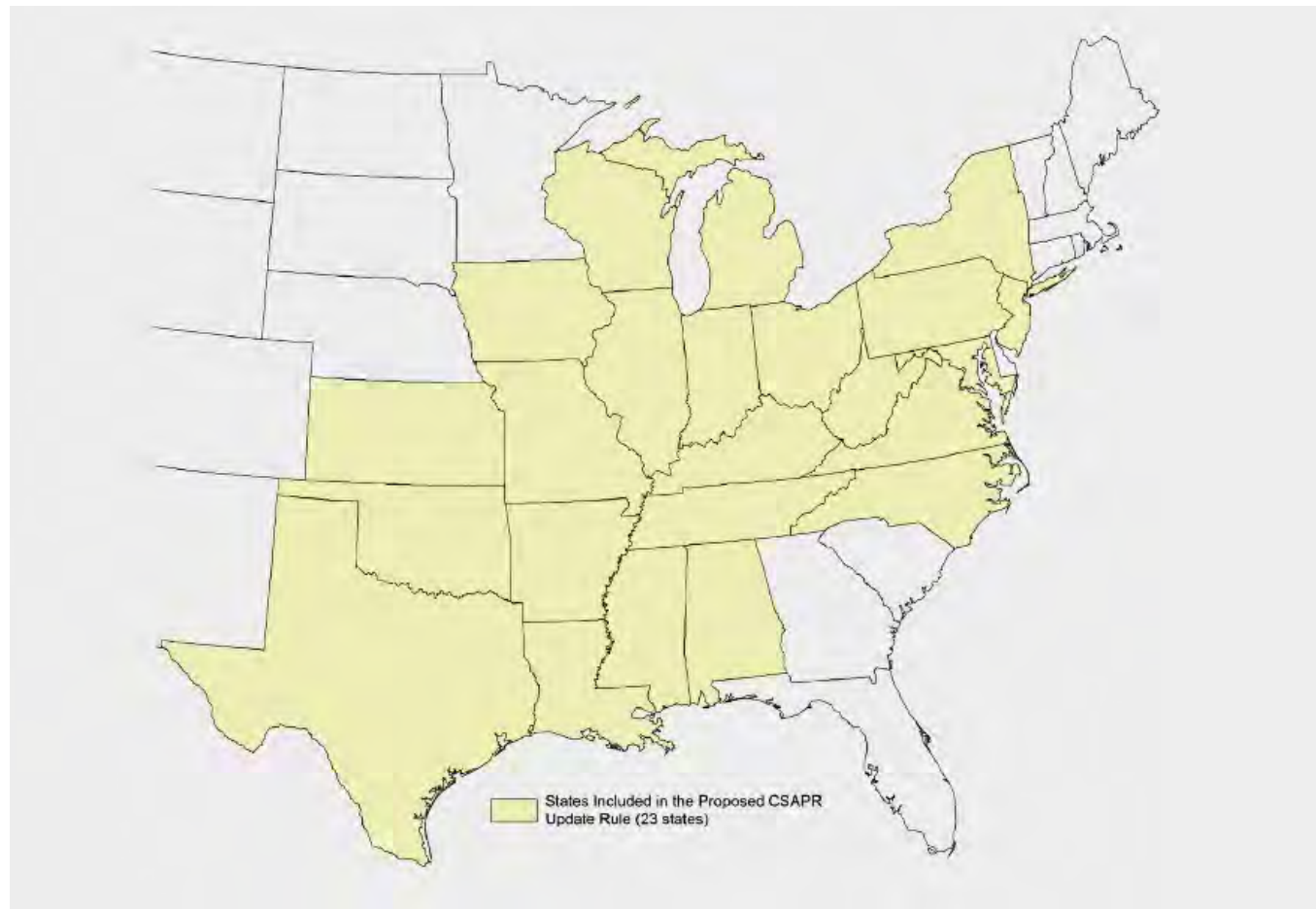
There are numerous documents related to the proposed update to the CSAPR available from EPA: [www.epa.gov/airmarkets/proposed-cross-state-air-pollution-update-rule](http://www.epa.gov/airmarkets/proposed-cross-state-air-pollution-update-rule)



- The Cross State Air Pollution Rule (CSAPR) finalized in 2011 was designed to meet the **1997** ozone NAAQS.
- The proposed rule would reduce air quality impacts of the interstate transport of air pollution on downwind areas' ability to meet the **2008** ozone NAAQS.
- The propose rule also responds to the July 2015 remand of certain CSAPR allowance budgets by the U.S. Court of Appeals for the D.C. Circuit.
- The proposed rule would reduce summertime emissions of NOx from power plants in 23 eastern states (see map next slide).

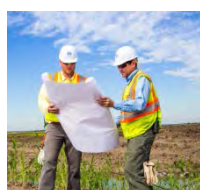
Source: EPA Fact Sheets and RIA for Proposed Update of CSAPR





Source: EPA Fact Sheet for Proposed Update of CSAPR

- The proposed rule affects 3,047 EGUs at 913 coal, gas and oil-fired facilities.
- The proposed rule affects fossil fuel-fired EGUs with a nameplate capacity of greater than 25 MWe
- All affected states in the proposed rule except Kansas were included in the original CSAPR ozone season program (1997 ozone NAAQS)
- EPA expects that most of the proposed CSAPR Update emissions reductions will occur between 2017 and 2020
- EPA does not anticipate the Clean Power Plan (CPP) will have significant interactions with the near-term ozone season NOx reductions required by this proposed regulation
- EPA has indicated that implementation of the 2015 ozone NAAQS may use the framework of the CSAPR, which could later impact the state budgets developed in the proposed CSAPR Update



Source: EPA Fact Sheets and RIA for Proposed Update of CSAPR

- The Proposed CSAPR Update Rule was issued by EPA on November 16, 2015
- The proposed rule was published in the Federal Register December 3, 2015
- Public hearing on the proposed rule was held December 17, 2015
- Public comment period will close on February 1, 2016
- First compliance period proposed to begin with the 2017 ozone season



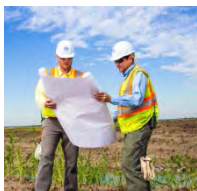
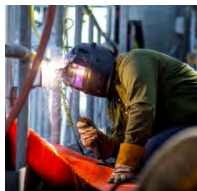
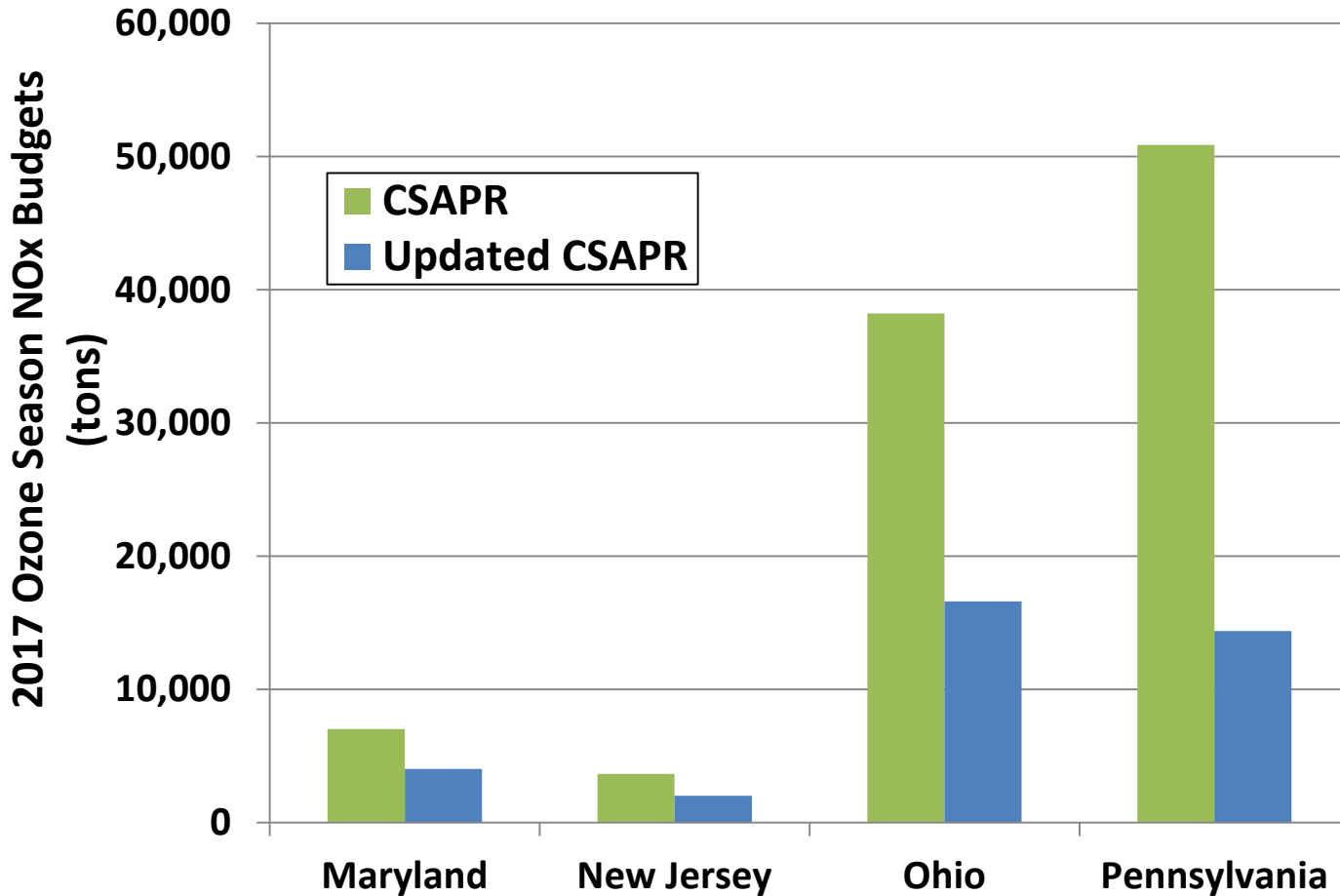
Source: EPA Fact Sheets and RIA for Proposed Update of CSAPR

# **Proposed Update to the Cross State Air Pollution Rule (CSAPR)**

## **Potential Impacts on Fossil Fuel- Fired Power Plants**

- The Phase 2 CSAPR ozone season (OS) NO<sub>x</sub> emissions budgets for each affected state would be replaced with updated OS NO<sub>x</sub> budgets proposed in this rule
- The proposed rule would remove two states from the CSAPR OS NO<sub>x</sub> trading program
  - Florida and South Carolina
- At a later date, EPA may update the CSAPR yet again for the 2015 8-hour ozone NAAQS (discussed later in this workshop).
- EPA found ozone season NO<sub>x</sub> reductions from affected sources can be made quickly and affordably by;
  - Optimizing operation of existing pollution control technology
  - Turning on existing pollution controls that are currently idled
  - Upgrading to state-of-the art low NO<sub>x</sub> combustion controls, and
  - Shifting generation to lower-emitting power plants
- EPA did not consider retrofitting SCR or SNCR systems as a compliance option for this proposed rule due to the time requirements to implement such retrofits

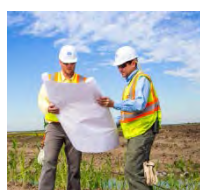




Source: EPA Proposed Update of CSAPR Regulatory Impact Assessment and EPA database of tolled CSAPR budgets.

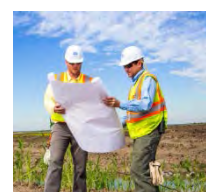
- EGUs covered by the CSAPR ozone season (OS) trading program in the proposed federal implementation plans (FIPs) are able to trade OS NO<sub>x</sub> emission allowances among EGUs within their state and across state boundaries (emissions and use of allowances subject to certain limits)
  - The rule proposes to allow 2015 and 2016 vintage OS NO<sub>x</sub> allowances for compliance (requires four pre-2017 vintage allowances to cover one ton of NO<sub>x</sub> emitted in 2017 or later)
  - 2017 vintage OS NO<sub>x</sub> allowances may be banked for future use
  - The assurance provisions of the CSAPR limit affected EGU emissions of OS NO<sub>x</sub> to the state's OS NO<sub>x</sub> budget plus an increment equal to 21 percent of the state OS NO<sub>x</sub> budget (penalties for exceeding assurance levels)

Source: EPA Fact Sheets and RIA for Proposed Update of CSAPR

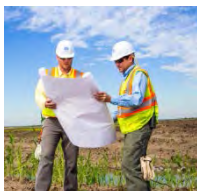
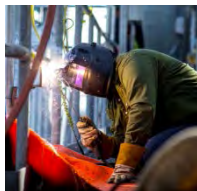


Time Period	Proposed Rule	More Stringent Alternative	Less Stringent Alternative
2017 - OS	85,000	88,000	24,000
2020 - OS	83,000	84,000	24,000
2017 - Annual	90,000	93,000	24,000
2020 - Annual	91,000	92,000	24,000

Source: EPA RIA for Proposed Update of CSAPR



- Purchase of OS NOx allowances
- Use of banked 2015 and 2016 CSAPR OS NOx allowances (4 allowances per 1 ton NOx emitted)
- Use of idled SNCR and SCR systems
- Optimization of performance of existing combustion NOx controls and SCR or SNCR systems
- Potential modifications to existing catalyst management plans
- Potential use of spare catalyst layer(s) if available
- Upgrades of existing combustion NOx controls
- Load shifting from higher emitting NOx sources to lower emitting NOx sources (e.g., coal-fired units to natural gas combined cycle units)
- Retrofitting SNCR or SCR systems as part of a longer-term (post 2017) compliance strategy. Potential impacts of future regulations, including CPP and potential impacts of 2015 ozone NAAQS, should be considered when adopting this strategy.



# Clean Power Plan (CPP)

## Overview

## Some of the key documents available from the EPA include:

- Clean Power Plan Final Rule
- State-specific Fact Sheets
- Clean Power Plan Toolbox for States
- Clean Power Plan for Communities
- Regulatory Impact Analysis (RIA): Clean Power Plan Final Rule
- Power Sector Modeling
- Technical Support Document (TSD): Emission Performance Rate and Goal Computation
- TSD: GHG Mitigation Measures
- TSD: Resource Adequacy and Reliability Analysis
- Other documents

There are numerous documents related to the CPP available from the EPA at [www.epa.gov/cleanpowerplan/clean-power-plan-existing-power-plants](http://www.epa.gov/cleanpowerplan/clean-power-plan-existing-power-plants)



The following are examples of different acronyms used in the Federal Register:

## Different Acronyms - examples

<b>BSER</b> Best System of Emission Reduction	<b>GHG</b> Greenhouse Gas	<b>NGCC</b> Natural Gas Combined Cycle
<b>Btu/kWh</b> British Thermal Units per Kilowatt-hour	<b>GW</b> Gigawatt	<b>NOX</b> Nitrogen Oxides
<b>CAA</b> Clean Air Act	<b>HAP</b> Hazardous Air Pollutant	<b>NSPS</b> New Source Performance Standard
<b>CCS</b> Carbon Capture and Storage (or Sequestration)	<b>HRS</b> Heat Recovery Steam Generator	<b>NSR</b> New Source Review
<b>CEMS</b> Continuous Emissions Monitoring System	<b>IGCC</b> Integrated Gasification Combined Cycle	<b>PM</b> Particulate Matter
<b>CHP</b> Combined Heat and Power	<b>IPM</b> Integrated Planning Model	<b>PM2.5</b> Fine Particulate Matter
<b>CO2</b> Carbon Dioxide	<b>IRP</b> Integrated Resource Plan	<b>RE</b> Renewable Energy
<b>ECMPS</b> Emission Collection and Monitoring Plan System	<b>ISO</b> Independent System Operator	<b>REC</b> Renewable Energy Credit
<b>EE</b> Energy Efficiency	<b>kW</b> Kilowatt	<b>RES</b> Renewable Energy Standard
<b>EGU</b> Electric Generating Unit	<b>kWh</b> Kilowatt-hour	<b>RGGI</b> Regional Greenhouse Gas Initiative
<b>EM&amp;V</b> Evaluation, Measurement and Verification	<b>lb CO2/MWh</b> Pounds of CO2 per Megawatt-hour	<b>RIA</b> Regulatory Impact Analysis
<b>EPA</b> Environmental Protection Agency	<b>MMBtu</b> Million British Thermal Units	<b>RPS</b> Renewable Portfolio Standard
<b>ERC</b> Emission Rate Credit	<b>MW</b> Megawatt	<b>SCC</b> Social Cost of Carbon
<b>FR</b> Federal Register	<b>MWh</b> Megawatt-hour	<b>SIP</b> State Implementation Plan
	<b>NAAQS</b> National Ambient Air Quality Standards	<b>SO2</b> Sulfur Dioxide
		<b>TSD</b> Technical Support Document



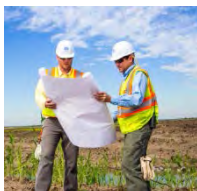
- Affected sources – Electric Generating Units (EGUs)
  - 1,000 fossil fuel plants, with about 3,100 units
  - Vermont and Washington, D.C. not included (no fossil fuel-fired power plants)
  - At this time, EPA is not setting CO<sub>2</sub> emission performance goals for Alaska, Hawaii, Guam or Puerto Rico.
- Power sector GHG emission reduction goals
  - 32 percent below 2005 greenhouse gas (GHG) emission levels by 2030
- EPA projects a co-benefit 72 percent reduction of NO<sub>x</sub> emissions from 2005 levels by 2030

Source: EPA Fact Sheets and RIA for CPP

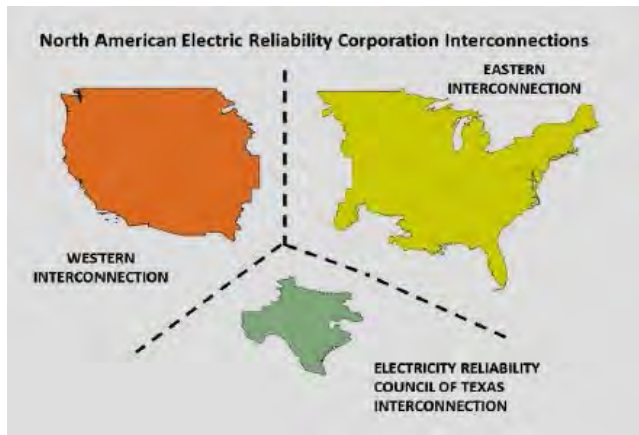


- Section 111(d) of the Clean Air Act (CAA) creates a partnership between EPA, states, tribes and U.S. territories, with EPA setting a goal and states and tribes choosing how they will meet it.
- The CPP followed the above approach, with EPA establishing interim (2022 to 2029) and final (2030) CO<sub>2</sub> emission performance rates for two subcategories of fossil fuel-fired electric generating units (EGUs)
  - Fossil fuel-fired electric steam generating units (generally, coal-, and oil-fired power plants)
  - Natural gas-fired combined cycle generating units
- To maximize the range of choices available to states in implementing the standards and to utilities in meeting them, EPA established interim and final statewide goals in three forms (discussed later)
- EPA provided guidelines for the development, submittal and implementation of state plans in the CPP

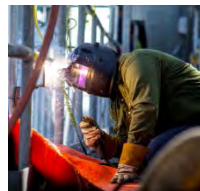
Source: EPA Fact Sheets and RIA for CPP



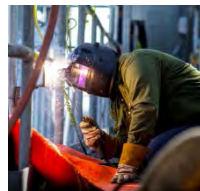
- EPA identified three building blocks (BB) for the Best System of Emission Reductions (BSER):
  1. Improving the heat rate of affected coal-fired steam EGUs
  2. Substituting increased generation from lower-emitting existing natural gas combined cycle units for for reduced generation from higher-emitting affected steam EGUs
  3. Substituting increased generation from new zero-emitting generating capacity for reduced generation from affected fossil-fired generating units
- EPA used the above building blocks to determine individual state emission goals – from a 2012 baseline
- EPA assessed the BSER in three NERC interconnections:



Source: EPA Fact Sheets and RIA for Proposed Update of CSAPR



- EPA applied the three BB to all coal plants and all of the natural gas power plants in each region to produce regional emission performance rates for each category
- From these regional coal plant and natural gas power plant rates, EPA chose the most readily achievable emission performance rate for each category.
- The resulting performance rates for 2030 were;
  - For fossil fuel-fired steam generating units - 1,305 lbs CO<sub>2</sub>/MWh
  - For stationary combustion turbines - 771 lbs CO<sub>2</sub>/MWh
- These emission performance rates, applied to each state's particular mix of fossil fuel-fired EGUs, generate the state's carbon intensity goal for 2030 (and interim rates for the period 2022–2029)
- The emission performance rates along with each state's mix of affected EGUs were used to establish state-specific CO<sub>2</sub> goals. EPA established interim and final statewide goals in three forms;
  - Rate-based state goal (lbs CO<sub>2</sub>/MWh)
  - Mass-based state goal (tons of CO<sub>2</sub>)
  - Mass-based state goal with a new source complement (tons of CO<sub>2</sub>)



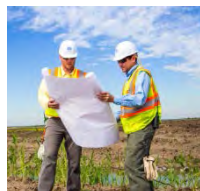
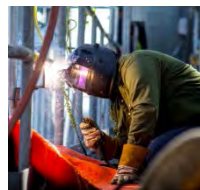
- States will develop and implement plans that ensure power plants in their state achieve the interim (2022 to 2029) and final (2030) CO<sub>2</sub> emissions performance rates, rate-based goals, or mass-based goals
- Each state will determine whether to apply the emission performance rates to each affected EGU or to take an alternative approach and meet either an equivalent statewide rate-based goal or statewide mass-based goal.
- EPA is not prescribing what measures to be implemented by the individual states
- States have flexibility to choose the form of the goal as well as how they will meet it
- States have flexibility to submit individual state or multi-state implementation plans

Source: EPA Fact Sheets and RIA for CPP

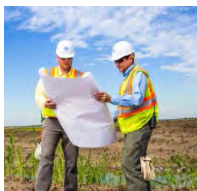
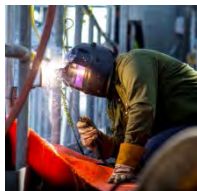


- EPA is creating a Clean Energy Incentive Program (CEIP)
- The CEIP rewards early investments in wind and solar generation, as well as demand-side energy efficiency programs implemented in low-income communities, that deliver results during 2020 and/or 2021
- EPA intends to make allowances or emission rate credits (ERCs) available to states that incentivize these investments
- EPA is providing additional incentives to encourage energy efficiency investments in low-income communities

Source: EPA Fact Sheets and RIA for CPP



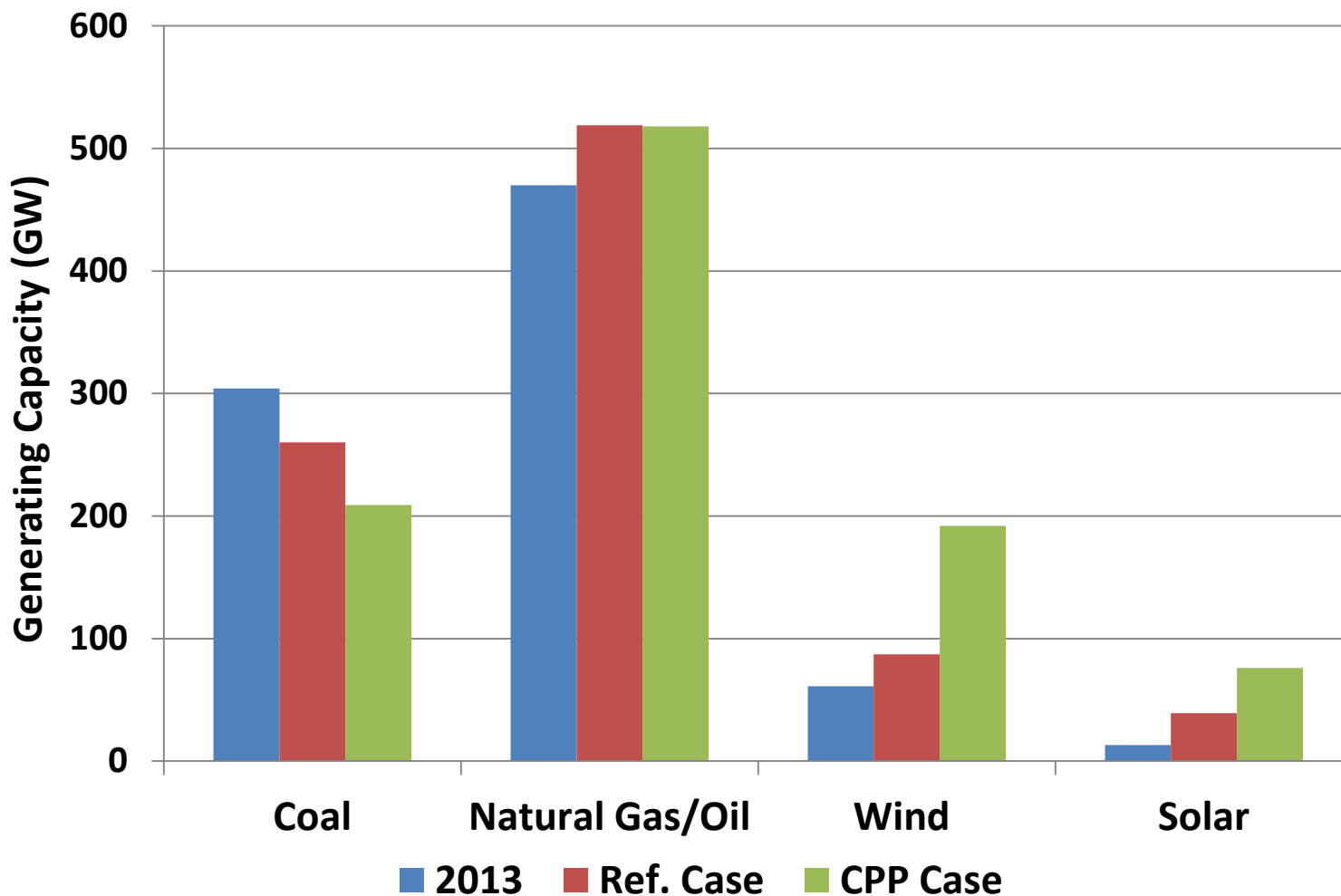
- States submit state plan or an initial submittal with an extension request by September 6, 2016.
- Final state plan submittals by September 6, 2018
- Clean Energy Incentive Program (CEIP) rewards early investments in renewable energy (RE) and demand-side energy efficiency (EE) measures during 2020/2021
- First compliance year for EGUs – 2022
- Interim compliance periods
  - Years 2022-2024
  - Years 2025-2027
  - Years 2028-2029
- CPP goals fully in place - 2030



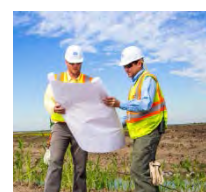
# **Clean Power Plan (CPP)**

## **Potential Impacts on Fossil Fuel-Fired Power Plants**



Data Source: Analysis of the Impacts of the Clean Power Plan, U.S. Energy Information Administration, May 2015



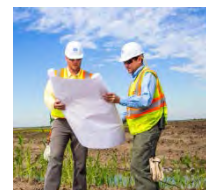
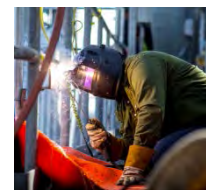
- EPA reported that the impact estimates in the CPP Regulatory Impact Assessment (RIA) are illustrative of approaches states may take (given the flexibility afforded states in complying with emission guidelines)
- The following tables summarize EPA’s projection of climate and air pollutant emission reductions for two approaches;

### Rate-Based Plan Approach

Year	CO <sub>2</sub> (10 <sup>6</sup> short tons)	SO <sub>2</sub> (10 <sup>3</sup> short tons)	NO <sub>x</sub> (10 <sup>3</sup> short tons)
2020	69	14	50
2025	232	178	165
2030	415	318	282

### Mass-Based Plan Approach

Year	CO <sub>2</sub> (10 <sup>6</sup> short tons)	SO <sub>2</sub> (10 <sup>3</sup> short tons)	NO <sub>x</sub> (10 <sup>3</sup> short tons)
2020	82	54	60
2025	264	185	203
2030	413	280	278

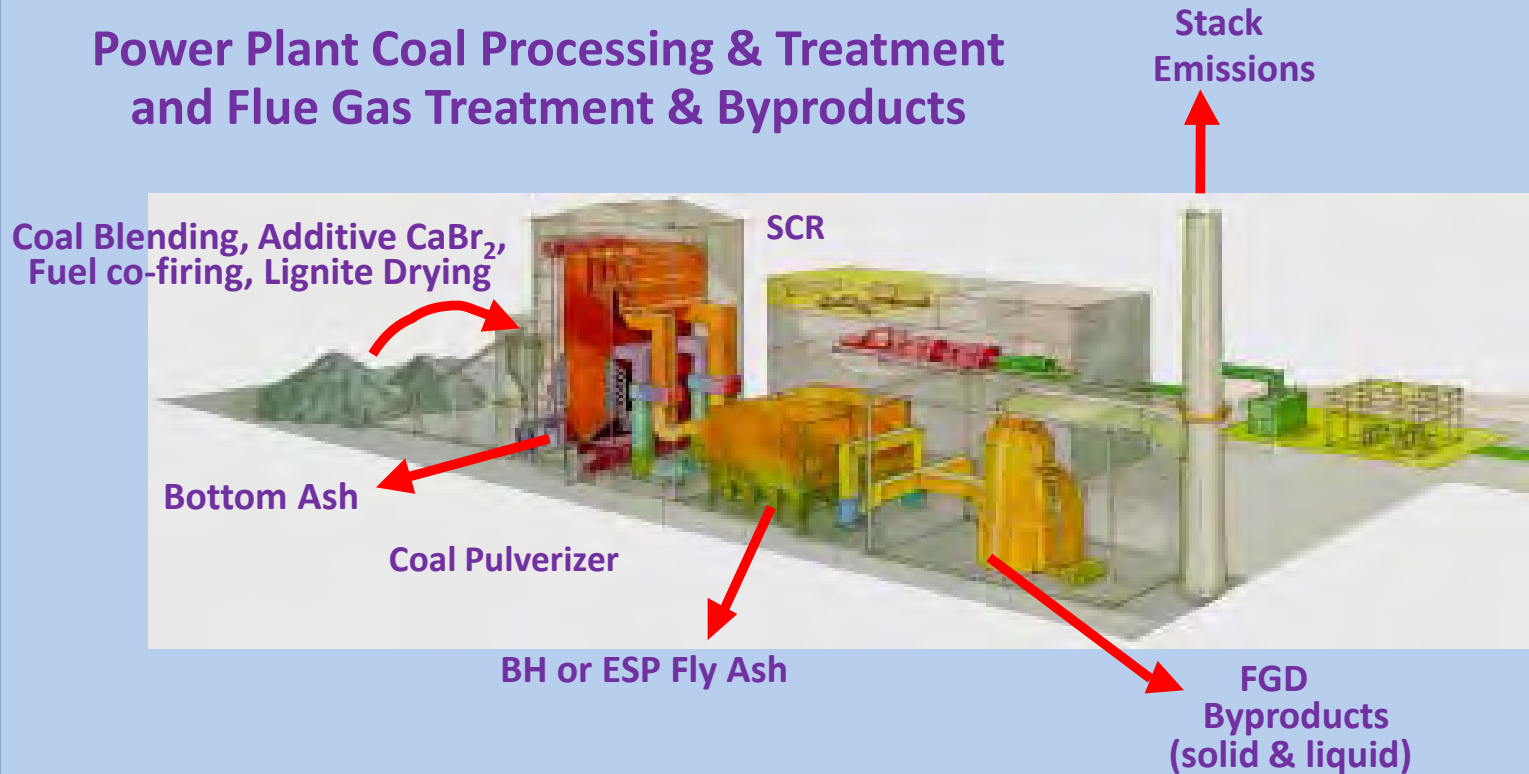


- The CPP may have longer-term (e.g., 2020+) impacts on existing fossil fuel-fired power plants
- Examples of potential impacts due to various state implementation plans (yet to be submitted) include:
  - Additional cycling operation of existing fossil fuel-fired power plants due to increased addition of intermittent resources (e.g. solar and wind)
  - Reduced capacity factors or retirements of certain coal-fired power plants
  - Potential increased emphasis to operate at lower load levels
  - Increased utilization of existing natural gas combined cycle power plants
  - Increased focus on heat rate improvement opportunities at coal-fired power plants
  - Potential use of natural gas or biomass co-firing (or fuel conversions) at some existing coal-fired units
  - Potential changes to existing operating conditions of existing AQCS

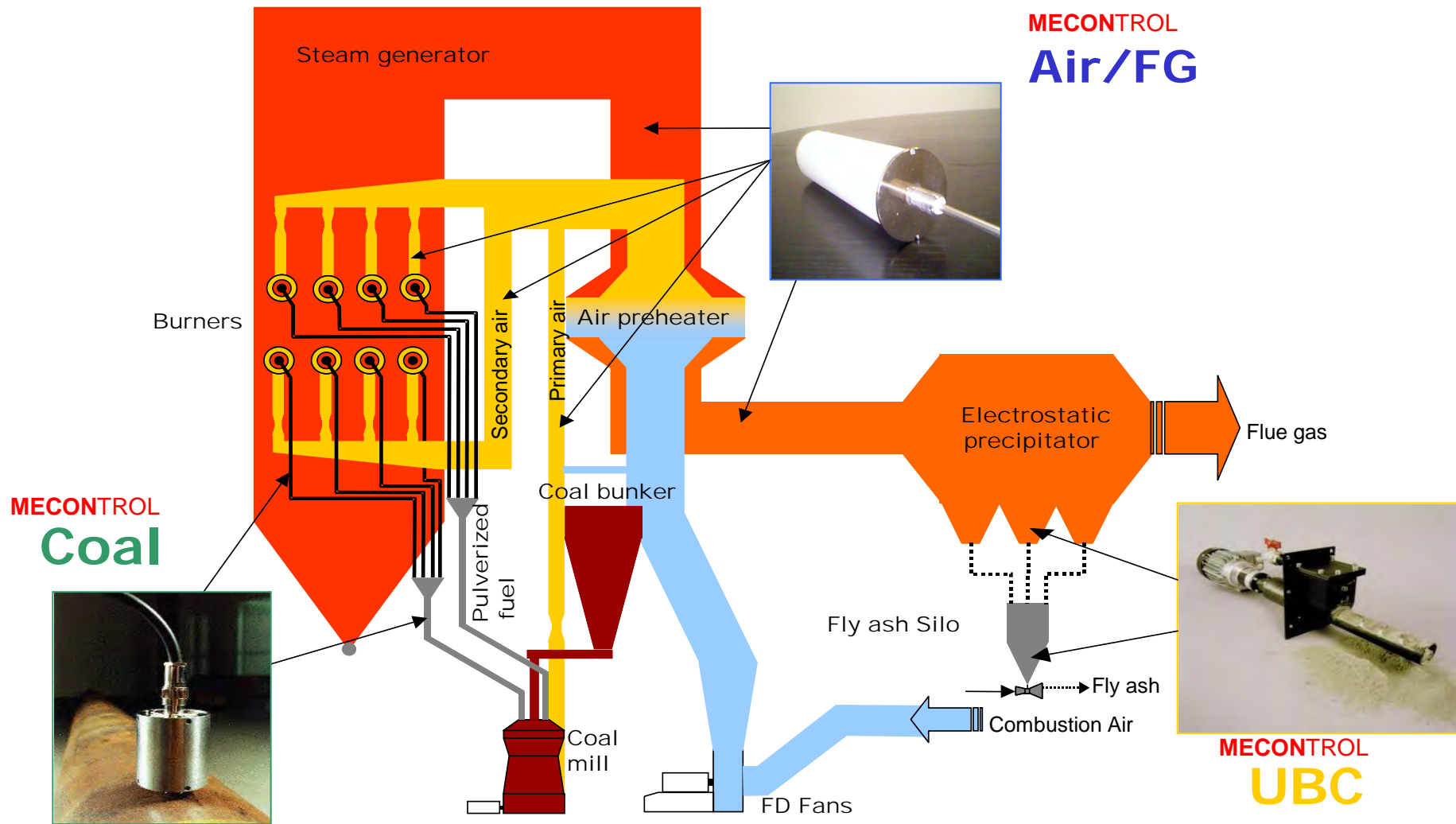


# Coal-Fired Power Plant – Fuel & AQCS - Examples

## Power Plant Coal Processing & Treatment and Flue Gas Treatment & Byproducts

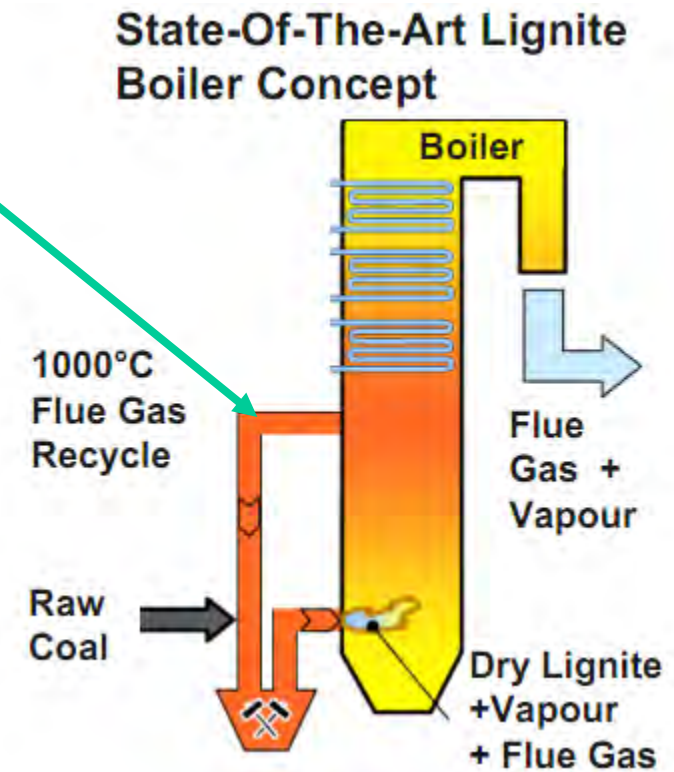


# "New" Instrumentation systems for Boiler Optimization



# Lignite Boiler – lignite drying

- High Temperature (up to 1400C, very high dust content / abrasive) applications:
  - Cooled antennas,
  - Air canons
  - Others under development

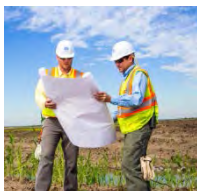
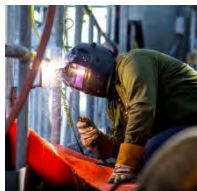


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# Power Plant Equipment Influenced by More Frequent Ramp-up/Ramp-downs and Startups



- Designing, operating, and maintaining fuel treatment systems while accommodating more frequent ramp-up/ramp-downs of the power plant (due to revised dispatch priority) is a reality.
- This includes potentially more frequent unit shutdowns and startups plus revised unit ramp rates (MW-minute values) to accommodate electrical grid load following.



- Revised Dispatch Priority (either due to internal or external reasons)
- Electricity Pricing
- Grid Load Demand
- Age and/or Heat Rate of Existing Power Plant
- Natural Gas Pricing vs. Coal Pricing
- Renewables Dispatching to Grid (e.g., Wind, Solar, Bio-mass, etc.)
- Newer Power Plants Connected to Grid (e.g. coal, NG-CC, NG-SC, nuclear)
- New Proposed Combined Heat & Power (CHP) Connected to Grid
- New Proposed Distributed Generation (DG) Power Plants Connected to Grid
- Limits and Changes in Electrical Transmission to Grid (e.g., new corridors)
- Environmental Issues, Regulations, and Guidelines
- Other reasons or issues

# **2015 8-hour Ozone National Ambient Air Quality Standard (NAAQS)**

## **Overview**

Some of the key documents available at the EPA site include:

- Final Rule - Federal Register - October 26, 2015
- Regulatory Impact Analysis (RIA)
- Interactive Ozone Maps and Tables
- Various Fact sheets
- Memo: Implementing the 2015 Ozone National Ambient Air Quality Standards
- Slides from the Webinar Presentation on October 21, 2015
- Various Technical Support Documents (TSD)

There are numerous documents related to the 2015 8-hour Ozone NAAQS available from EPA at following EPA web site:

<http://www3.epa.gov/ozonepollution/actions.html>



- Once EPA sets a new air quality standard, or revises an existing standard, the Clean Air Act requires EPA to designate areas based on local air quality
  - Meeting the standards (attainment areas)
  - Not meeting them (nonattainment areas)
  - Unclassifiable, meaning there is not enough information to make a determination
- Governors make initial designation recommendations, and EPA works with states and tribes as it determines initial designations and boundaries for nonattainment areas
- EPA issues two standards, as required by the Clean Air Act
  - A primary standard, to protect public health
  - A secondary standard, to protect the public welfare (in this case, trees, plants and ecosystems)



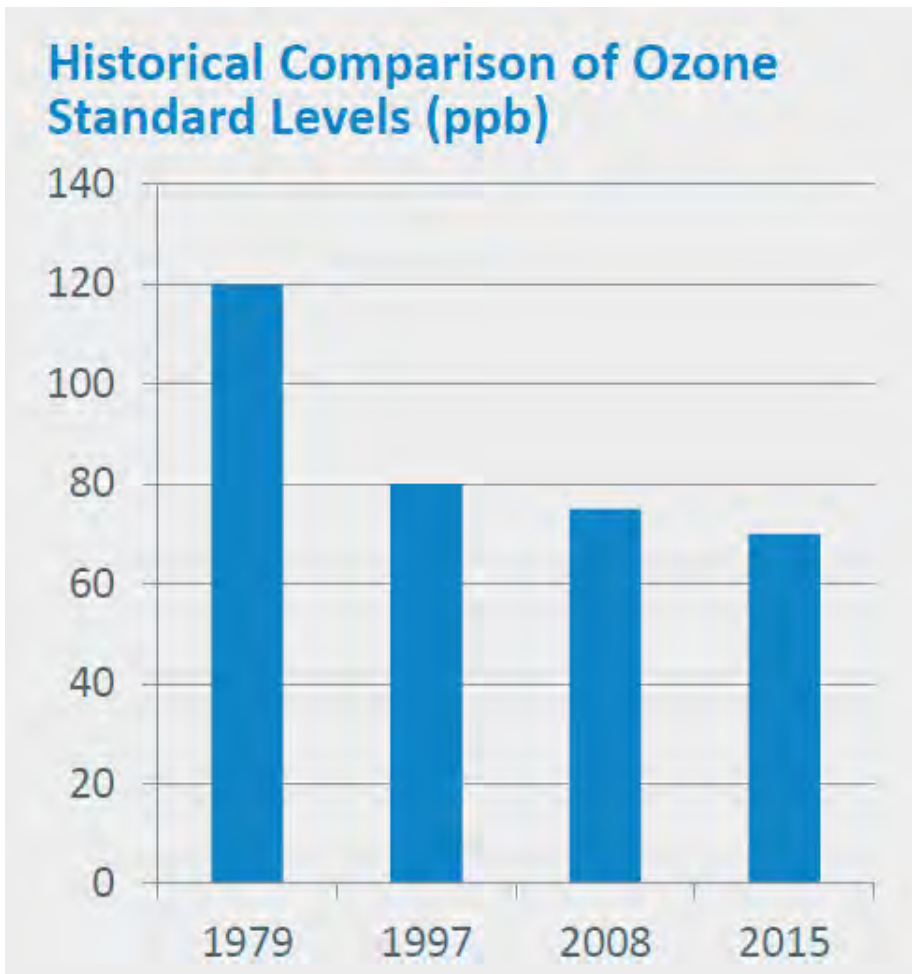
- States with nonattainment areas:
  - Develop emission inventories
  - Implement a preconstruction permitting program designed to provide additional air quality safeguards for those areas
- States with nonattainment areas classified as “Moderate” or higher:
  - Must develop state implementation plans (SIPs) showing how the areas will meet the standards
  - Adopt reasonably available control technology (RACT) standards for certain types of emission sources in the nonattainment area



- Ozone National Ambient Air Quality Standards (NAAQS) set a limit on the amount of ozone allowed in the outside air
- Ozone levels are declining – national average ozone levels have gone down by a third since 1980
- EPA indicates that over 40 million Americans live in counties with air quality above the 2008 standard of 75 parts per billion (ppb)
- EPA determined that the science on ozone and health showed that the 2008 standard isn't strong enough to protect public health as the Clean Air Act requires
- EPA's projections show the vast majority of U.S. counties will meet the standards by 2025 just with the rules and programs now in place or underway



Source: EPA, Overview of EPA's Updates to the Air Quality Standards for Ground Level Ozone, 2015.



Note: 1979 and 1997 NAAQS based on 1-hour average, 2008 and 2015 NAAQS based on 8-hour average.

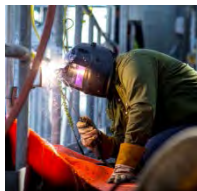
Source : EPA 2015 ozone standard

Source: Patricio Silver, Senior Analyst, System Planning, ISO New England, [ISO New England Environmental Update](#), November 3, 2013

- EPA strengthened the primary standard to 70 ppb, which will further improve air quality and public health protection.
- EPA also revised the level of the secondary standard to 70 ppb to provide increased protection against vegetation-related effects on public welfare.
- The secondary standard increased protection for natural forests in Class I and other similarly protected areas against an array of vegetation-related effects of O<sub>3</sub>.
- The EPA retained the indicator (O<sub>3</sub>), averaging time (8-hour) and form (annual fourth-highest daily maximum, averaged over 3 years) of the existing primary and secondary standards.



- In addition to changing the primary and secondary standards EPA also:
  - Changed the air quality index (AQI) to reflect the revisions to the primary standard
  - Revised data handling conventions for O<sub>3</sub>
  - Extended the O<sub>3</sub> monitoring season in 33 states
  - Revised the requirements for the Photochemical Assessment Monitoring Stations (PAMS) network
  - Revised regulations for the Prevention of Significant Deterioration (PSD) permitting program to add a provision grandfathering certain pending permits from certain requirements with respect to the revised standards
  - Provided schedules and other information related to implementing the revised standards
  - Provided revisions to the schedules associated with exceptional events demonstration submittals for the revised O<sub>3</sub> standards and other future revised NAAQS
  - Made minor changes related to monitoring for other pollutants

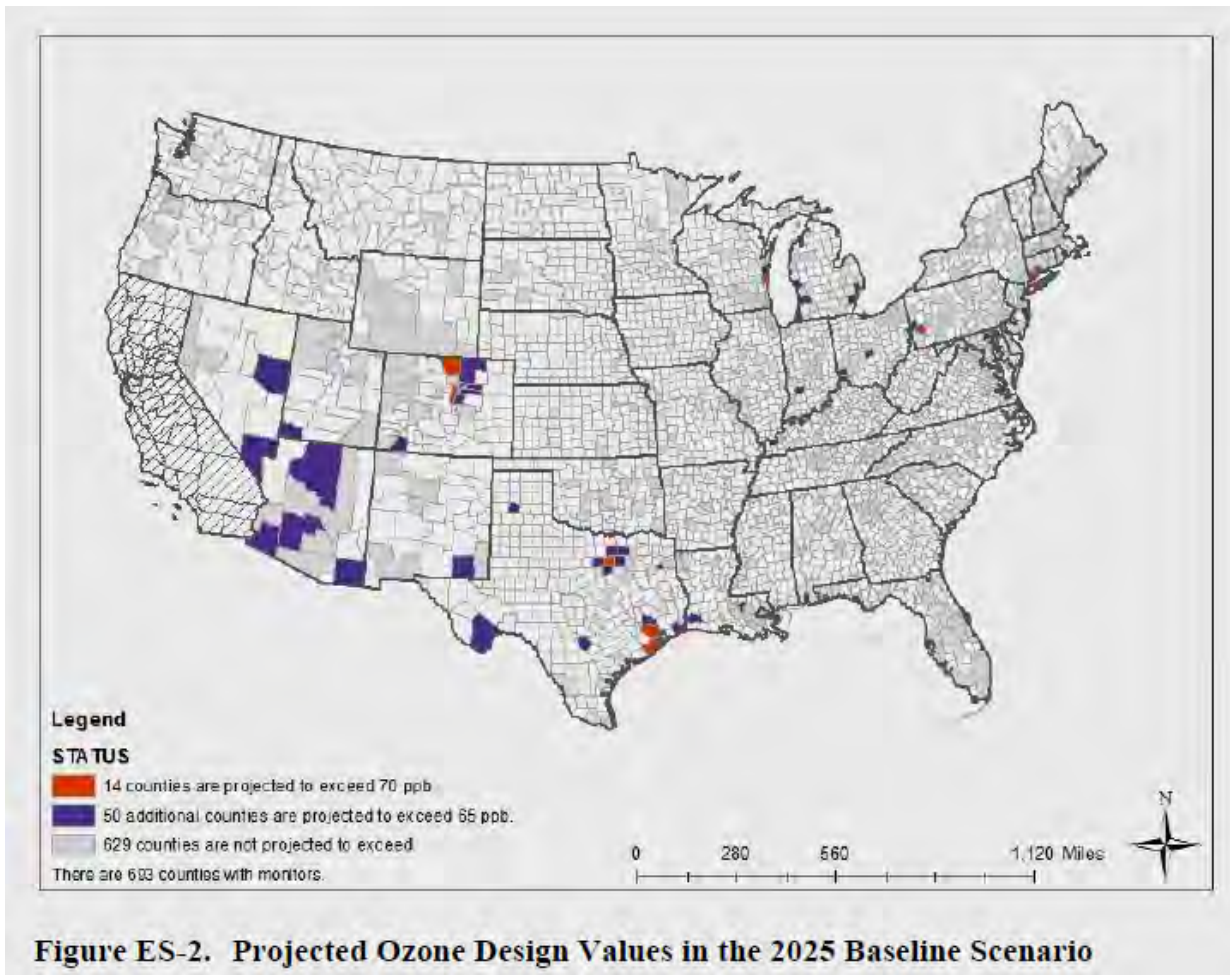


- February 2016 EPA expects to issue designation guidance
- October 1, 2016 States' designation recommendations due
- By June 1, 2017 – EPA responds to states' and tribes' initial recommendations
- October 1, 2017 EPA issues final area designations
- 2020 to 2021 – Complete implementation plans for “moderate” and above classification
- 2020 to 2037 – Nonattainment areas are required to meet the primary standard, with deadlines depending upon the severity of an area's ozone classification



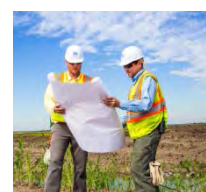
# **2015 8-hour Ozone National Ambient Air Quality Standard (NAAQS)**

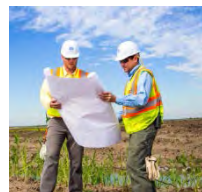
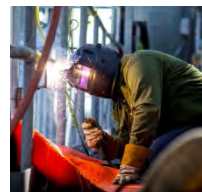
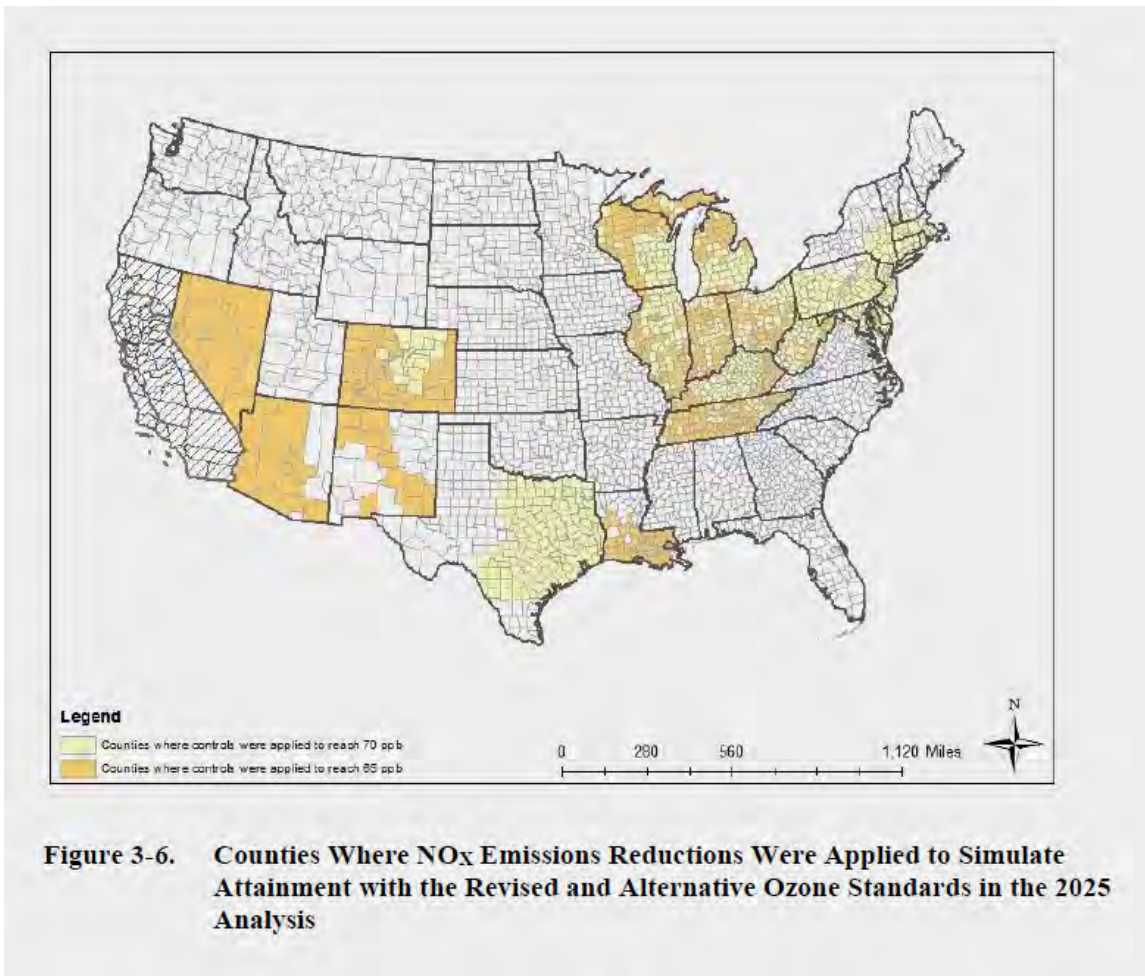
## **Potential Impacts on Fossil Fuel-Fired Power Plants**



**Note: Baseline includes impacts of MATS, CSAPR, and CPP**

Source: EPA Regulatory Impact Assessment of the Final Revisions to the National Ambient Air Quality Standards for Ground Level Ozone, September 2015





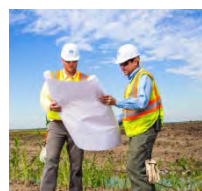
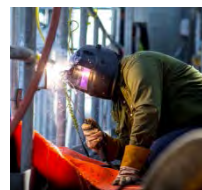
Source: EPA Regulatory Impact Assessment of the Final Revisions to the National Ambient Air Quality Standards for Ground Level Ozone, September 2015

**Table 3-4. Summary of Emissions Reductions by Sector for the Identified Control Strategies Applied for the Revised 70 ppb Ozone Standard in 2025, except California (1,000 tons/year)<sup>a</sup>**

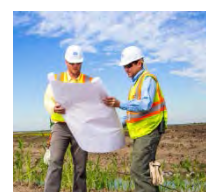
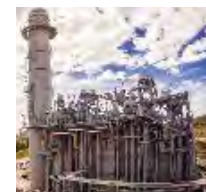
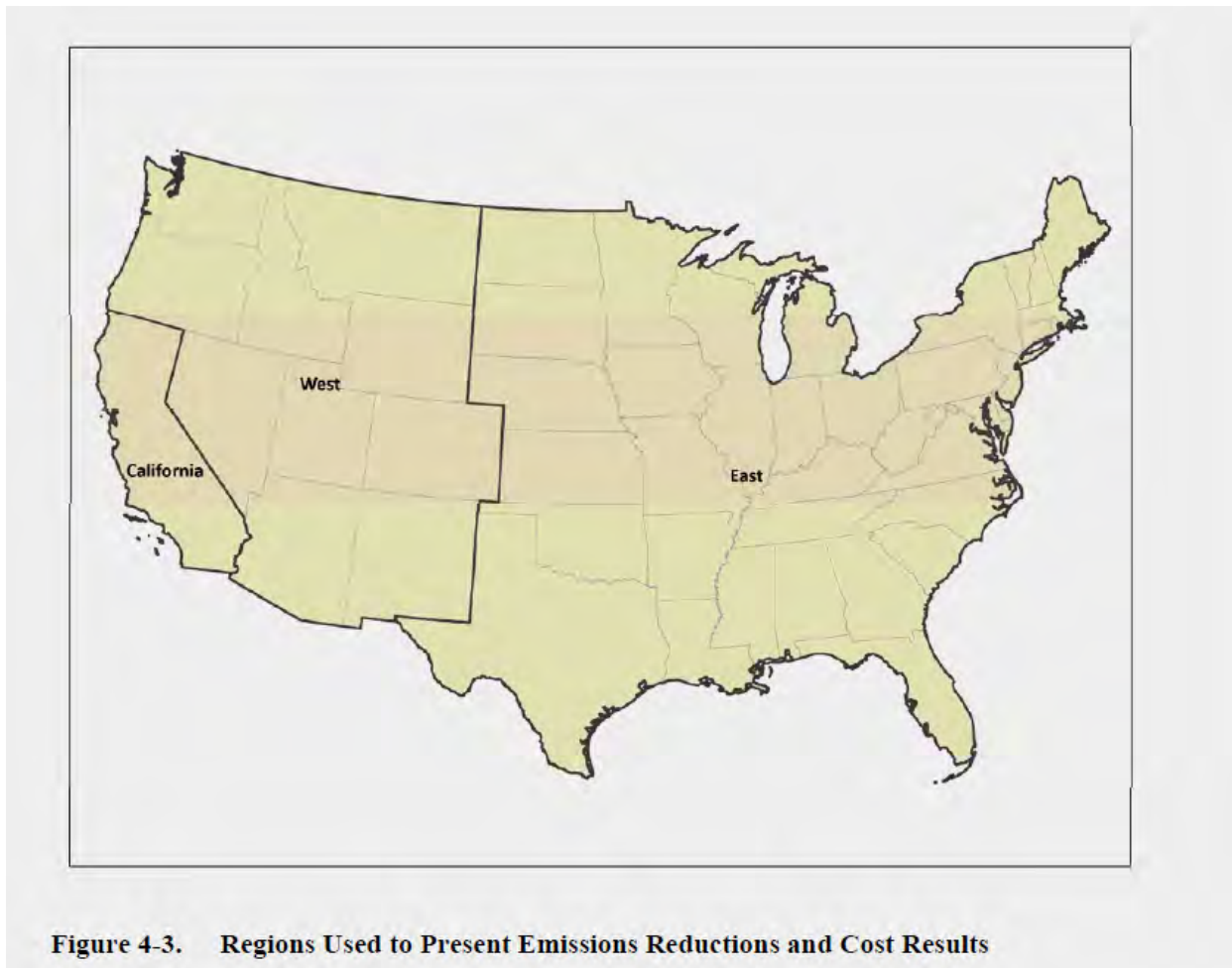
Geographic Area	Emissions Sector	NO <sub>x</sub>	VOC
East	EGU	45	-
	Non-EGU Point	85	1
	Nonpoint	100	19
	Nonroad	3	-
	Onroad	-	-
	<b>Total</b>		<b>230</b>
West	EGU	-	-
	Non-EGU Point	6	-
	Nonpoint	1	-
	Nonroad	-	-
	Onroad	-	-
	<b>Total</b>		<b>7</b>

<sup>a</sup> Emissions reduction estimates are rounded to two significant figures.

**Note: Identified controls for EGUs included SCR and SNCR**



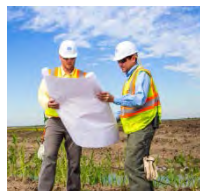
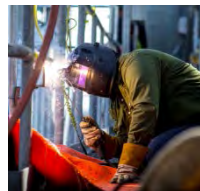
Source: EPA Regulatory Impact Assessment of the Final Revisions to the National Ambient Air Quality Standards for Ground Level Ozone, September 2015



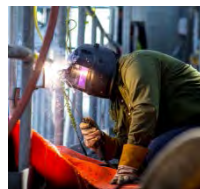
Source: EPA Regulatory Impact Assessment of the Final Revisions to the National Ambient Air Quality Standards for Ground Level Ozone, September 2015

# Summary

- Proposed Updates to the Cross State Air Pollution Rule (CSAPR)
  - This proposed rule, if promulgated, may require near-term (by 2017 ozone season) NO<sub>x</sub> compliance activity by some affected EGUs
  - These impacts are may include changes in ways existing AQCS are operated, emissions dispatching, allowance trading, and potentially retrofits of new NO<sub>x</sub> control systems for longer-range compliance plans
- Clean Power Plan (CPP)
  - The potential impacts of the CPP on existing EGUs are somewhat uncertain until states begin to formulate and submit their state compliance plans
  - The potential impacts on existing EGUs are expected to occur in the more distant future (2020+) than the proposed update to CSAPR
  - Potential impacts of the CPP on the future operating profiles of existing EGUs may affect the operations of existing air quality control systems
  - EPA projects reductions in NO<sub>x</sub> emissions as a “co-benefit” of the CPP These co-benefits, may have little impact on early (e.g., 2017 to 2020) ozone season NO<sub>x</sub> emission reduction requirements as a result of the proposed update to CSAPR



- 2015 8-hour Ozone National Ambient Air Quality Standard (NAAQS)
  - EPA has lowered the 8-hour ozone NAAQS from 75 ppb to 70 ppb
  - EPA identified 45,000 additional EGU NO<sub>x</sub> reductions in the East, and zero additional EGU NO<sub>x</sub> reductions in the West, for the identified control strategies to meet the updated 8-hour ozone NAAQS
  - EPA identified 85,000 additional non-EGU point source NO<sub>x</sub> in the East, and 6,000 additional non-EGU NO<sub>x</sub> reductions in the West, for the identified control strategies to meet the updated 8-hour ozone NAAQS



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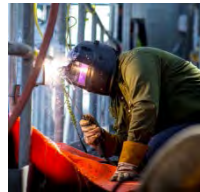
Email: [dennis.ahern@cbi.com](mailto:dennis.ahern@cbi.com)

# Extra Slides

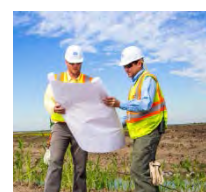
# Examples of Fossil Fuels

## Fossil Fuels Types – Examples

- Natural Gas
- Liquefied Natural Gas (LNG)
- Bio-gas
- Diesel Oil
- Bio Diesel Oil
- Gasified Coal (IGCC)
- Coal (bituminous, sub-bituminous, anthracite, lignite)
- Bio-mass (woody, mill residue, switchgrass, etc.)
- Refuse Derived Fuel (RDF)
- Municipal Solid Waste (MSW)
- Tire-Derived Fuel
- Black Liquor
- Pulp & Paper Byproducts
- Light Oil
- Heavy Oil
- Orimulsion
- Naphtha, Gasoline
- Liquefied Petroleum Gas (LPG)
- Hydrogen
- Propane
- Blast Furnace Gas
- Refinery Off-gas
- Oil Refinery Refuse Fuels
- Coke Oven Gas
- Landfill Gas
- Producer Gas
- Coal Bed Methane
- Gasification Fuels
- Bagasse
- Pitch Coke (from coal tar pitch)
- Petroleum Coke
- Wood, Peat
- Coal Liquefaction Fuels
- Shale Oil Fuels
- Bitumens, Asphalts, Tar Sand Fuels
- Other Fuels



Bio-Mass Types		
Woody Bio-mass	Animal Bedding	Barley Waste
Corn Stover	Whole Tree Chips	Malt Waste
Straw	Orchard Pruning	Cellulose Mattress Fill
Switchgrass	Vineyard Pruning	Wood Chips
Forest Residue	Nut Shell Waste	Sugarcane
Tire-derived Fuel	Forest Thinning	Wood Residuals
Agricultural Waste	Forestry Wood Waste	Oat Hulls
Forest Waste	Paper Mill Sludge	Rice Straw or Hulls
Urban Waste	Chicken Litter	Corn Waste
Municipal Solid Waste	Bagasse	Wheat Straw
Logging Waste	Poultry Litter	Potato Stillage
Mill Residue	Eucalyptus Bio-mass	Coffee Grounds
Egg Layer Manure	Animal Waste	Animal Manure
Wood Pellets	Sewage Sludge	Local Wood Waste
Peat	Pig Manure	Vegetative Waste
Sawmill Byproducts	Construction Debris (C&D)	Other Bio-mass



# Recovering Resources from Bio-Mass Coal Fines and Fly Ash

- Coal Fines can be collected, dried, pucked and fired to recover lost potential thermal value.
- Lignite can be thermally treated to increase the btu output.
- Biomass can be torrified and fired for lower carbon emissions.
- Remove Mercury and high carbon content in Fly Ash to produce a valuable product for use in concrete aggregate.

Your Vulcan® Systems Dryer can treat all these at your Power Plant.



[www.VULCANSYSTEMS.com](http://www.VULCANSYSTEMS.com)

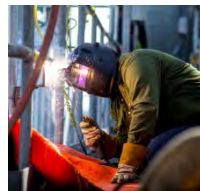
# Natural Gas – Fuel

Component (% by volume)	Natural Gas - A	Natural Gas - B	Natural Gas - C	Natural Gas - D
Methane	94.1	85.00	93.33	96.6
Ethane	3.01	7.10	trace	1.78
Hydrogen	0.01	trace	1.82	0.002
Other Hydrocarbons	0.70	3.3	0.25	0.13
Carbon Monoxide	trace	trace	0.45	trace
Carbon Dioxide	0.71	0.60	0.22	0.44
Nitrogen	1.41	4.00	3.40	1.02
Oxygen	0.01	trace	0.35	trace
Trace Components	trace	trace	trace	trace

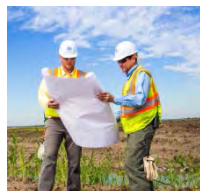
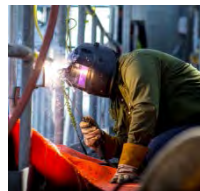
Note: the exact composition of pipeline quality natural gas can vary, but typically the main component is methane (CH<sub>4</sub>, usually 80 to 95% vol)

# **Fuel Treatment Technologies (examples)**

- **Natural Gas Treatment** (production facilities, compression station, pipeline, inlet gas facilities, gas treating, gas dehydration, NGL extraction, removal of  $N_2$  and capture of He (if desired), recompression, processing along pipeline system to power plant, processing at power plant before combustion, etc.). These processes accomplish hydrocarbon separation, removal of  $H_2S$ ,  $CO_2$ ,  $H_2O$ , Hg, particulate matter PM, NGL extraction, hydrocarbon dewpoint control, and proper pressure, temperature, odorant, avoid hydrates, etc.)
- **Bio-gas Treatment** (digester or landfill,  $H_2S$ , pressure,  $H_2O$ , Siloxane, VOC, particulate matter, upgrading biogas for pipeline, etc.)
- **Hydrogen Treatment** ( $H_2S$ , VOC,  $CO_2$ ,  $H_2O$ , PM, pressure, etc.)
- **Diesel Oil Treatment** (S, ash, etc.)
- **Bio Diesel Oil Treatment** (S, ash, etc.)



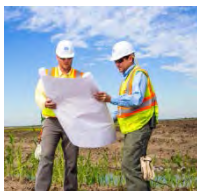
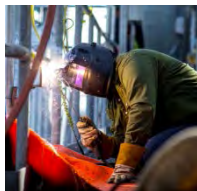
- **Gasified Coal or Other Gasified Fuel Treatment (IGCC)** ( $H_2S$ ,  $CO_2$ ,  $H_2$ ,  $CO$ ,  $H_2O$ , shift reactions, trace metals, particulate matter, etc.)
- **Coal Treatment** (coal sizing, breaking, crushing, screening, coal physical & chemical cleaning, coal fines recovery, thermal drying, coal blending, additive  $CaBr_2$ , co-firing natural gas or bio-mass, pulverizer optimization, lignite drying, etc.)
- **Heavy Oil Treatment** (S, ash, alkali additive, temperature, pressure)
- **Bio-mass Treatment** (sizing, shaping, pelleting, bark drying, gasification, farm waste treatment, pyrolysis, torrefaction, fermentation, bio-gas production, ethanol production, etc.)
- **RDF Fuel Treatment** (sizing, sorting, removal of metals, etc.)
- **Tire Derived Fuel** (shredding, sizing, removal of metals, etc.)
- **Numerous Other Fuels & Fuel Treatment Technologies**



# Air Quality Regulations Impacting Combustion Turbines



- Types of Regulations – examples
  - Federal Regulations
  - State Regulations
  - Stack Flue Gas Modeling of Ground Level Concentrations
  
- Air Permit Items – examples
  - A typical combustion turbine project air permit includes stack flue gas specie concentrations and test methods:
    - Nitrogen Oxides (NO<sub>x</sub>)
    - Carbon Monoxide (CO)
    - Volatile Organic Compounds (VOC)
    - Particulate Matter (PM)
    - Ammonia Slip (NH<sub>3</sub>)
    - Other Species



- Examples of Regulations and Topics - examples
  - 40 CFR 60, Subpart GG, New Sources Performance Standards for Stationary Gas Turbines
  - 40 CFR 60, Subpart Da, New Source Performance Standards for Steam Electric Generation Units (for in-duct burners)
  - 40 CFR 52, Subpart A —Approval and Promulgation of Implementation Plans, Section 52.21, “Prevention of Significant Deterioration of Air Quality”
  - 40 CFR 60, New Source Performance Standards
  - National Ambient Air Quality Standards (NAAQS)
  - Prevention of Significant Deterioration (PSD)
  - Start-up, Shut-down, and Malfunction Issues (SSM)
  - State Implementation Plans (SIPS)
  - Permit Requirements
  - Other Regulations and Topics



# Flue Gas Description

## Combustion Turbine (Natural Gas Fuel)



The fundamental combustion equation for burning natural gas fuel is:



There are a variety of chemical reactions during the combustion of natural gas with air including:





# Flue Gas Composition – Leaving Combustion Turbine – Natural Gas – 100% Conditions – Conceptual Examples

Flue Gas Component (100% load – steady state) (% volume)	Natural Gas A7 (example)	Natural Gas A8 (example)
<b>N<sub>2</sub> + Ar</b>	<b>73.9</b>	<b>74.2</b>
<b>CO<sub>2</sub></b>	<b>3.9</b>	<b>3.8</b>
<b>O<sub>2</sub></b>	<b>12.0</b>	<b>12.2</b>
<b>H<sub>2</sub>O</b>	<b>10.2</b>	<b>9.8</b>
<b>NO<sub>x</sub> (ppmvd, @ 15% O<sub>2</sub> basis)</b>	<b>12</b>	<b>15</b>
<b>CO (ppmvd)</b>	<b>9</b>	<b>8</b>
<b>UHC (ppmvw, CH<sub>4</sub> basis)</b>	<b>7</b>	<b>6</b>
<b>VOC (ppmvw, CH<sub>4</sub> basis)</b>	<b>1.4</b>	<b>1.3</b>
<b>SO<sub>2</sub> (ppmvw)</b>	<b>&lt; 0.5</b>	<b>&lt; 0.5</b>
<b>Particulate Matter (TPM, filterable + condensable) (lb/MMBtu, HHV basis)</b>	<b>0.008</b>	<b>0.007</b>
<b>SO<sub>3</sub>/H<sub>2</sub>SO<sub>4</sub> (ppmvw)</b>	<b>&lt; 0.5</b>	<b>&lt; 0.5</b>
<b>Other</b>	<b>Trace</b>	<b>Trace</b>

Note: the above values are conceptual examples; actual emission values for a specific combustion turbine vary depending on site specifics and conditions.



# Flue Gas Composition – Bulk Composition – Entering AQCS System (e.g., FGD)

## Coal vs. Natural Gas – 100% Conditions – Examples

Flue Gas Component (% by Vol)	Coal – A1 PRB (Example)	Coal – A2 Bituminous (Example)	Coal – A3 Lignite (Example)	Natural Gas A4 (Example)	Natural Gas A5 (Example)	Natural Gas A6 (Example)
N <sub>2</sub>	71.26	75.27	69.03	72.25	72.22	71.89
CO <sub>2</sub>	12.08	10.76	11.07	7.04	6.85	7.55
O <sub>2</sub>	5.28	7.31	6.09	5.47	5.44	4.39
H <sub>2</sub> O	11.09	6.42	13.6	15.16	15.41	16.09
Ash	yes	yes	yes	Nil	Nil	Nil
NO <sub>x</sub>	yes	yes	yes	yes	yes	yes
CO	yes	yes	yes	yes	yes	yes
VOC	yes	yes	yes	yes	yes	yes
SO <sub>2</sub>	yes	yes	yes	Nil	Nil	Nil
SO <sub>3</sub> /H <sub>2</sub> SO <sub>4</sub>	yes	yes	yes	Nil	Nil	Nil
HCl/HF/HBr	yes	yes	yes	Trace	Trace	Trace
Trace Metals (Hg, Se, etc.)	yes	yes	yes	Trace	Trace	Trace

Flue Gas Adiabatic Saturation Temperature (AST) Values, within a flue gas desulfurization (FGD) system, for various coal and natural gas types, at full firing conditions (examples, showing potential influence of flue gas moisture content) <sup>1</sup>

Parameter	Coal – A1 PRB (example)	Coal – A2 Bituminous (example)	Coal – A3 Lignite (example)	Natural Gas A4 (example)	Natural Gas A5 (example)	Natural Gas A6 (example)
Adiabatic Saturation Temperature (FGDS, deg F)	134	124	138	141	142	143
Flue Gas Moisture (Inlet FGDS, % vol H <sub>2</sub> O)	11.09	6.42	13.6	15.16	15.41	16.09
Flue Gas Molecular Weight (wet) (lb/lb-mole)	29.16	29.57	28.81	27.95	27.90	27.89

Note: 1) in addition to flue gas moisture content, the AQCS inlet flue gas inlet temperature and composition can impact the flue gas adiabatic saturation temperature (AST) values, thus influencing the temperature of WFGD system and WWTS streams.



# Clean Power Plan and Ozone - How does it fit in?

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William Frazier, CB&I  
Dennis Ahern, CB&I

Training Class 12  
2016 NO<sub>x</sub> – Combustion – CCR Round Table  
Feb. 1, 2016  
Orlando, Florida

