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Stakeholder Meeting

Installed Capacity Demand Curves

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New York Independent System Operator

Agenda

1. Tariff Requirements
2. Zones and Localities
3. Technology Screening Criteria
4. Peaking Technology Options
5. Combined Cycle Technology Options
6. Unit Assumptions
7. Environmental Requirements






Tariff Requirements






- Services Tariff requirements
  - "shall assess… the current localized levelized embedded cost of a peaking unit in each NYCA Locality and the Rest of State", to meet minimum capacity requirements.
  - " a peaking unit is defined as the unit with technology that results in the lowest fixed costs and highest variable costs among all other units' technology that are economically viable."
- FERC precedent regarding peaking unit technology: "only reasonably large scale, standard generating facilities that could be practically constructed in a particular location should be considered." [See, e.g., New York Independent System Operator, Inc., 134 FERC ¶ 61,058 at P 37 (2011)]
- Also assessing combined cycle plant for informational purposes;
  - Combined cycle plant, defined as "the unit with technology that results in the lowest cost net of EAS revenues under current conditions, accounting for the amount of capacity excess associated with the technology"

Zones and Localities






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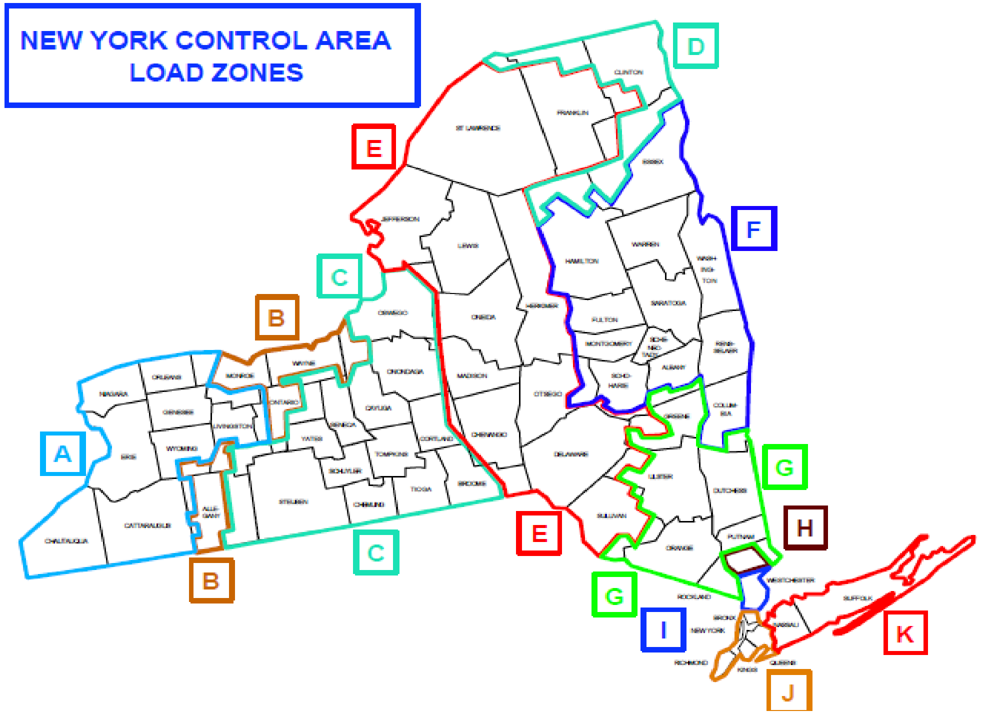
Zones and Localities

- Previous Demand Curve Reset (DCR) developed costs estimates for candidate technologies in Zones C, F, G, J and K.
- Current DCR process plans to develop costs for the candidate technologies in the same Zones, plus any New Capacity Zone (NCZ) proposed by the NYISO in the filing to FERC required by the NCZ Study



Technology Screening

Proposed Screening Technology Criteria

- Standard generating facility technology – available to most market participants
- Proven Technology
- Unit characteristics that can be economically dispatched
- Ability to cycle and provide peaking service
- Can be practically constructed in a particular location
- Can meet environmental requirements and regulations

Technology Screening Summary from Last Demand Curve Reset

Generating Technologies [1]	Failed Screening Criteria
Intermittent resources (e.g. wind, solar PV, concentrating solar)	Inability to be dispatched
Dispatchable renewable resources (e.g., hydro, biofuels, MSW, LFG)	Limited fuel availability; cannot provide peak service and cycle daily
Energy Storage (Fuel cells, batteries, flywheel, pumped hydro and CAES)	Fuel cell, batteries, flywheel are not economically viable CAES and pumped hydro have site specific requirements and costs
Nuclear and coal-fired resources	Long lead time; high fixed costs
PV – photo voltaic; MSW – municipal solid waste; LFG – landfill gas; CAES – compressed air energy storage	

[1] Demand Response was also considered. It was concluded that Demand Response cannot provide the response of a generator, nor can the fixed and variable costs be determined on a comparable basis.






Peaking Technology Options

Aeroderivative Combustion Turbines

- Number of starts does not impact maintenance schedule
- Fast start up time (~10 minutes) and ramp rates
- Generally requires water injection for NOx control in addition to selective catalytic reduction system (SCR)
- Reasonably sized units (50 to 100 MW) available where multi-unit plants are advantageous

- GE LMS 100 Most Efficient Aero Combustion Turbine
  - LMS 100 PA+ (latest version)
  - Capacity exceeds 116 MW
  - LHV Heat rate 7,776 Btu/kWh

Aeroderivative Technology Combustion Turbines

Aeroderivative Combustion Turbine	Experience	ISO Capacity MW	LHV Heat Rate Btu/kWh
GE LM6000	First introduced in 1997; Good experience	51-58 depending on model	8,140-8,367 depending on model
Rolls-Royce (Siemens) Trent 60	First introduced in 1996; Good experience	66	8,303
GE LMS100	First introduced in 2006; Good experience	103-116 depending on model	7,776-7,828 depending on model
P&W (MHPS) FT4000 SwiftPac 60/120	First introduced in 2012; First units went operational on June 29, 2015	70 single unit 140 twin pac design	8,265/8,245
	Reference: Gas Turbine World 2014-2015 Handbook, ISO Conditions		

Advanced Frame Combustion Turbines

- Advanced Frame Technology Combustion Turbines
  - Most efficient advanced frame units range in size from 231 to 337 MW
  - Dry Low NOx combustion
  - Can provide significant capacity in 10 minutes and full output in 30 minutes; turndown capability has improved
  - Lower installed cost ($/kW) than the aeroderivative units
  - Maintenance cost impacted by starts
  - G and H technology units have higher NOx emissions than F technology units but lower CO_2 emissions on a per MWh basis

Advanced Frame Technology Combustion Turbines

Frame Combustion Turbine	Experience	ISO Capacity MW	LHV Heat Rate Btu/kWh
GE 7FA.05	First 7FA.05 in operation in 4th Q 2014; 14 units now operating	231	8,640
Siemens SGT6-5000F5	First 5000F5 in operation in 2013; 23 units now operating	242	8,749
GE 7HA01	None operating	275	8,240
M501GAC	First 501GAC in operation in 2014; 8 units now operating	276	8,574
Siemens SGT6-8000H	First 8000H in operation in 2012; 14 units now operating	296	8,530
M501JAC	None operating	310	8,325
GE 7HA.02	None operating	337	8,210
	Reference: Gas Turbine World 2014-2015 Handbook, ISO Conditions		

Reciprocating Internal Combustion Engines

- Reciprocating Internal Combustion Engines
  - Small output units that can be installed in multi-unit blocks
  - Fast start up time as low as 5 minutes for natural gas engine and 7 minutes for dual fuel engine
  - Extremely fast shutdown, as low as 1 minute
  - Very high efficiency, good part load performance
  - Performance not impacted by ambient conditions (elevation, temperature)
  - Only requires moderate natural gas pressure (gas compression is not needed)
  - Installed cost similar to aeroderivative combustion turbines
  - Maintenance independent of number of starts
  - Emissions are higher than combustion turbines

Reciprocating Internal Combustion Engines

- Wartsila 18V50SG (gas only) and 18V50DF (dual fuel) engines
  - Offering low emissions design with emission rates close to combustion turbines
  - 18V50SG
    - Net capacity 18.478 MW
    - LHV heat rate 7,463 Btu/kWh
  - 18V50DF
    - Net capacity 16.769 MW (firing natural gas or distillate oil)
    - LHV heat rate 7,614 Btu/kWh firing natural gas and 8,194 Btu/kWh firing distillate

Combined Cycle Technology






Latest Advanced Combined Cycle Plant Options

Frame Combustion Turbine	1x1 Combined Cycle		2x1 Combined Cycle	
	Capacity MW	LHV Heat Rate Btu/kWh	Capacity MW	LHV Heat Rate Btu/kWh
GE 7FA.05	359	5,740	723	5,700
Siemens SGT6-5000F5	360	5,882	720	5,812
GE 7HA01	406	5,570	817	5,540
M501GAC	412.4	5,735	828.6	5,726
Siemens SGT6-8000H	440	5.687	880	<5,687
M501JAC	450	5,594	900	<5,594
M501J	470	5,549	942.9	5,531
GE 7HA.02	501	5,530	1005	5,510
	Reference: Gas Turbine World 2014-2015 Handbook ISO Conditions			

Combined Cycle Plant Options

- 2x1 combined cycle configurations have economy of scale advantage over 1x1 combined cycle configurations, if the additional capacity can be economically dispatched
- Use of heat recovery steam generator (HRSG) provides optimal temperature profile for the SCR catalyst
- Siemens SGT6-8000H was the first H technology unit to reach commercial operation
  - Has more than one year of operating experience
  - Has larger capacity if it can be economically dispatched
- Siemens 1x1 SGT6-5000F combined cycle; still a reasonable option



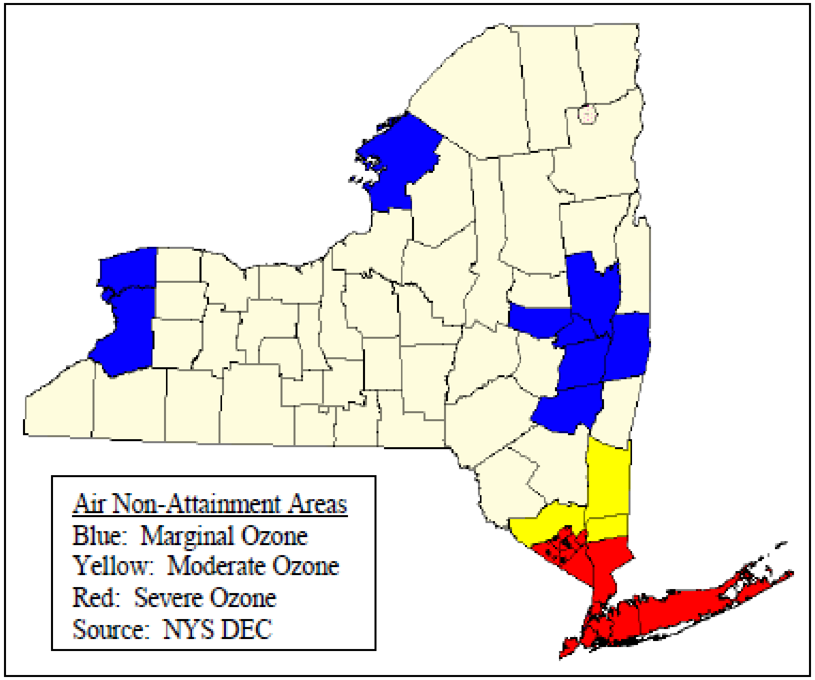
Environmental Permitting Considerations



General Environmental Considerations for Plant Design

- Air emissions:
  - Plant location and attainment status
  - Nonattainment New Source Review (NNSR) and Prevention of Significant Deterioration (PSD) permitting requirements
  - Other federal and state regulations (e.g., NSPS, NESHAPs, New York State regulations)
  - Air Quality Control Systems (AQCS) available for peaking units and combined cycle units.
- Water use considerations:
  - Air cooled condensers (ACC) versus cooling towers for natural gas combined cycle plants
  - Inter-stage cooling for GE LMS100 (wet or dry)
- Noise mitigation:
  - Very site specific

Nonattainment Areas in New York at Last Demand Curve Reset Process

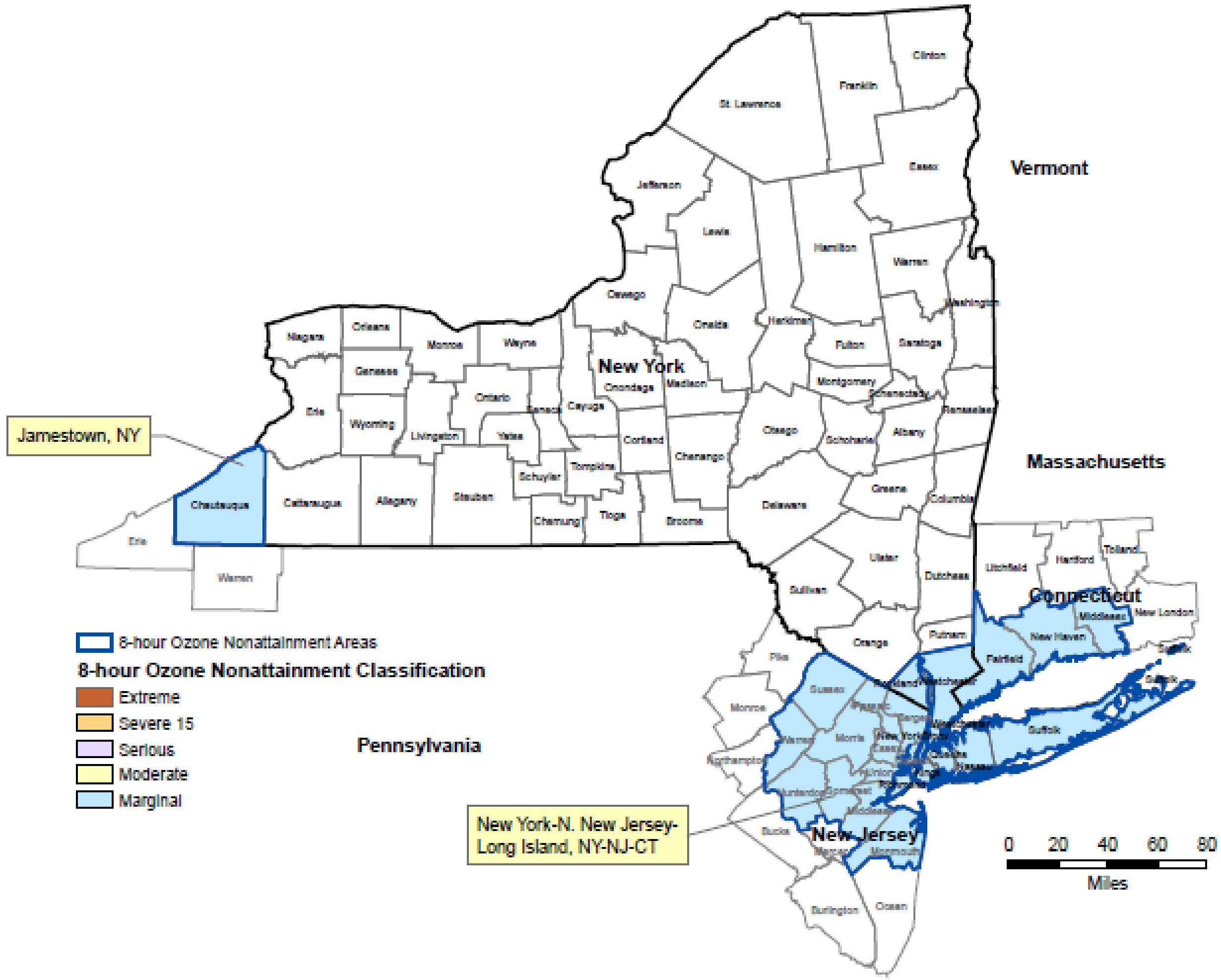


Ozone Nonattainment Areas

PM-2.5 Nonattainment Areas

New York County was also designated nonattainment for PM-10 at time of the last DCR

Current Nonattainment Areas in New York



Since last DCR, PM-10 and PM-2.5 nonattainment areas were re-designated as “attainment or unclassifiable”

NNSR Major Facility Thresholds and Offset Ratios

Contaminant	Major Facility Threshold (tons/year)	Emission Offset Ratios
Marginal, Moderate, or Ozone Transport Region (OTR):		
Volatile Organic Compounds (VOC)	50	At least 1.15:1
Nitrogen oxides (NO_X)	100	At least 1.15:1
Severe:		
Volatile Organic Compounds (VOC)	25	At least 1.3:1
Nitrogen oxides (NO_X)	25	At least 1.3:1

Annual emissions based on potential to emit (PTE), at 8,760 hours/year of operation.

PSD Major Facility Thresholds and Significant Emission Rates

Pollutant	NGCC Major Source Thresh. (tons/year)	CT and RICE Major Source Thresh. (tons/year)	Significant Emissions Rate (tons/year)
Carbon monoxide (CO)	100	250	100
Nitrogen oxides (NO_X)	100	250	40
Sulfur dioxide (SO_2)	100	250	40
Coarse particulate matter (PM-10)	100	250	15
Fine particulate matter (PM-2.5)	100	250	10
Ozone (O_3): as VOCs or NO_X	100	250	40
Greenhouse gases (GHG): as CO_{2e}	Note 1	Note 1	75,000

NGCC – natural gas combined cycle; CT – combustion turbine; RICE – reciprocating internal combustion engine

- Annual emissions based on potential to emit (PTE), at 8,760 hours/year of operation.
- Per NYSDEC October 15, 2014 Enforcement Discretion for State GHG Tailoring Rule Provisions Memorandum, GHGs alone will not trigger Prevention of Significant Deterioration New Source Review (PSD NSR).
- CT and RICE major source thresholds are 250 tons/year since these sources are not one of the source categories listed in section 201-2.1(b)(21)(iii)(a) through (z) of 6 CRR-NY.

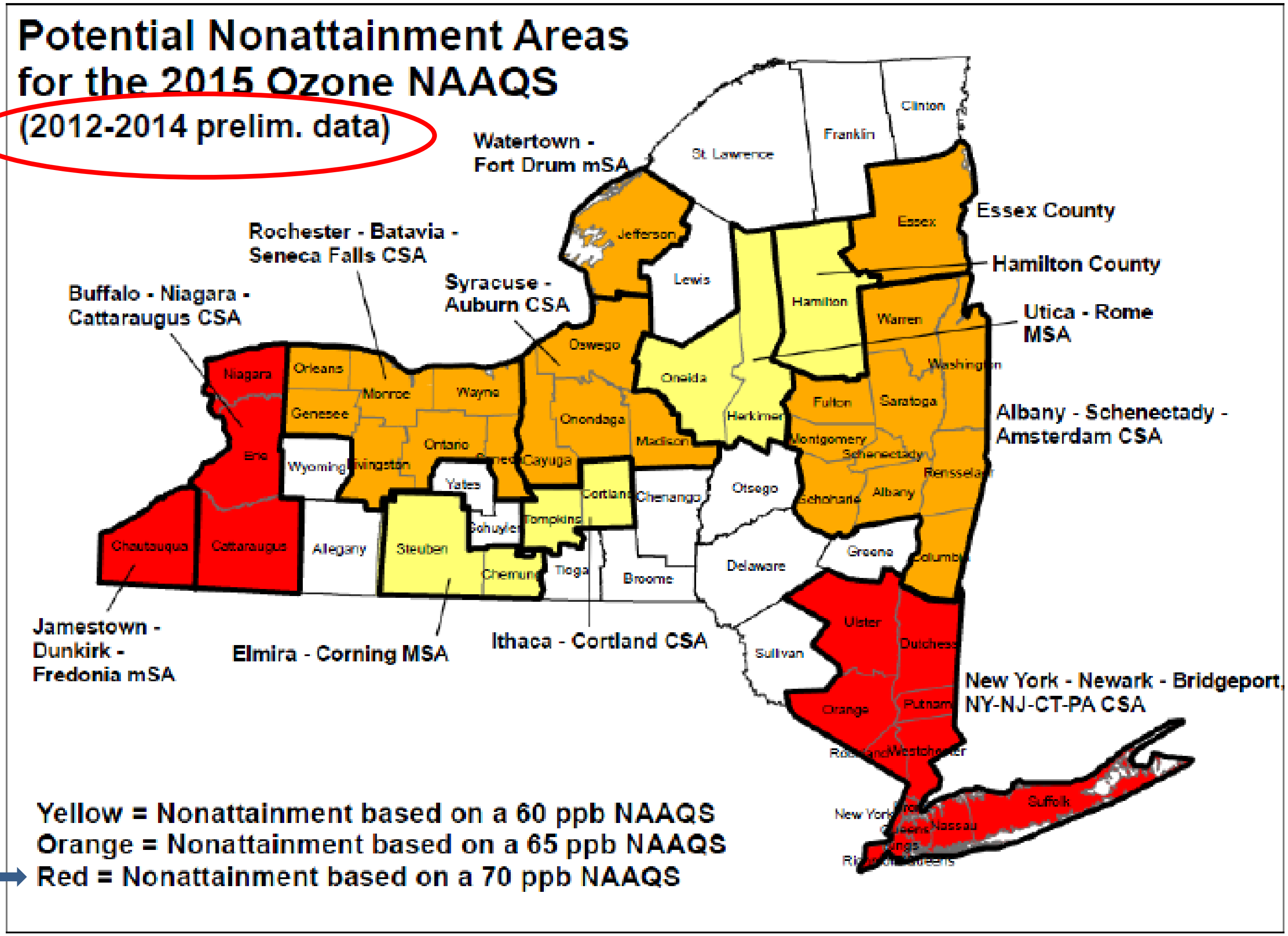
Initial Assessment of Major Source Thresholds

- All evaluated technologies are likely to require SCR/CO catalyst in Zones G-K
  - These zones are expected to require dual fuel operation
  - Lower half of Zone G and Zones H-K are in severe nonattainment areas and have low NO_X and VOC major source thresholds
  - These combined factors are expected to result in unacceptable operating hour restrictions to remain a minor source without SCR/CO catalyst
- For Rest of State, frame CTs in simple cycle configuration may avoid "major" classification for NNSR and PSD by accepting federally enforceable operating hour restrictions
  - Operating hours restriction was utilized in the last DCR for the Rest of State peaking unit
  - Viability of using an operating hours restriction for this DCR remains under evaluation
    - Operating hours restriction, if viable, would only be an option for a gas-only peaking unit
    - Continuing to assess gas-only configuration for Rest of State peaking unit
- Verification of these initial findings to be confirmed with detailed calculations of emissions for each technology in each of the study zones and after consultation with NYDEC.

Air Quality Control System Requirements

- Major sources in nonattainment areas for ozone
  - Lowest achievable emission rate (LAER) technology
    - LAER is a rate that has been achieved or is achievable for defined source, does not consider cost-effectiveness
    - Selective catalytic reduction (SCR) system for NO_X control is expected LAER technology
  - Offsets at prescribed ratios
  - Other requirements
- Major sources in attainment areas:
  - Best available control technology (BACT)
    - BACT is a case-by case determination and includes cost-effectiveness considerations
    - SCR is expected BACT determination and CO catalyst is expected BACT for CO and VOC control
  - Air quality analysis
  - Other requirements

Potential Impacts of 2015 8-Hour Ozone NAAQS



2015 8-hour NAAQS

Source: Implementation of the 2015 Ozone Standard, Rob Sliwinski, Director, Bureau of Air Quality Planning, NYSDEC, May 30, 2015.

- Designations schedule
  - February 2016 Environment Protection Agency (EPA) issues designation guidance
  - October 1, 2016 States' recommendations due
  - October 1, 2017 EPA issues final area designations
    - Likely based on 2014-2016 air quality data
    - Early-certified 2017 data may also be relevant
- Implementation-related rules/guidance to be issued by EPA
  - Designation guidance
  - Background ozone issues
  - Final ozone modeling guidance
  - Other

Carbon Pollution Standards for New Power Plants

- Base-load combustion turbines
  - Emission limit of 1,000 lbs CO_2/MWh-g or 1,030 lb CO_2/MWh-n
  - Limit applies to all sizes of affected base-load units
- Non-base load units
  - Limit based on clean fuels; input based standard
  - Non-base load status based on a sliding scale for capacity factor based on a unit's nameplate design efficiency (e.g., GE and Siemens quote design efficiencies based on LHV and ISO conditions for the LMS100 and SGT6-5000(F) of 44% and 39%, respectively).

Comparison of Carbon Pollution Standards to NYCRR Part 251 Requirements

Generating Facility Type	Carbon Pollution Standards	NYCRR Part 251 [1]
Simple Cycle Combustion Turbine Gas-Fired	120 lbs CO_2/MMBtu	1,450 lbs CO_2/MWh-g or 160 lbs CO_2/MMBtu
Simple Cycle Combustion Turbine Multi-Fuel Fired [2]	120 to 160 lbs CO_2/MMBtu	1,450 lbs CO_2/MWh-g or 160 lbs CO_2/MMBtu
Combined Cycle Combustion Turbines	1,000 lbs/MWh-g or 1,030 lbs/MWh-n	925 lbs CO_2/MWh-g or 120 lbs/MMBtu
Stationary Internal Combustion Engines (gaseous fuels)	N.A.	925 lbs CO_2/MWh-g or 120 lbs/MMBtu
Stationary Internal Combustion Engines (liquid fuel or liquid and gaseous fuels)	N.A.	1,450 lbs CO_2/MWh-g or 160 lbs/MMBtu

[1]New York Codes, Rules and Regulations
[2]For units determined to be non-base load units

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