NOx Emission Control Technology Installation Timing for Non-EGU Sources

Final Report

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DISCLAIMER

This report presents the results of SC&A's research on questions pertaining to control installation timing needs for industrial sources covered by the EPA's Good Neighbor Federal Implementation Plan (FIP) for the 2015 ozone NAAQS. The report includes summaries of comments regarding control installation timing needs that the EPA received during the public comment period and information obtained by SC&A or the EPA from control technology vendors, state permitting staff, and other entities, but it does not necessarily endorse or adopt the views of these commenters or other entities. Additionally, although statements by individual state permitting staff and control-installation vendors have been documented accurately and reflect these individuals' or entities' experiences and expertise, SC&A was not able to independently verify or substantiate these statements in the time provided.

The information presented in this report regarding the potential for supply-chain delays reflects current economic conditions (that is, conditions as of 2022) and current constraints on manufacturing capacity and skilled labor relevant to pollution control installation. The report discusses to some extent whether these conditions may be anticipated to continue into the future by considering several current economic indicators, but because of a lack of information available to SC&A it does not project key economic indicators that may be relevant to NOx control installation timing estimates for industries affected by this final rule. Although the information presented in this report informed the EPA's evaluation of the installation timing issues raised during the public comment period on the Good Neighbor FIP, this report does not necessarily reflect the views of the EPA or EPA staff and does not constitute EPA endorsement of any of the conclusions herein. This report does not supply facility-specific information that would be relevant or reliable in any future determination of necessity for additional time, on a source-specific basis, to come into compliance with any Clean Air Act requirement.

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ACRONYMS

ABC	Associated Builders and Contractors
AF&PC	Arkansas Forest & Paper Council
AISI	American Iron and Steel Institute
ASNCR	advanced selective noncatalytic reduction
BF	blast furnace
BLS	Bureau of Labor Statistics
BOF	basic oxygen furnace
BTS	Bureau of Transportation Statistics
Btu	British thermal unit
CAA	Clean Air Act
CAIR	Clean Air Interstate Rule
CBI	Construction Backlog Indicator
CEM	Continuous Emissions Monitor
CIBO	Council of Industrial Boiler Owners
CO	carbon monoxide
CO_2	carbon dioxide
EAF	electric arc furnace
EGU	electricity generating unit
EPA	United States Environmental Protection Agency
EPC	engineering, procurement, and construction
ESP	electro-static precipitator
FERC	United States Federal Energy Regulatory Commission
FGR	flue gas recirculation
FIP	Federal Implementation Plan
FTE	full-time equivalent
g	gram
hp	horsepower
hr	hour
ICAC	Institute of Clean Air Companies
ICI	industrial/commercial/institutional
IMA-NA	Industrial Minerals Association – North America
INGAA	Interstate Natural Gas Association of America
IR	ignition timing retard
lb	pound
LC	layered combustion
LDC	local distribution company
LDEQ	Louisiana Department of Environmental Quality
LEC	low emissions combustion
LMF	ladle metallurgy furnace
LNB	low NOx burner
LN^{tm}	Covanta Patented Low NOx Technology
m	meter
m^3	cubic meters

MMBtu	million British thermal units
MRRA	Minnesota Resource Recovery Association
MSW	municipal solid waste
MW	megawatt
MWC	municipal solid waste combustor
NAAQS	National Ambient Air Quality Standard
NAICS	North American Industry Classification System
NETL	National Energy Technology Labs
NGR	natural gas reburn
NNSR	nonattainment new source review
NSCR	non-selective catalytic reduction
NSR	New Source Review
non-EGU	non-electric generating unit
NOx	Nitrogen oxides
OEAS	oxygen enriched air staging
OEM	original equipment manufacturer
OFA	overfire air
ppb	parts per billion
ppmvd	parts per million by volume, dry
PM	particulate matter
PSD	Prevention of Significant Deterioration
PTE	Potential to Emit
RACT	Reasonably Available Control Technology
RDF	refuse-derived fuel
RFP	request for proposal
RFQ	request for quotation
RICE	reciprocating internal combustion engine
SMA	Steel Manufacturing Association
SSINA	Specialty Steel Industry of North America
SWANA	Solid Waste Association of North America
TCEQ	Texas Commissions on Environmental Quality
tpy	tons per year
TSD	Technical Support Document
SCD	supply chain delay
SCR	selective catalytic reduction
SNCR	selective noncatalytic reduction
ULNB	ultra-low NOx burner
USLM	U.S. Lime & Minerals
VOC	volatile organic compound
WPC	Wisconsin Paper Council

Executive Summary

The United States Environmental Protection Agency (EPA) proposed a "Good Neighbor" Federal Implementation Plan (FIP) to address regional ozone transport for the 2015 ozone National Ambient Air Quality Standard (NAAQS), which published in the Federal Register on April 6, 2022.[1] This proposed rule identified proposed oxides of nitrogen (NOx) emission limits for certain industrial stationary sources in states that were determined by EPA to be impacting the ability of downwind states to meet the ozone NAAQS.[2] The objective of this report is to provide EPA with information on the amount of time needed for non-electricity generating units (non-EGUs) in the specified industries to install the NOx control technologies necessary to comply with the requirements of the final FIP.

To address the timing needs for installation of NOx emission controls in the non-EGU sectors covered by the rule, the EPA enlisted SC&A, Inc. (SC&A) to examine a number of issues. These include:

- The time required to install NOx controls on affected NOx emission sources;
- The time required for state permitting staff to process permit modifications required for compliance with the final rule;
- Constraints on skilled labor relevant to air pollution control installation; and
- Supply chain constraints.

These issues are summarized below.

Summary of Overall Control Installation Timing and Permit Processing Time Estimates
Based on our findings drawn from information taken from a variety of sources as discussed later in this report, Table ES-1 provides a summary of the estimated range of calendar months needed for affected sources to complete all phases of NOx control installation (design, engineering, vendor selection, permitting, equipment fabrication, and control installation). These sources include prior technical studies, comments received on the proposed FIP, and control equipment vendor contacts. Two timelines are presented in Table ES-1 – the "Estimated Install Timeline" and the "Supply Chain Delay (SCD) Install Timeline."

- The "Estimated Install Timeline" – This timeline does not factor in any supply chain or other delays. It should be understood to reflect the amount of time expected to install the control at a single affected unit without any consideration of supply chain delays. Under ideal circumstances, without any supply chain delays, the entire estimated population of affected units could be addressed within this timeline. There are situations for some affected units where a single facility has multiple affected units. In those situations, the amount of time per control installation could be reduced. An example is the application of compact SCR at a natural gas compressor station. Where multiple RICE can be addressed at the same time, the amount of calendar time per engine could be reduced (mainly through the time required to issue a single

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[1] EPA, *Federal Implementation Plan Addressing Regional Ozone Transport for the 2015 Ozone National Ambient Air Quality Standard*, Proposed Rule, 87 FR 20036, April 6, 2022.

[2] Updated air quality modeling and analysis by the EPA was completed, and as a result Alabama, Minnesota, and Wisconsin will not be subject to non-EGU control requirements in the final FIP rulemaking. EPA is not finalizing a FIP for Tennessee or Wyoming at this time. Also, while Nevada is still included for non-EGU requirements, no existing affected industrial units under the final FIP were identified by EPA.

air permit modification for all affected RICE at the station). Sufficient data were not available to conduct case-by-case assessments of where such situations might arise.

- SCD Install Timeline -- In situations where supply chain delays are expected, based on current economic conditions and capacities (that is, as of 2022), a separate set of estimates incorporates our best estimates of the length of such delays ("SCD Install Timeline"). These estimates should be understood to reflect not only economic conditions and capacities as of 2022 but also the time required to address the entire population of affected units, if these supply chain delays were to continue unabated into the future. However, as noted later in the report, the most recent economic data tend to indicate that supply chain disruptions observed in the 2020-2022 timeframe associated with the pandemic and the war in Ukraine may already be lessening.

In cases where the timeline in both the "Estimated Install Timeline" and "SCD Install Timeline" columns is the same, there is no significant supply chain delay that results in a change to the initial "Estimated Install Timeline." In other words, in these cases, it would be possible for all units to be controlled in the same timeframe as a single unit.

The NOx controls represented in Table ES-1 are low NOx burners (LNB), selective catalytic reduction (SCR); selective non-catalytic reduction (SNCR); non-selective catalytic reduction (NSCR); low NOx burner and flue gas recirculation (LNB + FGR); Covanta's patented Low NOx Technology (LN^{tm}) + SNCR; and advanced selective noncatalytic reduction (ASNCR).

Table ES-1. Estimated Time Required to Achieve All Phases of NOx Control of Non-EGUs

Industry	Emissions Source Group	Control Technology	Estimated Installs	Estimated Install Timeline (months)[a]	SCD Install Timeline (months)[a]
Cement and Concrete Product Manufacturing	Kilns	SNCR	16	17 - 24	35 - 58
Glass and Glass Product Manufacturing	Melting Furnaces	LNB	61	9 - 15	9 - 15
Iron and Steel Mills and Ferroalloy Manufacturing	Reheat Furnaces	LNB	19	9 - 15	9 - 15
Pipeline Transportation of Natural Gas[b]	RICE 2-Cycle	Layered Combustion	394	6 - 12	40 – 72*
Pipeline Transportation of Natural Gas[b]	RICE 4-Cycle Rich Burn	NSCR	30	6 - 12	6 - 12

Industry	Emissions Source Group	Control Technology	Estimated Installs	Estimated Install Timeline (months)[a]	SCD Install Timeline (months)[a]
Pipeline Transportation of Natural Gas[b]	RICE unspecified	NSCR or Layered Combustion	323	6 - 12	40 – 72*
Pipeline Transportation of Natural Gas[b]	RICE 4-Cycle Lean Burn reciprocating	SCR	158	10 - 19	10 - 19
Affected Non-EGU Industries[c]	Boilers	LNB + FGR	151	9 - 15	9 - 15
Affected Non-EGU Industries[c]	Boilers	SCR	15	14 - 25	26 - 37
Municipal Waste Management	MWC Boilers	LN^{tm} + SNCR	4	22 - 28	22 - 28
Municipal Waste Management	MWC Boilers	ASNCR	57	17 - 23	35 - 57

***** We note that the 72-month estimates reflect an upper-bound assumption relating to how many potentially affected engine units are old enough to necessitate specialized labor, which is currently (as of 2022) found to be in limited supply. Further caveats associated with these estimates are discussed elsewhere in the report.

Timeframe for Permitting Processes

In general, we estimate that any permit needed for control installations at an individual source can be issued within a few weeks or months for minor modifications, and within a year for control installations that trigger major modification permitting requirements. For certain states with large numbers of affected sources, there could be a need for additional time, up to a year, to issue necessary permits, e.g., if state resource levels remain unchanged and the state lacks expedited permitting processes. In all cases, any necessary permitting should be complete within a two-year timeframe, and other aspects of control installation can likely proceed to some extent in tandem with the permitting process. We have not added time needed for issuance of permits onto the SCD install timeline because, in the event that supply-chain delays extend the installation timeframe beyond the 3-year period leading to 2026, the permitting process likely would not impact that installation timeframe, as permitting can occur within this timeframe and any potential supply chain delays should not delay the permitting process.

Some state permitting authorities may have a larger permit modification labor burden than others. This is due to both the estimated number of EGU and non-EGU affected units in their jurisdiction as well as the type of permit modifications that may be needed. Major modifications at existing sources are those that would increase emissions by “significant” amounts and thus trigger Prevention of Significant Deterioration (PSD) or Nonattainment New Source Review (NNSR) requirements. Large add-on controls, like SCR or SNCR, may in some cases require PSD or NNSR permits. We anticipate that most control installations will not result in significant emissions increases and thus will require only minor permit modifications, if any. For purposes of this analysis, however, we conservatively assume that all SCR/SNCR installations will require major permit modifications.

The estimated non-EGU NOx controls for the final FIP are divided into two groups. The SCR/SNCR group are all non-EGU applications for these controls, except for compact SCR systems applied to reciprocating internal combustion engines (RICE). The "other NOx controls" category represents mainly combustion controls (e.g., LNB, layered combustion) or packaged post-combustion controls (e.g., NSCR, compact SCR). There will be approximately three years available to achieve compliance with the final FIP, once the final rule is issued. To allow for sufficient time for control design, fabrication and installation, construction permits may need to be processed within the first 18 to 24 months.

Table ES-2 provides a breakdown of the number of affected units by state to identify the states that may have larger numbers of permit modifications to process.[3]

Permitting backlogs are more likely in the states indicated in Table ES-2 with significant numbers of affected units. The states with highlighted cells in Table ES-2 are those that may need to process many major permit modifications (>20) or many minor modifications (>80) within the first two years following rule finalization (this timeframe is expected in order to allow sufficient time for control installation). The presence of an expedited permit review program should help alleviate a significant short-term increase in state permitting review manpower needs in Indiana, Louisiana, and Texas.

Table ES-2. EGU and Non-EGU NOx Control Installations by State

State (Expedited Program?)	Estimated Non-EGU Control Installations		
	SCR / SNCR	Other NOx Controls	Total
Arkansas (N)	2	32	34
California (Y)	6	7	13
Illinois (Y)	8	53	61
Indiana (Y)	12	41	53
Kentucky (Y)	2	46	48
Louisiana (Y)	25	174	199
Maryland (N)	0	2	2
Michigan (N)	16	45	61
Mississippi (N)	6	57	63
Missouri (N)	1	39	40
New Jersey (N)	10	1	11
New York (N)	19	11	30
Ohio (N)	14	96	110
Oklahoma (N)	72	63	135
Pennsylvania (N)	22	63	85
Texas (Y)	19	158	177
Utah (N)	1	5	6

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[3] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

State (Expedited Program?)	**Estimated Non-EGU Control Installations**		
	SCR / SNCR	**Other NOx Controls**	**Total**
Virginia (N)	8	29	37
West Virginia (N)	5	58	63
Totals	**248**	**980**	**1,228**

In addition, there may be states where permitting staff resources are stressed by a combination of EGU and non-EGU permit modifications, although through 2026, the EGU permitting resulting from this rule is expected to be relatively small. However, as indicated by the analysis in Section 4 that included information from state permitting agencies, it is expected that at most the incremental permitting load would be under 3 full-time staff per year in all affected states.

Skilled Labor and Other Supply Chain Constraints

Table ES-1 also provides an indication of whether supply chain issues have the potential to extend the estimated time required for control installations. Potential sources of supply chain delays include: competition for engineering, procurement, and construction (EPC) contractors (associated with large controls, such as SCR or SNCR systems); equipment fabrication; skilled installation labor; local construction labor (again for large control systems); and raw materials.

In the case of raw materials, sufficient availability of SCR catalyst material was identified as a concern during discussions with control equipment vendors. This concern is mainly driven by a potentially significant demand placed on catalyst manufacturers by the expected number of existing EGUs that will elect to optimize their SCR systems by 2026. EPA expects that 229 EGU SCR optimizations will have been conducted by the 2023 ozone season. In addition, as early as the 2026/2027 ozone seasons, EPA also projects that a small number of EGUs will retrofit SCR (new system installs) on 2.5 – 8 GW (approximately 16 EGUs assuming a 500 MW unit capacity).[4] EGU SCR "optimizations" cover an array of operational or physical alterations:

- Operational optimizations: these can be made without any physical alterations to the source or SCR system or routine catalyst change-out schedules and include increasing maintenance, optimizing reagent injection, or changing combustion conditions to assure that the exhaust is meeting optimal temperatures for the SCR system (e.g., assuring that the EGU's dispatch schedule maintains adequate exhaust temperature);
- Physical optimizations: these include a complete change-out of catalyst material or the addition of another catalyst layer.

Depending on the number of EGU operators that elect physical optimizations to their SCR systems, a short-term spike in demand for catalyst material could be a concern. However, EPA expects that very few EGU operators will elect to conduct physical optimizations. Of the 229 EGUs noted earlier that could

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[4] U.S. EPA, "EGU NOx Mitigation Strategies Final Rule TSD," Technical Support Document (TSD) for the Final Federal Good Neighbor Plan for the 2015 Ozone National Ambient Air Quality Standards, Docket ID No. EPA-HQ-OAR-2021-0668, March 2023.

optimize their SCRs, 139 of them would have optimizations with emission reductions of 10 tons or less. Also, 191 of the 229 EGUs that could optimize their SCRs (or 83%) are combined cycle and combustion turbines. These natural gas-fired units generally require far less catalyst than coal-fired EGUs of the same size and avoid many of the challenges created by fly ash, the presence of sulfur trioxide, and other metals in the inlet to the SCR. In general, layers of catalysts can generally be swapped out during routine maintenance shutdowns. While catalyst layers are sometimes changed on a rotating schedule, it would not take significantly more time to swap out the entire amount of catalyst. We were unable to source sufficient information from catalyst suppliers to gauge the significance of these new demands including the potential length of any associated supply chain delay.

However, it is likely the case that any resulting increase in catalyst demand can be met via new production and/or the recycling of catalyst material from retired EGUs equipped with SCR. It can be noted that roughly 24 GW of EGUs with SCR are currently planning to retire (or have retired) between Jan 2021 and May 2026.[5] This would lower demand for catalyst, likely significantly more than any increased demand from EGU SCR optimization or retrofits and the non-EGU new SCR installs addressed in this report. In addition, the catalyst material from these retired units will be available for recycling (reducing the need to source new raw materials).

Descriptions of where supply chain delays are expected, as well as their length, are provided below:

- No expected supply chain delay: for control installations in Table ES-1, where the “SCD timeline” is the same as the “estimated install timeline,” the control technology is expected to be readily available or to have a short lead time for design and fabrication (e.g., compact SCR[6] or NSCR applied to RICE; LNB for furnaces in glass and glass products and reheat furnaces in iron and steel). Further, skilled labor for control equipment design and installation is expected to be available to meet the expected demand for services.
- Supply chain delay potential: additional time will likely be needed due to an identified supply chain limitation. Situations where supply chain delays are expected are summarized below along with an estimate of the length of delay:
    - <u>Cement and concrete product manufacturing, kilns installing SNCR for compliance</u>: an estimated 16 units may be competing for SNCR EPC contractors along with MWCs (61 units). Although 36 EGU SNCR optimization projects are expected, as stated previously, these should mostly be able to be handled by in-house personnel. The pool of identified US SNCR vendors is less than 10, and the number of these vendors that actually conducts the design (including modeling), engineering, fabrication, and installation may be no more than half of this (5 vendors). Based on discussions with control equipment vendors, 5 SNCR installation projects per year is a representative annual capacity for each vendor.
    - <u>MWC boilers</u>: these 61 sources are estimated to achieve compliance by applying either LN^{tm} + SNCR or ASNCR. The pool of SNCR EPC contractors will likely be limited to those with boiler expertise in the MWC sector. For the four installations of LN^{tm} + SNCR, these

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[5] EPA, “Appendix A: Final Rule State Emission Budget Calculations and Engineering Analytics” (this is a spreadsheet that is an appendix to the Ozone Transport Policy Analysis Final Rule TSD).

[6] Note: compact SCR systems are the same in design as the SCRs applied to RICE in the final rule non-EGU cost analysis.

all involve a single OEM for the original MWC unit (Covanta using their own proprietary technology). Given the lack of competition for these facilities and no other supply chain delays expected, it is assumed that Covanta can address these installations within the required installation timeline.

The 57 expected MWC ASNCR and 16 cement kiln SNCR installations may be competing for the same set of vendors. On-line information suggests that there are 3 to 5 vendors capable of supplying ASNCR technology. The total number of EPC contractors for SNCR is somewhat larger, but, if selected, we expect that those companies would still subcontract to the more limited pool of experienced ASNCR equipment suppliers and installers to complete a total of 73 SNCR or ASNCR installations.

Assuming that initial studies and permitting requires up to 12 months, there are two years available before the compliance deadline of May 2026 for final design, engineering, fabrication, and installation. Discussions with vendors suggest that full capacity is on the order of 5 projects at any one time for most suppliers (five per year). Therefore, 15 to 25 installations could be addressed by the estimated vendor pool per year; or 30 to 50 units within 2 years. This leaves an additional 23 to 43 units that may not be able to be addressed by May 2026 (which could be some combination of cement kiln SNCR or MWC ASNCR installations). If the vendor pool is able to address 15 to 25 units per year, then approximately an additional 18 to 34 months (that is, 23 units/15 units/year x 12 months/year to 43 units/15 units/year x 12 months/year) might be needed to address all affected units. This results in a total supply chain delay timeline of 35 to 58 months (17 to 24 months + 18 to 34 months) for cement installations of SNCR and 35 to 57 months (17 to 23 months + 18 to 34 months, again showing the broadest range of values) for ASNCR installation at MWCs. These timing estimates are based on current vendor capacity, and these estimates will decline if such capacity increases to meet the demand related to SNCR or ASNCR installations.

- Pipeline transportation of natural gas, RICE: application of layered combustion controls to some RICE may involve emissions units that are over 60 years old. Comments received by EPA indicate that while retrofit kits should be available for these RICE, these installations may require skilled labor familiar with these units and the specialized control kits to be applied. A key uncertainty is the number of RICE that might elect to apply these combustion kits versus NSCR or another compliance option (e.g., engine replacement or electrification). EPA's estimates in Table ES-1 above indicate that 394 RICE are estimated to apply layered combustion and 323 RICE are estimated to apply either layered combustion or NSCR. This results in a likely quite high upper range estimate of 717 units that could require specialized labor to address (technicians with the skills to apply layered combustion control kits to older RICE). This is a highly conservative estimate in that we do not have information on the number of older engines (i.e., those approaching 60 years of age or older), and it is likely that a much smaller set of units than the total number of units would undertake these types of control installations. Therefore, this number should be considered an upper bound reflective of the lack of data on engine age. As noted, we have also not attempted to assess whether alternative compliance approaches such as replacement of these engines with newer engines, or an increase in the necessary labor pool, could affect these estimates. Industry comments that reflect actions taken nearly 20 years ago suggest that a skilled labor pool is available to address at most 75 RICE per year. However, as discussed in Section 5, information on the growth of available skilled labor as the RICE population has increased over the last 20 years indicates the potential for retrofit capacity of up to twice that amount (or, 150 RICE per year). Hence, depending on the number of older RICE that industry elects to control with layered combustion, potentially the full amount of time needed to complete installations on all affected units is 717/150 = 4.8 years (58 months). For the portion of RICE estimated to be addressed by either layered combustion or NSCR, if half of the RICE are addressed by layered combustion, this results in a total estimate of 506 units. The total amount of time required to address them by the available skilled labor pool is then 506/150 = 3.3 years (40 months). Given that the total number of RICE that may require retrofits in response to this final rule is estimated at about 905, we estimate that the maximum length of control installation time for all sources in this category may potentially be as long as 905/150 = 72 months.

Note that these estimates do not include any consideration of delays that could occur from review required by the Federal Energy Regulatory Commission (FERC). While this concern was identified by commenters on the proposed rule, we were not able to complete an evaluation of these claims. We note that capacity utilization of compressor stations in the U.S. is about 40%; therefore, the ability to coordinate outages and work with FERC may not present a substantial basis for assuming much if any delay in control installation timing on this basis.

The estimated supply chain delay timeline is expected to range from 40 to 72 months. However, we again emphasize that the upper-bound estimate is unlikely to occur in reality. It assumes that all 717 identified engines are so old that they require specialized labor, that no such engines could be replaced with newer engines due to their age, and that there is no growth beyond 2022 in the pool of specialized labor in response to the rule.

- Affected industries, boilers: For sources that require SCR for compliance, some level of competition for EPC vendors is expected with EGUs that adopt SCR retrofits for compliance. The amount of EGU capacity electing to conduct SCR retrofits is expected to be relatively small (2.5 - 8 GW), and for purposes of this report, are expected to occur during the 2023-2027 timeframe. Finally, SCR EPCs for the EGU sector are generally a different group of vendors than those that serve the non-EGU sector.

  The number of non-EGU boiler SCR installations estimated isn't exceptionally large as indicated in Table ES-1; however, information gathered from vendor contacts indicates continuing delays for equipment fabrication and certain imported components. Overall, a supply chain delay of up to 12 months is likely to persist for affected boilers.

> An additional supply chain delay concern is the availability of SCR catalyst material due to overlapping demands with EGU SCR optimizations or retrofits. As addressed above, the number of EGU SCR physical optimizations requiring additional catalyst material is expected to be very small and to be completed by the 2023 ozone season. Recent and ongoing EGU retirements with SCR systems will also reduce demand for catalyst and also provide catalyst material for recycling. Considering only the additional 12 months of supply chain delay related to equipment fabrication, the full amount of time needed for SCR installation at an affected industry boiler could extend to 37 months.

Section 5 of this report provides information from a variety of indicators that offer some insight into the potential for skilled labor and supply chain constraint concerns. We find that in most cases, skilled labor and key materials in the supply chain have become more available than they were in 2020, and even when compared to the concerns noted by commenters. However, the progress that has been made in alleviating supply chain issues may need to be balanced with an understanding of the increased demand for key materials and skilled labor that might result from a requirement to install NOx controls on both EGU and non-EGU sources. Based on these indicators and input from control equipment vendors, access to raw materials (e.g., sheet stainless steel) and key components (e.g., electrical controllers, pumps) has either returned to near pre-pandemic levels or is expected to by early 2023.

Overall Conclusions

Based on the findings summarized above, the following types of affected units may experience difficulty in compliance with the final rule by May 2026:

- Kilns in cement and concrete product manufacturing installing SNCR for compliance: due mainly to limitations in the SNCR vendor pool and the overlapping needs for SNCR vendor support by MWCs and EGUs, an additional 18 to 34 months beyond the ”estimated install timeline” may be needed. The supply chain delay timeline is therefore estimated to range from 35 to 58 months.
- RICE in pipeline transportation of natural gas applying layered combustion controls for compliance: assuming the maximum number of engines that could apply this control are so old that they need to be addressed by a limited pool of skilled labor, there is a potential that all affected units will not be able to achieve compliance by May 2026. The supply chain delay timeline is estimated to range from 40 to 72 months.
- Boilers in affected industries installing SCR for compliance may experience delays in equipment fabrication. The supply chain delay timeline is 26 to 37 months.
- MWCs installing either LN^{tm} + SNCR or ASNCR might be competing for vendors in a limited pool of vendors with expertise in the municipal waste industry and with the application of ASNCR. The supply chain delay timeline is estimated to be 35 to 57 months.

1. Introduction

EPA proposed a FIP to address regional ozone transport for the 2015 ozone NAAQS, published in the Federal Register on April 6, 2022.[7] This proposed rule included provisions to establish emission limits on NOx emitted by certain industrial stationary sources in states that have been determined by EPA to be impacting the ability of downwind states to meet the ozone NAAQS. The objective of this report is to provide EPA with information on the time needed for non-EGU NOx emission sources in the specified industries to install NOx controls that would enable these units to meet the emission limits.

In its proposed rule, EPA proposed that the non-EGU NOx controls should be in place in time for the 2026 ozone season and needed to understand issues that could prevent industries from meeting this important deadline. Therefore, EPA solicited comment on issues related to the timing needed to install these controls, issues of technical feasibility related to installing these controls in the specified industries, and other related topics. This report draws on information provided by commenters in response to the proposed rule as well as additional EPA technical reports, industry information, and information obtained directly via communication with industry and state contacts. This report also addresses updates to the non-EGU analysis for the final rule in terms of the number of units that are likely to need to install pollution controls.

While EPA has prepared similar reports on the timing needed to install NOx control technologies on non-EGU sources, the timing of this proposal introduced issues outside prior analyses and potentially beyond the control of industry. The national and international supply chains have been disrupted first by the Covid-19 pandemic that began in 2020 and then by the Russian invasion of Ukraine beginning in early 2022. These supply chain issues were frequently mentioned in comments received by EPA and have the potential to impact the amount of time it will take for many non-EGU emission sources to install NOx controls. Thus, this report addresses these issues and based on analysis of recent economic information, attempts to put these issues in perspective to estimate any delays that supply chain issues may cause to the processes needed to install NOx controls.

Section 2 of this document provides a brief background on each of the non-EGU industries and the corresponding NOx emission sources that EPA has identified as industries and sources impacting the ability of downwind states to meet the ozone NAAQS. Section 3 briefly describes the NOx control technologies that EPA expects affected non-EGU sources will apply to meet the NOx emission limits in the final rule. Section 4 summarizes the evaluation of the timing needed to install NOx controls on the non-EGU emission sources in these industries, both on an individual basis as well as in combination with the entirety of expected NOx controls for non-EGUs and EGUs combined that would be needed to comply with the final rule. Section 5 discusses some of the potential supply chain issues and provides an evaluation of the current economic factors impacting control installation. Finally, a summary of the results from this report is presented in Section 6.

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[7] EPA, *Federal Implementation Plan Addressing Regional Ozone Transport for the 2015 Ozone National Ambient Air Quality Standard*, Proposed Rule, 87FR20036, April 6, 2022.

2. Affected Industries—Emission Sources and Unique Issues

The affected non-EGU industries in the final rule for the FIP are as follows:

- Pipeline Transportation of Natural Gas;
- Cement and Concrete Product Manufacturing;
- Iron and Steel Mills and Ferroalloy Manufacturing;
- Glass and Glass Products Manufacturing;
- Basic Chemical Manufacturing;
- Petroleum and Coal Products Manufacturing;
- Pulp, Paper, and Paperboard Mills;
- Metal Ore Mining; and
- Solid Waste Incinerators and Combustors (indicated as Municipal Waste Combustors (MWCs).

A general overview of the affected non-EGU industries is provided below along with a description of the primary sources of NOx emissions in these industries. The industries for which boilers are the only affected sources are addressed as a group in a separate subsection.

2.1 Cement and Concrete Product Manufacturing

Within the cement and concrete product manufacturing industry, EPA's final rule would apply NOx emission limits to kilns used in the production of clinker (all within North American Industry Classification System (NAICS) code 32731x). Cement clinker is used in producing cement, and is produced by grinding and mixing raw materials, and then heating (calcining) them at high temperatures within a kiln. Clinker is made up of glass-hard, spherically shaped nodules that range from an eighth to two inches in diameter. Limestone and other calcareous materials (calcium carbonate containing substances, including gypsum), sand, clay, shale, and iron ore are key raw materials.[8] Some amount of recycled concrete and other materials may also be used in clinker production (e.g., fly ash, slag).

After the raw materials are ground and mixed, they are fed into a kiln. Clinker production is performed using either a dry or wet process. In a wet process, the dry raw materials are mixed with water to form a slurry. In a dry process, the materials are dried to less than one percent prior to pyroprocessing in the kiln. For some plants using the dry process, an additional pre-calciner kiln is added before the main kiln (calciner) to increase the overall thermal efficiency of the process. Both the pre-calciner and main kilns can be fired on a variety of fuels (gas, liquid or solid) up to 2,700°F. After exiting the kiln, the clinker passes through a clinker cooler, where some thermal energy is recovered to return to the process. The clinker is then ground and mixed with other materials to produce finished cement.[9]

Essentially all the NOx emissions associated with cement manufacturing are attributed to the kilns due to the high process temperatures. The specific types of kilns that produce NOx emissions and that may be affected by the final rule are discussed below.

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[8] Shaped by Concrete, Sustainably Producing Concrete, website at https://howcementismade.com/.

[9] Shaped by Concrete, Sustainably Producing Concrete, website at https://howcementismade.com/.

Long Wet Kiln

Long wet kilns transform slurry to clinker. The slurry enters the kiln at room temperature with a moisture content of 40%. Wet kilns must be 200 meters (m) long to allow enough time for evaporation. Long wet kilns are not energy efficient because (1) the high moisture content of the slurry must be evaporated by inefficient heat transfer and (2) the construction and maintenance of such a long kiln. Wet kilns are uncommon today because of their required length and energy demands.[10]

Long Dry Kiln

Long dry kilns transform dry blended materials into clinker. Long dry kilns refer to a dry kiln without a preheater or precalciner, hence why they must be longer. This process is more energy efficient than the long wet kiln because (1) the low moisture content of the material allows for a shorter kiln and (2) less heat transfer energy requirements (i.e., little evaporation necessary).[11]

Preheater Kiln

The preheater kiln preheats the materials before entry to the dry kiln to improve overall thermal efficiency. The purpose is to minimize the latent heat requirement of the kiln. The dry powder concrete material, limestone, and other materials enter at the top of the preheater. A series of four to six cyclones keep the material suspended in the air. Hot gases, typically recycled from the clinker cooler, travel up the preheater kiln and heat the cement materials passing down. This is an efficient means of heat transfer. The preheater kiln decarbonizes 30-40% of the material before entering the dry kiln.[12,13]

Precalciner Kiln

A precalciner kiln preheats the materials before entry to the kiln to improve overall thermal efficiency. The precalciner kiln has an additional burner beyond that used in the preheater kiln. Many designs contain a preheater and precalciner in series for maximum operation efficiency. The materials exit the precalciner kiln and enter the dry kiln at approximately 1,700°F. This additional process allows for 85-95% decarbonization of the material before it enters the kiln.[14] In a preheater/precalciner setup, fuel is fired in the precalciner and rotary kiln. Conventional kilns only use fuel within the dry or wet kiln. This unique design of preheater/precalciner systems allows for a shorter dry kiln, in comparison to conventional kilns.

NOx Emission Limits for Affected Units in Cement and Concrete Products Manufacturing

The NOx emission limits in the final rule for affected kilns in concrete and cement products manufacturing that have the potential to emit (PTE) 100 tons per year (tpy) of NOx are shown in Table 2-1.

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[10] Understanding Cement, Manufacturing - the cement kiln, website at https://www.understanding-cement.com/kiln.html.

[11] Ibid.

[12] Ibid.

[13] Agico Cement, Precalciner, website at https://www.cementplantequipment.com/products/precalciner/.

[14] Agico Cement, Precalciner, website at https://www.cementplantequipment.com/products/precalciner/.

Table 2-1. NOx Emission Limits of Kilns from the Cement and Concrete Industry[15]

Kiln Type	NOx Emissions Limit (lb NOx/ton of clinker)
Long Wet	4.0
Long Dry	3.0
Preheater	3.8
Precalciner	2.3
Preheater/Precalciner	2.8

2.2 Glass and Glass Products Manufacturing

The glass and glass products manufacturing industry manufactures plate glass, glass bottles and containers, automobile windshields, glass tubing, and insulation fiberglass. The NAICS code for glass and glass products manufacturing is 3272xx.[16] Raw materials used in glass production include silica, soda ash, limestone, dolomite, and other chemicals.[17]

Glass products are classified by chemical composition and the type of glass product produced. Glass products include flat glass, container glass, pressed and blown glass, and fiberglass. The manufacturing of such glass occurs in four phases: (1) preparation of raw material, (2) melting in the furnace, (3) forming, and (4) finishing. Phase 1 and 2, the preparation and melting of raw materials, is identical for all glass products. The forming and finishing processes differ depending on the desired glass product. Container glass and pressed/blown glass use pressing or blowing to form the desired product. Flat glass is formed by float, drawing, or rolling processes.

Glass melting furnaces heat the raw materials at high temperatures before glass formation. The furnaces have high energy demands and are the source of most NOx emissions in glass manufacturing. This is due to the high process temperatures where nitrogen and oxygen react.[18] NOx emissions from different furnaces in the glass and glass product manufacturing industry are discussed below.

Container Glass Manufacturing Furnace

Container glass furnaces produce glass products that hold a certain form. Container glass is composed of soda lime, clear or colored, and is pressed or blown into the shape of bottles, ampoules, etc. This type of furnace is used in most glassmaking operations. These furnaces are designed to operate for 24 hours a day and can perform large-scale production.[19]

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[15] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

[16] EPA, Office of Air and Radiation, "Non-EGU Sectors TSD," Draft Technical Support Document for the Proposed Rule, Docket ID No. EPA-HQ-OAR-2021-0668, December 2021.

[17] EPA, Glass Manufacturing Effluent Guidelines, website at https://www.epa.gov/eg/glass-manufacturing-effluent-guidelines.

[18] EPA, Office of Air and Radiation, "Non-EGU Sectors TSD," Draft Technical Support Document for the Proposed Rule, Docket ID No. EPA-HQ-OAR-2021-0668, December 2021.

[19] Glasstech Refractory, Container Glass Furnaces, website at http://www.glasstechrefractory.com/industrial-solutions/container-glass-furnaces.

Furnaces consist of three main parts, the melter, refiner, and regenerators or checkers. Most furnaces use natural gas, but others can use oil, propane, or electricity. The glass melting furnace reaches temperatures of 1,500 to 1,700°C (2,700 to 3,100°F). Furnaces range in size from 450 to > 1,400 square feet of melter surface. The melter is a rectangular basin that melts raw materials and removes seeds, i.e., fining. Furnaces contain three to seven natural gas burners above glass level to heat the glass at very high temperatures. The burner ports also capture combustion emissions for further processing. After it is melted, the glass passes through a water-cooled tunnel to the refiner. The refiner allows the glass to slowly cool. Regenerators use recycled flue gas which saves energy.[20]

Pressed/Blown Glass Manufacturing Furnace or Fiberglass Manufacturing Furnace

In creating blown glass, or molded glass, gobs of melted glass from the glass furnace are placed in a molding cavity where air is blown into the glass to expand it to a container shape with a neck. Once it is shaped, the molded glass is now a "parison." This is referred to as the Blow & Blow Process, where compressed air distinguishes the bottle neck finish and gives a uniform shape. During the Press & Blow Process, used to create larger containers, a plunger is inserted into the glass and air is injected to form the bottle shape.[21]

Glass fiber manufacturing is the high-temperature conversion of various raw materials (predominantly borosilicate) into a homogeneous melt, followed by the fabrication of this melt into glass fibers. The two basic types of glass fiber products—textile and wool—are manufactured by similar processes. The primary component of glass fiber is sand, but it also includes varying quantities of feldspar, sodium sulfate, anhydrous borax, boric acid, and many other materials.

Furnace designs vary, but most are large, shallow, and well-insulated vessels fired from above. Raw materials are continuously added into the furnace where they slowly melt and mix into the molten glass. The mixing of the molten glass and raw materials is facilitated by the natural convection of gases rising through the molten glass. Some operators inject air into the bottom of the bed to facilitate convection.

Wool fiberglass insulation has five phases: (1) preparation of molten glass, (2) formation of fibers into a wool fiberglass mat, (3) curing the binder-coated fiberglass mat, (4) cooling the mat, and (5) backing, cutting, and packaging the insulation.

Flat Glass Manufacturing Furnace

The flat glass furnaces behave similarly to container and blown glass furnaces. Flat glass furnaces melt fine-grained ingredients at 1,500°C. Melting, refining, and homogenizing can take up to 50 hours to produce molten glass at 1,100°C, free from inclusions and bubbles. The melting process can be modified by operators depending on the desired product.[22]

During the Float Bath process, molten glass from the furnace flows over a refractory spout onto a level surface of molten tin. The molten glass starts at 1,100°C when leaving the furnace and cools to 600°C

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[20] Glass Packing Institute, Glass Furnace Operations, website at https://www.gpi.org/glass-furnace-operation.

[21] Qorpak, Glass Bottle Manufacturing Process, website at https://www.qorpak.com/pages/glassbottlemanufacturingprocess#:~:text=Blown%20Glass%20is%20also%20known,then%20known%20as%20a%20Parison.

[22] Eurotherm, Flat Glass Manufacturing, website at https://www.eurotherm.com/us/glass-manufacture/flat-glass-manufacturing/.

during the float bath process. This gradual temperature cooling treatment relieves stresses in the glass and is called “lehr”. Too much stress and the glass will break beneath the cutter.

After the glass has cooled, the glass is inspected by machinery and workers to remove deformed or cracked glass. Inspection technology allows more than 100 million measurements a second across the ribbon, locating flaws the unaided eye would be unable to see.

NOx Emission Limits for Affected Units in Glass and Glass Products Manufacturing

The NOx emission limits on furnaces in glass and glass products manufacturing apply to furnaces that have the potential to emit (PTE) 100 tons per year (tpy) of NOx. The final NOx emission limits for glass manufacturing furnaces are shown in Table 2-2.

Table 2-2. Summary of Final NOx Control Requirements for Glass and Glass Product Industry[23]

NOx Emission Source	NOx Emissions Limit (lb NOx/ton of glass produced)
Container Glass Furnace	4.0
Pressed/Blown Glass Furnace	4.0
Fiberglass Furnace	4.0
Flat Glass Furnace	7.0

2.3 Iron and Steel Mills and Ferroalloy Manufacturing

The iron and steel mills and ferroalloy manufacturing industry is primarily engaged in the production of various steel products, including carbon, alloy, and stainless steels. It is identified by NAICS code 3311 (and related 5- and 6-digit NAICS codes) and encompasses various manufacturing processes. These include:

(1) direct reduction of iron ore;
(2) manufacturing pig iron in molten or solid form;
(3) converting pig iron into steel;
(4) manufacturing ferroalloys;
(5) making steel;
(6) making steel and manufacturing shapes (e.g., bar, plate, rod, sheet, strip, wire); and,
(7) making steel and forming pipe and tube.[24]

Integrated iron and steel production is often misconstrued with electric arc furnace (EAF) steel production. For integrated iron and steel production, a blast furnace (BF) transforms iron ore to molten iron. A basic oxygen furnace (BOF) and molten “pig iron” together create molten steel. This process generates more emissions than EAF steel production. In the BOF, high-purity oxygen oxidizes impurities

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[23] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

[24] EPA-HQ-OAR-2021-0668-0504. Comment submitted by Steel Manufacturers Association (SMA) and Specialty Steel Industry of North America (SSINA).

in the molten bath. Carbon is removed in the form of carbon monoxide (CO) and carbon dioxide (CO_2).[25,26] The molten steel is now the proper grade to be shaped and cooled.[27]

Unlike the BF/BOF process, the EAF process uses electrodes to melt the scrap metal. Oxy-fuel, including natural gas burners, are used to supplement the EAF to obtain the necessary energy requirements. During the refining process for EAF, impurities called "slag" conjoin at the top of the molten metal. Molten slag is removed out a slag door by tipping the furnace, i.e., slagging. The final step is tapping where molten steel is poured in a ladle. Usually, the steel will be further refined in a ladle metallurgy station and/or argon oxygen decarburization. The steel is then cooled and formed into slabs.[28]

Ferroalloys are an alloy of iron with higher impurities of aluminum, magnesium, or silicon. Ferroalloy processing is typically done in a submerged EAF, that, like EAF steel production, use carbon electrodes to heat the scrap metal. A carbon source agent "coke" is typically added. The major alloys produced are silicon alloys (ferrosilicon and calcium silicide), chromium alloys (high carbon ferrochromium in various grades and ferrochrome-silicon), and manganese alloys (standard ferromanganese and silicomanganese).[29,30]

In 2021, 16.39 million metric tons of raw steel was produced in the US, a substantial increase (42%) from 11.57 million metric tons in 2020.[31] One hundred percent of steel can be repurposed without compromising strength or quality, making it the most recycled material.[32] However, the production of iron and steel is energy intensive. In 2021, 6.34 megawatt (MW)-hours of energy per metric ton of raw steel was consumed in the US.[33]

SC&A understands that Reheat furnaces are the only NOx sources at iron and steel mills that are subject to this final rule.

Reheat Furnace

Reheat furnaces at BF/BOR within iron and steel mills heat cold steel to the necessary temperature (~1200°F) before additional processing. The furnace is heated typically with natural gas, which emits

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[25] EPA, Office of Air and Radiation, Office of Air Quality Planning and Standards, "Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Iron and Steel Industry," September 2012.

[26] EPA, Office of Air Quality Planning and Standards, "Alternative Control Techniques Document -- NOx Emissions from Iron and Steel Mills," September 1994.

[27] EPA-HQ-OAR-2021-0668-0504. Comment submitted by Steel Manufacturers Association (SMA) and Specialty Steel Industry of North America (SSINA).

[28] EPA-HQ-OAR-2021-0668-0504. Comment submitted by Steel Manufacturers Association (SMA) and Specialty Steel Industry of North America (SSINA).

[29] EPA, Office of Air and Radiation, Office of Air Quality Planning and Standards, "Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources," AP-42, Fifth Edition, Chapter 12.4: Ferroalloy Production, January 1995.

[30] EPA, Ferroalloy Manufacturing Effluent Guidelines, website at https://www.epa.gov/eg/ferroalloy-manufacturing-effluent-guidelines.

[31] United States Steel, Energy Conservation, website at https://www.ussteel.com/sustainability/environmental/energy-conservation.

[32] American Iron and Steel Institute, Sustainability, website at http://www.recycle-steel.org/.

[33] United States Steel, Energy Conservation, website at https://www.ussteel.com/sustainability/environmental/energy-conservation.

NOx. Emissions are typically vented through the building roof monitor. The next stage after the reheat furnace is hot rolling.[34]

NOx Emission Limits for Affected Units in Iron and Steel Mills and Ferroalloy Manufacturing

For the iron and steel mills and ferroalloy manufacturing industry, the only sources included in the final rule are reheat furnaces that have the potential to emit (PTE) 100 tons per year (tpy) of NOx and boilers as affected sources. The affected reheat furnaces would be required to install LNB, with emission limits established based on testing at the unit, as shown in Table 2-3. Boilers are discussed in Section 2.5.

Table 2-3. Summary of Final NOx Control Requirements for the Iron and Steel Industry[35]

NOx Emission Source	NOx Emission Limit or Control Efficiency	Expected Controls	Best Estimate of NOx Reduction
Reheat Furnace	Test and set limit based on installation of Low NOx Burners	LNB	50%

2.4 Pipeline Transportation of Natural Gas

The Pipeline Transportation of Natural Gas industry falls under NAICS code 486210 and comprises establishments primarily engaged in the pipeline transportation of natural gas from processing plants to local distribution systems. This industry includes the storage of natural gas because the storage is usually done by the pipeline establishment and because a pipeline is inherently a network in which all the nodes are interdependent.

Natural gas compressor stations are located periodically along a transmission pipeline (e.g., every 50 – 100 miles). They function to raise the pressure of the gas to make up for losses due to pipeline friction and changes in pipeline elevation.[36] In 2017, there were reported to be 2,304 compressor stations operating in the U.S. Detailed information was available for 1,197 (or 52% of the total), which indicated that about 80% had more than one compressor unit and around 7 percent had more than 10 compressors. Typically, for compressor stations with multiple units, some of these will be back-up compressors. Available information suggests that capacity utilization at natural gas compressor stations is relatively modest. Assessments of capacity utilization indicate that around 25% of stations are utilized at less than 40% of their capacity. Over 40% of stations are utilized at less than 80% of their capacity. In certifications provided by the U.S. Federal Energy Regulatory Commission (FERC), pipeline operators are required to retain sufficient compression capacity to meet demand on peak demand days (e.g., coldest multi-day event for winter heating). Information from one pipeline operator indicated that their system capacity utilization averaged 30%, and that average utilization in the U.S. was 40%.[37]

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[34] AMETEK Land, Reheat Furnace, website at https://www.ametek-land.com/applications/steel/hotrollingreheatfurnace.

[35] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

[36] National Energy Technology Labs (NETL), "Natural Gas Compressors and Processors – Overview and Potential Impact on Power System Reliability," NETL-PUB-21531, July 2017.

[37] EPA-HQ-OAR-2021-0668-0380. Comment submitted by TC Energy.

The NOx sources addressed by the FIP are the prime movers of natural gas compressors: reciprocating internal combustion engines (RICE). All the identified sources are fired by pipeline gas.[38] RICE used at compressor stations affected by the FIP are those >1,000 horsepower (hp). RICE are further differentiated by three engine types:

- 2-stroke lean-burn
- 4-stroke lean-burn
- 4-stroke rich-burn

The final rule includes EPA's NOx emission limits on RICE in pipeline transportation of natural gas with nameplate rating of ≥1,000 brake-horsepower (bhp). Table 2-4 provides the NOx emission limits for these RICE.

Table 2-4. Proposed NOx Emission Limits for Natural Gas-Fired RICE in Pipeline Transportation of Natural Gas[39]

Engine Type	Emissions Limit (g/hp-hr)
4-Stroke Rich Burn	1.0
4-Stroke Lean Burn	1.5
2-Stroke Lean Burn	3.0

2.5 Boilers in the Iron and Steel Mills and Ferroalloy Manufacturing, Basic Chemical Manufacturing, Petroleum and Coal Products Manufacturing, Pulp, Paper, and Paperboard Mills, and Metal Ore Mining Industries

The non-EGU affected industries with boilers subject to the final rule are: Iron and Steel Mills and Ferroalloy Manufacturing; Basic Chemical Manufacturing; Petroleum and Coal Products Manufacturing; Pulp, Paper, and Paperboard Mills; and Metal Ore Mining. The final rule includes NOx emission limits on boilers using fossil fuels n all affected industries. These fuels include coal, residual oil, distillate oil, and natural gas. Natural gas units are the most common of the non-EGU boilers affected by the final rule. The emission limits (30 day rolling average) for these boilers by fuel type can be seen in Table 2-5. These limits apply to boilers used in the affected industries that have a design capacity of ≥100 MMBtu/hr.

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[38] National Energy Technology Labs (NETL), "Natural Gas Compressors and Processors – Overview and Potential Impact on Power System Reliability," NETL-PUB-21531, July 2017. 77% of stations were fueled by natural gas, 17% could operate on either electricity or natural gas, and 6% were powered solely by electricity.

[39] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

Table 2-5. NOx Emission Limits for Non-EGU Affected Industry Boilers[40]

Unit Type	Emissions Limit (lb NOx/MMBtu)
Coal	0.20
Residual Oil	0.20
Distillate Oil	0.12
Natural Gas	0.08

Basic chemical manufacturing includes both organic and inorganic chemicals manufacturing (i.e., NAICS code 3251). Petroleum and coal products manufacturing includes NAICS code 3241). Pulp, paper, and paperboard mills include newsprint mills (i.e., NAICS code 3221). Metal ore mining includes NAICS codes 2122. Additional descriptions for these affected industries are provided below.

Boilers utilize the combustion of fuel to produce steam. The hot steam is then employed for space and water heating purposes or for power generation via steam-powered turbines. The three main types of boilers are described below:[41]

- Firetube boilers. Hot gases produced by the combustion of fuel are used to heat water. The hot gases are contained within metal tubes that run through a water bath. Heat transfer through thermal conduction heats the water bath and produces steam. Typically, firetube boilers are small, with capacity below 100 million British thermal units (MMBtu)/hr.
- Watertube boilers. Hot gases produced by fuel combustion heat the metal tubes containing water. Typically, there are several tubes configured as a "wall." Watertube boilers vary in size from less than 10 MMBtu/hr to 10,000 MMBtu/hr.
- Fuel-firing. Fuel is fed into a furnace and the high gas temperatures generated are used to heat water. Fuel-firing boilers include stoker, cyclone, pulverized coal, and fluidized beds. Stokers burn solid fuel and generate heat either as flame or as hot gas. Pulverized coal enters the burner as fine particles. The combustion in the furnace produces hot gases. The ash (the unburned fraction) exits in molten or solid form. Fluidized beds utilize an inert material to "suspend" the fuel. The suspension allows for better mixing of the fuel and subsequently better combustion and heat transfer to tubes.

A brief description of each of the affected industries with boilers is provided in the following sections.

Basic Chemical Manufacturing

The Basic Chemical Manufacturing industry transforms inorganic and organic materials into a desired chemical product. The products include basic chemicals, coatings and adhesives, resins, cleaning products, pesticides, and pharmaceuticals. The Basic Chemical Manufacturing industry is identified by NAICS code 3251.

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[40] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

[41] Northeast States for Coordinated Air Use Management (NESCAUM), "Applicability and Feasibility of NOx, SO2, and PM Emissions Control Technologies for Industrial, Commercial, and Institutional (ICI) Boilers," January 2009. Available at https://www.nescaum.org/documents/ici-boilers-20081118-final.pdf.

Boilers in the Basic Chemical Manufacturing industry play a crucial role. Boilers are used in producing steam, boiling, and energy production. Steam is commonly used because it evenly distributes heat, carries ample heat, and is an efficient energy transfer process. Steam allows for easy adjustments of temperature and pressure, as well as slowly cooling or heating a chemical reactor.

Some processes in the Basic Chemical Manufacturing industry that use boilers are as follows:

- Boilers power exhaust fans to vent fumes during production.
- Boilers heat and cool reactors with steam or water.
- Waste heat boilers reuse heat energy to reduce waste.
- Boilers produce the electricity needed to run the plant.

Petroleum and Coal Products Manufacturing

The Petroleum and Coal Products Manufacturing industry transforms crude petroleum and coal into desired products. Some of these products include gasoline, diesel fuel, asphalt, lubricating oils, paraffin waxes, and transmission fluids. This industry is dominated by petroleum refineries. The Petroleum and Coal Products Manufacturing industry is identified by NAICS code 3241.

Crude oil is superheated in a furnace and turns from a liquid to a gas. The superheated gas is transferred to the bottom of the distillation tower. The oil begins to cool and return to a liquid in the tower. Using stacking trays, heavier oils will remain at the bottom of the distillation tower while lighter oils will raise to the top of the tower. This process discriminates crude oil by boiling point, density, and grade. Light oils have less than 10 elements of carbon and low boiling points under 120°C. These oils become propane and natural gas, for example. Lighter oils are more valuable and require less processing. Heavy oils have greater than 30 elements of carbon and higher boiling points over 300°C. These oils become residual oil, asphalt, or tar. Oil refineries have cracking units that transform unusable heavy oils into lighter oils. This is accomplished by catalysts breaking long chain carbon bonds into shorter hydrocarbons. These lighter fuels are now more valuable to the industry.

Boilers play a crucial role in the Petroleum and Coal Products Manufacturing industry. Their main purpose is to heat oil for distillation. Boilers heat the crude oil in the furnace, distillation tower, and cracking unit to promote the separation of oil grades. Refineries typically use water tube and fire tube boilers.

Pulp, Paper, and Paperboard Mills

Paper production begins with harvesting trees. Next, the bark is removed, and the wood chips are placed in a digester to remove their lignin content. This process is very energy intensive, using half the total energy demand of an entire pulp and paper plant in this one step.[42] What remains is "pulp," which is then filtered and bleached, and then additives are added into the pulp. To process pulp into paper, the pulp is squeezed through rollers to form sheets. This also removes most additional water content in the paper. The paper is then rolled into reels for any further processing, such as cutting, color, or strength additives. The Pulp, Paper, and Paperboard Mill industry is identified by NAICS code 3221.

Boilers play a crucial role in the pulp and paper industry. Boilers are primarily used in this industry in producing steam, boiling, and energy production. Steam is commonly used because it evenly distributes

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[42] Energy Link, Top 4 Energy Consumers in the Paper Manufacturing Industry, website at https://goenergylink.com/blog/paper-manufacturing-industry-the-top-4-energy-consumers/.

heat, promotes uniformity and increased strength in the final paper product. Steam is also used because it carries ample heat and is an efficient energy transfer process. Steam allows for easy adjustments of temperature and pressure, depending on the grade of paper needed.

Some processes in the pulp and paper industry that use boilers are as follows:

- In the digester, tree scapings are boiled to remove lignin and make pulp.
- Steam uniformly heats the paper rolls during the rolling process.
- Steam dries the paper before rolling.
- Boilers are used in the reuse and purification of water.
- Boilers produce the electricity needed to run the plant.

Metal Ore Mining Industry

The metal ore mining industry extracts desired metals to produce a product. The most mined metals include iron and copper. Other examples include nickel, rare earth metals, cobalt, manganite, and uranium ores. Metals are mined for renewable energy, electronic wiring, steel production, and batteries. The Metal Ore Mining Industry is identified by NAICS code 2122.

Metal ore mines can be above or below ground. Metals originate in rock with some ores containing less than a percent of the desired metal. As a result, massive amounts of rock must be extracted to meet demand. The Metal Ore Mining Industry requires heavy machinery and explosives to crush and drill through rock. A meta-analysis on energy consumption was performed on the gold, copper, nickel, lithium, and iron mining industries. Copper is the most energy intensive and 46% of the energy consumed is diesel, mainly for off-grid mobile equipment.[43]

After the rock is extracted, it undergoes crushing and grinding, a concentrator to remove impurities, and metals recovery.[44] Although most of the energy consumption in the mining industry is off grid, boilers are used as a power source and/or output steam to produce heat energy. Boilers have been used in ore mining and beneficiation, or the removal process of gangue minerals. Metals recovery requires heat and steam and is a process in the metal ore mining industry that can utilize boilers.[45]

2.6 Municipal Waste Combustors

Municipal waste combustion involves the burning of garbage and other nonhazardous solids, collectively referred to as municipal solid waste (MSW), to generate electric power.[46] The NAICS code for Solid Waste Incinerators and Combustors is 562213. MSW is a mixture of energy-rich materials such as paper, plastics, yard waste, and products made from wood. For every 100 pounds of MSW in the United States, about 85 pounds can be burned as fuel to generate electricity. Waste-to-energy plants can reduce 2,000

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[43] Allen, M. Mining Energy Consumption 2021, Engeco.

[44] EPA, Explore a Metal Mine that Reports to the TRI Program, website at: https://www.epa.gov/toxics-release-inventory-tri-program/explore-metal-mine-reports-tri-program.

[45] DHB Boiler, Mining, website at: https://dhbboiler.com/mining/.

[46] EPA, AP-42 Compilation of Air Pollutant Emissions Factors, Section 2.1 Refuse Combustion, October 1996, available at https://www3.epa.gov/ttnchie1/ap42/ch02/final/c02s01.pdf.

pounds of garbage to ash weighing about 300 pounds to 600 pounds, and they reduce the volume of waste by about 87%.[47]

Municipal waste combustors (MWC) are intended to reduce the volume of MSW through combustion of that solid waste. MSW is a fuel that tends to be a heterogeneous mixture of heavy and light materials of various combustibility. Most MWCs are designed to recover some of the heat generated from the MSW combustion process through heat absorption by radiant and convective water-cooled and steam-cooled tubing surfaces. MWCs may incorporate the steam generator within the MWC as an integral component, or the steam generator is a separate entity acting as a waste heat recovery device attached to the MWC. There are many designs and configurations of MWC units, often depending upon the intended volume of MSW throughput, characteristics of the design "municipal waste fuel", and the experience and preferences of the owner/operator and engineering/design organization.[48]

Nitrogen oxides in the MWCs are formed primarily during combustion through the oxidation of nitrogen-containing compounds in the waste at relatively low temperatures (<1,090^oC or 2,000^oF), and negligibly through the fixation of atmospheric nitrogen, which occurs at much higher temperatures. Because of the kind of fuel MWCs use and the relatively low temperatures at which they operate, 70–80% of NOx formed in MSW incineration is associated with nitrogen in the MSW.[49]

There are different types of waste-to-energy systems or technologies. The most common type used in the United States is the mass-burn system, where unprocessed MSW is burned in a large incinerator with a boiler and a generator for producing electricity. Another less common type of system processes MSW to remove most of incombustible materials to produce refuse-derived fuel (RDF).[50] There is also a smaller and more portable type of system known as modular systems.

Mass Burn Facilities

At an MSW combustion facility, MSW is unloaded from collection trucks and placed in a trash storage bunker. An overhead crane sorts the waste and then lifts it into a combustion chamber to be burned. The heat released from burning converts water to steam, which is then sent to a turbine generator to produce electricity.

The remaining ash is collected and taken to a landfill where a high-efficiency baghouse filtering system captures particulates. As the gas stream travels through these filters, more than 99 percent of PM is removed. Captured fly ash particles fall into hoppers (funnel-shaped receptacles) and are transported by an enclosed conveyor system to the ash discharger. They are then wetted to prevent dust and mixed with the bottom ash from the grate. The facility transports the ash residue to an enclosed building where it is loaded into covered, leak-proof trucks and taken to a landfill designed to protect against

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[47] U.S. Energy Information Administration (EIA), Biomass explained Waste-to-energy (Municipal Solid Waste), website at https://www.eia.gov/energyexplained/biomass/waste-to-energy-in-depth.php#:~:text=Waste%2Dto%2Denergy%20plants%20burn,and%20products%20made%20from%20wood.

[48] Ozone Transport Commission Stationary, Area Sources Committee, "Municipal Waste Combustor Workgroup Report," April 2022.

[49] EPA, AP-42 Compilation of Air Pollutant Emissions Factors, Section 2.1 Refuse Combustion, October 1996, available at https://www3.epa.gov/ttnchie1/ap42/ch02/final/c02s01.pdf.

[50] U.S. Energy Information Administration (EIA), Biomass explained Waste-to-energy (Municipal Solid Waste), website at https://www.eia.gov/energyexplained/biomass/waste-to-energy-in-depth.php#:~:text=Waste%2Dto%2Denergy%20plants%20burn,and%20products%20made%20from%20wood.

groundwater contamination. Ash residue from the furnace can be processed for removal of recyclable scrap metals.[51]

There are 2 major sub-categories of mass burn MWCs—mass burn waterwall MWCs and rotary waterwall MWCs, discussed below.[52]

Mass Burn Waterwall MWCs

Mass burn waterwall MWCs have lower furnace primary combustion zones made of waterwall tubes for heat transfer in the combustion zone. For mass burn waterwall MWCs, the MSW fuel is typically loaded into charging hoppers and fed to hydraulic rams that push the MSW fuel onto the stoker grate in the furnace for combustion. Most stokers utilize a reciprocating grate action, utilizing either forward or reverse acting grate movement, which moves the combusting MSW fuel across the furnace to allow time for drying and complete combustion. Generally, there will be a large volume of fuel at the front end of the grate that burns down to a small amount of ash at the back of the grate. The grate may have a slightly downward angle from fuel introduction to the ash drop off to help move the MSW fuel through the furnace. The reciprocating action of the grates also tends to agitate the MSW fuel, generally causing the MSW fuel to roll and mix. This agitation helps ensure all the MSW fuel is exposed to the high temperatures in the bed of combusting MSW fuel and helps provide contact with combustion air, resulting in more complete combustion of the MSW fuel as it travels across the furnace. Combustion ash that does not leave the stoker grate as fly ash is dropped off at the end of the stoker through a discharge chute for disposal or further processing.

Mass burn waterwall MWCs may also incorporate auxiliary fuel burners to help bring the MWCs to temperature to begin combustion of the MSW fuel, to supplement the heat input necessary to attain the steam generator output rating with varying MSW fuel quality, or to ensure sufficient flue gas temperatures are attained for proper emissions control.

Combustion air is generally introduced to the combustion zone utilizing pressurized air as underfire (primary) air or overfire (secondary) air. At least one proprietary design, however, splits the overfire air into two distinct zones, effectively creating three combustion air introduction zones.

Underfire air is introduced under the stoker grate, sometimes through a series of plenums that allow for underfire air introduced to various portions of the grate area to be controlled to enhance combustion based on MSW fuel characteristics. The underfire air travels from the plenums to the combustion zone through holes in the grate to assure good distribution across the grate. Underfire air systems are generally designed to be able to provide up to 70% of the total combustion air requirement, with typical underfire air operating requirements utilizing 50% to 60% of the total combustion air.

Overfire air is introduced into the furnace above the grate level through multiple ports in the furnace walls. The primary purpose of the overfire air is to provide the amount of air necessary to mix the furnace gasses leaving the grate combustion zone and provide the oxygen required to complete the combustion process. Proper control of the overfire air may also be utilized to provide some control of

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[51] EPA, Energy Recovery from the Combustion of Municipal Solid Waste (MSW), website at https://www.epa.gov/smm/energy-recovery-combustion-municipal-solid-waste-msw.

[52] Ozone Transport Commission Stationary, Area Sources Committee, "Municipal Waste Combustor Workgroup Report," April 2022.

the NOx emission rate leaving the high temperature zone of the furnace. The amount of overfire air is typically 40% to 50% of the total required combustion air and is somewhat dependent upon MSW fuel quality and NOx emission control requirements.

Rotary Waterwall MWCs

A rotary waterwall MWC utilizes a water-cooled, tilted, rotating cylindrical combustion chamber. The MSW fuel is typically loaded into charging hoppers and fed to hydraulic rams that push the MSW fuel into the slowly rotating combustion chamber. The rotation of the tilted cylindrical combustion chamber causes the MSW fuel to tumble and advance the length of the cylindrical combustion chamber, ensuring all the MSW fuel is exposed to high temperatures and combustion air for a sufficient amount of time for drying and complete combustion of the MSW fuel. Combustion ash that does not leave the rotary burner as fly ash is dropped off at the end of the rotary burner through a discharge chute for disposal or further processing.

Rotary burner MWCs may also incorporate auxiliary fuel burners to help bring the MWCs to temperature to begin combustion of the MSW fuel, to supplement the heat input necessary to attain the steam generator output rating with varying MSW fuel quality, or to ensure sufficient flue gas temperatures are attained for proper emissions control.

Combustion air for rotary burner MWCs is introduced to the rotating combustion chamber by a pressurized plenum surrounding the rotating combustion chamber. The combustion air enters the rotating combustion chamber through the walls of the chamber, generally through spaces between waterwall tubes. Underfire air is introduced at the bottom of the rotating combustion chamber and through the bed of combusting MSW. Overfire air is introduced into the rotating combustion chamber over the bed of combusting MSW. Dampers are utilized to proportion the total air flow and control the overfire air/underfire air split. Because the waterwall tubes form the floor of the combustion zone and effectively remove heat from that surface, peak combustion temperatures may tend to be lower than experienced with other MWC designs, helping reduce the NOx emissions relative to those other MWC designs. Also, as the water-cooled surfaces require lower amounts of initial combustion zone excess air for cooling of combustor components, lower amounts of total excess air may be required for many rotary burner MWCs compared to some other MWC designs. The reduced excess air requirements may also help to reduce base NOx emissions relative to other MWC designs.

Refuse-Derived Fuel Systems

Refuse-Derived Fuel (RDF) systems use mechanical methods to shred incoming MSW, separate out non-combustible materials, and produce a combustible mixture that is suitable as a fuel in a dedicated furnace or as a supplemental fuel in a conventional boiler system.[53]

In an RDF system, the following processes are performed:[54]

- Crushing process: Refuse is crushed to the appropriate size for drying.
- Drying process: High-temperature blast dries and deodorizes refuse.

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[53] EPA, Energy Recovery from the Combustion of Municipal Solid Waste (MSW), website at https://www.epa.gov/smm/energy-recovery-combustion-municipal-solid-waste-msw.

[54] Kawasaki Heavy Industries, Refuse-derived Fuel (RDF) Manufacturing Plant, website at https://global.kawasaki.com/en/industrial_equipment/environment_recycling/waste/rdf.html.

- Sorting and Crushing process: Unsuitable substances for fuel such as iron and stone are removed. Refuse is crushed to the appropriate size for forming RDF.
- Solidifying process: Additive is supplied to prevent corruption. Substances are formed to produce high-density and high-strength RDF that is suitable for transportation, storage, and combustion.

Modular System

Modular Systems burn unprocessed, mixed MSW. They differ from mass burn facilities in that they are much smaller and are portable. They can be moved from site to site.[55] One of the most common types of modular system is the starved air or controlled air type combustor which incorporates two combustion chambers. Air is supplied to the primary chamber at sub-stoichiometric levels and the resultant incomplete combustion products (CO and organic compounds) pass into the secondary combustion chamber where combustion is completed with the additional air. Another modular system design is the excess air combustor which, like the starved air combustor, also consists of two chambers but is functionally similar to mass burn units in its use of excess air in the primary chamber.[56]

NOx Emission Limits for Affected Units in Municipal Waste Combustion

Table 2-6 summarizes the NOx emission limits for large MWCs, which are defined as incinerators that combust greater than 250 tons per day of municipal solid waste. Note that both the 24-hour average limit and the 30-day average limit must be met.

Table 2-6. NOx Emission Limits for Large MWCs[57]

Unit Type	Emissions Limit (parts per million by volume, dry basis NOx [ppmvd])
Combustors or Incinerators	110 ppmvd on a 24-hour averaging period and 105 ppmvd on a 30-day averaging period

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[55] EPA, Energy Recovery from the Combustion of Municipal Solid Waste (MSW), website at https://www.epa.gov/smm/energy-recovery-combustion-municipal-solid-waste-msw.

[56] EPA, AP-42 Compilation of Air Pollutant Emissions Factors, Section 2.1 Refuse Combustion, October 1996, available at https://www3.epa.gov/ttnchie1/ap42/ch02/final/c02s01.pdf.

[57] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

3. Non-EGU NOx Emission Controls

This section provides brief descriptions of the NOx control technologies that SC&A estimates affected non-EGU sources may apply to meet the emission limits of the final rule. It is not meant to cover all possible NOx control technologies that could achieve the NOx emission limits for the sources affected by the final rule.

3.1 External Combustion Controls

Low NOx Burners

Low NOx burners (LNB) are designed to control combustion fuel and air mixing in such a way as to create larger and more branched flames, which reduce peak flame temperatures. By lowering peak flame temperatures, thermal NOx formation is reduced. The initial stage of combustion occurs in a fuel rich, oxygen deficient zone where NOx is formed. A reducing atmosphere follows where hydrocarbons are formed which react with the already formed NOx. In the third stage of combustion, internal air staging (additional air) completes the combustion but may result in additional NOx formation. This however can be minimized by completing the combustion in an air lean environment.[58]

LNBs can be applied to a variety of industrial NOx emission sources including furnaces, some kilns, and boilers, but can vary in the level of NOx control achieved across such sources. In the iron and steel industry, reheat furnaces show a relatively high NOx reduction potential of 66% with the application of LNB. In contrast, LNB technology only reduces NOx emissions from indirect-fired cement kilns by 25%. LNB can reduce NOx emissions by 50% NOx from industrial boilers, regardless of fuel type.[59]

Flue Gas Recirculation

In FGR, cooled flue gas and ambient air are mixed to become the combustion air and are reintroduced to the system by fans and flues. The mixing reduces the oxygen content of the combustion air supply and lowers the combustion temperature. FGR is feasible if there is no minimum operation temperature and/or oxygen requirement for the boiler as FGR lowers the temperature range and oxygen levels in the boiler. FGR may affect fan capacity, furnace pressure, burner pressure drop, and turndown stability, so it may not be feasible for boilers where these are critical parameters. FGR is commonly implemented in conjunction with LNB.[60]

Covanta Patented Low NOx Technology

Covanta's patented Low NOx Technology (LN^{tm}) is a proprietary combustion technology developed by Covanta to reduce NOx emissions from MSW combustion. LN^{tm} encompasses a process that modifies combustion in a furnace by diverting a portion of the secondary emissions and then injecting it at a higher elevation in the furnace. This system optimizes combustion and reduces NOx emissions by distributing combustion air between the primary, secondary, and tertiary levels and providing additional fuel/air staging for NOx control while still providing enough air for complete combustion. This system has been installed on many MWC units operated by Covanta. It has been shown that this system can achieve an annual NOx emission limit of 90 ppm and a daily NOx emission limit of 110 ppm. However,

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[58] Goes Heating Systems, Low NOx Burners, website at https://goesheatingsystems.com/low-nox-burners/.

[59] EPA, Office of Air and Radiation, "Non-EGU Sectors TSD," Draft Technical Support Document for the Proposed Rule, Docket ID No. EPA-HQ-OAR-2021-0668, December 2021.

[60] EPA, Menu of Control Measures for NAAQS Implementation, menuofcontrolmeasures.pdf, website at https://www.epa.gov/sites/default/files/2016-02/documents/menuofcontrolmeasures.pdf.

the proprietary aspects of the technology may make it unlikely that it could be applied to non-Covanta MWCs. Additionally, not all Covanta MWC configurations may be able to incorporate the components needed for LN^{tm}. This technology is typically used in conjunction with selective non-catalytic reduction (SNCR)[61] and, for the sources for which LN^{tm} is the control technology applied in the final rule cost analysis, it is always paired with SNCR.

Selective Catalytic Reduction

Selective catalytic reduction (SCR) is the most widely used post-combustion NOx reduction technology. SCR uses a reducing agent to convert NOx to desirable gases. The reductant is typically ammonia or urea. In ammonia reduction, NOx in the flue gas is injected with aqueous ammonia onto a catalyst that speeds up the reaction. After completion, NOx has been converted to nitrogen gas and water. Urea reduction operates similarly, but the products are carbon dioxide, nitrogen gas, and water.

SCR requires regular maintenance to perform properly, as it is a temperature-dependent system, ideally operating between 550-800°F.[62] When temperatures are out of this range, “ammonia slip” occurs. Ammonia slip is a major issue in SCR operation in that ammonia will pass through the SCR unreacted. Ammonia gas must be properly distributed in the chamber for the needed chemical reactions to occur. Due to the harsh nature of flue gases and ammonia, SCR equipment has a finite life. This is especially true for the catalyst. The catalyst pores can get clogged and contaminated by soot particles depending on the effectiveness of large particle ash filters, often used with SCR that are applied to coal-fired units If catalyst pores become clogged and contaminated by soot particles, the operator may need to replace the catalyst.

SCR is a dominant NOx control technology due to its high NOx removal efficiency. SCR can typically achieve greater than 80% NOx reduction. SCR has been successfully used on boilers, annealing furnaces, four stroke lean burn spark ignition engines, and other equipment. SCR may not be feasible if the flue gas temperature is not within an acceptable range, in exhaust environments that could poison the catalyst (e.g., acid gases; alkali metals, such as sodium or potassium), or in operations with limited space that may be insufficient for SCR installation. For the external combustion sources, SCR is EPA’s applied control technology for some of the affected boilers in the final rule cost analysis.

Selective Non-Catalytic Reduction

SNCR is another post-combustion technology. The major difference between SCR and SNCR is that SNCR does not use a catalyst. The SNCR procedure is like SCR in that ammonia or urea is injected into the flue gas to convert NOx to clean gas. The absence of a catalyst allows for higher flue gas temperatures between 1,400 to 1,600°F. SNCR has the potential to reduce NOx emissions by 35 to 75%.[63] SNCR has many of the same disadvantages as SCR. SNCR is prone to ammonia slip, installation spacing is a concern, and the flue gas temperature must be in the proper range. In the final rule cost analysis, SNCR is the control EPA’s technology applied at affected cement kilns and in combination with LN^{tm} at some affected MSW combustors and incinerators.

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[61] Ozone Transport Commission Stationary, Area Sources Committee, “Municipal Waste Combustor Workgroup Report,” April 2022.

[62] EPA, Office of Air and Radiation, “Non-EGU Sectors TSD,” Draft Technical Support Document for the Proposed Rule, Docket ID No. EPA-HQ-OAR-2021-0668, December 2021.

[63] Ibid.

Advanced SNCR

Advanced selective non-catalytic reduction (ASNCR) can be used to upgrade existing SNCR installations or can be used as a new retrofit technology for MWCs. As with SNCR, ASNCR involves the injection of reagents into the proper temperature zones of a furnace to reduce the NOx concentration in the flue gas. The main difference between ASNCR and SNCR is that ASNCR uses advanced furnace temperature monitoring that provides near real-time feedback on the temperature profile of the furnace. The ASNCR system then automatically adjusts the individual injector flow rates to optimize the NOx emission reductions. This helps to reduce the magnitude of NOx spikes that occur in MWC furnaces due to combusting a mixture of fuels while also keeping a low level of ammonia slip. ANSCR can reduce NOx emissions by about 70% and should be applicable to many MWCs as a retrofit control technology, although the furnace configuration and other factors could limit the NOx reduction potential.[64] In the final rule cost analysis, ASNCR is the control technology that is applied to a majority of the affected MSW combustors and incinerators.

3.2 Internal Combustion Controls for Engines

Layered Combustion

Layered combustion (LC) which is used for 2-stroke lean burn engines consists of multiple technologies:

- High-pressure fuel injection
- Turbocharging
- Precombustion chamber
- Cylinder head modifications

The estimated range of NOx reductions from the use of LC technologies is 60 – 90%.[65] For 2-stroke engines, the final rule contains an emissions limit of 3.0 g NOx/hp-hr, which should be achievable using LC controls. In the final rule cost analysis, LC is the applied control technology for 2-stroke lean burn engines.

Non-Selective Catalytic Reduction

For rich burn RICE (excess oxygen less than 0.5% in the exhaust), non-selective catalytic reduction (NSCR) is the commonly accepted emissions control, not only for NOx, but for CO and volatile organic compounds (VOC) as well. NSCR is often referred to as a 3-way catalyst control, since it addresses all 3 pollutants (CO and VOC are oxidized, while NOx is reduced to nitrogen). It is also used in gasoline vehicles ("catalytic converters"). Automatic air to fuel control systems are needed to maintain exhaust oxygen levels below 0.5 percent. NOx control efficiencies are reported to range from 90 – 98 percent.[66] NSCR is the applied control technology for 4-stroke rich burn engines in the final rule cost analysis.

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[64] Ozone Transport Commission Stationary, Area Sources Committee, "Municipal Waste Combustor Workgroup Report," April 2022.

[65] EPA, Office of Air and Radiation, "Non-EGU Sectors TSD," Draft Technical Support Document for the Proposed Rule, Docket ID No. EPA-HQ-OAR-2021-0668, December 2021.

[66] EPA, Office of Air Quality Planning and Standards, EPA-453/R-93-032 Alternative Control Techniques Document – NOx Emissions from Stationary Reciprocating Internal Combustion Engines, July 1993, available at https://www3.epa.gov/airquality/ctg_act/199307_nox_epa453_r-93-032_internal_combustion_engines.pdf.

Selective Catalytic Reduction

For lean burn RICE and gas turbines, SCR might be considered in cases where LC controls are not able to meet the desired NOx emission limits. As of 2014, SCR application on sources in the pipeline transportation of natural gas industry was very limited, especially as a retrofit; however, some new four-stroke lean-burn engines had been sited with SCR.[67] Just as with external combustion sources described above, SCR involves the injection of a reagent (ammonia or urea) to "selectively" reduce NOx across a catalyst bed. The application of SCR is more challenging for RICE due to the need for the exhaust gas to be within an effective operating range (480 – 800 Fahrenheit) and fluctuations in NO/NO_2 ratios in the exhaust (which affect the required reagent feed rate). Applications on engines with variable power loads is particularly challenging, and the use of a continuous emissions monitor (CEM) may be required for precise reagent control. SCR is the applied control technology for 4-stroke lean burn engines in the final rule cost analysis.

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[67] Interstate Natural Gas Association of America (INGAA), "Availability and Limitations of NOx Emission Control Resources for Natural Gas-Fired Prime Movers Used in the Interstate Natural Gas Transmission Industry," prepared by Innovative Environmental Solutions and Optimized Technical Solutions, INGAA Foundation Final Report No. 2014.03, July 2014.

4. Timing to Install Controls

4.1 Phases Common to Control Installations

This section discusses steps or work elements required to install NOx control technologies for non-EGUs to attain compliance with this rule.

In general, installation of NOx control equipment for regulatory compliance occurs in two major distinct phases: the analysis phase culminating in a decision, typically designated as pre-award/preconstruction activities, and the implementation phase of an engineering, procurement, and construction (EPC) contract award. Considering that design, construction materials, labor to install controls, and commissioning can account for a large portion of the project's total capital cost, corporate management often expends significant effort upfront analyzing options for regulatory compliance to minimize financial risk before awarding a contract for materials and services.

The path to contract award contains several work elements. Figures 4-1 and 4-2 illustrate general timelines for control installation, showing these work elements. Timelines for some of the common steps for NOx control installation were adapted from an EPA technical memorandum.[68] A final step for obtaining operating permits was also added for situations where those are required (some states have a combined process for permits to construct and operate, while in others, these are two separate processes). The timeline for large add-on controls such as SNCR or SCR to large industrial sources (including large MWCs) is shown in Figure 4-1 while the general timeline addressing combustion controls and small add-on controls, such as compact SCR or NSCR applied to RICE, is shown in Figure 4-2. The longer general timeline indicated for large add-on controls reflects the likely challenges in engineering and fabrication (including site-specific design and construction challenges).

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[68] B. Lange, Eastern Research Group, "NOx APCD Installation Times Early Findings," prepared for D. Misenheimer, US EPA, March 2017.

Phase		Month																									
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Analysis																											
1	Conceptual Studies / Design	🟩	🟩	🟩																							
2	Specifications / Vendor Bids / Financing				🟩	🟩	🟩	🟩																			
Implementation																											
3	Construction Permit			🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩														
4	Detailed Engineering / Fabrication													🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩					
5	Site Work / Mobilization																					🟩	🟩				
6	Equipment Installation																							🟩	🟩		
7	Start-up / Testing																									🟩	
8	Operating Permit																									🟩	🟩

Figure 4-1. General Installation Timeline: Large Add-On Controls

Phase		Month															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Analysis																	
1	Conceptual Studies / Design	🟩															
2	Specifications / Vendor Bids / Financing		🟩	🟩													
Implementation																	
3	Construction Permit			🟩	🟩	🟩	🟩	🟩	🟩								
4	Detailed Engineering / Fabrication									🟩	🟩	🟩	🟩	🟩			
5	Site Work / Mobilization													🟩			
6	Equipment Installation														🟩		
7	Start-up / Testing															🟩	
8	Operating Permit																🟩

Figure 4-2. General Installation Timeline: Combustion Controls or Compact Add-On Controls

As indicated in the figures above, some overlap can occur among the phases of installation. For example, review of construction permit applications often occurs before the end of the analysis phase, since affected sources would not go out to bid on a project or sign contracts with vendors before receiving construction permits. In addition, site work can also begin before the control equipment is fabricated and delivered. The greater the amount of such overlap in phases of installation, the less time control installation may take. Additional descriptions of the activities occurring within each phase of control installation follow:

1. Conceptual Studies/Design Basis – In the first phase of technology evaluation, an engineering review and assessment of the combustion unit is conducted to determine the preferred compliance alternative. During this phase, the specifications of the control technology are determined, and bids are requested from vendors. A request for proposal (RFP) is often a route by which to accomplish this. An RFP is submitted for emission control vendors to present competing technologies, their capabilities, and their approximate costs (often +-30%, or study-level in accuracy).[69] The RFP process is a broad market sweep that invites control vendors to propose a remedy for regulatory compliance, which then allows the owner to focus on a technology, consider budgetary constraints, and narrow the list of competing vendors. The RFP process can often take 3-4 weeks depending on the extent of the project.
   The final part of the pre-award phase involves selecting a control vendor, otherwise known as the Request for Quotation (RFQ) process. For the vendor, creating a bid package can incur substantial development costs since this requires assembling sufficient staff to develop an accurate price based on current market conditions for key inputs (materials, labor, etc.) while adhering to the client's specifications in the RFQ. Typically, the vendor commits a month to create a bid package, but the process can end in 6-8 weeks. An owner's review of vendor bids may take 3-4 months before targeting a single vendor. However, much of this effort can be conducted simultaneously with the permit application process (discussed below), leaving the final contract signature to be done. Depending on the complexity of the control retrofit, commenters on similar EPA rulemakings stated that it can take 6-8 months after the rule is finalized to select a control option and hire an installation contractor.
2. Specifications/Vendor Bids/Financing– Once both parties (i.e., a buyer organization and seller organization) agree on the technical and commercial terms and conditions of the proposal, they move on to next steps like contract signing and statement of work, which formalize the purchase transactions. Financing for equipment purchases is also conducted during this phase.
3. Preparation and Review of Construction Permits – Before construction to install the technology can commence, the facility must prepare, submit, and receive approval for a construction permit from the relevant federal, state or local regulatory authority. The construction permit covers modifying existing equipment or installing new equipment. A construction permit application can include the following elements: a) project description, b) emission controls, c) project operation, d) site layout, e) waste disposal, and f) construction activities. The permitting agency reviews the application and issues a draft approval. Construction permit processing times typically range from 3 months to a year.

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[69] B. Lange, Eastern Research Group, "NOx APCD Installation Times Early Findings," prepared for D. Misenheimer, US EPA, March 2017.

4. Detail Engineering/Fabrication – Even after a company hires a vendor, the company needs additional time to order and install equipment. The length of time depends on the types of equipment or controls chosen and obtaining certain pieces of equipment sometimes involves significant lead times. When engineering details are finalized, equipment is fabricated under this phase.
5. Site Work/Mobilization – During the pre-construction stage, a site investigation must be completed. A site investigation identifies any steps that need to be implemented on the job site before the actual construction begins. Most of the construction activities, such as earthwork, foundations, process electrical and control tie-ins to existing items, can occur while the emitting unit is in operation.
6. Equipment Installation – This phase addresses all on-site installation activities. For most types of NOx control, the affected units may need to be shut down to allow for installation.
7. Startup and Testing – Newly installed equipment requires a shakedown or a trial period to identify and address any issues before the control device is declared operational.
8. Revision and Review of Operating Permits - Facilities must also modify their Title V operating permit to incorporate the added control devices and the associated reduced emission limits. The review and revision of operating permits can include the following elements: a) current and projected emissions, b) identification of regulatory status for multiple Clean Air Act programs, such as Prevention of Significant Deterioration (PSD)/ New Source Review (NSR), Regional Haze, and various Federal water programs (e.g., National Pollutant Discharge Elimination System), and c) state and local requirements.

Table 4-1 presents estimates of the amount of time required for individual sources affected by the final rule to install the controls that EPA estimates might likely be installed for compliance.[70] The amount of time required for equipment design/fabrication/installation was taken from information in comments to the proposed rule and supporting technical documents. These estimates do not include the additional time required for the analysis phase and permitting. Thus, estimates of the time needed for the analysis phase and permitting are presented in a separate column. Assumptions for these phases are as follows:[71]

- Conceptual Studies/Design: range of months for SNCR/SCR: 1 - 5 months; low end of range assumed for combustion controls and compact add-ons.
- Specs/Vendor Bids/Financing: range of months for SNCR/SCR: 2 - 6 months; low end of range assumed for combustion controls and compact add-ons.
- Permitting: range of months for any control type: 2 – 12 months; includes both construction and operating permit phases. The final two months are assumed for the operating permit, where those are separate from construction permits. For layered combustion or NSCR applied to RICE in natural gas transportation or LNB applied to boilers and furnaces, 2 – 3 months is expected. For all other controls, a range of 6 - 12 months is expected.

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[70] For facilities that have multiple affected units to address, the amount of time required to install each control could be reduced on average, since a single permit review process would likely be involved among other efficiencies in equipment design, fabrication, and installation.

[71] Lange, B., Eastern Research Group, Technical Memorandum (NOx APCD Installation Times Early Findings) to D. Misenheimer, US EPA, March 3, 2017.

Table 4-1. Estimated Time Requirements for Individual Sources Affected by the Final Rule

Industry	Emissions Source Group	Estimated Control Technology	Estimated Time Required (months)		
			Equipment Design / Fabrication / Installation	Analysis Phase / Permitting	Total Range
Cement and Concrete Product Manufacturing	Kilns	SNCR	11 - 12	6 - 12	17 - 24
Glass and Glass Product Manufacturing	Melting Furnaces	LNB	6 - 9	3 - 6	9 - 15
Iron and Steel Mills and Ferroalloy Manufacturing	Reheat Furnaces	LNB	6 - 9	3 - 6	9 - 15
Pipeline Transportation of Natural Gas	RICE 2-Cycle	Layered Combustion	3 - 6	3 - 6	6 - 12
Pipeline Transportation of Natural Gas	RICE 4-Cycle Rich Burn	NSCR	3 - 6	3 - 6	6 - 12
Pipeline Transportation of Natural Gas	RICE unspecified	NSCR or Layered Combustion	3 - 6	3 - 6	6 - 12
Pipeline Transportation of Natural Gas	RICE 4-Cycle Lean Burn	SCR	7 - 13	3 - 6	10 - 19
Affected Non-EGU[a] Industries	Boilers	LNB + FGR	6 - 9	3 - 6	9 - 15
Affected Non-EGU[a] Industries	Boilers	SCR	8 - 13	6 - 12	14 - 25
Municipal Waste Management	MWC Boilers	LN^{tm} + SNCR	16	6 - 12	22 - 28
Municipal Waste Management	MWC Boilers	ASNCR	11	6 - 12	17 – 23

[a] The affected non-EGU industries with boilers include Iron and Steel Mills and Ferroalloy Manufacturing, Metal Ore Mining, Basic Chemical Manufacturing, Petroleum and Coal Products Manufacturing, and Pulp, Paper, and Paperboard Mills.

Based on contacts with state permitting staff, the time estimated in this report for permitting is conservatively long (that is, more likely to be overstated than understated).[72] The effort required to prepare and review air permit modifications for NOx control installations is much less than the effort required for the initial operating (Title V) permit. Most state permitting staff that offered information for this report indicated that permit modifications were likely to be processed in less than six months; and, for some states, expedited permitting programs are in place. These programs allow for a source to pay an additional fee to have their permit modification expedited. On the other hand, it is possible that some control installations may have the potential to trigger more complex reviews. In those instances,

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[72] S. Roe, SC&A, Inc., personal communications with: L. Warden, Oklahoma Department of Environmental Quality, October 24, 2022; S. Short, Texas Commission on Environmental Quality, October 27, 2022; B. Johnston, Louisiana Department of Environmental Quality, October 25, 2022; and H. Bouchareb, Minnesota Pollution Control Agency, September 7, 2022.

the permit timelines indicated above are appropriate (including time required for public comment, if needed). For all NOx controls, except large SCR/SNCR applications, the estimated time required for analysis and permitting is 3 to 6 months. For large SCR/SNCR applications, the estimated time required is 6 to 12 months.

4.2 Issues Identified by Commenters Related to Timing

EPA solicited and received comments on the proposed rule related to the timing of control installations for non-EGU NOx sources. Often, commenters indicated that 36 months for installation of controls was not feasible, without identifying alternative timelines for achieving compliance.[73] However, while few commenters identified alternative control installation timelines, commenters identified several key issues that could impact the timeline. These are discussed below.

Supply Chain Concerns

Concerns expressed by regulated-industry commenters on access to NOx control technologies included the following:

- A limited pool of skilled installers: especially for combustion controls on RICE for natural gas transmission. Discussions with control equipment vendors have also indicated a limited pool of SNCR suppliers with MWC expertise. *Industries potentially impacted: Pipeline Transportation of Natural Gas and Solid Waste Incinerators and Combustors.*
- Competition among affected units to source control equipment vendors: for example, operators of ICI boilers and MWCs may have to compete with EGUs for SCR and SNCR vendors. A small number of EGU SCR retrofits are expected between 2023 and 2027 (2.6 - 8 GW of capacity). Also, the Agency estimates roughly 265 SCR and SNCR EGU optimization projects are expected within this time period. Given their much larger size and history with EGUs, commenters were concerned that some of these equipment vendors would focus attention first on affected EGUs. As a result, the size of the vendor pool available to service non-EGU affected units would be smaller. *Industries potentially impacted: Iron and Steel Mills and Ferroalloy Manufacturing, Metal Ore Mining, Basic Chemical Manufacturing, Petroleum and Coal Products Manufacturing, and Pulp, Paper, and Paperboard Mills, and Solid Waste Incinerators and Combustors.*
- General concern about long lead times for selected equipment vendors to design, fabricate and install control equipment. These comments did not offer specifics about the expected source(s) of equipment delays; however, they seem to stem from known production outages for control equipment components (such as those obtained from Chinese suppliers), transportation bottlenecks (including delays at US ports), and known current backlogs of North American equipment fabricators.

Supply chain issues and their potential to cause control installation delays are assessed in Section 5 of this report.

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[73] For example, steel industry comment [EPA-HQ-OAR-2021-0668-0360. Comment submitted by JSW Steel (USA) Inc. and JSW Steel USA Ohio, Inc.]. Paper industry comment [EPA-HQ-OAR-2021-0668-0338. Comment submitted by Wisconsin Paper Council (WPC)], requests extension to the 2028 ozone season. Solid waste combustion (resource recovery) industry comment [EPA-HQ-OAR-2021-0668-0301. Comment submitted by Minnesota Resource Recovery Association (MRRA)].

Additional Issues

As mentioned previously, operators of furnaces used in glass manufacturing expressed concern about the need to install controls at an early point in the useful life of the furnace lining (refractory).[74] A number of commenters from the glass manufacturing industry said installing a control would require a cold shutdown of the furnace which would likely damage the refractory (furnaces are designed to run continuously between re-linings). Since a refractory might have a service life of 6 to 15 years, rule compliance extensions were requested of potentially many years beyond the May 2026 deadline (i.e., dependent on unit-specific circumstances).

While not a requirement of this final rule, commenters said some non-EGU coal-fired boiler operators and other non-EGUs may opt to switch to natural gas to achieve compliance. But these commenters said, if the natural gas infrastructure is not in place locally, additional time would likely be needed to bring natural gas to the site.[75]

4.3 Evaluation of Timing for Each Industry

This section includes an industry-specific assessment of the amount of time required for installation of each type of NOx control technology estimated to be installed in that industry to comply with the final rule. This discussion is focused on the time needed for an individual control technology installation. Note that the installation timing estimates presented in this section do not include the additional estimated time that could be needed assuming supply chain delays, which are discussed in Section 5. Section 4.4 provides an analysis of the timing needed to install NOx control technologies on all affected units (including EGU installations required by May 2026).

Cement and Concrete Product Manufacturing

Table 4-2 provides EPA's estimates of the NOx controls likely to be installed in the cement manufacturing industry and the number of affected units by emissions source group.76 A total of 16 SNCR systems are estimated to require installation, including both process and preheater/precalciner kilns.

Table 4-2. Potential Control Installations for Cement and Concrete Product Manufacturing

Emissions Source Group	Control Technology	Number of Units
Kiln- Dry Process	Selective Non-Catalytic Reduction	8
Preheater/Precalciner Kiln	Selective Non-Catalytic Reduction	4
Preheater Kiln	Selective Non-Catalytic Reduction	3
Kiln- Wet Process	Selective Non-Catalytic Reduction	1
	Total SNCR	***16***

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[74] EPA-HQ-OAR-2021-0668-0406. Comment submitted by Ardagh Glass Inc. EPA-HQ-OAR-2021-0668-0548. Comment submitted by Glass Packaging Institute (GPI). EPA-HQ-OAR-2021-0668-0321. Comment submitted by Vitro Flat Glass LLC and Vitro Meadville Flat Glass, LLC.

[75] EPA-HQ-OAR-2021-0668-0320. Comment submitted by Genesis Alkali Wyoming, LP. EPA-HQ-OAR-2021-0668-0437. Comment submitted by American Forest & Paper Association (AF&PA).

[76] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

Although excessive on-off cycling of a cement kiln could also damage the refractory material (e.g., brick lining), some amount of cycling occurs in the industry for varying reasons.[77] Still, some consideration of timing for a kiln shutdown for the purposes of installing air pollution controls may be needed (i.e., timing to coincide with other preventive maintenance needs).

References on time for compliance are as follows without emission source group categorization. EPA's 2021 Non-EGU sectors TSD estimates the cement and concrete product manufacturing industry will take between 10-12 months for SNCR to be installed.[78] In the same TSD, EPA also noted an estimate of 19 months for SNCR applied to EGUs.[79] This latter estimate took into greater account the time needed for engineering, design, testing and permitting, albeit for an EGU application.

The Institute of Clean Air Companies (ICAC) timeline for installing SNCR is shown in Table 4-3 divided into phases (this information was also used in subsequent EPA timelines).[80] These values apply to industrial boilers, kilns, preheater kilns, and preheater/precalciner kilns. The total SNCR installation timeline is estimated to be 11 to 12 months as shown in Table 4-3. No consideration of the amount of time required for permitting was included in the ICAC timeline. Therefore, 6 to 12 months was added to the total time in Table 4-3 to accommodate this phase (this results in a conservatively long timeline, since permitting analyses may proceed concurrent with other phases). This results in a total timeline of 17 to 24 months. These values should be understood to reflect the time required for a single affected unit to apply the control.

Table 4-3. ICAC Timeline for SNCR Installation for Cement and Concrete Product Manufacturing[81]

Phase	Timeline (weeks)
1. Conceptual Studies / Design	2-4
2. Specifications / Vendor Bids / Financing	8-12
3. Construction Permit	--
4. Detailed Engineering / Fabrication	16
5. Site Work / Mobilization	--
6. Equipment Installation	8-12
7. Start-up / Testing	9
8. Operating Permit	--
Total time:	***11-12 months***
Total time, including permitting:	***17-24 months***

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[77] Infinity for Cement Equipment, Kiln Refractory Requirement, Properties & Factors Affect Wear, website at https://feeco.com/rotary-kiln-refractory-preventative-care/.

[78] Page 87. Non-EGU Sectors TSD, Draft Technical Support Document (TSD) for the Proposed Rule, Docket ID No. EPA-HQ-OAR-2021-0668, December 2021.

[79] Page 88 Non-EGU Sectors TSD, Draft Technical Support Document (TSD) for the Proposed Rule, Docket ID No. EPA-HQ-OAR-2021-0668, December 2021.

[80] ICAC, 2006. Typical Installation Timelines for NOx Emissions Control Technologies on Industrial Sources, December 4, 2006.

[81] Ibid.

Glass and Glass Product Manufacturing

Table 4-4 provides EPA's estimates for the NOx controls likely to be installed for the glass and glass products manufacturing industry.[82] A total of 61 LNB control installations are estimated for the industry, including container, pressed and blown, and flat glass processes.

Table 4-4. Potential Control Installations for Glass and Glass Product Manufacturing

Emissions Source Group	Control Technology	Number of Units
Container Glass: Melting Furnace	Low NOx Burner	36
Flat Glass: Melting Furnace	Low NOx Burner	12
Pressed and Blown Glass: Melting Furnace	Low NOx Burner	11
Furnace: General	Low NOx Burner	1
Unspecified	Low NOx Burner	1
	Total	***61***

Vitro Glass and other commenters stated that more than 36 months would be needed to install controls.[83] Supply chain delays, competition among affected units to procure and install controls, and time requirements for engineering and permitting were all mentioned as concerns. A complete shut-down of a glass furnace for NOx control installation requires a re-lining of the furnace (since the lining is damaged during cooling). A flat glass furnace might run continuously for 15 years between re-linings. Ardagh Glass indicated a 10-year timeframe for furnace re-bricking.[84] Commenters asked for flexibility to account for this issue, so that a manufacturer would not incur the cost of a re-lining well before the end of the useful life of the refractory.

As shown in Table 4-5, the expected installation timeline for installing LNB to glass furnaces is 9 to 15 months. This is based on general installation timelines for LNB or LNB+FGR applied to industrial sources of 6 to 9 months from ICAC[85] which are also documented in a 2017 EPA technical memorandum.[86] The total includes an additional 3 to 6 months to cover the conceptual studies/design and permitting phases (this is a conservatively long, or more likely an overstated estimate, since some of these phases may proceed concurrently). Based on discussions with state permitting staff, that amount of time should be sufficient to address situations where more complex permitting issues arise (e.g., PSD). The timeline in Table 4-5 reflects the time required to install LNB for a single affected unit.

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[82] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

[83] EPA-HQ-OAR-2021-0668-0321. Comment submitted by Vitro Flat Glass LLC and Vitro Meadville Flat Glass, LLC.

[84] EPA-HQ-OAR-2021-0668-0406. Comment submitted by Ardagh Glass Inc. Commenter referenced San Joaquin Valley Air Pollution Control District's Rule 4354, which allows for compliance deadlines based in part on furnace rebuilds.

[85] ICAC 2006. Typical Installation Timelines for NOx Emissions Control Technologies on Industrial Sources, December 4, 2006.

[86] Lange, B., Eastern Research Group, Technical Memorandum (NOx APCD Installation Times Early Findings) to D. Misenheimer, US EPA, March 3, 2017.

Table 4-5. LNB or LNB+FGR Installation Timeline for Glass and Glass Products Manufacturing

Phase	Installation Timeline (weeks)
1. Conceptual Studies / Design	--
2. Specifications / Vendor Bids / Financing	6-10
3. Construction Permits	--
4. Detailed Engineering / Fabrication	6-9
5. Site Work / Mobilization	10-12
6. Equipment Installation	2-3
7. Start-up / Testing	1
8. Operating Permits	--
Total time:	***6 - 9 months***
Total time including permitting:	***9 – 15 months***

Iron and Steel Mills and Ferroalloy Manufacturing

Table 4-6 provides EPA's estimates for the NOx controls likely to be installed for reheat furnaces in the iron and steel and ferroalloy manufacturing industry based on analyses performed for the final rule.[87] There are 19 reheat furnaces in the iron and steel industry that are estimated to need combustion controls (LNB) to meet the applicable NOx control requirements.

Table 4-6. Potential Control Installations for Iron and Steel Mills and Ferroalloy Manufacturing

Emissions Source Group	Control Technology	Number of Units
Natural Gas: Reheat Furnaces	Low NOx Burners	19

The installation timeline for LNB on reheat furnaces is estimated to be the same as that shown above in Table 4-5 for other LNB installations.

Pipeline Transportation of Natural Gas

Table 4-7 provides EPA's estimates for the NOx controls likely to be installed for pipeline transportation of natural gas.[88] EPA has estimated the number of engines that may have to install controls according to the final rule cost analysis to be approximately 905. For 323 of these RICE, the combustion configuration was unknown, and those RICE are estimated to apply either NSCR or layered combustion.

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[87] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

[88] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

Table 4-7. Potential Control Installations for Pipeline Transportation of Natural Gas

Emissions Source Group	Control Technology	Number of Units
2-cycle Lean Burn	Layered Combustion	394
4-cycle Rich Burn	Non-Selective Catalytic Reduction	30
Reciprocating	Non-Selective Catalytic Reduction or Layered Combustion	323
4-cycle Lean Burn	Selective Catalytic Reduction	158
	Total	***905***

For pipeline transportation of natural gas, most of the comments pertaining to this industry addressed the time needed to implement combustion controls. Commenters stated that the 3-year timeframe for compliance with the proposed FIP was not technically feasible due to concerns about the supply chain (in particular, the size of the skilled labor pool with expertise in RICE retrofits), permitting backlogs due to the large number of potentially affected units, and the need to allow sufficient time for planning around taking compressors offline to avoid system reliability concerns (including the need to meet FERC pipeline pressure obligations by each compressor station).

In 2006, an air pollution controls association estimated that the amount of time required to conduct conceptual studies/engineering, develop specifications/vendor bids/financing, and equipment installation ranged from 2 to 3.5 months.[89] This is similar to a minimum time estimate from EPA of 3.5 months.[90]

Estimates for NOx control installation timing provided in industry comments to the proposed rule ranged from 21 months[91] to 60 months[92]. The higher estimates incorporate asserted expected delays from permitting or supply chain concerns (i.e., all affected units encounter delays). The ranges cover different control technologies (SCR, NSCR) and all engine types.[93]

Table 4-8 shows the estimated installation timelines for RICE SCR and NSCR/LC installation. The values in Table 4-8 apply to a single unit. An additional three to six months of time was added to both the EPA and ICAC timelines to account for permitting. This six-month estimate is based on contacts with permitting staff in multiple states. It represents a conservative (or lengthier) timeframe for these controls that should account for situations where more complex permitting issues arise (e.g., PSD). It is also

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[89] Institute of Clean Air Companies (ICAC), "Typical Installation Timelines for NOx Emissions Control Technologies on Industrial Sources," December 2006.

[90] Eastern Research Group, "RICE Retrofits: Development Time for NOx Control Measures," Technical Memorandum to D. Misenheimer, US EPA, March 2017.

[91] EPA-HQ-OAR-2021-0668-0380. Comment submitted by TC Energy.

[92] EPA-HQ-OAR-2021-0668-0371. Comment submitted by INNIO Waukesha Gas Engines (INNIO Waukesha). While this commenter suggested allowing until May 1, 2028 for all installations to be completed, they also proposed phasing in the controls beginning two years from the effective date of the rule. The commenter suggested a six-year phase in from effective date; however, they also indicated that 48-60 months would be sufficient.

[93] We note that these estimates from commenters could not be independently verified for this report.

conservative (that is, likely overstates the needed timelines) because some of the phases identified in the timelines shown in Table 4-8 for both controls may proceed concurrently.

Table 4-8. Timeline for Installation of NOx Controls for RICE in Pipeline Transportation of Natural Gas

	Installation Timeline (weeks)	
	SCR	**NSCR/LC**
Phase	**US EPA [94]**	**US EPA [95] and ICAC[96]**
1. Conceptual Studies / Design	--	4-6
2. Specifications / Vendor Bids / Financing	6-8	2-4
3. Construction Permits	--	--
4. Detailed Engineering / Fabrication	6-16	4-6
5. Site Work / Mobilization	--	--
6. Equipment Installation	14-28	1-2 (US EPA) 2-4 (ICAC)
7. Start-up / Testing	2-6	1-2
8. Operating Permits	--	--
Total time:	***7 – 13 months***	***3 – 6 months***
Total time, including permitting:	***10 – 19 months***	***6 – 12 months***

Boilers in Affected Industries

Table 4-9 provides EPA's estimates for the NOx controls likely to be installed for boilers at industries affected by the final rule.[97] They are addressed collectively here, because the sources and control types are similar across industries. Generally, the sources are medium (10 – 100 million Btu/hr) and large boilers (>100 million Btu/hr) fired on a variety of gaseous, liquid, and solid fuels. Combustion controls estimated for rule compliance are mainly the application of low NOx burners with flue gas recirculation (151 total installations), while post-combustion controls are estimated to be SCR (15 total installations).

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[94] Non-EGU Sectors TSD, Draft Technical Support Document (TSD) for the Proposed Rule, Docket ID No. EPA-HQ-OAR-2021-0668, December 2021.

[95] Eastern Research Group, "RICE Retrofits: Development Time for NOx Control measures," Technical Memorandum to D. Misenheimer, US EPA, March 2017.

[96] Institute of Clean Air Companies, "Typical Installation Timelines for NOx Emissions Control Technologies on Industrial Sources, Washington DC, December 4, 2006.

[97] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

Table 4-9. Potential Control Installations for Boilers in Affected Industries

Industry	Emissions Source Group	Control Technology	Number of Units
Basic Chemical Manufacturing	Boilers - Distillate Oil	Selective Catalytic Reduction	4
	Boilers - Natural Gas	Low NOx Burners and Flue Gas Recirculation	86
	Boilers - Natural Gas: Cogeneration	Low NOx Burners and Flue Gas Recirculation	1
	Boilers - Residual Oil	Selective Catalytic Reduction	1
	Boilers - Subbituminous Coal: Traveling Grate (Overfeed) Stoker	Selective Catalytic Reduction	1
Petroleum and Coal Products Manufacturing	Boilers - Natural Gas	Low NOx Burners and Flue Gas Recirculation	9
	Boilers - Natural Gas: Cogeneration	Low NOx Burners and Flue Gas Recirculation	1
	Boilers - Residual Oil	Low NOx Burners and Flue Gas Recirculation	4
Iron and Steel Mills and Ferroalloy Manufacturing	Boilers - Coke Oven Gas/Natural Gas	Low NOx Burners and Flue Gas Recirculation	3
	Boilers - Natural Gas	Low NOx Burners and Flue Gas Recirculation	9
Metal Ore Mining	Boilers - Distillate Oil/ Natural Gas	Low NOx Burners and Flue Gas Recirculation	2
Pulp, Paper, and Paperboard Mills	Boilers - Bituminous Coal: Pulverized Coal: Dry Bottom	Selective Catalytic Reduction	1
	Boilers - Bituminous Coal: Spreader Stoker	Selective Catalytic Reduction	1
	Boilers - Coal: Dry Bottom	Selective Catalytic Reduction	4
	Boilers - Distillate Oil/Natural Gas	Selective Catalytic Reduction	2
	Boilers - Natural Gas	Low NOx Burners and Flue Gas Recirculation	32
	Boilers - Natural Gas/Bituminous Coal: Dry Bottom (Tangential)	Selective Catalytic Reduction	1
	Boilers - Natural Gas: Cogeneration	Low NOx Burners and Flue Gas Recirculation	2
	Boilers - Residual Oil /Natural Gas	Low NOx Burners and Flue Gas Recirculation	1
	Boilers - Residual Oil/Distillate Oil	Low NOx Burners and Flue Gas Recirculation	1
		Total Combustion Controls	***151***
		Total SCR	***15***

The timeline for installation of LNB+FGR to boilers in the affected industries is estimated to be the same as the values provided in Table 4-5 above (a total of 9-15 months).

According to EPA, the expected time needed to implement SCR controls on boilers in these industries is 8-13 months, as shown in Table 4-10.[98] An additional 6-12 months was also added to address permitting, which is a conservatively long estimate since permitting analyses may generally proceed concurrent with other phases.

Table 4-10. EPA's Estimated Potential Installation Timeline for Applying SCR to Boilers in the Affected Industries

	Installation Timeline (weeks)
Phase	**SCR [99]**
1. Conceptual Studies / Design	1-4
2. Specifications / Vendor Bids / Financing	5-8
3. Construction Permits	--
4. Detailed Engineering / Fabrication	4-6
5. Site Work / Mobilization	12-22
6. Equipment Installation	4-8
7. Start-up / Testing	5-10
8. Operating Permits	--
Total time:	***8 – 13 months***
Total time, including permitting:	***14 – 25 months***

Municipal Waste Combustion

As shown in Table 4-11, EPA has estimated that 57 MWCs may install ASNCR, with an additional four MWC units likely to install Covanta's low NOx combustion controls in combination with an existing SNCR system.[100]

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[98] Lange, B., Eastern Research Group, Technical Memorandum (NOX APCD Installation Times Early Findings) to D. Misenheimer, US EPA, March 3, 2017. This estimate is believed to be based on an earlier ICAC estimate of 7 to 9 months for SCR applied to non-EGU sources. Institute of Clean Air Companies, "Typical Installation Timelines for NOx Emissions Control Technologies on Industrial Sources, Washington DC, December 4, 2006.

[99] Lange, B., Eastern Research Group, Technical Memorandum (NO_X APCD Installation Times Early Findings) to D. Misenheimer, US EPA, March 3, 2017.

[100] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

Table 4-11. Potential Control Installations for MWCs

Emissions Source Group	Control Technology	Number of Units
MB/WW	ASNCR	43
MB/RC	ASNCR	9
MB/WW	LN^{tm} + SNCR	4
CLEERGAS gasification	ASNCR	1
RDF	ASNCR	4
	Total Combustion Controls	***4***
	Total ASNCR/SNCR	***61***

Beyond Plastics and other commenters provided a 2020 engineering study that assessed options for reducing NOx at an incinerator in Baltimore. The study evaluated options for technologies that could achieve a 24-hour limit of 110 ppm.[101] Table 4-12 summarizes the number of months estimated for each phase of the control installation, as well as the total project time. The report notes that permitting may add an additional 6 to 12 or more months to the total time (consistent with the permitting timeframes needed for large add-on controls at other sources discussed earlier).[102] This was a unit-specific study, so the installation timing for this or other units may be impacted by site-specific considerations.

The total time indicated for application of ASNCR is 17-23 months, which includes 6-12 months for permitting. The report did not include LN^{tm} + SNCR as one of the options evaluated. However, it did include FGR in combination with an existing SNCR system, which is the option that likely aligns most closely with LN^{tm} + SNCR. Therefore, this option is included in Table 4-12 with a total timeline of 22-28 months.

Table 4-12. Estimated Time by Phase for Control Installation Options for a Large MWC (months)

	Installation Timeline (months)	
Phase	**ASNCR**	**FGR + Existing SNCR**
1. Conceptual Studies / Design	3	4
2. Specifications / Vendor Bids / Financing	4	7
3. Construction Permits	--	--
4. Detailed Engineering / Fabrication	--	--
5. Site Work / Mobilization	3	4
6. Equipment Installation	2	3
7. Start-up / Testing	1	2
8. Operating Permits	--	--
Total time:	***11***	***16***
Total time, including permitting:	***17-23***	***22-28***

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[101] EPA-HQ-OAR-2021-0668-0757. Comment submitted by Beyond Plastics, et. al.

[102] EPA-HQ-OAR-2021-0668-0757. Comment submitted by Beyond Plastics, et. al.

4.4 Cumulative Effect of Numerous Control Installations at Same Time on Timing and Demand for Materials and Services

Overlapping control requirements for the EGU and non-EGU sources may produce challenges for both the air pollution control industry (e.g., SCR fabricators) and other aligned trades (potentially catalyst material producers), including those tasked with manufacturing and installing structural components for large add-on controls. However, vendors have made statements that the availability of raw materials for fabrication may be increasing.[103]

Table 4-13 below summarizes the total number of potential non-EGU and EGU control installations estimated for compliance with the final rule.[104] An estimated 229 EGU SCR optimizations and 36 EGU SNCR optimizations are estimated by May 2026 for this rule. Also, EPA expects that 2.5-8 GW of EGU capacity may be in the process of applying SCR retrofits between 2023 and 2030. Assuming a nominal capacity of 500 MW, this represents a maximum of 16 EGU SCR retrofits. Since it is possible that the EGU SCR retrofits could occur by the 2026 or 2027 ozone season, they were added to the control installations shown in Table 4-13. The EGU SCR/SNCR optimizations are also included in the table because there is a potential for overlap in the need for skilled workers to address these optimizations and new non-EGU equipment installs (SCRs/SNCRs). For EGU SCR/SNCR optimizations, EPA expects that the vast majority of these will be accomplished by optimizing operations rather than a physical optimization (such as the addition of catalyst layers). Operational optimizations are expected to be completed by existing EGU personnel rather than equipment vendors.

Table 4-13. Potential Non-EGU and EGU Control Installations by the 2026 Ozone Season

Sector	**Control Technology**	**Number of Installations***
Non-EGU	External Combustion - SCR	15
	External Combustion - SNCR/ASNCR	77
	External Combustion – Combustion Controls	231
	RICE – Compact SCR	158
	RICE - NSCR	192
	RICE - LC	555
	Total Non-EGU	**1,228**
EGU (through 2026)**	Optimize Existing SCR**	229
	Optimize Existing SNCR**	36
	SCR Retrofits	16
	Combustion Controls	10
	Total EGU	**291**
All Sectors	***New SCR + SCR Optimizations***	***260***
	SNCR/ASNCR + SNCR Optimizations	***113***

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[103] Discussions with control equipment vendors have not indicated any current concerns for the availability of raw materials, such as plate or sheet steel, cement, etc., required for the fabrication of control equipment or the structural components for their installation. During the pandemic, delays were experienced by equipment fabricators for sheet stainless steel, but those delays have been alleviated.

[104] U.S. EPA, Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. Technical Memorandum, March 15, 2023.

	RICE NSCR	***192***
	RICE Compact SCR	***158***
	External Combustion Controls	***241***
	Internal Combustion Controls	***555***
	Total Non-EGU and EGU	***1,519***
*Note that for 323 RICE, EPA estimates these units to adopt either LC or NSCR. These control applications were assumed to breakdown 50:50 for representation in this table. Also, note that the EGU control counts only include applications in the states with estimated non-EGU controls (i.e., EGU controls for compliance in 2023 in Alabama, Minnesota, Nevada, and Wisconsin are not included here). **In most cases, optimization of existing SCR/SNCR controls means to employ practices to improve the removal rate for existing post-combustion controls such as adjusting the ammonia injection rate, or adding or regenerating catalyst more frequently, or changes in combustion unit operation or EGU dispatching to maintain optimal SCR exhaust temperatures.		

An estimated 905 RICE units in the natural gas transportation industry may have to install controls in order to comply with the final rule. The compact SCR and NSCR controls for RICE are supplied by a different set of vendors than those for non-EGU external combustion sources and EGUs. However, some overlap in demand for catalyst material (e.g., platinum) is expected among these affected sources.

One possible consideration for control installation timing indicated by the estimates in Table 4-13 above relate to overlapping requirements for SCR installation/optimization services:

- Number of potential SCR installations and optimizations across the EGU and non-EGU sectors: there is potential for competition for SCR EPC vendors, in particular for flue gas modeling and design services. However, based on discussions with SCR vendors, non-EGU design and installation services are handled by a different group of vendors than EGUs. Given the relatively small number of non-EGU installations required, there should be sufficient EPC support for non-EGUs to cover design and engineering services. A separate question is whether equipment fabricators can address an increase in demand for new SCR and SNCR installs in a timely manner. As further addressed in Section 5 of this report, equipment fabrication across North America experienced delay associated with supply chain disruption in the recent past. A discussion of the potential impacts of SCR catalyst requirements from EGU retrofit and optimization projects is provided later in this section.
- RICE SCR and NSCR applications: because there is expected to be some overlap in catalyst demand, the same question regarding catalyst material applies here as mentioned above. Different equipment vendors serve RICE than those above for external combustion sources, so there is no concern of overlapping demands.

Each of these areas is addressed in more detail below.

<u>Non-EGU SCR Installations and EGU SCR Optimizations</u>

While Table 4-13 above indicates a total of 418 SCR installations and optimizations across EGUs and non-EGUs (15 non-EGU external combustion sources, 158 RICE, 16 EGU SCR retrofits, and 229 EGU SCR optimizations), it is important to divide this total into applicable market segments. This is because different sets of vendors serve each segment:

- EGUs and large industrial systems: the vendor pool is largely made up of large, sometimes multi-national, companies that may be a sub-unit of power plant constructors (e.g., Babcock & Wilcox, General Electric, Mitsubishi Power Systems Americas). These vendors have sufficient size to take on the financial risk for SCR installations of this scale (e.g., hundreds of MW EGU or very large industrial boilers). This pool of vendors generally designs the system, and then manages the subcontracted fabrication and installation phases (so, this pool is referred to here as engineering, procurement and construction or EPC contractors). An on-line survey and discussions with some vendors indicate that there are about 10 vendors in this pool in the US market.[105] It is important to note that vendors indicated that perhaps only half of these large vendors do the design work and manage the fabrication and installation. The rest of the vendors subcontract out all phases. Appendix A provides a listing of SCR and SNCR vendors with a focus on North American companies. There may be additional European or Asian (especially Japanese) vendors serving the North American market. The pool of EPCs may help address a small number of EGU SCR optimizations noted above (however, in most cases the EGU operator will likely undertake optimizations without EPC support); but is not expected to pursue smaller non-EGU systems, such as those that EPA estimates for non-EGU boilers.
- Smaller industrial systems: this pool includes a larger number of vendors serving the industrial sector and smaller EGUs, such as natural gas turbine plants. These vendors may handle all phases of SCR design, fabrication, and installation. There appears to be at least 12 vendors for this pool in the US market (see Appendix A). Given the size of this vendor pool, operators of the 15 affected non-EGU units needing SCR should have ample access to vendor support.
- Compact SCR systems: seven vendors were identified that provide compact systems for internal combustion engines (see Appendix A). These vendors appear to offer all phases of compact SCR design, fabrication, and installation.

Skilled Labor. A discussion of available skilled labor for the design phases of SCR systems is presented below. Section 5 provides an assessment of the fabrication and installation labor needed.

Large system vendors typically handle all the major phases of SCR installation through EPC contracts. This includes SCR design, fabrication, and installation. Regarding the fabrication and installation work, much of that is subcontracted out to equipment fabricators and local construction companies. SCR contacts have indicated that, currently, their staffing levels might support the design and installation of a half dozen or so systems per year (EGU-sized systems). This compares to twenty or more projects per year in the late 1990s by the largest vendors to address the demand spurred by the NOx SIP Call. The relative lack of large SCR projects during the last ten or more years led to a contraction in the number of vendors and their staffing levels. Vendors were reluctant to suggest that the air pollution control industry could not quickly respond to a surge in demand, and that, for some companies, additional

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[105] A&WMA Buyers Guide, website at https://awmabuyersguide.com/. Air Pollution Control Equipment Manufacturers Listings, An Authoritative List of the Best Air Pollution Control Equipment, website at https://www.airpollutioncontrolequipment.com/more-air-pollution-control-equipment-manufacturers-listings/. Institute of Clean Air Companies, ICAC Members, website at https://www.icac.com/page/Members. T. Licata, Licata Energy & Environmental Consultants, Inc., personal communication with S. Roe, SC&A, Inc., September 2022. D. Harajda, Mitsubishi Power Systems Americas, Inc., personal communication with S. Roe, SC&A, Inc., September 2022. F. Collinsworth, CECO Environmental, personal communication with S. Roe, SC&A, Inc., September 2022. B. Gretta, SCR Solutions, personal communication with S. Roe, SC&A, Inc., October 2022. R. Sadler, Catalytic Combustion, Inc., personal communication with S. Roe, SC&A, Inc., October 2022.

system design support could be leveraged from overseas staff.[106] In addition to US fabricators, large SCR system vendors use equipment fabricators in Canada and Mexico, when needed. As noted above, EPA does expect a relatively small amount of EGU capacity to be retrofit with SCR between 2023 and 2027 (2.5 - 8 GW of capacity or 16 units). However, given the fact that this pool of large system vendors is not expected to serve the affected non-EGU sources, and that EPA estimates only 15 non-EGU SCR systems will be installed for compliance with the final rule, significant competition for skilled designers of non-EGU SCR systems is not expected.

In addition, regarding EGU SCR optimizations, discussions with SCR vendors indicate that most EGUs may want to use the original equipment manufacturer (OEM) to conduct these optimizations (the OEM here meaning the builder of the power plant). Thus, SCR vendor support would only be needed for a very small number of the total 229 EGU optimizations estimated by EPA, since most optimizations will be done through operational changes conducted by plant staff. Moreover, 2022 data from EGU sources with existing SCRs illustrates that optimization has already occurred at many sources and future optimization is just a continuation of scheduled routine maintenance and operation for most sources, and does not constitute unplanned, incremental demand on system resources in these cases. Complementing this notion, EPA's assumptions for deriving emission performance consistent with optimization utilizes a methodology that allows for routine – rather than increased – catalyst replacement. The pool of qualified vendors is much larger than just these OEMs. It includes smaller SCR system vendors and architectural and engineering firms with power sector expertise. Where physical optimizations are employed, they could range from simple catalyst upgrades or additions of catalyst layers or to upgrades of the reagent mixing systems and/or ammonia flow control units.[107] Those requiring enhanced mixing would require vendors with flow modeling expertise (generally, the large SCR vendor pool). Again, EPA's expectations for EGU optimizations are that the vast majority of these will be operational optimizations, including more frequent maintenance, or changes to the operation of the combustion unit or dispatching of the EGU to maintain optimal exhaust temperatures for the SCR. These are changes that will not place additional demand on the skilled labor pool.

For non-EGUs, EPA has estimated that 15 SCR systems, excluding compact SCR systems that are expected to be applied to natural gas compressor engines, will likely be installed. The 12 or so vendors of the small SCR vendor pool may need to be able to design/fabricate/install on average 1 or 2 SCR systems prior to May 2026. Based on discussions with vendors, the number of new systems should easily be designed and engineered within 1 to 2 years. Equipment fabrication and installation should also be completed during the timelines indicated above barring delays in fabrication or raw materials supply. More information on indicators for fabrication activity are provided in Section 5.

EPA estimates that another 77 SNCR/ASNCRs will likely be installed for non-EGU affected units with about three quarters of those being MSW combustors. Nine SNCR vendors were identified from an internet search that serve the North American market (see Appendix A). At least three of these also provide ASNCR based on information from their websites. If all 77 installations are distributed among the SNCR system vendors, on average, each would need to have the capacity to design, fabricate and install 8 to 9 SNCR/ASNCR systems within a three-year period (or 2 to 3 each per year). Based on

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[106] For example, Mitsubishi Power Systems Americas also have SCR designers in Japan.

[107] D. Harajda, Mitsubishi Power Systems Americas, personal communication with S. Roe, SC&A, Inc., September 2022.

discussions with system vendors, this number of new installations should be achievable for the control industry.

One potential complicating factor related to the number of estimated new non-EGU SNCR/ASNCR installations is that 61 are in the municipal waste combustion industry. Not all the vendors listed in Appendix A may have expertise working with MWCs, and this could reduce the size of the vendor pool. If the pool with MWC expertise is assumed to be only 3 to 5 vendors, then on average, each would need to install 12 to 20 systems by May 2026. This number of installations per vendor could be difficult for vendors to support based on discussions with control equipment vendors, which suggested that 3 to 5 systems per year is the capacity for some vendors. If, on the other hand, a larger number of vendors have or gain sufficient expertise to work with MWCs, then the number of installations requested of each vendor would be reduced, and the vendor pool may be able to support the demand for new SNCR/ASNCR installations at MWCs by May 2026.

For compact SCR and NSCR systems applied to RICE, feedback from one system supplier did not indicate a significant concern for the air pollution control industry to meet the demand for the estimated 350 systems by May 2026.[108] This is because of the influence of the construction of data centers in recent years. Many diesel- and natural gas-powered RICE have been installed at data centers in recent years for backup power, and many of these have required SCR. A single large data center could require dozens of compact SCR systems. Therefore, the contact believed that an additional demand of several hundred compact SCR systems over a 3-year period would not be difficult for the industry to meet.

Availability of Raw Materials. Discussions with control equipment vendors did not uncover any concerns regarding the availability of raw materials needed to fabricate and install NOx controls (e.g., sheet or plate steel, cement). Some concerns were raised in comments by a large-scale SCR OEM and catalyst supplier about the availability of sufficient catalyst to cover all the new SCR systems and optimizations.[109] A 600 MW EGU might have 3 to 4 layers of catalyst of 300 cubic meters (m^3) each. A single SCR optimization project could involve the addition of another layer, or it could involve a complete change-out of catalyst. It is anticipated that most of the 229 EGU SCR optimizations will have been conducted by the 2023 ozone season. In addition, it is anticipated that a small number of EGUs will retrofit SCR (new system installs) on 2.5 – 8 GW (potentially up to 16 EGUs at 500 MW capacity) by the 2026 or 2027 ozone season.[110] EGU SCR "optimizations" cover an array of operational or physical alterations:

- Operational optimizations: these can be made without any physical alterations to the source or SCR system and include increasing maintenance, optimizing reagent injection, or changing combustion conditions to assure that the exhaust is meeting optimal temperatures for the SCR system (e.g., assuring that the EGU is dispatch schedule maintains adequate exhaust temperature);

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[108] R. Sadler, Catalytic Combustion, personal communication with S. Roe, SC&A, Inc., October 10, 2022.

[109] D. Harajda, Mitsubishi Power Americas, personal communication with S. Roe, SC&A, Inc., October 27, 2022.

[110] U.S. EPA, "EGU NOx Mitigation Strategies Final Rule TSD," Technical Support Document (TSD) for the Final Federal Good Neighbor Plan for the 2015 Ozone National Ambient Air Quality Standards, Docket ID No. EPA-HQ-OAR-2021-0668, March 2023.

- Physical optimizations: these include a complete change-out of catalyst material or the addition of another catalyst layer.

Depending on the number of EGU operators that elect physical optimizations to their SCR systems, a short-term spike in demand for catalyst material could be a concern. However, very few EGU operators are expected to elect to conduct physical optimizations. We were unable to source sufficient information from catalyst suppliers to gauge the significance of these new demands including the potential length of any associated supply chain delay.

The information reviewed indicates that any resulting increase in catalyst demand can easily be met via new production and/or the recycling of catalyst material from retired EGUs equipped with SCR. It can be noted that roughly 24 GW of EGUs with SCR are currently planning to retire (or have retired) between Jan 2021 and May 2026.[111] This would lower demand for catalyst, likely significantly more than any increased demand from EGU SCR optimization or retrofits and the non-EGU new SCR installs addressed in this report. In addition, the catalyst material from these retired units will be available for recycling (reducing the need to source new raw materials).

RICE NOx Combustion Control Installations

EPA has estimated for the final rule that layered combustion (LC) installations could be from 394 to 717 affected units out of a total of an estimated 905 engines anticipated to install some form of NOx control. The higher end of the range addresses compressor engines for which EPA did not have details on engine cycle; depending on configuration, operators could apply either LC or NSCR.

4.5 Control Vendor Demand/Capacity

Industry commenters on the rule stated a concern about vendor capacity in terms of the availability of SCR or SNCR manufacturers to simultaneously meet the needs of both EGU and non-EGU sources affected by the rule. Table 4-14 provides a summary of the number of EGU and non-EGUs estimated to install either SCR or SNCR. Note that these exclude compact SCR systems applied to RICE. An internet search identified over 20 companies operating in the US that provide SCR design/construction/installation (see Appendix A). At least nine of these serve the large EGU market (coal-fired power plants) and smaller EGUs (e.g., natural gas turbine plants). The others serve small EGUs and non-EGU sources. Nine SNCR vendors were identified that serve the US market.

As indicated in Table 4-14, a potential for overlap exists between EGU and non-EGU sector projects. As indicated by the estimated number of SCR/SNCR applications per vendor in Table 4-14, for large-scale SCR systems, the estimated 5 to 16 SCR retrofits for EGUs could be addressed by a vendor pool of at least nine identified by EPA. We do not display optimizations in the table below because EPA expects that many of these optimizations can be accomplished through in-house labor and in a relatively short time period (about 2 months based on past experience). Additionally, these optimizations are expected to occur by the 2023 ozone season.

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[111] EPA “Appendix A: Final Rule State Emission Budget Calculations and Engineering Analytics” of Ozone Transport Policy Analysis Final Rule TSD.

Table 4-14. Estimated Demand for SCR or SNCR Projects by 2026

Parameter	Large-Scale SCR	Small-Scale SCR	SNCR / ASNCR	Applications per Vendor
Equipment Vendors	**9**	**14**	**9**	
Estimated Applications				
EGU SCR (~2.5 – 8 GW by 2027)	5 – 16*			~0.5-2
Affected Industry Boiler SCR Installs		15		~1
Cement Kiln SNCR Installs			16	~2
MWC SNCR/ASNCR Installs			61	~7

*Based on an assumed nominal 500 MW average unit capacity.

For small-scale SCR applied to non-EGU boilers, the applications per vendor presume that only the remaining small-scale SCR vendors are the available pool of suppliers (i.e., that large system providers are not interested in systems of that scale). This results in only around 1 application per vendor. Total non-EGU SNCR/ASNCR applications per vendor total 9. Over a 3-year period, this suggests that each vendor might have around 3 applications per year, which is within the typical capacity constraints suggested during vendor contacts.

We find that there are at least nine companies offering SNCR systems in the US (see Appendix A). Between EGU SNCR optimizations and non-EGU SNCR installations, the average number of applications per vendor is 13. Spread across 2 years (assuming another year for initial studies and permitting as mentioned in earlier in Section 4), this average becomes 7 per vendor per year. However, as noted above, a majority of the EGU SNCR optimizations are not expected to require vendor support, so the 7 applications per vendor per year is likely a maximum estimate, with a more likely estimate being 4 applications per vendor per year if the EGU optimizations are excluded. Note that the MWC applications will likely be drawing from a smaller pool of vendors than the 9 indicated, however. This is because not all SNCR vendors will have the expertise with MWCs (including those that have designed and installed ASNCR). Therefore, MWC SNCR installs may have an increased risk for supply chain delays associated with sourcing the skilled labor required to meet a May 2026 deadline.

Note that compact SCR and NSCR applied to RICE are not addressed in Table 4-14, since those are supplied primarily by a different set of vendors than the larger EGU and non-EGU systems. As indicated previously, the number of vendors for those systems appears to be sufficient based on vendor discussions.

4.6 Permitting Processes

As shown in Table 4-1, the typical time needed to obtain construction and operating permits for non-EGU NOx control installations is estimated to be 3-6 months for some industry/control source combinations and 6-12 months for other, more complex permits (e.g., SCR or SNCR). The Table 4-1 estimates of the amount of time required for permit reviews included in the installation timelines is conservative (that is, overstated), so that complex permitting issues can be addressed, where needed. This section provides an analysis of the permitting load that could occur by state based on the number and type of control installations estimated in each state. This informs our assessment of whether the permitting load in any covered state might overwhelm existing permitting staff and pose a risk of delay in control installations.

For states that have permitting programs that allow for expedited review, the permitting processes may be less of a concern. Especially in situations where emission reductions from existing sources are involved (rather than new sources of emissions), minor permit revisions can often be granted within 8 weeks if not sooner.[112]

A key permitting issue for any control installation is whether the change to the source is considered a minor or major modification to the existing permit. Installation of a NOx control will not always trigger substantive permit reviews. For example, if a combustion control retrofit kit is being installed on a RICE and does not lead to any increase in emissions, the owner/operator may only need a minor permit modification. Installation of a NOx control device that results in a significant increase in emissions of another regulated pollutant, however, would constitute a major modification to the source requiring a lengthier major NNSR or PSD permitting process.

Contacts with permitting agency staff in several states provided the following information relevant to estimating the timelines needed for non-EGU sources to obtain the permits necessary to comply with the final rule:

- Louisiana: Minor permit revisions take about 40 hours. Louisiana Department of Environmental Quality's current staffing includes 46 permitting staff.[113]
- Texas: The Texas Commission on Environmental Quality (TCEQ) has around 90 permitting staff,[114] and has a target of completing operating permit modifications within 120 days.[115] The number of ongoing permitting projects in Texas are 974, and the state is keeping up with the current workload based on information available for this report.
- Oklahoma: Permitting staff indicated that their estimate of affected units was 109, and that these were located at around 40 facilities.[116] The Oklahoma Department of Environmental Quality currently has 15 permitting staff and three open positions.

Table 4-15 provides a summary of the estimated number of non-EGU NOx control installations by state.[117] The controls are broken out by large add-on controls (SCR or SNCR) and other NOx controls. The latter include NSCR and compact SCR applied to RICE and combustion controls (layered combustion, LNB, LNB + FGR). The number of control installations were broken down into these two categories since

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[112] B. Johnston, Louisiana Department of Environmental Quality (LDEQ), personal communication with S. Roe, SC&A, Inc., October 25, 2022. Based on the number and type of affected units, LDEQ felt confident that ATCs could be issued in a timely manner that would not impact an operator from meeting the compliance schedule indicated in the proposed rule.

[113] B. Johnston, Louisiana Department of Environmental Quality (LDEQ), personal communication with S. Roe, SC&A, Inc., October 25, 2022. Based on the number and type of affected units, LDEQ felt confident that ATCs could be issued in a timely manner that would not impact an operator from meeting the compliance schedule indicated in the proposed rule.

[114] S. Short, Acting Director, Office of Air, Texas Commission on Environmental Quality, personal communication with S. Roe, SC&A, Inc., October 31, 2022.

[115] This target is for the alteration of a new source review permit. TCEQ also mentioned a target of 330 days for revision of a general operating permit or 365 days for revision of a site operating permit. Source: Short, S. Acting Director, Office of Air, TCEQ, personal communication with S. Roe, SC&A, Inc., October 27, 2022.

[116] L. Warden, Engineering and Permitting Group Manager, OKDEQ, personal communication with S. Roe, SC&A, Inc., October 24, 2022.

[117] EPA, Office of Air Quality Planning and Standards, "Non-EGU Unit Results – Scenarios – 12-01-2022.xlsx."

large add-on controls may require more time by permit reviewers than combustion controls or packaged add-on controls.

Table 4-15 also includes an indication of whether a state has an expedited permit review process available. Most state expedited permitting programs allow a source operator to pay an additional fee to have their permit or permit revision processed on an expedited manner. Additionally, some states have other requirements for expedited review, such as the unit owner or operator being a member of an environmental stewardship program.

Finally, Table 4-15 provides an estimate of the incremental state permitting staff load that might result from the non-EGU controls needed to comply with the final rule. This is estimated in terms of annual staff full time equivalent (FTE) hours, with 2,000 hours assumed to be a typical FTE workload per year. The state incremental FTE permitting load is calculated as 400 hours per major modification (based on the information provided by Minnesota)[118] and 40 hours per minor modification (based on the information provided by Louisiana), with each multiplied by the number of expected units needing permits in each category. The resulting total incremental permit hour burden is divided by 2,000 hours per FTE and by 2 years, since there will be approximately 2 years during which these permits might be processed.

Table 4-15. Estimated Non-EGU NOx Control Installations by 2026 by State

State (Expedited Program?)	SCR / SNCR (Major Modification)	Other NOx Controls (Minor Modification)	Total	Estimated Annual FTE increment*
Arkansas (N)	2	32	34	0.5
California (Y)	6	7	13	0.7
Illinois (Y)	0	61	61	0.6
Indiana (Y)	7	44	51	1.1
Kentucky (Y)	0	48	48	0.5
Louisiana (Y)	4	195	199	2.4
Maryland (N)	0	2	2	0.0
Michigan (N)	3	58	61	0.9
Mississippi (N)	0	63	63	0.6
Missouri (N)	1	39	40	0.5
New Jersey (N)	10	1	11	1.0
New York (N)	18	12	30	1.9
Ohio (N)	2	108	110	1.3
Oklahoma (N)	9	126	135	2.2
Pennsylvania (N)	21	66	87	2.8
Texas (Y)	1	176	177	1.9
Utah (N)	0	6	6	0.1
Virginia (N)	8	29	37	1.1

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[118] Sources in Minnesota were included in the proposed rule, but not in the final rule.

State (Expedited Program?)	SCR / SNCR (Major Modification)	Other NOx Controls (Minor Modification)	Total	Estimated Annual FTE increment*
West Virginia (N)	0	63	63	0.6
Totals	**92**	**1,136**	**1,228**	**21**

*****Estimated as 400 hours per major modification, 40 hours per minor modification, with 2,000 hours per FTE per year, and with 2 years available.

With the number of staff present in Louisiana, the Table 4-15 incremental FTE of 2.4 represents about a 5% increase in workload. We anticipate that this incremental workload increase can be accommodated in Louisiana. Note this number of affected units represents an upper end to the number of permit modifications needed to support the rule as some sources may have more than one affected unit and will likely seek permit modifications for them at the same time.

Even though the number of estimated NOx control installations for Texas is high, a large fraction of these is for controls on natural gas-fired compression engines (RICE). TCEQ staff has indicated it can address the expected increase in permit workload for non-EGUs.[119] Assuming that the bulk of permits need to be processed within a two-year period, roughly a 2% increase in permit staffing workload, or a 9% increase in ongoing permit workload is estimated to result from the final rule. We anticipate that this incremental workload increase can be addressed.

In Oklahoma, it appears there may be an incremental increase in permit review labor associated with permit modification reviews of around 12 to 15% (depending on whether Oklahoma has 15 or 18 permitting staff). Oklahoma permitting staff could face a relatively higher permitting load on a per-FTE basis. However, as in Texas, many of the units in Oklahoma are RICE and thus not likely to trigger major modification review.

Available time and resources did not allow for permitting staff levels to be collected from each affected state to conduct similar assessments to the analyses above for Louisiana, Texas, and Oklahoma. Based on the state-specific assessments above, all of the incremental FTE estimates associated with permitting appear to be manageable, as all are less than 3 FTE per year. Thus, no additional delays are attributed to permitting beyond the standard timeframe needed for permitting as listed in Table 4-1.

Note that the permitting load from EGU controls was not included in this assessment, as only a handful of NOx retrofit controls (beyond optimizations of existing controls) are expected in compliance with the final rule by 2026. As indicated in Section 4, the total number of expected EGU SCR retrofits and combustion control installs is estimated to be between 15 and 50. Spread across all states affected by the rule, the incremental permitting workload is expected to be small. In addition, we anticipate that the vast majority of EGU SCR/SNCR optimizations will be completed in-house with operational changes that will not affect the operation of the existing control equipment. Rather, the operational changes will be mainly increased maintenance, changes to combustion unit operation, or changes in EGU dispatching (that maintain exhaust at optimal temperatures for control operation). It is assumed that these

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[119] S. Short, Acting Director, Office of Air, Texas Commission on Environmental Quality, personal communication with S. Roe, SC&A, Inc., October 31, 2022.

operational changes are all within the conditions of the existing operating permit and no revisions will be required.

5. Potential for Supply Chain Delays and Constraints

5.1 Supply Chain Concerns

Supply chain concerns can be organized into the following three phases of control equipment installation:

1. Producer constraints in raw materials and control equipment component production. Raw materials include bar and plate steel and catalyst components. Note that bar and plate steel products are manufactured by an industry addressed by the final rule.

2. Shipping delays for raw materials and components (especially imported components). Examples of control equipment components are pumps, nozzles, fans, motors, and electronic controllers.

3. Constraints in the skilled labor pools involved in control equipment design, fabrication, and installation. Depending on NOx control type and application, the skilled labor pool could include the initial system modelers and equipment designers, equipment fabricators, control equipment installers, and other local construction trades needed for control installation (e.g., equipment foundations, structural supports).

Producer constraints in raw materials and control equipment components were identified as concerns by both commenters and control equipment vendors. One of the raw materials of concern was catalyst material for SCR systems (including oxides of base metals and various precious metals). As described in Section 4.4, while there are overlapping needs for catalyst material for both the EGU and non-EGU sectors, EPA expects that the incremental demands will be small, and that additional catalyst material will be available for recycling due to recent and ongoing EGU retirements.

Based on input from control equipment vendors, demand constraints brought on by the pandemic for bar and plate steel and equipment components (e.g., nozzles, pumps, fans, controllers) were easing in the final quarter of 2022. Vendor expectations are that any remaining producer constraints will resolve during 2023. Also, based on November 2022 statistics presented below (Figure 5-1) from the Bureau of Transportation Statistics, business inventories are trending back toward pre-pandemic levels.

Statistics presented below also indicate that shipping delays that occurred during the pandemic are abating (Figures 5-2 through 5-8). These include statistics on shipping, truck activity and more generalized supply chain indices.

Available statistics for the skilled labor pools needed for control equipment fabrication indicate a high level of capacity utilization for the US, especially for the fabricated metals sector which includes manufacturers involved in constructing many add-on controls (Figure 5--9). Other fabricators in Canada and Mexico are also commonly used by US control equipment vendors. While the data for Mexico are not presented at the same level of detail as the US statistics, they indicate high levels of capacity utilization in the manufacturing sectors of both countries (Figures 5-10 and 5-11). This supports feedback from some equipment vendors about long lead times (> 12 months) experienced during 2022.

Section 5.2 below addresses the potential for constraints in local installation labor. These are the specialty contractors that might be needed for construction of large add-on controls, such as SCR or SNCR. As indicated by those statistics, some states have still not recovered in terms of employment levels of specialty contractors. Although the number of large add-on controls for the non-EGU sector is small as addressed elsewhere in this report, these statistics indicate that there could be some localized challenges in sourcing installation labor. However, no analysis was undertaken of the capacity for labor mobility for control installation projects.

Information gathered to characterize each of the three areas of supply chain concern and related comments are summarized below.

Potential Producer Constraints for NOx Control Equipment Components and Associated Raw Materials

Comments were due on the proposed rule by June of 2022, and so commenters discussed their experience or perception of these supply-chain issues as of that time period. As discussed further below, recent economic indicators suggest some of these concerns are ameliorating.

In their comments on the proposed rule, CIBO noted current delays in the delivery of specialized parts for SCR systems (which may also affect other control types). These include variable frequency drives, programmable logic controllers, and ammonia pumps.[120] The lead time for variable frequency drives was cited as being around 1 year as compared to a year ago (from when these comments were submitted) when these drives were available off the shelf or had a lead time of around 1 month. Similarly, according to this commenter, typical lead times for ammonia pumps were 18 months in the pre-Covid era but were around 24 months at the time the comment was submitted.

Control equipment vendors have also reported delays in components that are typically imported: electronic control equipment, nozzles, and pumps. Many of these parts are imported from Asia (especially Taiwan and China). However, the situation seems to be improving, and one vendor expected that the supply delays may be resolved sometime in 2023.

The Utah Petroleum Association/Utah Mining Association commented that lead times for combustor and controller parts had increased from 40 weeks to 80 – 120 weeks, as of the time the comment was submitted.[121] They also commented that skilled labor shortages are expected, especially in rural areas. The commenter also mentioned that more NOx reductions and other environmental benefits could be obtained by extending electricity system distribution, so that electrification could become a compliance option.

The Associated General Contractors of America commented that current lead times for procurement of certain construction materials could impact the timelines for various industries subject to the proposed rule.[122] Examples mentioned were six-month lead times for fittings used in water supply systems and lead times of over a year for aluminum used in metal fabrication of bridges. Some of these construction materials would also be used to support large NOx control systems.

Regarding component supplies from U.S. manufacturers, Figure 5--1 below shows the inventory to sales ratio for US business through September 2022.[123] These data from the Bureau of Transportation

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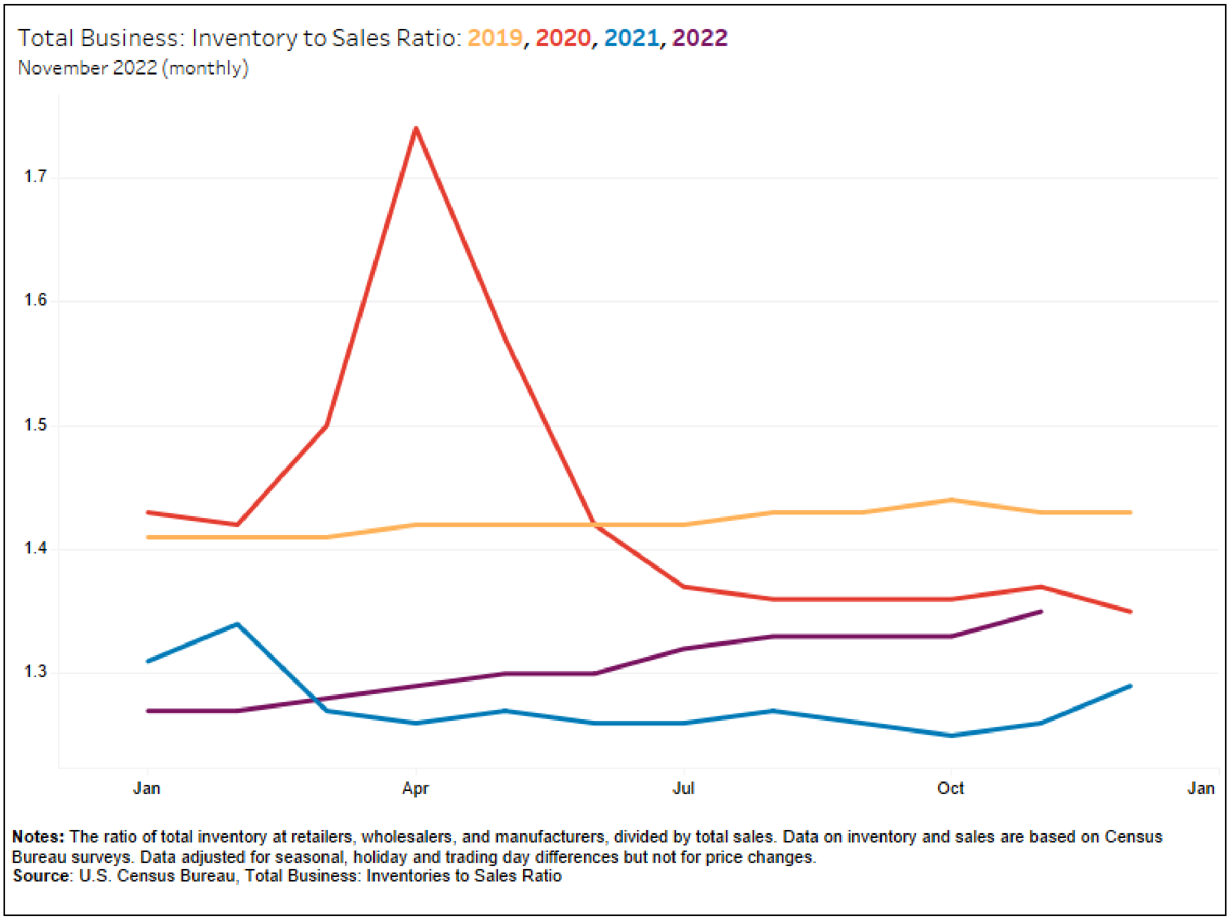
[120] EPA-HQ-OAR-2021-0668-0362. Comment submitted by Council of Industrial Boiler Owners (CIBO).

[121] EPA-HQ-OAR-2021-0668-0378. Comment submitted by Utah Petroleum Association (UPA) and Utah Mining Association (UMA).

[122] EPA-HQ-OAR-2021-0668-0415. Comment submitted by Associated General Contractors of America (AGC).

[123] Bureau of Transportation Statistics (BTS), Latest Supply Chain Indicators, website at https://www.bts.gov/freight-indicators#labor. The ratio of total inventory at retailers, wholesalers, and

Statistics (BTS) indicate that business inventories are improving relative to 2021; however, inventory levels have still not yet returned to pre-pandemic levels (2019).



Notes: The ratio of total inventory at retailers, wholesalers, and manufacturers, divided by total sales. Data on inventory and sales are based on Census Bureau surveys. Data adjusted for seasonal, holiday and trading day differences but not for price changes.
Source: U.S. Census Bureau, Total Business: Inventories to Sales Ratio

Figure 5-1. US Inventory to Sales Ratio

Shipping Delays for Raw Materials and Control Equipment Components

National indicators of shipping constraints from BTS indicate a mixed picture of economic recovery following the pandemic. Figure 5-2 shows that the number of container ships awaiting berth at US ports has improved somewhat over the past year at two of the four ports reported; however, overall, the number of ships remains high (about 90 at all US ports) with only a small reduction overall in the past year.

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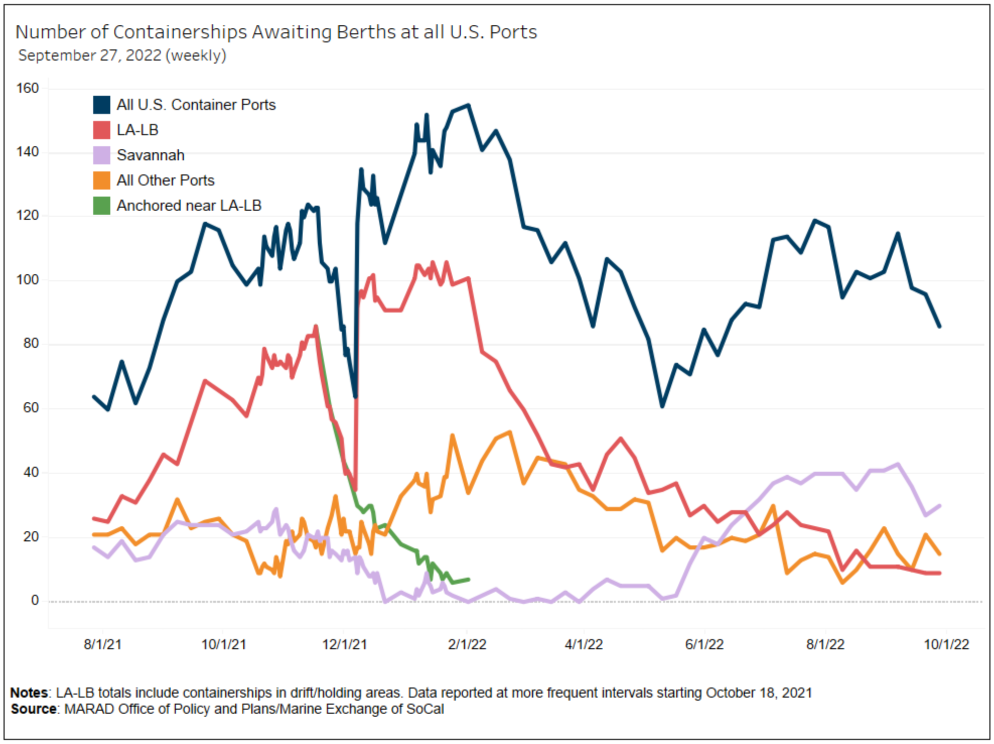
manufacturers, divided by total sales. Data on inventory and sales are based on Census Bureau surveys. Data adjusted for seasonal, holiday and trading day differences but not for price changes.

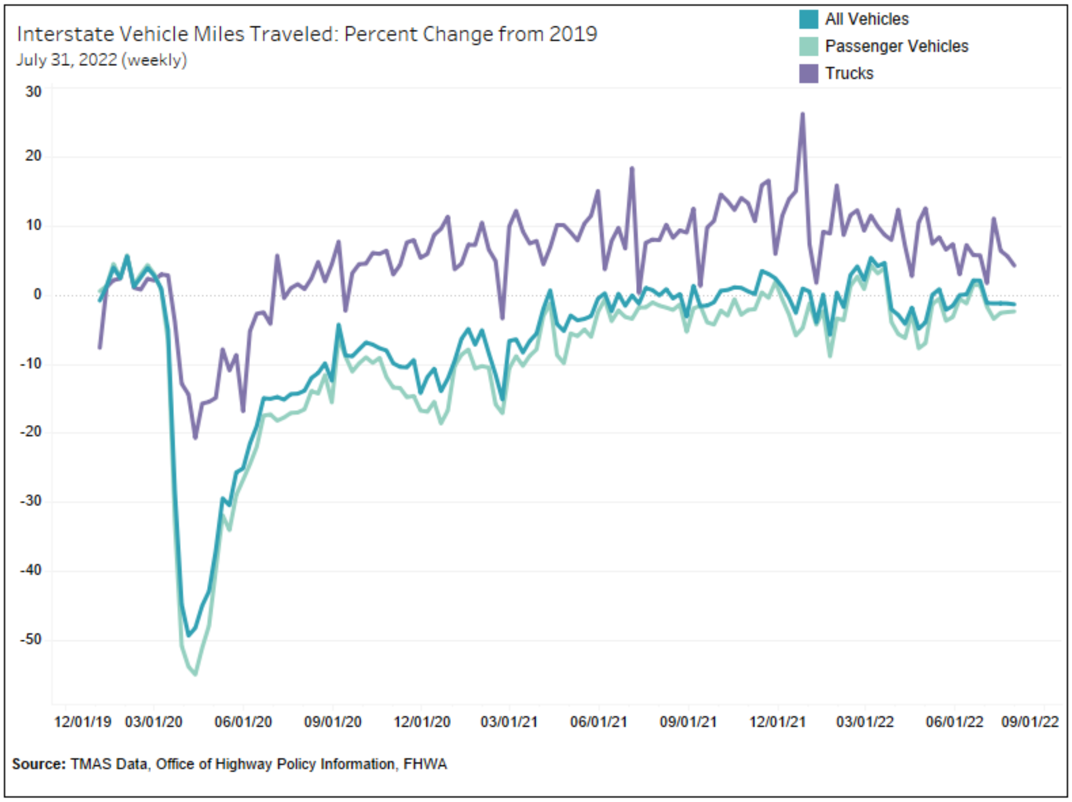

Number of Containerships Awaiting Berths at all U.S. Ports

September 27, 2022 (weekly)

Notes: LA-LB totals include containerships in drift/holding areas. Data reported at more frequent intervals starting October 18, 2021
Source: MARAD Office of Policy and Plans/Marine Exchange of SoCal

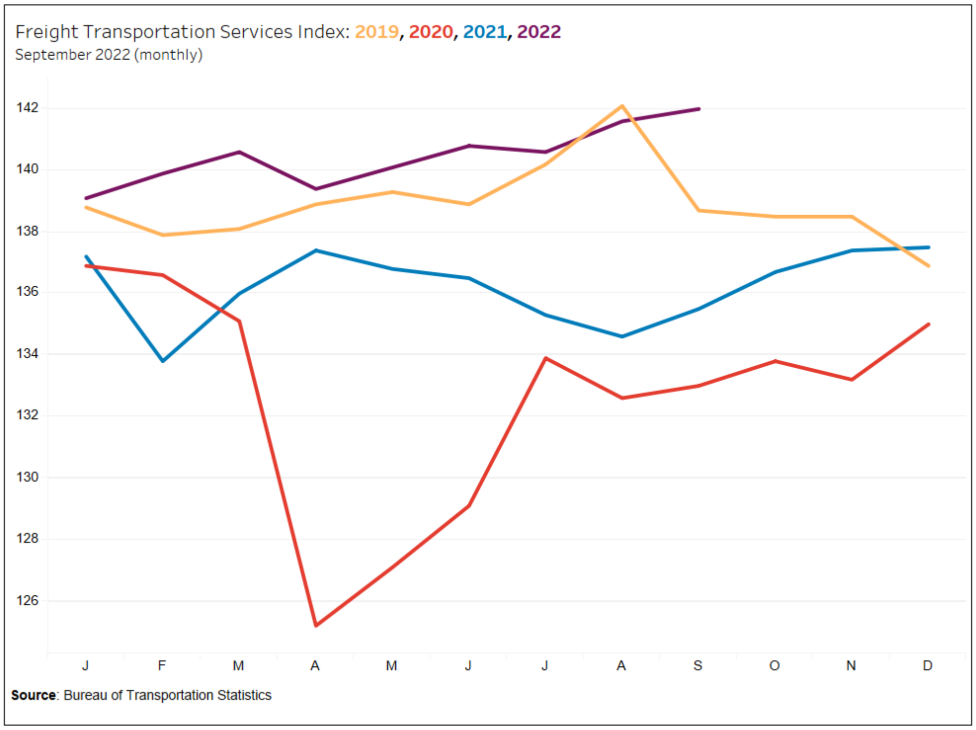
Figure 5-2. Containerships Awaiting Berth

For truck freight activity, the BTS data in Figure 5-3 below show that truck travel activity has returned to pre-pandemic levels. The BTS freight transportation services index through September 2022 shown in Figure 5-4 also indicates that services have recovered to near or above 2019 levels.



Source: TMAS Data, Office of Highway Policy Information, FHWA

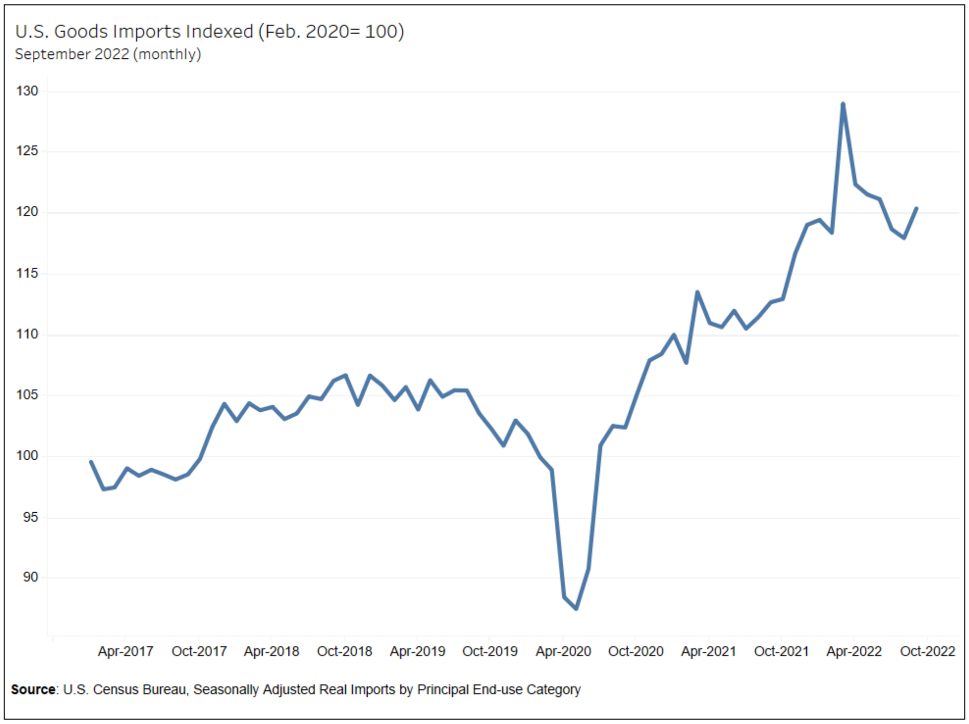
Figure 5-3. Interstate Vehicle-Miles Traveled (% Change from 2019)



Source: Bureau of Transportation Statistics

Figure 5-4. Freight Transportation Services Index

While the indicators above show that the transport of goods has largely returned to more normal levels, Figure 5-5 below shows another BTS indicator on the volume of imported goods, which is now well above pre-pandemic levels. Hence, there still seems to be strong potential for more freight delays for imported goods, although the imported goods appear to be heading back to more historic or normal levels.


U.S. Goods Imports Indexed (Feb. 2020= 100)
September 2022 (monthly)

Source: U.S. Census Bureau, Seasonally Adjusted Real Imports by Principal End-use Category

Figure 5-5. Index of US Imported Goods

Control equipment vendors have reported quotes from metal fabricators with significant lead times of up to a year for items such as electrical components (e.g., controllers) and valves. Typical lead times previously would have been 18 to 20 weeks. These reports are consistent with the supply chain indicators above on business inventories (such components need to be manufactured, rather than pulled from existing inventory).

Another sign that supply chain bottlenecks may be in the process of being resolved is illustrated by the recent RSM US Supply Chain Index.[124] Figure 5-6 below shows that the index just returned to a positive value for the first time in over two years. This index is a composite of ten subindices, which are shown in Figure 5-7. In particular, the subindices associated with inventory levels from manufacturers to retailers are above historical levels and the other subindices are all improving.

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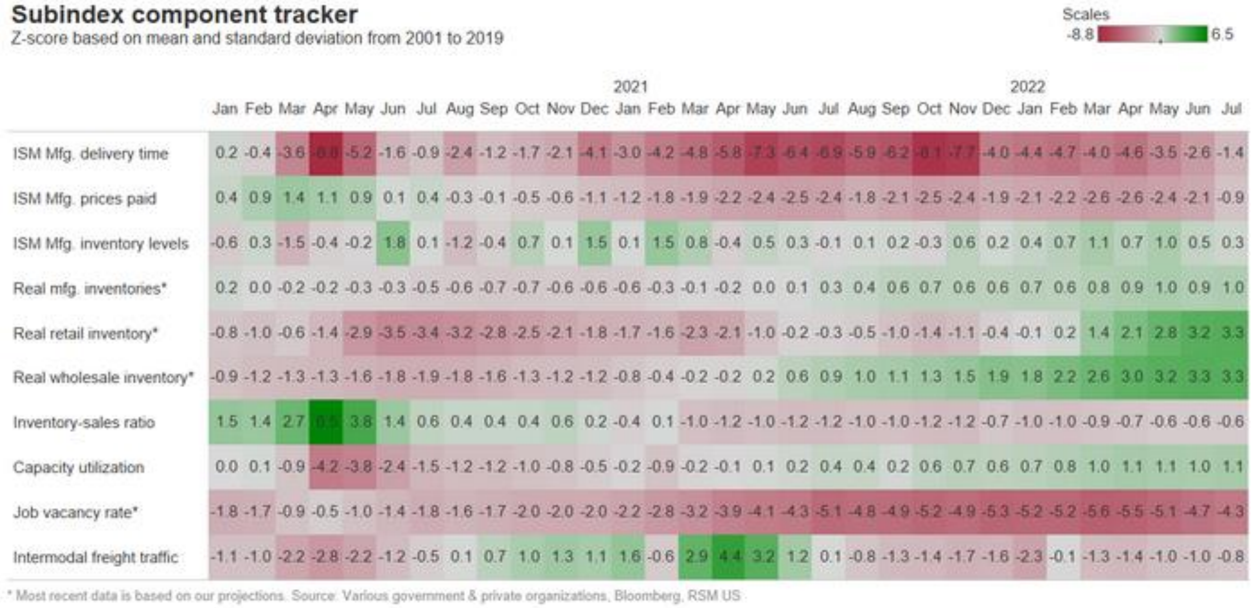
[124] The Real Economy Blog, RSM U.S. Supply Chain Index: Back to normal for first time since pandemic hit, website at https://realeconomy.rsmus.com/rsm-u-s-supply-chain-index-back-to-normal-for-first-time-since-pandemic-hit/.

Note: An index value of zero is defined as a normal level of supply chain efficiency. Positive values of the index suggest adequate levels; negative levels suggest deficiencies. Source: Various government & private organizations, Bloomberg, RSM US

Figure 5-6. RSM US Supply Chain Index



													2021												2022						
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
ISM Mfg. delivery time	0.2	-0.4	-3.6	-8.8	-5.2	-1.6	-0.9	-2.4	-1.2	-1.7	-2.1	-4.1	-3.0	-4.2	-4.8	-5.8	-7.3	-6.4	-6.9	-5.9	-6.2	-8.1	-7.7	-4.0	-4.4	-4.7	-4.0	-4.6	-3.5	-2.6	-1.4
ISM Mfg. prices paid	0.4	0.9	1.4	1.1	0.9	0.1	0.4	-0.3	-0.1	-0.5	-0.6	-1.1	-1.2	-1.8	-1.9	-2.2	-2.4	-2.5	-2.4	-1.8	-2.1	-2.5	-2.4	-1.9	-2.1	-2.2	-2.6	-2.6	-2.4	-2.1	-0.9
ISM Mfg. inventory levels	-0.6	0.3	-1.5	-0.4	-0.2	1.8	0.1	-1.2	-0.4	0.7	0.1	1.5	0.1	1.5	0.8	-0.4	0.5	0.3	-0.1	0.1	0.2	-0.3	0.6	0.2	0.4	0.7	1.1	0.7	1.0	0.5	0.3
Real mfg. inventories*	0.2	0.0	-0.2	-0.2	-0.3	-0.3	-0.5	-0.6	-0.7	-0.7	-0.6	-0.6	-0.6	-0.3	-0.1	-0.2	0.0	0.1	0.3	0.4	0.6	0.7	0.6	0.6	0.7	0.6	0.8	0.9	1.0	0.9	1.0
Real retail inventory*	-0.8	-1.0	-0.6	-1.4	-2.9	-3.5	-3.4	-3.2	-2.8	-2.5	-2.1	-1.8	-1.7	-1.6	-2.3	-2.1	-1.0	-0.2	-0.3	-0.5	-1.0	-1.4	-1.1	-0.4	-0.1	0.2	1.4	2.1	2.8	3.2	3.3
Real wholesale inventory*	-0.9	-1.2	-1.3	-1.3	-1.6	-1.8	-1.9	-1.8	-1.6	-1.3	-1.2	-1.2	-0.8	-0.4	-0.2	-0.2	0.2	0.6	0.9	1.0	1.1	1.3	1.5	1.9	1.8	2.2	2.6	3.0	3.2	3.3	3.3
Inventory-sales ratio	1.5	1.4	2.7	6.5	3.8	1.4	0.6	0.4	0.4	0.4	0.6	0.2	-0.4	0.1	-1.0	-1.2	-1.0	-1.2	-1.2	-1.0	-1.0	-1.2	-1.2	-0.7	-1.0	-1.0	-0.9	-0.7	-0.6	-0.6	-0.6
Capacity utilization	0.0	0.1	-0.9	-4.2	-3.8	-2.4	-1.5	-1.2	-1.2	-1.0	-0.8	-0.5	-0.2	-0.9	-0.2	-0.1	0.1	0.2	0.4	0.4	0.2	0.6	0.7	0.6	0.7	0.8	1.0	1.1	1.1	1.0	1.1
Job vacancy rate*	-1.8	-1.7	-0.9	-0.5	-1.0	-1.4	-1.8	-1.6	-1.7	-2.0	-2.0	-2.0	-2.2	-2.8	-3.2	-3.9	-4.1	-4.3	-5.1	-4.8	-4.9	-5.2	-4.9	-5.3	-5.2	-5.2	-5.6	-5.5	-5.1	-4.7	-4.3
Intermodal freight traffic	-1.1	-1.0	-2.2	-2.8	-2.2	-1.2	-0.5	0.1	0.7	1.0	1.3	1.1	1.6	-0.6	2.9	4.4	3.2	1.2	0.1	-0.8	-1.3	-1.4	-1.7	-1.6	-2.3	-0.1	-1.3	-1.4	-1.0	-1.0	-0.8

* Most recent data is based on our projections. Source: Various government & private organizations, Bloomberg, RSM US

Figure 5-7. RSM US Supply Chain Subindices

Figure 5-8 is a chart of the global supply chain pressure index produced by the Federal Reserve Bank of New York.[125] It also indicates that, at a global level, supply chain linkages are being re-established and

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[125] Federal Reserve Bank of New York, Global Supply Chain Pressure Index (GSCPI), website at https://www.newyorkfed.org/research/policy/gscpi#/interactive. The GSCPI integrates several commonly used

pressures reduced. However, supply chain pressure is near historically high levels. While there are good signs both in the US and at the global level for reduced supply chain disruption, it is still too early to know whether the supply chain issues noted by equipment vendors will resolve entirely in the coming years.

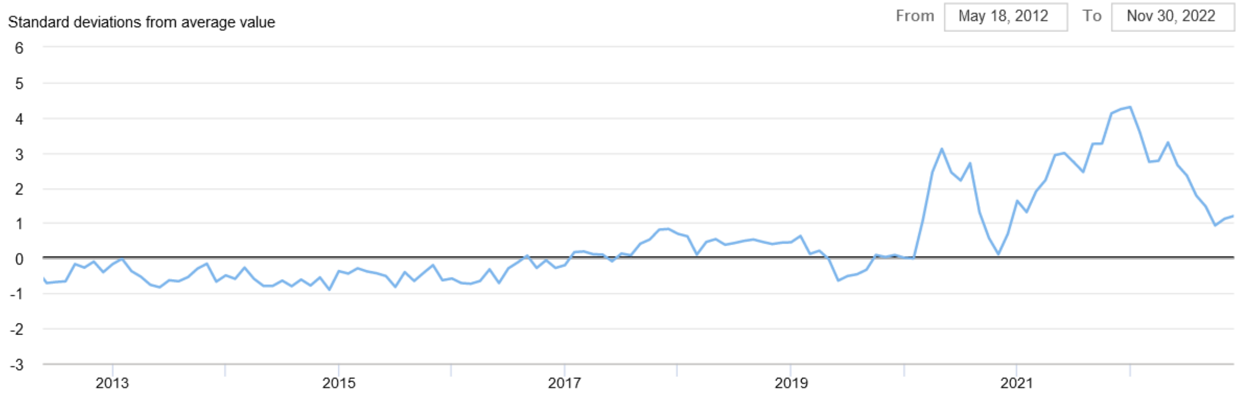

Figure 5-8. Global Supply Chain Index

Skilled Labor Constraints for Equipment Design, Fabrication, and Installation

Based on the potential number of NOx control installations for both the non-EGU and EGU sectors, the following non-EGU technologies and applications appear to be competing for limited skilled labor pools:

- SCR applied to ICI boilers;
- SNCR applied to cement kilns and MWCs; and
- Combustion controls applied to natural gas compressor station RICE.

Each of these constraints is addressed within a broader discussion of skilled labor constraints in this section.

SCR on ICI Boilers; and SNCR on Cement Kilns and MWCs. Some control equipment vendors offering SCR might also offer SNCR. These smaller non-EGU NOx sources may experience delays in contracting for equipment design, fabrication, and installation, since vendors may tend to focus on larger and likely more profitable contracts first.[126] For example, MWC units are often smaller than EGUs (usually less than 30 MW of capacity), and some commenters indicated that they would be competing for the same control equipment vendors. As described above in Section 4.5, there is a pool of SCR/SNCR vendors that service the EGU sector, and those vendors may not be inclined to bid on projects at these smaller scales. Those vendors will also likely be servicing the needs of EGUs with existing SCR systems that are optimizing those SCR systems for rule compliance. For both SCR and SNCR systems for these groups of affected non-EGU sources, it appears that a different set of equipment vendors would be serving them

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metrics with the aim of providing a comprehensive summary of potential supply chain disruptions. Global transportation costs are measured by employing data from the Baltic Dry Index (BDI) and the Harpex index, as well as airfreight cost indices from the U.S. Bureau of Labor Statistics. The GSCPI also uses several supply chain-related components from Purchasing Managers' Index (PMI) surveys, focusing on manufacturing firms across seven interconnected economies: China, the euro area, Japan, South Korea, Taiwan, the United Kingdom, and the United States.

[126] EPA-HQ-OAR-2021-0668-0301. Comment submitted by Minnesota Resource Recovery Association (MRRA).

as compared to the much larger EGU sources (at least from a design perspective). Based on the assessment in Section 4.5, it appears that competition for skilled labor is more likely to be an issue during equipment fabrication and installation phases. For example, large EPC contractors may provide the overall design and engineering of an SCR system but use subcontractors to fabricate and install equipment.

Control Equipment Fabrication Constraints. The comparisons of labor requirements above only include the US boilermaker occupation. Some of the labor needs might be supplied by other workers in aligned industries. These include metal fabrication, machinery, and construction. Local construction labor constraints are addressed below. For metal fabrication and machinery, Figure 5-9 below provides historic data through August 2022 of U.S. capacity utilization in these sectors, along with all manufacturing. As indicated by these data, since 2000, capacity utilization does not tend to peak much above 80%. Current levels of capacity utilization have increased well above their levels following the start of the pandemic. Overall manufacturing capacity stood at 79.6% at the end of August 2022. This compares to the average of 75.3% going back to 2000, and a maximum monthly value of 80.5%. For fabricated metals, the current value of 79.0% compares to a long-term average of 77.6% and a maximum value of 87.8%. For machinery, the current value is 83.5% compared to a long-term average of 75.4% and a maximum of 86.6%.

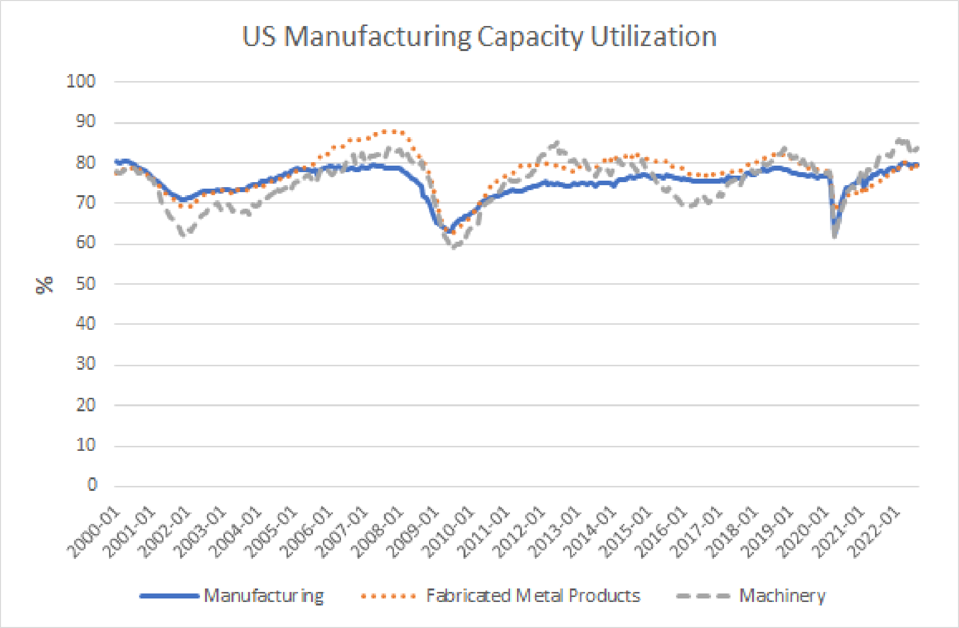

Figure 5-9. US Manufacturing Capacity Utilization[127]

It is important to note that equipment vendors have indicated that they draw support from fabricators throughout North America (including Canada and Mexico). Figure 5-10 presents a chart of Canadian manufacturing capacity that is similar to Figure 5-9 shown above for the U.S. The Canadian data indicate a similar situation as the U.S. for available capacity. The most recent data cover the second quarter of

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[127] Board of Governors of the Federal Reserve System, Industrial Production and Capacity Utilization - G.17, website at https://www.federalreserve.gov/releases/g17/current/table1.htm.

2022. Overall manufacturing and fabricated metals capacity are slightly below their long-term averages (back to the year 2000). Machinery capacity is slightly above the long-term average.

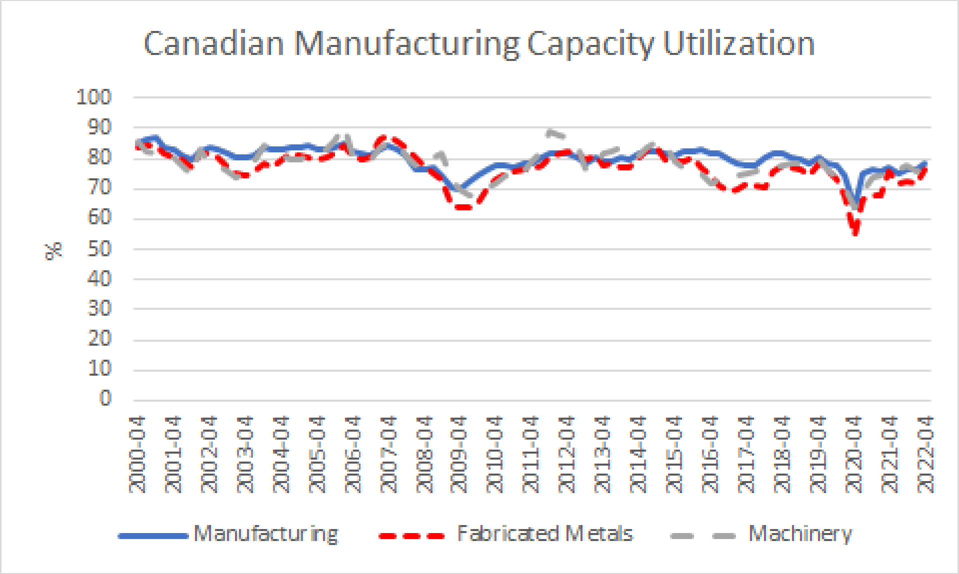

Figure 5-10. Canadian Manufacturing Capacity Utilization[128]

Similar disaggregated capacity utilization data were not identified for Mexico; however, Figure 5-11 provides historical data on the country's manufacturing capacity utilization. The most recent values indicate that capacity is being utilized at levels above historical averages. Taken together with the U.S. and Canadian data above, this information is consistent with reports from some vendors about delays in orders.

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[128] Statistics Canada, Industrial capacity utilization rates, by industry, website at https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1610010901.

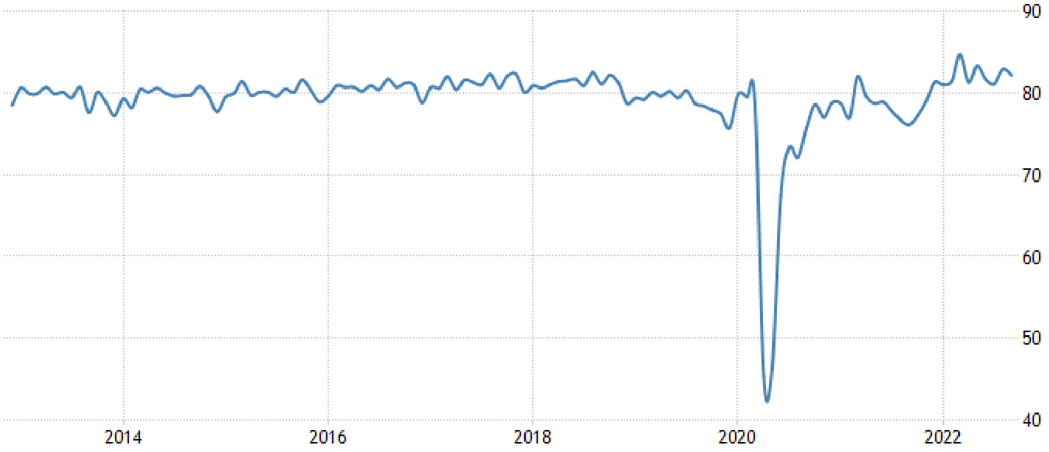

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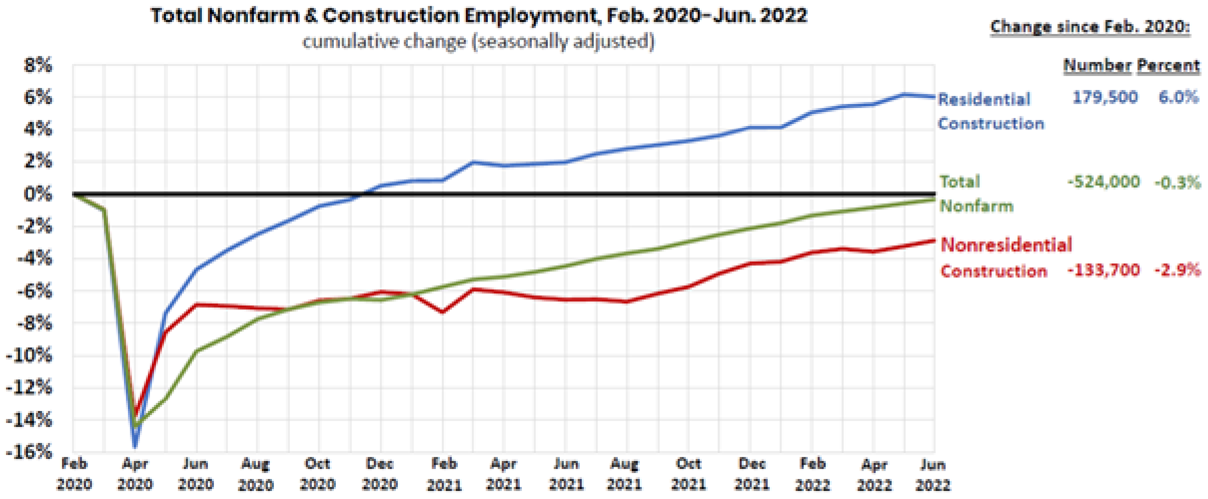
Figure 5-11. Mexican Manufacturing Capacity Utilization[129]

Constraints on Local Construction Labor. Specific to construction labor that could be involved in the installation of large air pollution control systems, such as SCR and SNCR, Figure 5-12 below indicates that nonresidential construction employment in the U.S. has still not recovered to pre-pandemic levels (still 3% below levels in February 2020).[130] A regional assessment of demand and supply of labor is provided in Section 5.2 below.



Source: BLS current employment statistics, https://www.bls.gov/ces/

Figure 5-12. US Nonfarm and Construction Employment

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[129] Primary source: National Institute of Geography and Statistics, Mexico, https://tradingeconomics.com/mexico/capacity-utilization. These values are for overall manufacturing capacity, rather than just the metal fabrication sector.

[130] Associated General Contractors of America (AGC), "July 2022 Construction Inflation Alert," July 2022.

Skilled labor for Installation of Controls for External Combustion Sources. One example of an analysis of impact to skilled labor necessary to install air pollution control equipment is the analysis EPA conducted in 2005 of boilermaker employment in the US, and its availability to address NOx and SO_2 control installations for the final Clean Air Interstate Rule (CAIR).[131] Note that the Bureau of Labor Statistics (BLS) defines boilermakers as follows:[132]

> *Construct, assemble, maintain, and repair stationary steam boilers and boiler house auxiliaries. Align structures or plate sections to assemble boiler frame tanks or vats, following blueprints. Work involves use of hand and power tools, plumb bobs, levels, wedges, dogs, or turnbuckles. Assist in testing assembled vessels. Direct cleaning of boilers and boiler furnaces. Inspect and repair boiler fittings, such as safety valves, regulators, automatic-control mechanisms, water columns, and auxiliary machines.*

Although the boilermaker labor category closely addresses the skilled labor pool that could be involved in air pollution control installation, we note that a much broader group of trades people are involved in the fabrication and installation of air pollution controls, such as SCR systems. For example, these include contracted metal fabricators that build the housing and ducting of SCR systems, electricians for installing control and monitoring systems, and local construction contractors that build and install the structural components to mount the new SCR system. Many of these skilled trades people would not be included in the BLS estimates of boilermakers. However, extracting employment estimates for all segments of these skilled trades aligned with the air pollution controls industry and related equipment/services is not possible. Thus, using boilermaker employment is a conservative surrogate for the full complement of skilled trades involved.

The key inputs to EPA's 2005 boilermaker labor analysis were:

- Boilermaker population: 28,000
- Percentage of boilermaker labor available for CAIR retrofits: 35%
- Number of annual hours worked by a boilermaker: 2,000 hours/year
- SCR duty rate: 0.175 year/MW (annual boilermaker labor per unit of EGU capacity)

Recent BLS employment estimates for boilermakers (May 2021) indicate a significant contraction for the occupation to 12,920.[133] EPA noted in 2005 that BLS was forecasting lower boilermaker employment due to both lower demand and an accelerated retirement rate among the aging workforce. This employment estimate and the previous labor analysis inputs above provide an annual available boilermaker labor supply estimate of 12,920 x 0.35 x 2,000 hours/yr = 9,044,000 hours/year.

Note the key assumption in the analysis above that 35% of the workforce is still considered available for control retrofits. Given the apparent contraction for the boilermaker occupation, that value may be

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[131] EPA, Office of Air and Radiation, "Technical Support Document for the Final Clean Air Interstate Rule, Boilermaker Labor Analysis and Installation Timing," Docket ID No. OAR-2003-0053, March 2005.

[132] U.S. Bureau of Labor Statistics, Occupational Employment and Wages, May 2021 47-2011 Boilermakers, website at https://www.bls.gov/oes/current/oes472011.htm#(1).

[133] U.S. Bureau of Labor Statistics, Occupational Employment and Wages, May 2021 47-2011 Boilermakers, website at https://www.bls.gov/oes/current/oes472011.htm#(1).

overstated.[134] On the other hand, while it is not clear from the 2005 technical memo, the SCR duty rates are likely based on estimates from large coal-fired power plants. Since the affected non-EGU boilers are likely to be smaller, the SCR systems would also be smaller and potentially much less labor intensive to install. For non-EGU sources, EPA estimated 15 SCR systems (excluding compact SCR units for RICE) would be installed on industrial boilers.[135] There are no SCR duty rates available for non-EGUs as there are for EGUs. For a rough gauge of the fabrication and installation labor requirement for SCRs for non-EGUs, the following assumptions were made:[136]

- SCR is being retrofitted to a 250 MMBtu industrial oil/gas boiler;
- EPC vendor percentage of total project cost is 20% (design, procurement, and construction management);
- Fabrication and installation labor percentage of total project cost is 40%; and
- The loaded average fabrication and installation labor rate is $70/hour.

EPA's SCR Cost Manual Spreadsheet[137] was used to generate a total capital cost for the project ($8.63 million in 2022 dollars). This value is assumed to be representative of the average for all non-EGU SCR installations. Application of the assumptions above to the estimated capital cost resulted in a fabrication/installation labor estimate of 39,400 hours. Applying this value to the 15 estimated non-EGU SCR systems (again, excluding compact SCR units for RICE) yields 0.6 million labor hours. Based on the available boilermaker labor estimate above, this load could be absorbed relatively easily. Note this does not account for the boilermaker labor that might be needed for non-EGU SNCR applications and EGU SCR/SNCR optimizations.

Skilled Labor for Combustion Controls on Natural Gas Transmission Compressor RICE. In their comments, TC Energy cited previous EPA rulemaking estimates that only about 75 engines could be retrofit annually on a sustained basis given resource constraints (skilled labor) and the time needed to procure and install equipment. TC Energy referenced a 2014 report by INGAA, t which is the source of the 75 engines per year estimate.138 A number of commenters representing this industry concluded that decades would be needed to address all RICE addressed by the rule. An example cited was the conversion of over 200 natural gas transmission RICE to add Low Emissions Combustion beginning in 1999 as part of the NOx SIP Call. The entire retrofit process took six years according to the commenters.

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[134] Discussions with SCR vendors indicate that metal fabricators are currently constrained across North America (includes, US, Canadian and Mexican suppliers).

[135] U.S. EPA. Technical Memorandum. Summary of Final Rule Applicability Criteria and Emissions Limits for Non-EGU Emissions Units, Assumed Control Technologies for Meeting the Final Emissions Limits, and Estimated Emissions Units, Emissions Reductions, and Costs. March 15, 2023.

[136] These assumptions are based on discussions with control equipment vendors, BLS labor statistics (U.S. Bureau of Labor Statistics, Occupational Employment and Wages, May 2021 47-2011 Boilermakers, website at https://www.bls.gov/oes/current/oes472011.htm#(2)), and industry wage/benefits information (Boilermakers Union Local 242, Wages & Benefits, website at https://boilermakers242.com/wages-benefits/).

[137] EPA, Cost Reports and Guidance for Air Pollution Regulations, website at https://www.epa.gov/economic-and-cost-analysis-air-pollution-regulations/cost-reports-and-guidance-air-pollution.

[138] Interstate Natural Gas Association of America (INGAA), "Availability and Limitations of NOx Emission Control Resources for Natural Gas-Fired Prime Movers Used in the Interstate Natural Gas Transmission Industry," prepared by Innovative Environmental Solutions and Optimized Technical Solutions, INGAA Foundation Final Report No. 2014.03, July 2014.

Multiple commenters referenced INGAA's estimated limit of 75 RICE retrofits per year based on the size of the skilled labor pool for such retrofits.[139] Although state-level data were not provided in these comments, INGAA estimated that most control retrofits would be directed at 2,050 two-stroke engines (this includes engines in 40 states and was thought to be ~80% complete at the time). INGAA pointed out that the 75 retrofits/year estimate compared to 50 retrofits/year carried out earlier during the NOx SIP Call.

The estimate of 75 retrofits per year provided by INGAA is now about 10 years old. INGAA also noted in its report that this estimate was based on current resource availability and did not take account of hiring and training to respond to a new regulations. A skilled labor pool has likely already grown given the extent of retrofits over the previous years to service the growing size of the current storage and transmission industry. In addition, there has been a significant expansion in RICE used for other applications, including backup power for data centers. Therefore, the skilled labor pool for engine retrofits should have grown with the size of the RICE population. Considering just the growth in natural gas production, which in the US has nearly doubled since 2005 (as indicated in the Figure 5-13 below), a skilled labor pool should be present to support the retrofits in the industry. Assuming that the size of the skilled labor pool has grown along with natural gas production and RICE-use expansion and would continue to grow in response to a regulatory mandate as INGAA acknowledged in their report, this would allow for a reasonable estimate that the size of the labor pool with the requisite skills could be doubled from the prior estimate and thus would be large enough to conduct 150 specialized retrofit installations per year (75 retrofits/yr x 2). Using EPA's estimate of 905 affected engines for the final rule as a very conservative upper-bound estimate for the number of units that may require such specialized labor, the maximum amount of time to apply the retrofit controls to this estimated number of engines would be just over 6 years (a lower upper-bound figure of 717 engines would reduce the time estimate accordingly).

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[139] Interstate Natural Gas Association of America (INGAA), "Availability and Limitations of NOx Emission Control Resources for Natural Gas-Fired Prime Movers Used in the Interstate Natural Gas Transmission Industry," prepared by Innovative Environmental Solutions and Optimized Technical Solutions, INGAA Foundation Final Report No. 2014.03, July 2014.

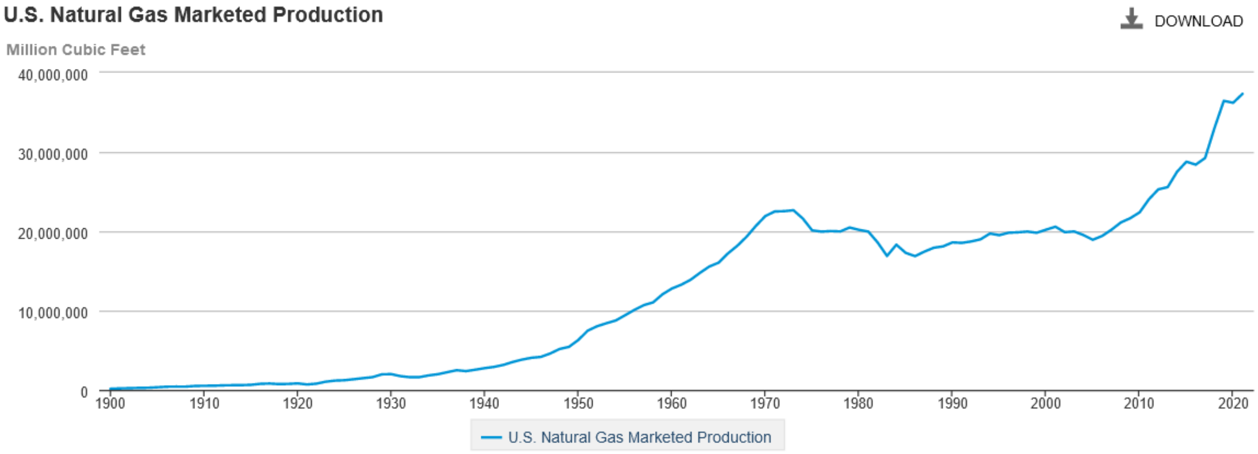

Figure 5-13. Historic US Natural Gas Production[140]

From a skilled labor perspective, industry commenters seemed to be most concerned about the population of RICE engines that were very old (>50 years). The concern is that there is a limited skilled labor pool that has the experience working with RICE of that vintage. In situations where the control is LC, rather than an add-on control, skilled mechanics would be needed. The data supplied to EPA on affected RICE and that are estimated to adopt LC does not include the age of the equipment.

5.2 Regional Analysis of Demand and Available Supply of Labor

For the purposes of examining regional labor constraints, to the extent they may exist, the metrics of most interest are those that address state-level construction labor that could be involved in the local installation of NOx controls, in particular, larger SCR and SNCR systems. Design and equipment fabrication could occur locally, however, in most cases, these services might come from suppliers outside of the region.

Figures 5-14 through 5-17 provide state-level summaries of employment within the Specialty Trade Contractors category from 2005 through October of 2022.[141] The state-level summaries provided represent the states with the greatest number of estimated non-EGU controls installations. BLS defines the Specialty Trade Contractors subsector as comprising establishments whose primary activity is performing specific activities (e.g., pouring concrete, site preparation, plumbing, painting, and electrical work) involved in building construction or other activities that are similar for all types of construction, but that are not responsible for the entire project. The work performed may include new work, additions, alterations, maintenance, and repairs. The production work performed by establishments in this subsector is usually subcontracted from establishments of the general contractor type or operative builders, but especially in remodeling and repair construction, work also may be done directly for the owner of the property. Specialty trade contractors usually perform most of their work at the construction site, although they may have shops where they perform prefabrication and other work.

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[140] U.S. Energy Information Administration (EIA), Natural Gas, website at https://www.eia.gov/dnav/ng/hist/n9050us2a.htm.

[141] U.S. Bureau of Labor Statistics and Federal Reserve Bank of St. Louis, All Employees: Construction: Specialty Trade Contractors in Texas [SMU48000002023800001SA], retrieved from FRED, Federal Reserve Bank of St. Louis; https://fred.stlouisfed.org/series/SMU48000002023800001SA, December 6, 2022.

Establishments primarily engaged in preparing sites for new construction are also included in this subsector.[142]

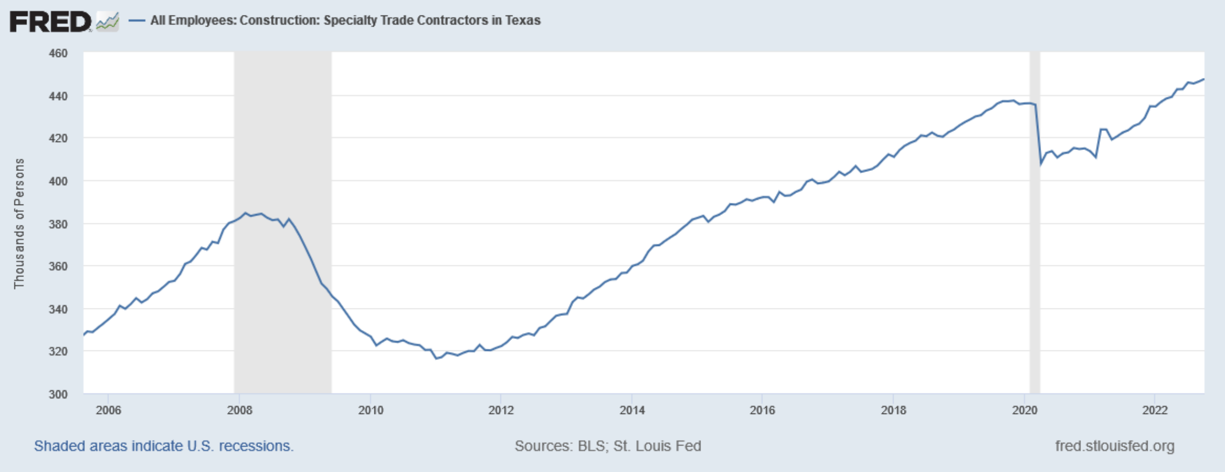

Figure 5-14. Specialty Trade Contractors in Texas

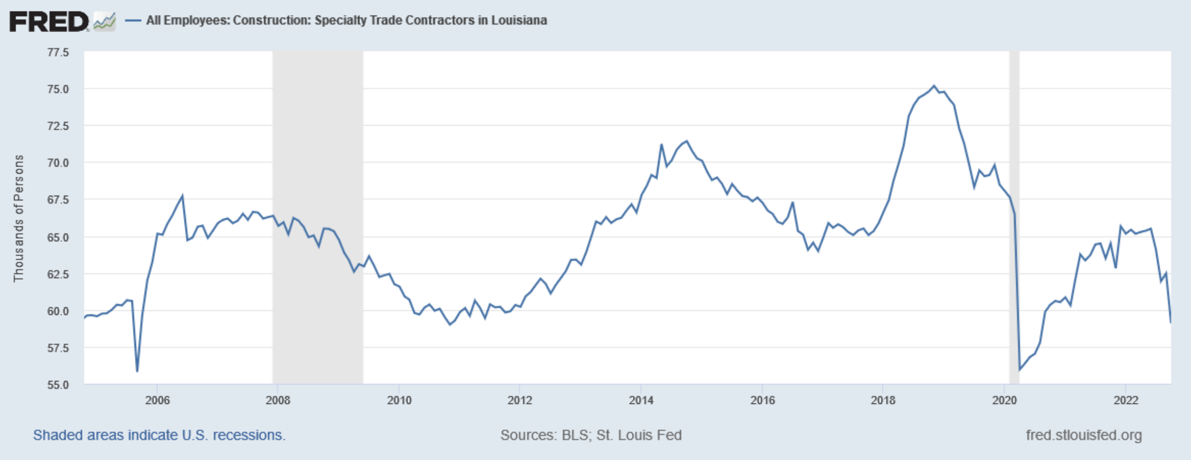

Figure 5-15. Specialty Trade Contractors in Louisiana

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[142] U.S. Bureau of Labor Statistics, Specialty Trade Contractors: NAICS 238, website at: https://www.bls.gov/iag/tgs/iag238.htm.

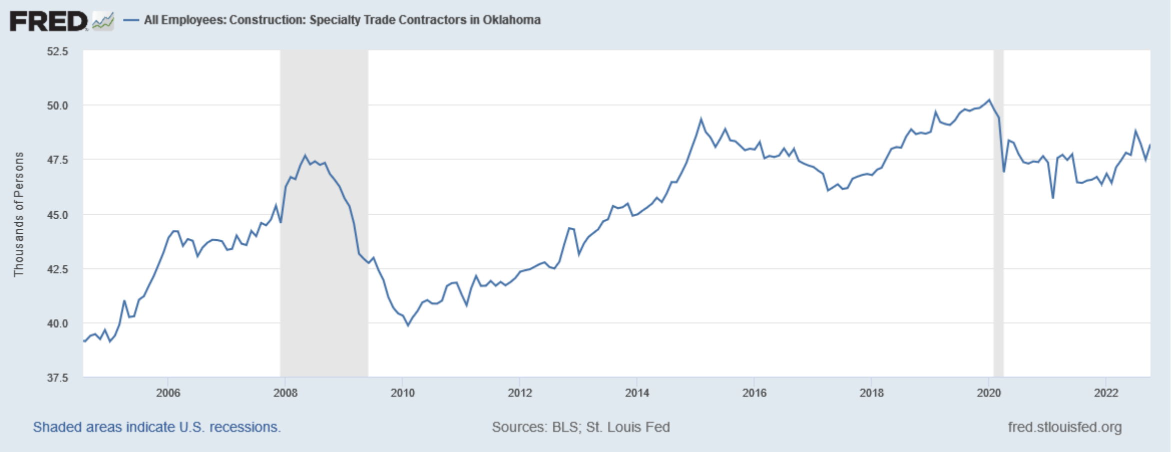

Figure 5-16. Specialty Trade Contractors in Oklahoma

Figure 5-17. Specialty Trade Contractors in Ohio

As indicated by these summaries, employment has rebounded to above pre-pandemic levels in Texas and Ohio. Louisiana's employment level is still well below 2019 levels, initially slowing through 2021, but with sharp declines in the number of employees again in 2022. This information doesn't necessarily provide a sense of available labor capacity going forward; however, it does indicate that some states have lost installation labor capacity as compared to historic levels, though it could also indicate that the overall installation labor market could potentially be higher than current levels.

A forward-looking indicator of construction activity is the Construction Backlog Indicator (CBI) from Associated Builders and Contractors (ABC).[143] A chart showing the latest (September 2022) CBI reading is shown in Figure 5-18 below. According to ABC, the CBI is a forward-looking national economic indicator that reflects the amount of work that will be performed by commercial and industrial contractors in the months ahead. We include data from this indicator in this report because this new, national economic data set is the only reliable leading economic indicator offering this level of specificity focused on the

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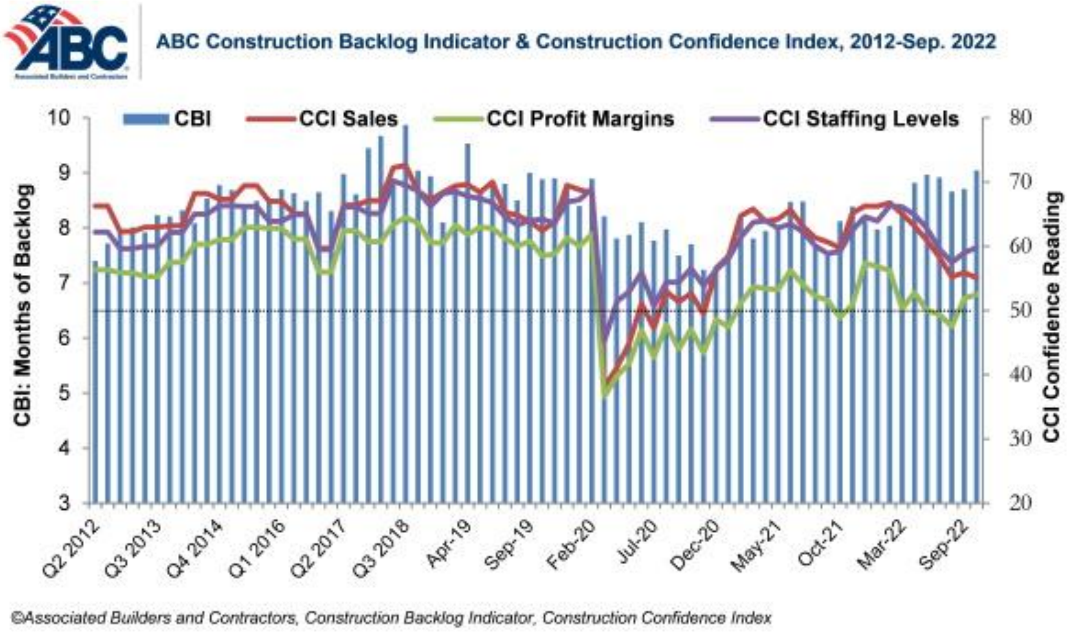
[143] CBI methodology: https://www.abc.org/Portals/1/Documents/CBI/CBIMethodology1.pdf. September release: https://www.abc.org/News-Media/News-Releases/entryid/19644/abcs-construction-backlog-indicator-jumps-in-september-contractor-confidence-remains-steady.

U.S. commercial and institutional, industrial, and infrastructure construction industries, which are among those affected by this final rule.



©Associated Builders and Contractors, Construction Backlog Indicator, Construction Confidence Index

Figure 5-18. Construction Backlog Indicator through September 2022

The CBI measures months of backlog in construction activity. The September 2022 value of 9.0 is an increase above the value of 8.7 measured in August 2022. It is also 1.4 points higher than the value from September 2021. Figure 5-18 also provides ABC's Construction Confidence Index, which has three separate readings representing sales, profit margins, and staffing. Any value above 50 indicates expectations for growth over the next six months. So, while values are down from a year ago, the readings all continue to point toward higher levels of construction activity.

6. Summary of Results

6.1 Estimated Time Needed for Controls to be Installed on All Non-EGU Emissions Units

Assuming that all phases of permitting and control installation proceed without delays and not accounting for any supply chain constraints noted in Section 6.3 below, when looked at individually, the estimated non-EGU emissions units could potentially install controls to achieve compliance within 28 months of final rule publication (see Table 4-1).

If there are supply chain disruptions or delays (including vendor or equipment shortages, such that vendor capacity does not increase from its current level in order to meet demands for additional control installations), this 28-month time estimate could increase in some cases. As described in more detail in Section 6.3 and summarized in Table 6-1 below, the total amount of time required including potential supply chain delays is as follows for the source types affected by potential delays:

- ASNCR application extends to 35 - 57 months (MWC),
- LC application to natural gas transmission system RICE extends to 40 – 72 months,
- Boilers extends to as much as 37 months, and
- Cement extends to as much as 58 months.

See Section 6.3 for additional details.

6.2 Estimated Time Needed for Non-EGU Emissions Units to Install Controls

After factoring in all information reviewed for this report, Table 6-1 below provides a summary of the number of months estimated to conduct all phases of control installation. Two timelines are provided in the last two columns of the table.

Table 6-1. Summary of Expected Calendar Time Required for Control Installation for an Individual Source

Industry	Emissions Source Group	Control Technology	Total Estimated Installs	Estimated Install Timeline (months)	SCD Install Timeline (months)
Cement and Concrete Product Manufacturing	Kilns	SNCR	16	17 - 24	35 - 58
Glass and Glass Product Manufacturing[a]	Melting Furnaces	LNB	61	9 – 15	9 – 15
Iron and Steel Mills and Ferroalloy Manufacturing	Reheat Furnaces	LNB	19	9 – 15	9 – 15
Pipeline Transportation of Natural Gas[b]	RICE 2-Cycle	Layered Combustion	394	6 – 12	40 – 72

Industry	Emissions Source Group	Control Technology	Total Estimated Installs	Estimated Install Timeline (months)	SCD Install Timeline (months)
Pipeline Transportation of Natural Gas[b]	RICE 4-Cycle Rich Burn	NSCR	30	6 – 12	6 – 12
Pipeline Transportation of Natural Gas[b]	RICE unspecified	NSCR or Layered Combustion	323	6 – 12	40 – 72
Pipeline Transportation of Natural Gas[b]	RICE 4-Cycle Lean Burn reciprocating	SCR	158	10 – 19	10 – 19
Affected Non-EGU Industries[c]	Boilers	LNB + FGR	151	9 – 15	9 – 15
Affected Non-EGU Industries[c]	Boilers	SCR	15	14 – 25	26 – 37
Municipal Waste Management	MWC Boilers	LN^{tm} + SNCR	4	22 – 28	22 – 28
Municipal Waste Management	MWC Boilers	ASNCR	57	17 – 23	35 - 57

The general approach for assessing time requirements is summarized below:

Step 1 – Estimate base time required for equipment design, vendor selection, fabrication, and installation (“estimated installation timeline”).

- These estimates were taken from comments received, previous EPA reports supporting the rule, and related technical reports (e.g., RACT assessments). Typically, these estimates are based on a range of months provided in a data source or combination of data sources. These timelines are further detailed in Section 4 (summarized in Table 4-1).

Step 2 – Estimate the additional amount of time associated with supply chain delays.

- These are addressed on a case-by-case basis in Section 6.3.

We note that these estimates presume that the current (i.e., 2022) state of supply chain delays, including those associated with current levels of skilled labor and availability of necessary materials and resources, are assumed to continue through 2026, though there is strong evidence of easing of supply chain delays discussed in Section 5.

6.3 Potential Impact of Supply Chain Constraints on Control Installation Timing

For key NOx source and control combinations, supply chain issues could increase the estimated install timeline. Supply chain concerns include: equipment vendor availability (e.g., EPCs that handle overall engineering/design, fabrication, and installation); equipment fabrication backlogs; skilled labor constraints; local installation labor constraints; and limitations on raw materials. The potential for these issues to delay equipment installation may be important considerations to support the need to include flexibility provisions for affected units to comply with the rule.

Descriptions of where supply chain delays are expected, as well as their length, are provided below:

- No expected supply chain delays: for control installations in Table 6-1, where the "SCD timeline" is the same as the "estimated install timeline", the control technology is expected to be readily available or to have a short lead time for design and fabrication (e.g., compact SCR[144] or NSCR applied to RICE; LNB for furnaces in the glass and glass product manufacturing and reheat furnaces in iron and steel). Further, skilled labor for control equipment design and installation is expected to be available to meet the estimated demand for services.
- Supply chain delay potential: additional time will likely be needed due to an identified supply chain limitation. Situations where supply chain delays are expected are summarized below along with an estimate of the length of delay:

    - <u>Cement and concrete product manufacturing, kilns installing SNCR for compliance:</u> estimated units (16) may be competing for SNCR EPCs along with MWCs (61). Although 36 EGU SNCR optimization projects are expected, as stated previously, in-house personnel should be able to accommodate these projects. The pool of identified US SNCR vendors is 9, but the number of these vendors that actually conduct the design (including modeling), engineering, fabrication, and installation may be less than this. Based on discussions with control equipment vendors, 5 SNCR installation projects per year is a representative annual capacity for each vendor.

    - <u>MWC boilers</u>: these 61 sources are estimated to achieve compliance by applying either LN^{tm} + SNCR or ASNCR. The pool of SNCR EPC contractors will likely be limited to those with boiler expertise in the MWC sector. For the four installations of LN^{tm} + SNCR, these all involve a single OEM for the original MWC unit (Covanta using their own proprietary technology). Given the lack of competition for these facilities and no other supply chain delays, it is assumed that Covanta can address these installations within the required installation timeline.

      The 57 expected ASCNR and 16 cement kiln SNCR installations may be competing for the same set of vendors. On-line information suggests that there are 3 to 5 vendors capable of supplying ASNCR technology. The total number of EPC contractors for SNCR is somewhat larger, but, if selected, it is possible that those companies would still subcontract to the more limited pool of experienced ASNCR equipment suppliers and installers to complete a total of 73 SNCR or ASCNR installations.

      Assuming that initial studies and permitting requires up to 12 months, there are two years available before the compliance deadline of May 2026 for final design, engineering, fabrication, and installation. Discussions with vendors suggest that full capacity is on the order of 5 projects at any one time for most suppliers (five per year). Therefore, for purposes of this exercise, we assume 15 to 25 installations could be addressed by the assumed vendor pool per year; or 30 to 50 units within 2 years. If vendor capacity does not expand, this leaves an additional 23 to 43 units that may have

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[144] Note: compact SCR systems are the same in design as the SCRs applied to RICE in the final rule cost analysis.

difficulty installing controls by May 2026 (which could be some combination of cement kiln SNCR or MWC ASNCR installations). With the current vendor pool able to address 15 to 25 units per year, approximately an additional 18 to 34 months (that is, 23 units/15 units/year x 12 months/year to 43 units/15 units/year x 12 months/year) may be needed to address installations at all affected units. This results in a total maximum supply chain delay timeline of 35 to 58 months (17 to 24 months + 18 to 34 months) for cement installations of SNCR and 35 to 57 months (17 to 23 months + 18 to 34 months, again showing the broadest range of values) for ASNCR installation at MWCs.

- Pipeline transportation of natural gas, RICE: Application of layered combustion controls to some RICE may involve emissions units that are over 60 years old. We note that the age of RICE that may install controls in response to this final rule is not available in the emissions inventory. Comments received by EPA indicate that while retrofit kits should be available for these RICE, installations on older units may require skilled labor familiar with these units and the specialized control kits to be applied. A key uncertainty is the number of RICE that will elect to apply these combustion kits versus NSCR or another compliance option (e.g., engine replacement or electrification). EPA's estimates in Table 6-1 above indicate that 394 RICE are estimated to apply layered combustion and 323 RICE are estimated to apply either layered combustion or NSCR. Based on these estimates and on the conservative assumption that all of these engines are approximately 60 years in age, this results in a likely high upper range estimate of 717 units that could require specialized labor to install controls (technicians with the skills to apply layered combustion control kits to older RICE). Industry comments, which we were not able to verify, cited an older report suggesting that a skilled labor pool is available to address at most 75 RICE per year. However, other estimates based on projections of available skilled labor for such RICE as reflected in Figure 5-13 that are more recent than the labor pool provided in the industry report show the potential for a RICE retrofit rate as high as 150 RICE per year. With 905 RICE potentially installing NOx controls according to the final rule non-EGU cost analysis, a retrofit rate of 150 per year would yield an absolute upper bound of 905/150 = 6 year (or 72 month) installation timeframe for this number of potential RICE retrofits. Hence, depending on the number of older RICE that industry decides to control with layered combustion, potentially the full amount of time needed to complete installations of layered combustion on all affected units is 717/150 = 4.8 years (58 months). For the portion of RICE estimated to be addressed by either layered combustion or NSCR, if half of the RICE are addressed by layered combustion or NSCR, this results in a total estimate of 506 units. The total amount of time required to address them by the available skilled labor pool is then 506/150 = 3.4 years (40 months). The estimated supply chain delay timeline if all 905 RICE install controls in response to this final rule is expected to range from 40 to 72 months. These estimates do not account for the potential for replacement of older RICE with new engines instead of retrofitting or further growth in the labor pool and other resources.

- Affected industries, boilers: sources that require installation of SCR for compliance aren't expected to compete for control equipment vendors that serve the EGU sector for equipment fabrication and installation, since EPA expects primarily optimization of SCRs at existing EGUs which do not require a vendor plus a relatively small number of SCR installations by May 2026. Also, EGU SCR EPCs are generally a different group of vendors than those that serve the non-EGU sector. The number of SCR installations estimated isn’t exceptionally large as indicated in Table 6-1; however, information gathered from vendor contacts indicates some potential delays for equipment fabrication and certain imported components. Considering this potential additional 12 months of supply chain delay related to equipment fabrication, the full amount of time needed for SCR installation at an affected industry boiler could extend to 26 to 37 months (as noted in the SCD timeline in Table 6-1).

Appendix A. North American SCR and SNCR Suppliers

This listing of SCR/SNCR vendors serving the North American market was developed from the on-line data sources cited below. Based on information presented on their corporate websites, each SCR supplier was allocated into one of the following market segments as shown in Table A-1:

- EGU and Large Non-EGUs: most of these vendors serve the EGU market; but a small number also serve large non-EGU sources (e.g., MWCs);
- Small EGUs and Non-EGUs: these vendors serve small EGUs, such as natural gas turbine power plants and the non-EGU sector;
- Internal Combustion Engines: these vendors supply compact SCR systems, primarily for implementation on RICE.

Table A-2 provides a listing of SCR catalyst manufacturers or recyclers. Table A-3 provides a listing of SNCR vendors.

Data Sources:

- AWMA Vendor Listings: https://awmabuyersguide.com/;
- Air Pollution Equipment.com: https://www.airpollutioncontrolequipment.com/more-air-pollution-control-equipment-manufacturers-listings/;
- Institute of Clean Air Companies: https://www.icac.com/page/Members;
- General internet search.

Table A-1. SCR Vendors

Company	Apparent Market Segment	Website
1. Babcock Power Inc.	EGU/large Non-EGU	www.babcockpower.com
2. Babcock & Wilcox	EGU/large Non-EGU	https://www.babcock.com/home/products/selective-catalytic-reduction-scr-systems/
3. BHI-FW	EGU/large Non-EGU	http://www.bhifw.com/eng/technologies/scr.html
4. Braden	EGU/large Non-EGU	https://braden.com/environmental-care-solutions/
5. CECO/Peerless	EGU/large Non-EGU	https://www.cecoenviro.com/products/selective-catalytic-reduction-scr-peerless-emissions/
6. CEECO Equipment	EGU/large Non-EGU	https://www.ceecoequipment.com/page/engineered-equipment-solutions
7. General Electric	EGU/large Non-EGU	https://www.ge.com/steam-power/services/aqcs/upgrades/nox
8. Fuel Tech Inc.	EGU/large Non-EGU	https://www.ftek.com/en-US/products/productssubapc/scr-systems-industrial
9. Mitsubishi Power Systems Americas, Inc.	EGU/large Non-EGU	https://power.mhi.com/products/aqcs/lineup/flue-gas-denitration
10. CTP Sinto America	Small EGU/Non-EGU	https://ctp-airpollutioncontrol.com/solutions/systems
11. Branch Environmental	Small EGU/Non-EGU	https://www.branchenv.com/selective-catalytic-reduction-scr/
12. Catalytic Products International	Small EGU/Non-EGU	https://www.cpilink.com/selective-catalytic-reduction
13. CORMETECH	Small EGU/Non-EGU	https://www.cormetech.com/screngineering-design/

Company	Apparent Market Segment	Website
14. Durr Systems	Small EGU/Non-EGU	https://www.durr.com/en/products/environmental-technology/exhaust-gas-and-air-pollution-control
15. GEA	Small EGU/Non-EGU	https://www.gea.com/en/products/emission-control/catalytic-gas-cleaning/index.jsp
16. Hamon	Small EGU/Non-EGU	https://www.hamon.com/power/
17. Jardar Systems	Small EGU/Non-EGU	https://www.jardarsystems.com/pollution-control-systems.html
18. McGill AirCLEAN LLC	Small EGU/Non-EGU	https://www.mcgillairclean.com/proddenox
19. Nationwide Boiler	Small EGU/Non-EGU	https://www.nationwideboiler.com/environmental-solutions.html
20. SVI Industrial	Small EGU/Non-EGU	https://sviindustrial.com/selective-catalytic-reduction-systems/
21. Turner EnviroLogic	Small EGU/Non-EGU	https://www.tenviro.com/Systems/Selective-Catalytic-Reduction-Systems-SCRs
22. Catalytic Combustion	RICE: compact SCR	https://www.catalyticcombustion.com/products/selective-catalytic-reduction/
23. DCL International	RICE: compact SCR	https://dcl-inc.com/products/scr-systems/
24. HUG Engineering	RICE: compact SCR and Small EGU/Non-EGU	https://hug-engineering.com/technologies/low-emissions/technology
25. Johnson-Matthey	RICE: compact SCR	https://matthey.com/products-and-markets/other-markets/stationary-emissions-control/scr-systems
26. Miratech	RICE: compact SCR	https://www.miratechcorp.com/our-products/scr-dpf-solutions/
27. MSHS	RICE: compact SCR and Small EGU/Non-EGU	https://www.mshs.com/emissions-aftermarket-treatments/selective-catalyst-reduction-scr-systems/;
28. NETT Technologies	RICE: compact SCR	https://www.nettinc.com/power-generator-scr-systems

Table A-2. SCR Catalyst Manufacturers or Recyclers

Company	Website
1. CDTi	https://cdti.com/engine-emissions-2022/
2. CORMETECH	https://www.cormetech.com/
3. Mitsubishi Power Systems Americas, Inc.	https://power.mhi.com/products/aqcs/lineup/flue-gas-denitration
4. Umicore	https://fcs.umicore.com/en/stationary-catalysts/
5. Environex	https://environex.com/services/industrial-catalyst/catalyst-replacement/

Table A-3. SNCR Vendors

Company	Website
1. Babcock Power Inc.	www.babcockpower.com
2. Babcock & Wilcox	https://www.babcock.com/home/products/selective-catalytic-reduction-scr-systems/
3. CECO Environmental	https://www.cecoenviro.com/products/selective-non-catalytic-reduction-sncr/
4. CORMETECH	https://www.cormetech.com/sncrengineering-design/
5. CTP Sinto America	https://ctp-airpollutioncontrol.com/solutions/systems
6. Durr Systems	https://www.durr.com/en/products/environmental-technology/exhaust-gas-and-air-pollution-control
7. Fuel Tech, Inc. (mentions also supplying ASNCR)	www.ftek.com; https://www.ftek.com/en-US/products/productssubapc/urea-sncr;
8. ISGEC (mentions also supplying ASNCR)	https://www.isgec.com/apce/ba-apce-DeNox.php
9. Mobotec (mentions also supplying ASNCR)	https://www.environmental-expert.com/products/rotamix-model-sncr-advanced-selective-non-catalytic-reduction-system-438786