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White Paper

Availability of Resources for Clean Air Projects

by

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Abstract

Availability of Resources for Clean Air Projects

The ability of power plants and other emissions sources to comply with clean air regulations within a given time frame is limited in part by the resources available for implementing the necessary modifications to the facility. The resources include labor, materials, and equipment. In this White Paper the assumptions used to assess the ability of power plants to comply with the Clean Air Interstate Rule (CAIR) within the regulatory time frame were examined. Assumptions were tested for their reasonableness against actual data and experience.

This White Paper will demonstrate that the assumed limitations on labor that US EPA and representatives of the utility industry expected would limit the ability of the air pollution control (APC) industry to respond to the CAIR were not realized. It was determined that US EPA underestimated the ability of the APC industry to respond to CAIR in its final 2005 analysis used for the CAIR. Estimates of labor demand in the final CAIR analysis were significantly higher than previous estimates by US EPA. In light of these higher expected demand loadings, the assumptions regarding the availability of labor were demonstrated in this White Paper to be too limiting and, by imposing a "hard cap" on labor availability, did not take into account the dynamic nature of U.S. labor markets, which US EPA had acknowledged in the past. Also, assumptions by US EPA and the representatives of the utility industry regarding the timing of orders relative to the finalization of the CAIR proved to be incorrect. As a result, both US EPA and representatives of the utility industry underestimated the ability of the APC industry to support the utility industry in its response to the CAIR. Other assumptions regarding supply and demand for other resources that were not envisioned to be limiting generally proved to be consistent with experience.

The findings of this White Paper have implications for future clean air initiatives and how the timing of these initiatives should be assessed. To this end, it may be beneficial to reexamine the topic of resource supply and demand, particularly with regard to labor, and develop assumptions that better reflect the demand and supply characteristics of the market for power plant labor.

Availability of Resources for Clean Air Projects

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1.0 Introduction

The Clean Air Interstate Rule (CAIR) created demand for NOx control systems and flue gas desulfurization systems, primarily Selective Catalytic Reduction (SCR) and Limestone Forced Oxidation (LSFO) systems, and other types of technology as well.

The resources necessary for retrofit of SCR and LSFO systems include the following:

- Construction/craft labor, particularly boilermakers
- Engineers to design the systems
- Construction Materials, such as steel plate, alloy steel, fabricated steel components, structural steel, and concrete
- Engineered equipment and specialty materials, such as slurry pumps, fans, motors and catalyst
- Reagents, especially limestone and ammonia

In the time leading up to finalization of CAIR, US EPA and the Utility Air Resources Group (UARG – an advocacy group for some electric utility companies) and the Institute of Clean Air Companies (ICAC – an organization that represents most of the suppliers of air pollution control technology) examined this issue.

This White Paper will review

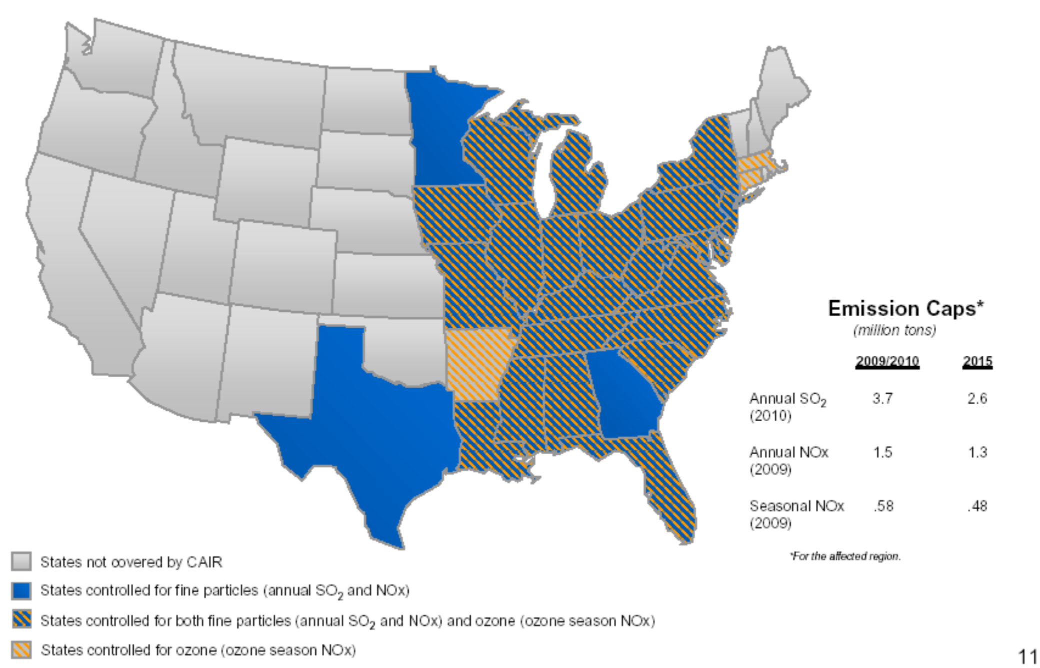
- the analysis by US EPA on feasibility of meeting CAIR
- the analysis by UARG on feasibility of meeting CAIR,
- and the analysis by ICAC on feasibility of meeting CAIR
- how these predictions compared to what actually occurred, and
- why there were some significant differences between predictions and actual performance

The section on the analysis by US EPA will include discussion of the CAIR rule and will be the longest of the three. It will describe the results of analysis of US EPA, UARG and ICAC performed prior to finalizing the CAIR rule. This paper will then examine how the predictions by US EPA, UARG, and ICAC compared with what actually occurred based upon actual new order data – and that the actual capabilities of the companies to respond to CAIR far exceeded the estimates of US EPA and UARG. Then, using the actual new order information on scrubbers and SCRs and the resource modeling information by these groups, the paper shows that resources will be readily available after CAIR Phase I installations for future clean air projects. Finally, this paper briefly discusses other resources needed for clean air projects and how US EPA's assumptions regarding these generally held true.

2.0 US EPA's Analysis

US EPA's CAIR set phased-in budgets on NOx and SO_2 for states in the eastern half of the United States that are expected to be mainly met through reductions in power plant emissions. As shown in Figure 1, CAIR covers 28 eastern states and the District of Columbia. CAIR emission "caps" are phased in, with Phase I complete by January 1, 2010 and Phase II is intended to be complete by January 1, 2015. CAIR allows states to participate in a "cap-and-trade" program that allows compliance either through control of emissions or through the use of pollutant emission allowances that may be banked for future use and/or traded between affected sources. So, in this sense, the "caps" are not real "caps" on emissions. Under CAIR, emissions "caps" can, and are expected to be, exceeded as a result of the use of banked allowances. It is important to note that CAIR was remanded by the courts, and several key aspects of CAIR are expected to be revised as a result of US EPA's Transport Rule.

Figure 1. CAIR Affected States and Emission "Caps" [1]



Before US EPA finalizes a rule, they analyze the impact on the economy and – in the case of rules that affect the utility industry – the impact on the utility industry. These impacts include the impact on the cost to produce electricity, whether there will be any significant disruptions in the electricity or fuel markets, and other effects. For CAIR, US EPA assessed whether the electric utility industry was capable of complying with CAIR in the time allowed.

Figures 2a and 2b are taken from the US Environmental Protection Agency's (US EPA) on-line information regarding the CAIR and reflect the results of analysis completed in 2005. [2] The blue lines show the "caps" and the red lines show the predicted actual emissions. As shown, according to this US EPA analysis, actual emissions under CAIR were expected to exceed the "caps" for several years (beyond 2020) due to the use of "banked" emissions allowances. The figures are annotated to show the schedule for emission reductions under CAIR. As shown, in the five-year period between 2005 and 2010 US EPA anticipated that national SO_2 emissions would be reduced by roughly 4 million tons. By comparison, in the five-year period between 2010 and 2015 US EPA anticipated that CAIR would cause SO_2 emissions to be reduced by only about another 1 million tons. This is one indication that the retrofit activities between 2010 and 2015 were expected by US EPA be much less intense than in the period prior to 2010.

2.1 US EPA's Projections of Retrofit Activity

According to Reference 2 (US EPA's October 2005 analysis of CAIR), in response to CAIR US EPA's expected retrofits of roughly 90,000 MW of new FGD systems and 37,000 MW of new SCR systems by 2020. An additional 22,700 MW of SCR and FGD was expected for new power plants. US EPA expected 36,000 MW of FGD and 15,000 MW of SCR to be completed by 2010 for Phase I. According to US EPA, this Phase I effort was expected to be performed over a period, due to the timing of the rulemaking, to be 3.25 years for the FGD systems and 2.25 years for the SCRs [3] – resulting in an intense retrofit period prior to 2010. So, when EPA issued CAIR EPA anticipated an average of over 11,000 MW of FGD retrofit activity per year (36,000/3.25) prior to 2010. On the other hand, after 2010 there are a full five years available for Phase II retrofit activity before the 2015 Phase II date, resulting in an average 7,260 MW of FGD retrofit activity per year– *a 34% drop in activity for FGD after 2010*. According to US EPA's analysis in 2005, EPA expected that the retrofits in the second phase (after 2010) would be smaller units, resulting in more actual retrofit projects in the period after 2010 than before (186 versus 153).[3] However, *due to the compressed schedule prior to 2010, this still*

Figure 2a. US EPA's Projections of SO_2 emissions.[2]

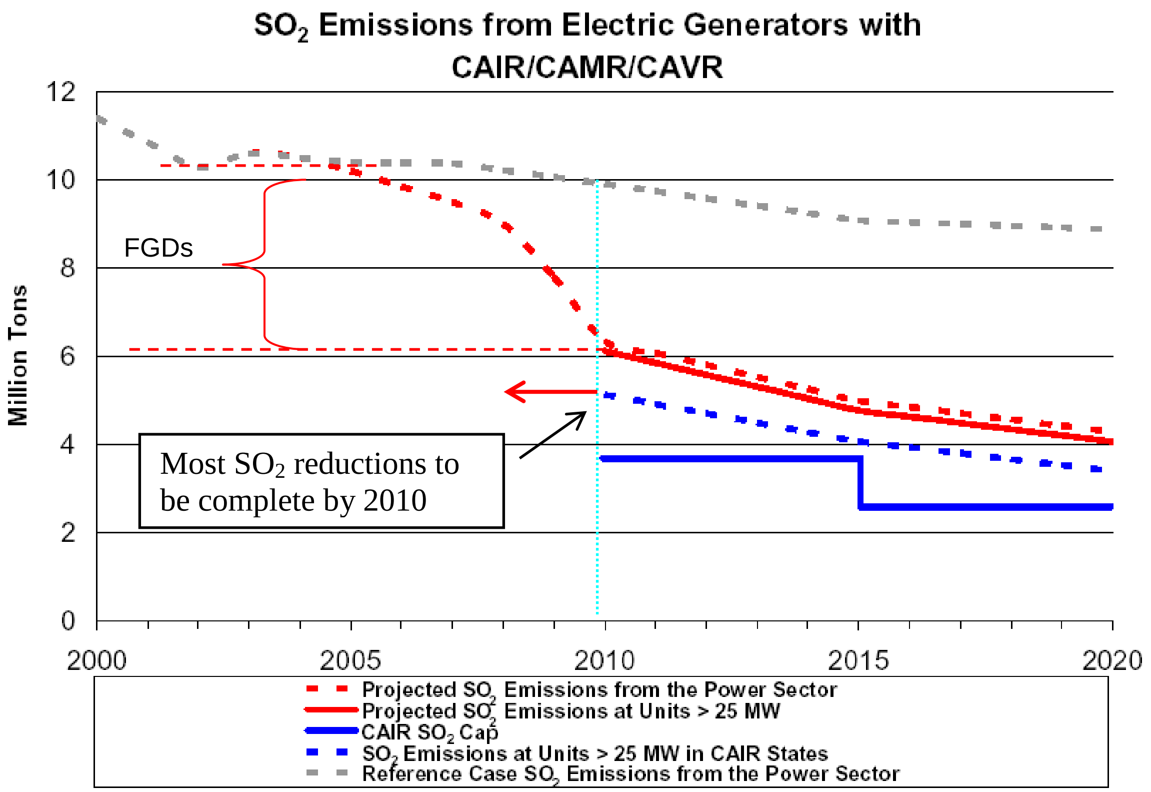
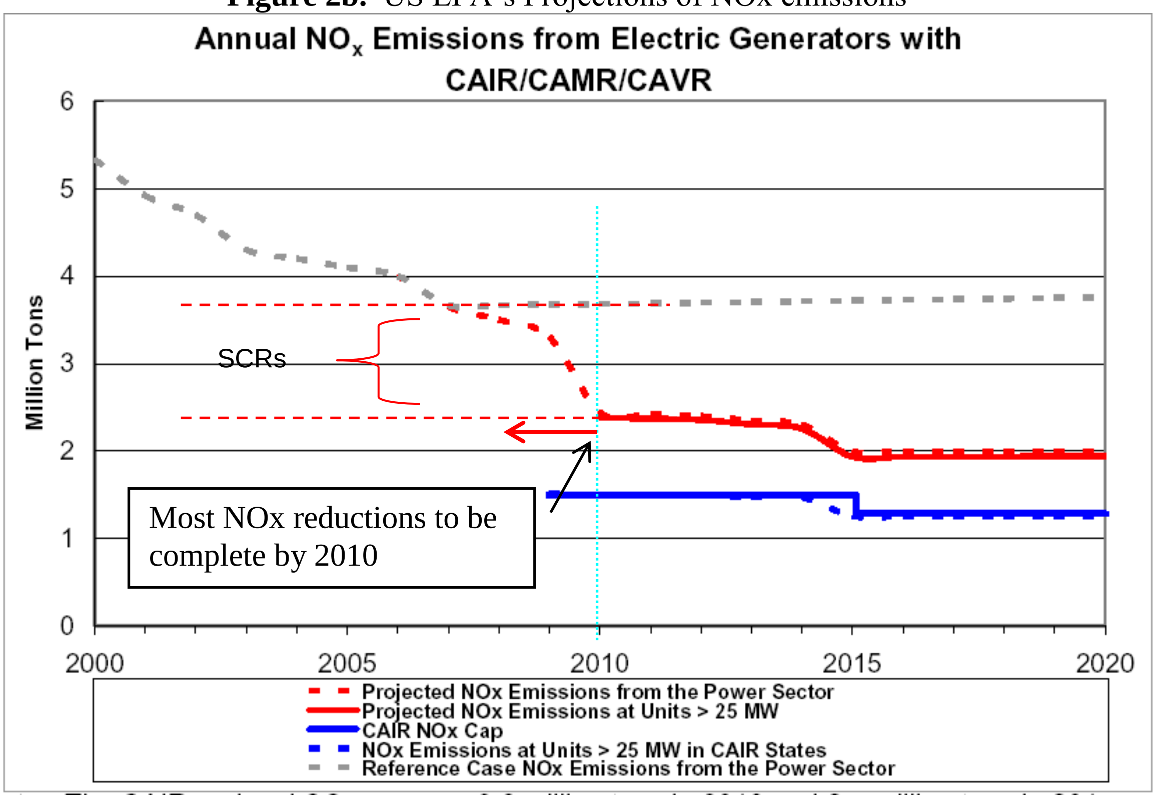


Figure 2b. US EPA's Projections of NOx emissions [2]



results in significantly fewer projects anticipated per year after 2010 (21% fewer projects per year). Therefore, US EPA anticipated that the level of retrofit activity expected would peak in the period prior to 2010 and drop off to a lower level after this peak.

It is important to note that *previous estimates by US EPA (estimates made prior to 2005) actually projected more retrofits (49 GW of FGD versus 36 GW and 24 GW of SCR versus 15 GW) prior to 2010 and fewer retrofits after 2010. Therefore, <u>US EPA originally anticipated much more activity prior to 2010 with a much steeper drop in activity at the end of Phase I</u>.* The difference is the result of changes in modeling assumptions. According to Reference 4, modeling of various multipollutant bills under consideration by Congress was performed in 2005, including modeling of the CAIR/CAMR/CAVR with an additional constraint (one not used in prior analysis) of a hard limit on labor supply (what we will refer to as a "hard cap") that was lower than some earlier US EPA estimates and using labor demand estimates based upon UARG comments that indicated higher labor demand than earlier US EPA estimates. This additional constraint to US EPA's analysis had the effect of artificially limiting the number of retrofits that could be performed prior to 2010 and explains the shift in results between the 2004 modeling and the 2005 modeling. The following section describes the background of this analysis in somewhat more detail.

2.2 Background on US EPA's Assessment of the Supply of Pollution Control Technologies

In 2002 US EPA examined the engineering and economic factors associated with a multipollutant emissions rule.[5] In this study US EPA concluded that the availability of construction materials, engineered equipment and reagents was more than adequate to meet the needs of the utility industry should there be a significant amount of retrofit activity for a multipollutant rule. At the time, US EPA was evaluating President Bush's proposed Clear Skies Act, which would have imposed SO_2 and NOx emissions requirements on utility boilers in a manner similar to the CAIR. The study determined that supply of engineered equipment, construction materials (steel, concrete, etc.) and reagents was more than adequate. According to the analysis, the sole area that had any risk of a tightening of resource supply, and thereby limiting retrofit activity, was the area of specialized construction labor, particularly boilermakers. Unlike most other construction trades, the boilermaker trade is fairly specialized to the power industry and a few other industries (petrochemical, shipbuilding). Therefore, it is typically the trade that is most limiting. However, the 2002 analysis showed that there were more than adequate resources, including boilermakers, to meet the expected demand posed by the Clear Skies Act.

In 2004, and in support of CAIR (then called the IAQR), US EPA again examined the availability of boilermaker labor in light of the most recent projections of retrofits. [6] According to this memo the demand for boilermakers in advance of the Phase I CAIR compliance dates would be most heavily concentrated in the 18-month period from March 2008 to October 2009 as equipment was installed prior to the Phase I CAIR SO_2 Compliance date of January 1, 2010. US EPA's analysis showed that there was adequate boilermaker labor to support the peak in boilermaker demand projected by US EPA. Nevertheless, later in this document this issue of when the peak in labor demand would be from CAIR retrofits is revisited.

In March 2005, and in response to comments on the proposed CAIR, US EPA issued a revised analysis using a more thorough analysis of the supply of boilermakers by US EPA and more conservative assumptions of labor demand that were based on information provided by the Utility Air Resources Group (UARG, an advocacy group for the electric power industry). [7, 8] Previous estimates by US EPA were based upon boilermaker demand requirements provided by companies that build FGD and SCR systems that were described in Reference 5. This new analysis by US EPA using UARG's more conservative (higher) boilermaker demand estimates included sensitivity testing in ten different scenarios to examine the effect of different assumptions. Two of the ten cases assumed a far more rapid retrofit effort than projected by US EPA or even required to comply with the rules as written. Of the ten cases tested, in eight of them US EPA estimated that there would be adequate boilermaker labor to meet the 2010 CAIR requirement. The only cases that showed a shortfall in labor were the two cases that assumed scenarios that entailed a far more rapid retrofit effort than projected by US EPA or even required to comply with the rules as written. Hence, under any expected scenario, US EPA's analysis showed that there would be an adequate supply of boilermaker labor. In fact, using the original boilermaker demand estimates described in Reference 5, all ten of the scenarios would have shown ample supply of boilermakers for the Phase I demand. The original boilermaker demand estimates used by US EPA were developed through discussions with companies that have constructed dozens of scrubbers and SCRs in the US while the UARG estimates for scrubber labor are based upon six data points provided by owners. However, recognizing that there is some uncertainty in all of these estimates, it is reasonable to test other estimates, such as those provided by UARG.

In October 2005 US EPA issued a further revised analysis of the scrubbers and SCRs that would be installed for CAIR, but now assuming labor demand similar to UARG's and with a hard cap on the labor available such that the labor would become the limiting factor in the number of retrofits that could be performed.[4] This analysis, with far more conservative assumptions about labor demand and availability than previous US EPA estimates is the analysis that eventually was referenced in the final CAIR rule. This assumption of a hard cap for labor was a significant departure in approach from previous analyses because it did not consider the dynamic nature of the labor market and the use of alternatives to on-site craft labor, which had been discussed in Reference 7 by US EPA.

The Dynamic Nature of the Market for Labor

The assumption of a hard cap on labor is a simplifying assumption that can be misleading because the market for labor is dynamic. It is important to keep in mind that, frequently, during periods of high demand, certain statistics may suggest that the demand for craft labor will exceed the "nominal" availability of labor. That is because these statistics compare local union enrollment versus demand and make specific assumptions about hours available which do not capture the dynamic nature of the real labor market. This "apparent" shortfall in supply is made up for in several ways, most of which are discussed further in Reference 7 by US EPA:

- Overtime – Because demand for boilermaker labor is not steady, boilermakers will work overtime during periods of high demand.
- Non-Union labor – Most boilermakers are members of the International Brotherhood of Boilermakers (IBB). But, some are not. Local craft labor supply is normally developed from IBB union enrollment statistics, which do not reflect the additional supply of non-union craft labor that may be used in some locations. The ability of an owner to use non-union labor on site will vary. But, even if one owner cannot use a "merit shop" constructor on site, the fact that another company can will help free up union labor.
- Non-Local labor – Because of the seasonal nature of boilermaker work, boilermakers will often travel to a different location for work. In fact, according to the IBB, in 2003 there were over 1300 Canadian union boilermakers working on NOx SIP Call projects in the United States.
- Other boilermaker sources – Boilermakers work in other fields than power, such as refining/petrochemical, shipbuilding, metals industries and other construction trades. US EPA's analysis assumed that no more than 35% of the assumed number of boilermakers were available for power plant environmental retrofit projects. However, in periods of

high demand the International Brotherhood of Boilermakers is capable of shifting some of its members in its 420 lodges to where the need is and, if need be, training them for power plant applications.

- New Boilermakers – Between 1999 and 2001, boilermakers increased by 35% mostly by new members (not retired members coming back). This was in response to new demand from SCRs being installed for the NOx SIP Call.[7]
- Alternative fabrication – The fabrication of the equipment can be modified so that some activities that would otherwise have to be done on site by union boilermakers can be done at fabrication shops by non-union workers, often at significant savings and with a reduction in demand for union boilermakers. This is an alternative to using union craft labor that is often chosen at facilities that can receive large fabricated components and can reduce overall cost by reducing on site construction efforts.

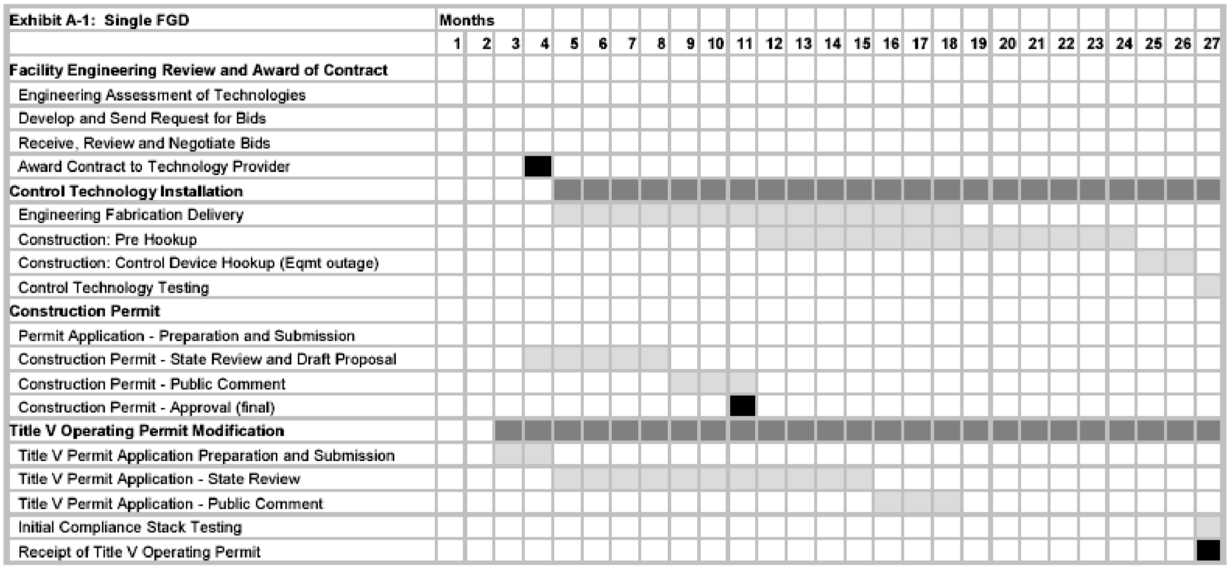
As a result, although some statistics may suggest that there isn't enough labor to perform projects, the projects nevertheless are completed in time because these statistics alone don't capture the dynamic nature of the labor market. In fact, this will be demonstrated later in this document with a "look back" analysis of CAIR Phase I and the NOx SIP Call.

2.3 US EPA's estimate of the time necessary to install the equipment to meet the requirement

Installing FGD and SCR systems are the most time-consuming projects required for CAIR Compliance. Of the specific projects, the most time consuming of these would be installation of multi-unit FGD or SCR systems. The multi-unit FGD installations involve multiple units ducted to a single absorber. SCR installations typically require SCR on each boiler.

In Reference 5, US EPA examined the time necessary for various types of FGD and SCR installations. As shown in Figure 3, US EPA anticipates a single FGD system to require 27 months. For a more complex project, such as multiple absorbers on multiple units at one site US EPA anticipated that it could require 36 months from initial assessment of technologies to completion of commissioning.

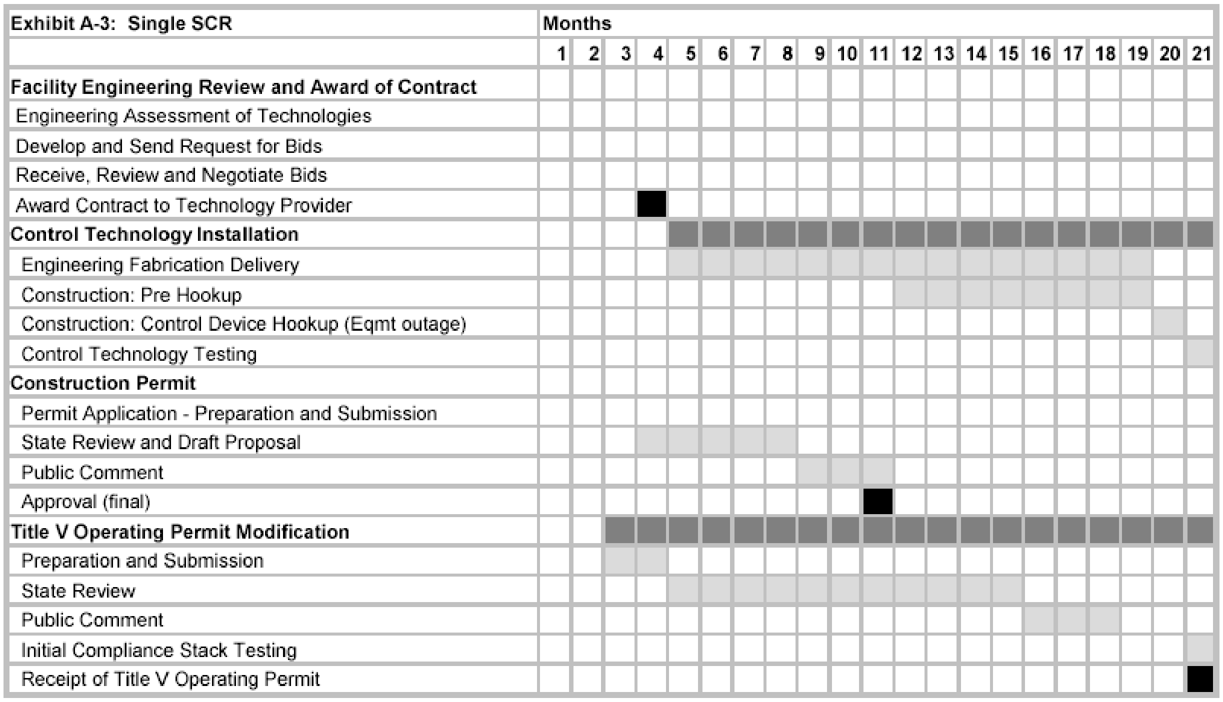
Figure 3. Schedule for Retrofit of a Single FGD at a Single Plant [5]



In Reference 5, US EPA also examined the time necessary for retrofit of SCR systems. Figure 4 shows the schedule for retrofit of SCR at a single boiler. This retrofit is projected to require about 21 months. Now, if there were multiple SCRs at one plant, the retrofit project for the plant would take longer. In Reference 5 US EPA estimates that if 7 SCRs are installed on one site, it could take 35 months.

It is fair to say that opinions vary on how long it takes to build an FGD system or SCR system. Certainly, the time will vary depending upon the particular facility.

Figure 4. Schedule for Retrofit of SCR a Single Boiler [5]



3.0 UARG's Assessment of the Time Needed to Respond to CAIR

Reference 8 is a study by UARG of the feasibility of complying with the CAIR rule. UARG wished to address comments made by the Institute of Clean Air Companies (see later in this document) that represents most of the suppliers of air pollution control technology. ICAC also provided input to US EPA on their 2004 CAIR analysis. Table 1 shows projected retrofit needs (in MW of equipment) to meet Phase I requirements of the proposed rule. Keep in mind that US EPA has made other estimates since then and perhaps UARG has made other estimates as well. Table 2 is taken from Reference 8 and shows estimated distribution of labor over a project life from initiation. The table provides two pieces of information. First, it shows the estimated time for an SCR or FGD project from the time a supplier receives an order. There is some engineering performed prior to the supplier receiving an order. So, the total project time for the utility potentially longer – anywhere from a few months to perhaps a year. Second, the table shows how the boilermaker demand would be distributed over the time of the project. One of UARG's criticisms was that it did not believe that US EPA or ICAC adequately addressed unevenness in the demand for craft labor on a project, and the possibility that this demand would peak to levels where the supply might not meet demand.

Table 1. Summary of FGD, SCR Retrofit Capacity Required To Meet Phase 1 (2010) of CAIR: Various Studies (from Ref.8)

Control Option	UARG	EPA January 2004	EPA May 2004
FGD	43	49	55
SCR	46	24	32
Total	89	73	87

Table 2. Fractional Demand for Boilermakers Time, as Percent *(Per Quarter Following Project Start)* from Ref. 8

Technology	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
FGD	0	0	0	0	10	27	34	23	6
SCR	0	0	0	20	25	40	15	n/a	n/a

Note that the length of time for an FGD project is shown as nine quarters, or 27 months and for an SCR it is seven quarters or 21 months. UARG actually stated in Ref. 8 that the 27 month and 21 month schedules for FGD and SCR, respectively, were too short by 5 months for FGD and 3 months for SCR. However, UARG used it in the analysis presented in comments to US EPA described in the next paragraph. Of course, there might also be some additional engineering preceding the order. But, using the schedule from Table 2, this suggests that for a utility to have a scrubber installed by January 1, 2010 the facility owner would have to place the order by the end of the third quarter 2007. Even if the preceding engineering effort were a year long, that means that the effort would require about 39 months, or roughly 3 ¼ years. Of course, not all projects are the same and some might be shorter and some longer.

UARG used the preceding information to estimate how long it would take to install the expected number of scrubbers and SCRs for Phase I CAIR compliance. In their analysis UARG set a firm limit (a "hard cap") to the availability of boilermaker craft labor and used estimated demands for boilermakers that were higher than what the US EPA originally used and higher than that offered in Reference 5. In UARG's analysis, if the demand for labor exceeded the firm limit they input on supply, then the work would be delayed to the next quarter. Hence "shortages" in labor would contribute to project delays. UARG examined "optimistic" and "probable" scenarios with the following results:

- The "optimistic" (optimistic being UARG's characterization) case assumed that utility orders started on January 1, 2006, after the date when UARG assumed State Implementation Plans would be finalized, which resulted in a completion date for all projects at the end of 2010.
- The "probable" (probable being UARG's characterization) case assumed that utility orders occurred on July 1, 2006, six months after assumed finalization of State Implementation Plans, which resulted in a completion date for all projects in the first quarter of 2011.

Another way to look at UARG's analysis is that, with the limitations they imposed on boilermaker labor and for the timing of when orders were placed, for all of these retrofits to be complete by January 1, 2010, the first orders had to start no later than January 1, 2005.

As will be shown, UARG's predictions significantly underestimated the actual ability of the APC industry to respond.

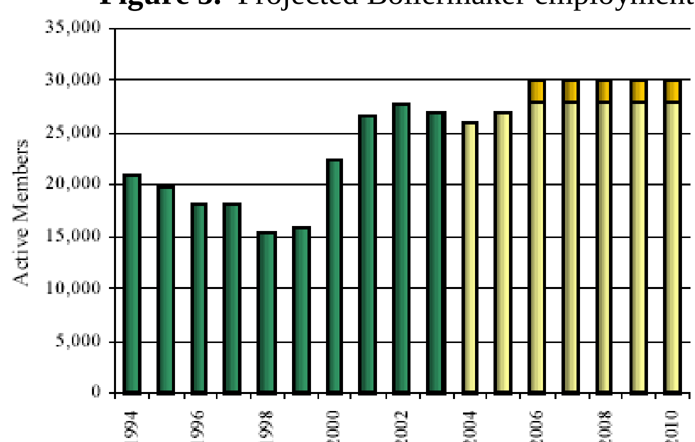
4.0 ICAC's Assessment of the Time Needed to Respond to CAIR

Reference 9 is a study by ICAC that examined the availability of boilermaker labor to complete the anticipated retrofit requirements of the proposed Interstate Air Quality Rule – IAQR, which later became known as CAIR. At that time the IAQR was a two-phase program similar to the final CAIR rule. US EPA had anticipated at the time* that:

- 49 GW of FGD and 24 GW of SCR would be needed by 2010 for the proposed IAQR
- 63 GW of FGD and 46 GW of SCR (inclusive of the installations for 2010) by 2015

According to ICAC, the National Association of Construction Boilermaker Employers (NACBE) – an association of the companies that employ boilermakers† – anticipated the number of boilermakers to grow to nearly 30,000 during the construction period for the CAIR, as

Figure 5. Projected Boilermaker employment [9]



* US EPA periodically updated their estimates
† Many of ICAC's member companies are also member companies of NACBE

shown in Figure 5. This increase was a direct result of the increased demand for boilermakers that would result from CAIR. ICAC also discussed the various ways boilermakers are used in the clean air projects and methods of construction that can reduce the demand for boilermakers.

ICAC performed an analysis of the IAQR (later called CAIR) and determined that:

- There was adequate capacity in the industry to execute all 63 GW of FGD and 46 GW of SCR US EPA estimated at the time would be needed by 2015
- Capacity, in fact, was sufficient to install all 63 GW of FGD and 46 GW of SCR by 2010.

In other words, according to ICAC, all of the CAIR-related retrofit activity anticipated by US EPA for 2015 could actually be completed by 2010. Of course, there would likely be additional work after 2010 to address new units and controls necessary to address emissions increases due to generation growth. But, this would be at a lower level of intensity. *So, when comparing ICAC's projections to those of US EPA's 2005 projections or UARG's projections, ICAC anticipated that there was adequate capacity to handle a much larger surge in construction activity prior to 2010 than either US EPA or UARG anticipated. Because the number of existing plants to be retrofit is finite, this surge prior to 2010 naturally implies that activity would drop off rapidly after 2010.*

In the next section the actual experience in responding to CAIR is examined.

5.0 Comparison of Actual Retrofit activity to the US EPA, UARG and ICAC Projections

On the subject of feasibility this White Paper has, so far, discussed what was being projected prior to the finalization of the CAIR rule. This was to provide background on the factors believed to impact the industry's ability to comply with the CAIR rule and also to show that different parties examined this subject of feasibility extensively from their perspectives. However, with the benefit of having real information to compare to the predictions, it is useful to examine how the predictions compare to the actual results.

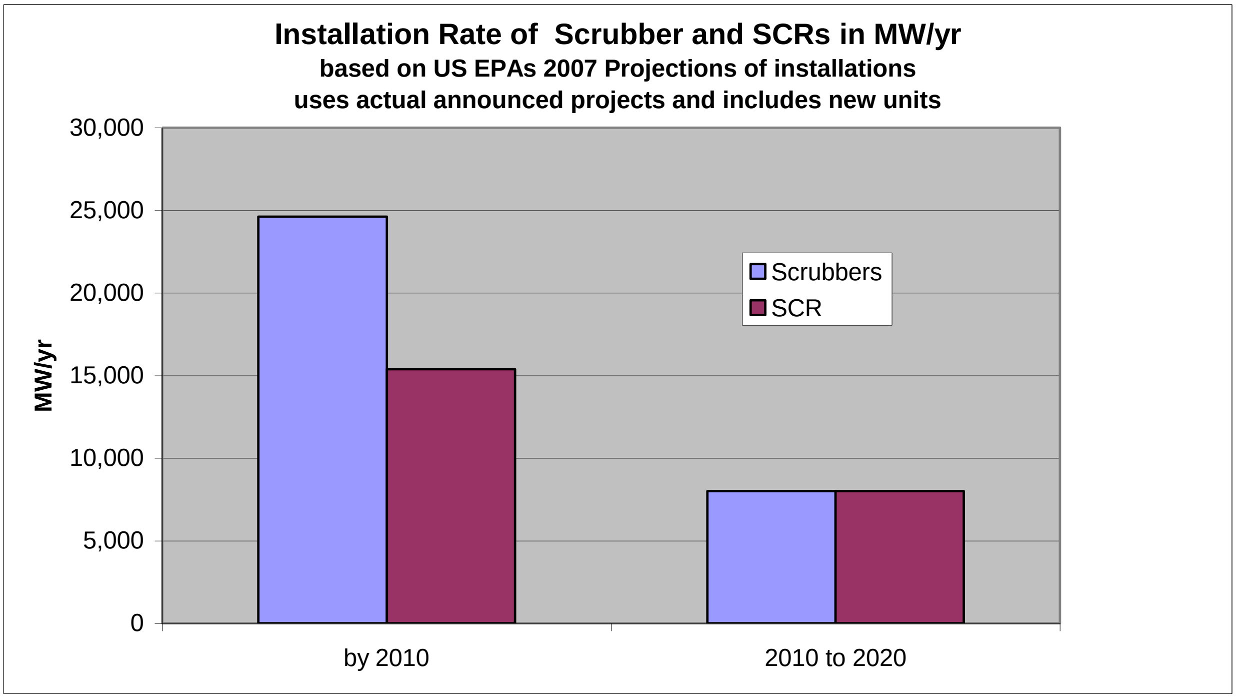
The intensive construction anticipated by US EPA, UARG, and ICAC, in fact, progressed as expected. There was a very high level of activity in the years leading up to the 2010 CAIR deadline for SO_2. This is also consistent with the expected peak in activity in that time. Although lead times on equipment and material and prices on these items had increased due to the increased demand and other factors, the projects were executed, and a few are still being completed. However, there was actually far more activity than any of the parties expected. In fact, in 2007 US EPA modified its estimate for the retrofits anticipated to be installed by 2010 – and this estimate was significantly higher than previous estimates. This estimate factored in projects that had been announced and committed to. In early 2007 US EPA revised its estimates that at least 55,000 MW of new FGD capacity was committed by 2009 and estimated about 80,000 MW of new FGD by 2010. This compares to US EPA's late 2005 estimate of about 36,000 MW by 2010 and 72000 MW by 2015. *In other words, with real project information, US EPA anticipated more FGD to be installed by 2010 than they previously expected to be installed by 2015*.

The greater amount of retrofit activity prior to 2010 means that the rate of installation should drop off even more dramatically after the Phase I CAIR deadline than US EPA had anticipated when the CAIR rule was finalized. With a finite number of boilers to retrofit, more activity before 2010 means less activity after 2010. Figure 6 shows estimated average installation rates using US EPA's 2007 projections divided by US EPA's assumed execution period of 3.25 years for pre-2010 retrofits of both SCR and FGD,[‡] respectively, and 10 years for the 2010 to 2020 period. As shown, both SCR and FGD installation activity are projected to drop off to about a third of their pre-2010 level in the period from 2010-2020. Keep in mind that a large proportion of the post-2010 retrofit activity is associated with new units that are likely to occur later in the period, or may not occur at all due to project cancellations.

Recalling UARG's projections, they projected that about 43,000 MW of FGD and 46,000 MW of SCR's would be needed but could not be installed before 2010. They expected that these could not be installed before the end of 2010 at the earliest. So, in reality FGD is being installed at a much faster rate than UARG anticipated or US EPA anticipated in 2005. And, SCR's were also installed at a faster rate than either US EPA or UARG anticipated could be installed in that time.

[‡] The pre-2010 execution period is based on an assumed start of activity at the end of 2006 and the final Phase I CAIR deadline of January 1, 2010 for SO_2.

Figure 6. Estimate of FGD and SCR installation rate in MW of capacity per year from US EPA 2007 projection– developed from data in Reference 10



Clearly, ICAC's estimate was the closest because they anticipated that all of the scrubbers and SCRs US EPA anticipated as necessary by 2015 could be performed by 2010, resulting in a much higher level of activity prior to 2010 and a lower level of activity after 2010.

Keep in mind that, except for the CAIR emission level requirements, there were three assumptions that were common to both the UARG analysis and the late 2005 US EPA analysis that predicted only 36,000 MW of scrubbers by 2010. These assumptions relate to

- The timing of orders
- The time it takes to fill an order (UARG used US EPA's estimate in their analysis although they state that they believe somewhat more time is needed)
- Assumptions regarding the demand for and availability of resources, especially craft labor[§]

Each of these is examined in the following sections.

[§] UARG did assume a less even demand for labor than did US EPA. However, with regard to total labor demand, US EPA's 2005 estimates were developed from those of UARG. And, both assumed a hard cap on labor supply.

5.1 Timing of orders.

Figures 7 and 8 show the historical and projected new orders for Flue Gas Desulfurization (both wet and dry) and SCR from the Institute of Clean Air Companies'(ICAC) 2006 Annual Market Outlook. ICAC is the trade association for suppliers of air pollution control technology companies that includes nearly every supplier of air pollution control to the electric utility industry. *This data is provided with the permission of ICAC.*

New orders show when the contract was signed. The project would be completed and the equipment brought on line at a later point. Clearly, 2005 and 2006 are the peak years for new FGD orders. In other words, new FGD orders peaked in 2005 and 2006 and have been dropping off since. Both UARG and US EPA assumed that no orders would be placed until after the State Implementation Plans required under CAIR were finalized, or at the end of 2006 at the earliest. Clearly, a large number of utility customers did not wait until that time. Figure 9 shows the data of Figure 7 another way – cumulative orders by the end of the year. *By the end of 2005 nearly 60,000 MW of FGD was ordered, which is when UARG and US EPA assumed the first orders would actually be placed. And, by the end of 2006, 86,000 MW - nearly all of the FGD US EPA's 2005 projections anticipated would be needed by 2020 - were ordered.* As shown, the cumulative orders in Figure 9 start to level off near 2009 because the new orders are slowing down per Figure 7. It stands to reason that if the orders were placed at an earlier date than UARG and US EPA projected, they will also be completed by an earlier date than UARG and US EPA projected.

The drop off of expected new orders has clear implications for later buyers. First, the "seller's market" that was experienced at the height of new order activity has become a "buyer's market" as the available new customers dropped off and the companies with built-up engineering capacity compete for the reduced amount of future business. Second, as will be shown in the next few pages, craft labor has become increasingly available in the years after the peak in demand for Phase I retrofits, making it easier to hire labor for scrubber and SCR projects.

Figure 7.

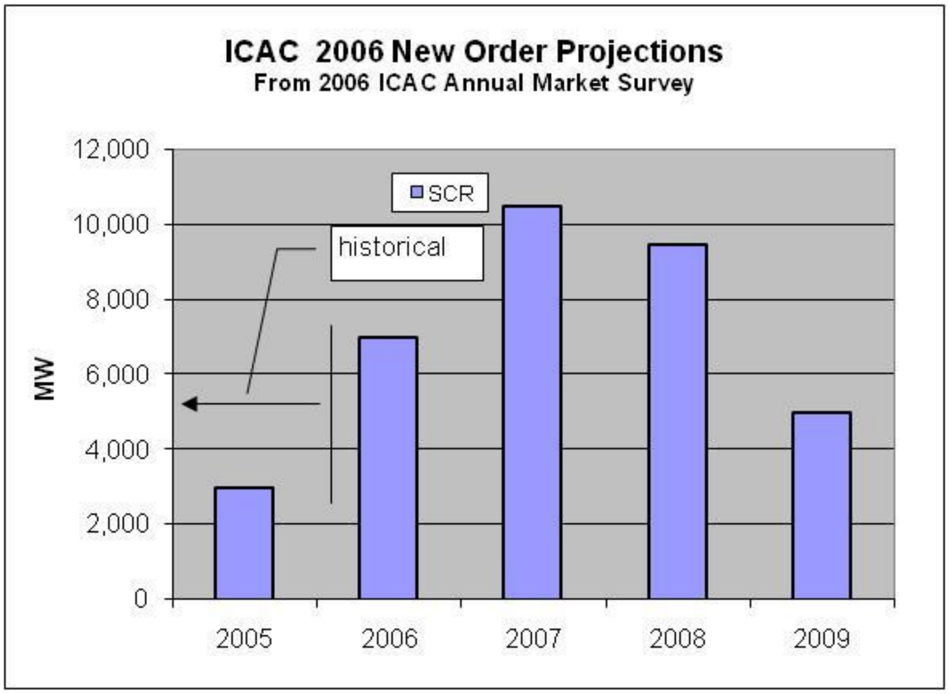


Figure 8.

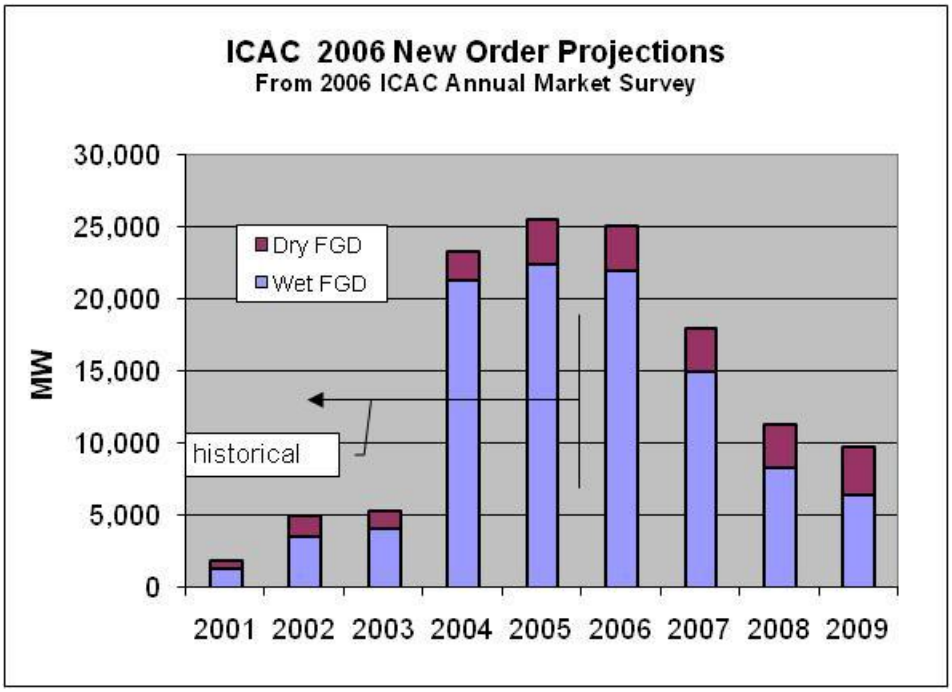
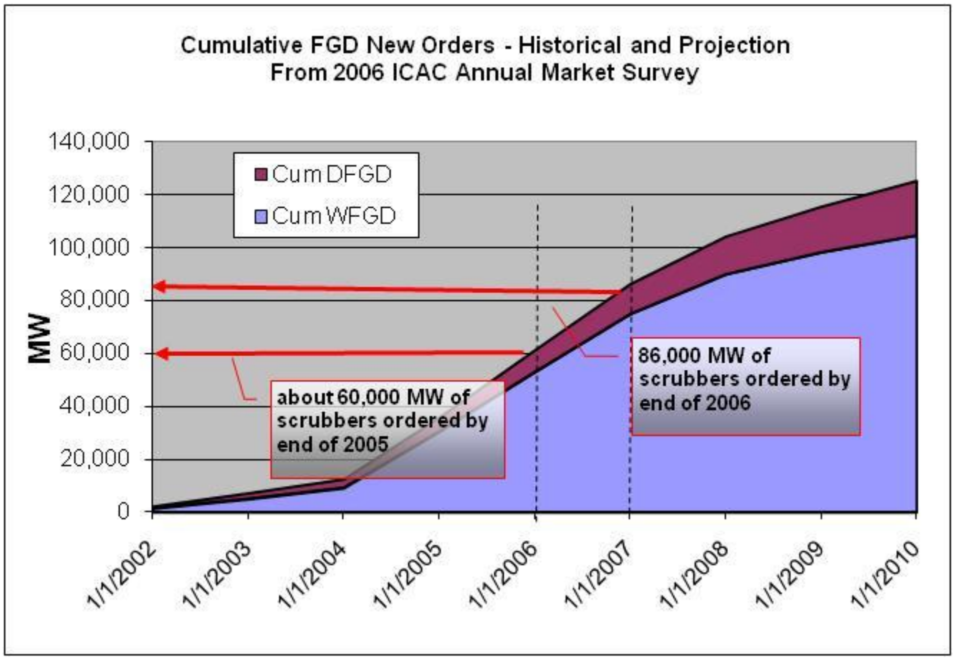


Figure 9.



5.2 The time it takes to fulfill an order

Even in early 2007, companies had been accepting new orders while planning to have these control systems operating prior to 2010. Table 3 shows several announcements of scrubbers, some as late as spring 2007, when most of the analysis for this paper was performed. As shown, these projects were apparently being committed to be performed in the roughly 2-3 year time period that is shown in Table 2. So, these companies and their utility customers expected that they would execute these projects in this time. Of course, since then CAIR was vacated and later remanded, and this may have had an effect on some of these projects.

Table 3. Some Wet FGD Order Announcements, Including Start Up Dates

Supplier	Plant	Announcement	Start Up	Reference
Babcock Power	Cholla 4 Cholla 3	October 2006	Mid 2008 Mid 2009	[11]
	Ghent 1, 3, 4 Brown 1, 2, 3	Dec 2005	2007-2009	[12]
Babcock & Wilcox	Hatfield's Ferry	July 2006	2009	[13]
Washington Group	Fort Martin	December 22, 2006	2009	[14,15]
Alstom	Spurlok 1	November 21, 2006	2009	[16]
Wheelabrator	Keystone	November 13, 2006	2009	[17]
Black&Veatch Chiyoda	Crist	April 4, 2007	2009	[18]

5.3 Availability of Resources

The resources necessary to build scrubbers and SCRs include:

- Craft labor, especially boilermakers
- Engineering labor to design the equipment
- Construction materials, especially steel, concrete, etc.
- Engineered equipment, such as pumps, valves, motors, catalyst, etc.

Craft Labor has been a major concern and will be examined in detail.

Craft Labor

Craft laborers are the skilled workers that are directly involved in building the equipment. As noted in previous parts of this report, UARG and US EPA tend to view boilermaker availability as the most critical craft labor availability issue. This is because of the specialized nature of this trade for power plant applications. Other crafts can often be drawn from the broader construction industry. So, supply of these other craft labor trades is normally less of a concern than supply of boilermakers. And, this is why US EPA and UARG put so much effort into analyzing boilermaker availability prior to finalizing the CAIR rule by US EPA and others.

With information regarding the actual orders and installations, it is possible to make estimates of the boilermaker demand from CAIR retrofits. Taking the information regarding actual and projected SCR and FGD projects and the boilermaker demand estimates of UARG and US EPA, estimates of boilermaker demand were developed. This used boilermaker time loading as shown in Table 4 and the boilermaker demand estimating factors shown in Table 4.

Table 4. Boilermaker demand estimating factors, in Boilermaker years/MW

	SCR	FGD
US EPA 2005 demand loading*	0.344	0.270
US EPA 2004 demand loading	0.175	0.152

* US EPA developed loading numbers in 2005 based on UARG information. So, these are from Reference 7 (by US EPA). But, Reference 8 (UARG's comments) provided the source for Reference 7.

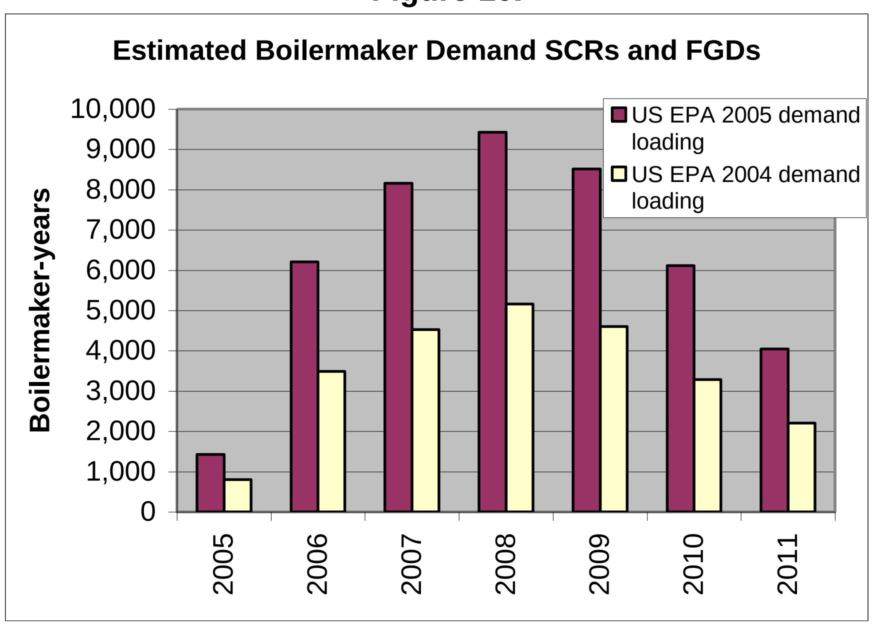
Since the order data available is annual order data, it is necessary to make projections of labor demand by year. Therefore, the information from Table 2, which breaks the demand down by quarter, was used to develop estimates of boilermaker demand by year as shown in Table 5. Note that by spreading the labor in this way, it effectively assumes that all orders for a given year are placed on December 31 of that year. This will postpone the demand (and the estimated peak) as well as the completion date from what would happen if the actual start date were used.

Table 5. Assumed distribution of boilermaker demand		
Project Year	SCR	FGD
Year of order	0%	0%
First year after order	20%	0%
Second year after order	80%	94%
Third year after order	0%	6%
Total	100%	100%

Figure 10 shows the estimates of demand loading for boilermakers for US clean air retrofits as well as pollution control on new units using ICAC's reported orders and the assumptions outlined in Tables 3 and 4. The units are boilermaker-years and are equivalent to a boilermaker working 1685 hours per year. As shown, the demand for boilermakers peaks in the period from 2007 to 2009 and falls off quickly after that. The drop off that starts in 2009 and continues to 2010 would not be affected by the lack of new order data for 2010. And, the further drop in 2011 is only minimally affected by the fact that there is no 2010 new order estimate because there would not be much boilermaker demand in that first year after the order. So, through 2011 on this figure should be a pretty good indicator of what one should expect for boilermaker demand trends for SCR and FGDs.

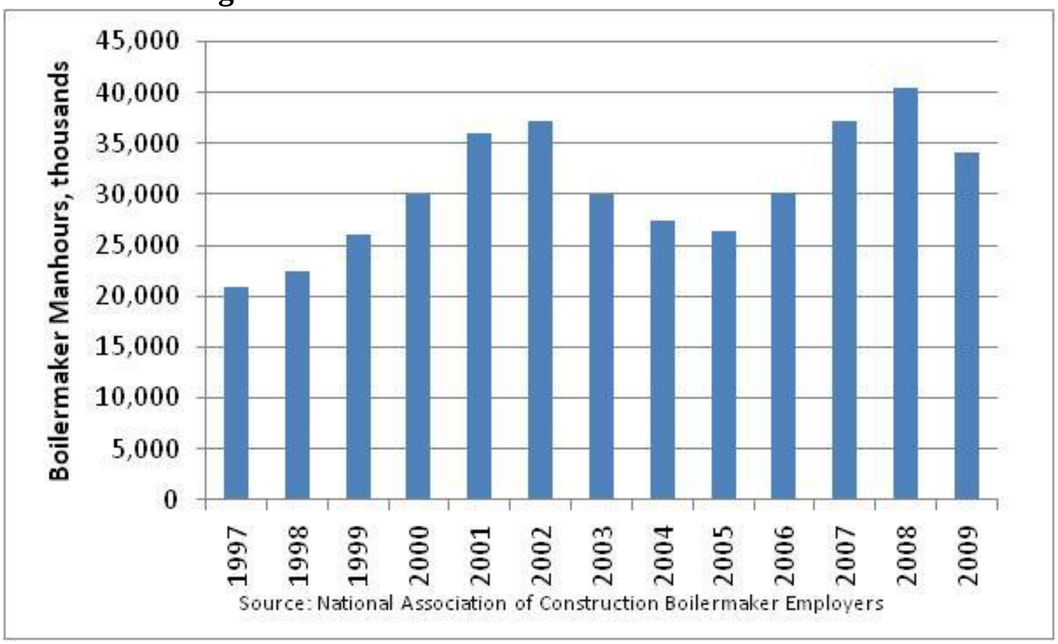
In its 2004 estimate (prior to adopting UARG's assumptions for boilermaker labor and hard caps on labor in 2005), US EPA projected a peak in boilermaker labor demand during the mid 2008 to mid 2009. [6] This, of course, is consistent with the prediction in Figure 10.

Figure 10.



The National Association of Construction Boilermaker Employers (NACBE) makes statistics on boilermaker manhours available on its web site. Figure 11 shows the historical trends in boilermaker manhours. The figure shows the peak in 2002 associated with NOx SIP Call activity that was preceded by a rapid run up in demand of more than 16 million manhours from 1997 to 2002. The figure also shows the more recent 2008 peak is consistent with the trend of Figure 10, with the peak in demand in 2008 and falling off in 2009. First and second quarter 2010 data from NACBE shows that 2010 will drop off more – again consistent with Figure 10. Bear in mind that Figure 11 includes demand for all boilermaker work while Figure 10 is only for SCRs and FGDs from CAIR.

Figure 11. Historical Total Boilermaker Manhours[19]

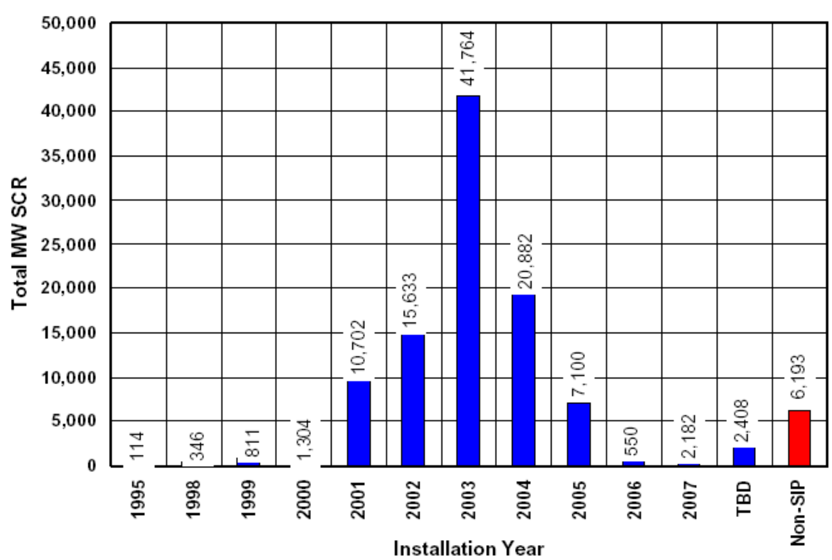


The IBB had 26,696 members in 2002.[7] There was substantial growth in the time between 1999 – when there were about 16,000 – and 2002. This was thanks to increased demand for boilermakers due to the NOx SIP Call and, according to IBB, new boilermakers joining the ranks. In other words, the dynamic behavior of the US labor market was driving resources (skilled laborers) to where they were needed (boilermakers). In their 2005 CAIR analysis US EPA asserted that 35% of total union boilermaker enrollment can be made available for clean air projects.[7] So, if the enrollment is 26,000 union boilermakers – EPA's conservative assessment from Reference 7 - then 9,100 union boilermakers were available for CAIR, not including other sources as described in earlier in this report.[**] As shown in Figure 10, this 9,100 number may have been reached at the peak year of 2008 (using US EPA's 2005 boilermaker demand based on UARG's estimates). But, for all other years it remained below 9,100. Using US EPA's 2004 estimates of boilermaker loading, the demand for boilermakers would have remained well below the 9,100 level for all years.

But, this 9,100 boilermaker "hard cap" on labor is likely a faulty assumption as will be shown in the following paragraphs. We can look to the past to test this.

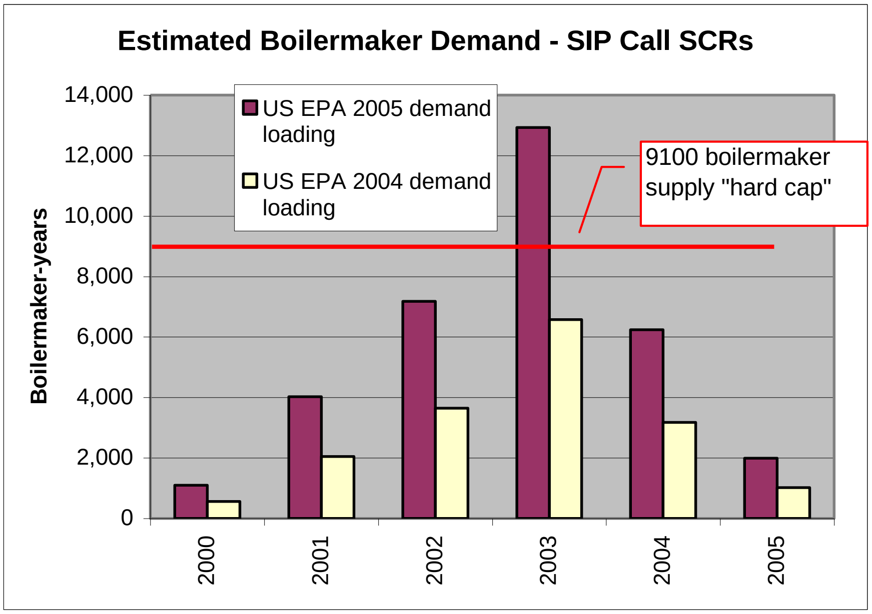
We can learn from previous peaks in demand. To appreciate how the market responds to sudden surges in labor demand, it is worth examining how the boilermaker labor market responded during the NOx SIP Call when SCR's were added to roughly 1/3 of the US coal fired fleet capacity. Figure 12 shows the SIP Call SCR installation in MW by year taken from Reference 8. As shown, there is a large peak of SCRs being placed into service in 2003. It is possible to estimate how many boilermakers were needed to achieve this installation level in a similar manner as Figure 10. Figure 13 shows the results.

Figure 12. SCR Installations for the NOx SIP Call [8]



[**] However, if boilermaker labor increases to 30,000, as expected by NACBE in Fig. 5, then 35% of this is 10,500.

Figure 13. Look-Back Estimate of Boilermaker demand based on Figure 12.



As shown in Figure 13, the demand for boilermakers should have peaked in the 2003 time period[††]. Even if the 2002 and 2003 levels are averaged, they average about 10,000 boilermakers using the 2005 US EPA demand loading, well above the 9100 boilermaker level that equates to the hard cap consistent with US EPA's 2005 assumptions (35% of 26,000). It appears that boilermaker activity peaked well above the "apparent" supply (if US EPA's 2005 demand loadings are used). *Either the 2005 US EPA boilermaker demand loadings are too high, the "hard cap" on labor is too low (or the "hard cap" concept simply incorrect), the labor market is dynamic and companies and workers adjust as needed to meet the needs, or all of the above.*

In fact, going forward, buyers of air pollution control equipment will be at an advantageous position to pick up recently experienced craft labor and construction managers as the Phase I CAIR projects are completed and labor has become increasingly available. The recent experience of these skilled laborers and construction managers will also likely translate into excellent productivity.

[††] It actually peaked in 2002, but the late prediction in Figure 13 is an anomaly of the model assumption that 80% of the labor is in the second year after order placement and that the unit starts up at the end of that second year.

Engineering labor to design the equipment

Engineering labor has not been raised as an issue that limits the ability of the APC industry to respond to clean air initiatives. This is likely because this has not been a problem. There are numerous suppliers of APC equipment. As a result, if one supplier becomes busy, there are several other options. Moreover, for owners that are building multiple scrubbers, standardization of equipment design between scrubbers is often performed. As a result this reduces process-specific changes between units, which reduces the demands on process engineers. This approach also results in benefits to the users in terms of standardization of operator training, spare parts and maintenance practices across facilities.

Availability and Cost of Materials

Materials such as steel, alloys, cement and fiberglass used in construction are traded globally, and US EPA assumed that availability of these materials would not be a limiting factor for CAIR. Demand from retrofit projects in the US, while significant, are relatively small compared to the global marketplace. As a result, price is much more of a concern than availability. During this last decade these materials experienced escalation that caught many by surprise. This was largely a result of rapidly increasing demand for these materials from Asian markets, especially China, where the equivalent of two power plants were being built each week. [20] Recent indexes show a significant drop off from the peak that occurred around mid 2008.

Cost escalation was an industry-wide issue – not isolated to scrubbers and SCRs. Figure 14 is from the 2007 US Department of Energy, Energy Information Administration's Annual Energy Outlook. The figure shows costs trends of power plant construction in "real" terms, adjusted for inflation. As shown there was a significant increase in electric power plant construction costs in the period from about 2003 to 2006, and other data shows that this continued into 2008, which correlates with the increase in power plant construction commodity prices. Figure 15, which is also from the Annual Energy Outlook shows trends for a range of commodities – and the trend is across all major power plant construction materials. It is also notable that while costs are higher than they were in the recent past, they are also about where they were in 1973 in real dollar terms. According to these indices, adjusted for inflation, power plant construction costs have remained within a roughly ± 20% range for the past 30+ years.

Figure 14. Trends in Real (inflation adjusted) Electric Utility Construction Costs, from 2007 EIA Annual Energy Outlook

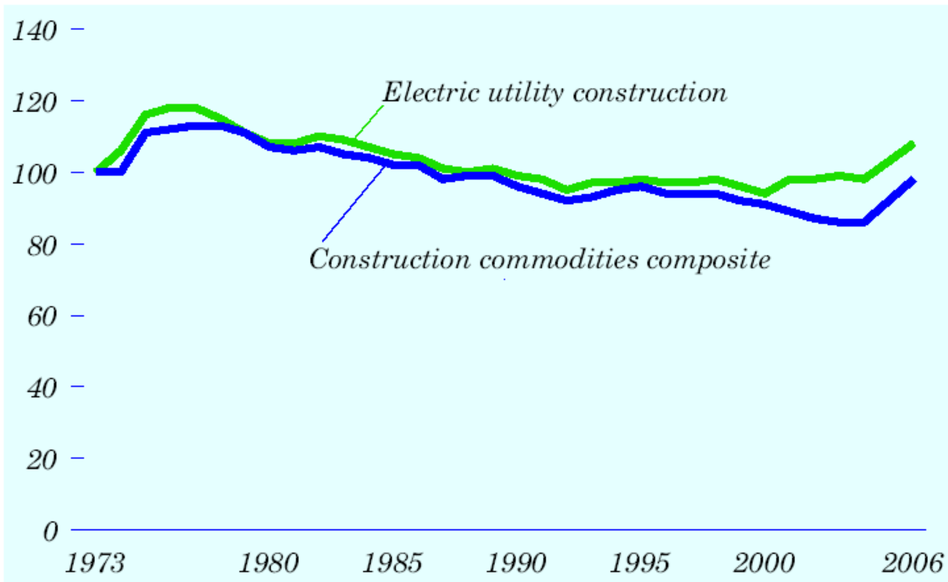
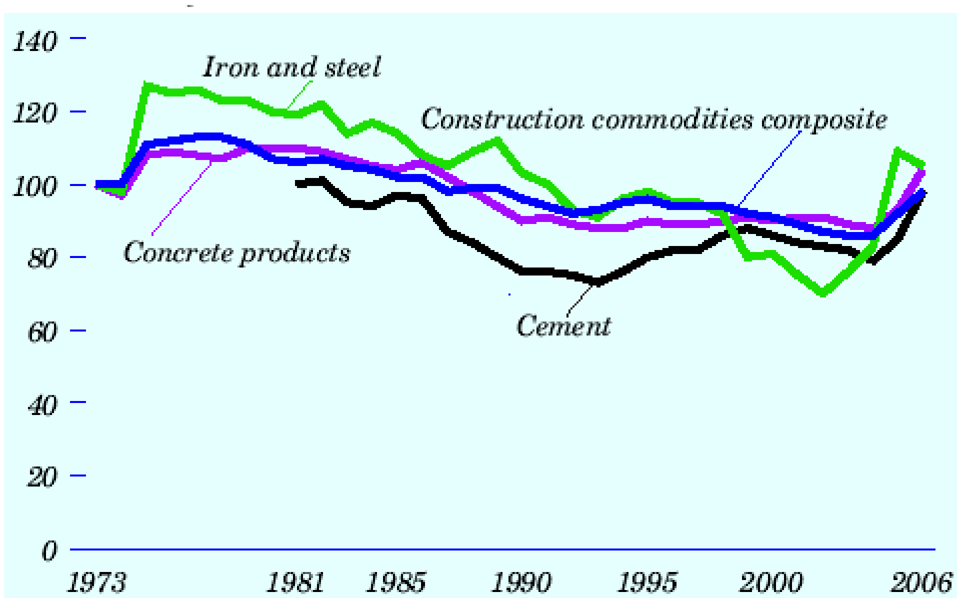


Figure 15. Trends in Real (inflation adjusted) Specific Construction Commodities, from 2007 EIA Annual Energy Outlook



Engineered Equipment

EPA determined that availability of engineered equipment would not be the limiting factor in the installation of SCR and scrubber systems in a multipollutant rule 5 and this generally proved to be the case although during the CAIR phase I retrofit period lead times on some engineered equipment items became longer. Items such as large recycle pumps, large electric motors to drive the pumps, and other such specialized equipment did see lead times increase significantly; however, this period of time where lead times became prolonged did not persist. This is partly because in response to demand, manufacturers expanded capacity or companies looking to buy this equipment found alternative suppliers, but it is also because "the rat passed through the snake" as suppliers worked to fill orders and free up shop space for new customers. Moreover, China has now become a manufacturer of large recycle pumps as they installed scrubbers on their coal-fired power plants. In a similar manner, in anticipation of the increased demand for SCR catalyst from the NOx SIP Call, many catalyst vendors increased capacity. So, experience has shown that supply of engineered equipment has not in general been a serious impediment to completion of clean air projects.

In both the case of the NOx SIP Call and in the case of Phase I of CAIR, the industry responded to the increase in demand by increasing supply. Moreover, it is unlikely that the demand for SCRs or wet FGD systems experienced during the NOx SIP Call or Phase I of CAIR will be experienced ever again because both programs entailed retrofit of a large portion of the coal fleet in a few short years, and there are now fewer plants remaining to retroft this equipment in the future.

6.0 Role of other technologies

Thus far, this White Paper has focused on scrubbers and SCR as the primary technologies of concern. This is because these are the most capital intensive technologies that were likely to be used for compliance with the CAIR, NOx SIP Call or US EPA's recently proposed Transport Rule, and therefore use of these technologies would put the greatest strain on available resources; however, there are other, less capital intensive, technologies or approaches that can be used for emissions compliance. Use of these less capital intensive technologies can reduce the need for scrubbers and SCR and relieve the strain on resources somewhat. For example, dry sorbent injection (DSI) is a technology that reduces SO_2 through injection of Trona, Sodium Bicarbonate or Hydrated Lime upstream of a particulate control device. DSI does not generally provide the SO_2 reductions that are possible with scrubbers; however, the reductions are nevertheless significant – typically in the range of 50% or more. Moreover, these technologies can be implemented very quickly – typically within one year.

For NOx control, selective non-catalytic reduction (SNCR) is a proven approach to achieve NOx reductions in the range of about 25% (varies based upon application), and can be implemented in under a year. Compared to scrubbers and SCR, both SNCR and DSI require relatively little in terms of labor resources.

It may also be possible to improve the scrubber performance of many older scrubbers that were installed in the 1970's and 1980's. For example, limestone forced oxidation wet scrubber system upgrades at the Vectren Culley Station Units 2 & 3, E.On's Trimble County Unit 1, and Michigan South Central Power's Endicott Station resulted in removal efficiencies in the range of 98% being achieved for each of these units. [21, 22, 23] Upgrades such as these can also be implemented very quickly and inexpensively when compared to installation of a new scrubber and they are probably better suited than FGD to the remaining unscrubbed plants that tend to be smaller in capacity.

These lower-cost approaches for SO_2 and NOx control that can be implemented quickly lend themselves well to the flexibility that has been incorporated into US EPA's criteria pollutant regulations. These methods do not require large commitments of capital. Utility companies can implement these methods and delay or avoid installation of more capital intensive technologies. Although SNCR has been incorporated into US EPA's analysis in the past, DSI and scrubber upgrades have not.

7.0 Implications of this Analysis

This White Paper assessed the demands on resources for constructing air pollution control equipment in response to clean air initiatives. It focused on NOx and SO_2 control equipment, particularly SCR and FGD systems; however, the lessons apply to other equipment that may be needed for future clean air programs. By examining US EPA's analysis of the capabilities of the air pollution control industry to respond to CAIR, it was determined that US EPA underestimated the ability of the industry to respond to CAIR in its 2005 analysis published with the rule. This was largely a result of assumptions that US EPA made regarding the demand for labor and the availability of labor to install the equipment that US EPA projected would be necessary for the industry to comply with CAIR. The assumptions regarding labor were demonstrated to be too conservative and did not take into account the dynamic nature of U.S. labor markets, which US EPA had previously acknowledged, by imposing a "hard cap" on labor availability. Assumptions regarding timing of orders also proved to be incorrect. Assumptions regarding other resources that were not envisioned to be limiting generally proved to be consistent with experience.

The findings of this White Paper have implications for future clean air initiatives and how the timing of these initiatives should be assessed. To this end, it may be beneficial to reexamine the topic of resource supply and demand, particularly with regard to labor, and develop assumptions that better reflect the demand and supply characteristics of the market for power plant labor.

Looking to the future, in addition to SCR and FGD systems, there are other technologies that are likely to play an increased role in future NOx and SO_2 reductions and will require less significant outlays of capital as well as construction resources. These lower-cost approaches for SO_2 and NOx control can be implemented quickly, may be better economic choices for smaller units, and lend themselves well to the flexibility that has been incorporated into US EPA's criteria pollutant regulations.

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