EPA's expert Chinkin compared his model results to all the available monitoring data and found that his base case model performed "exceptionally" when compared with the actual data from national monitoring networks. FOF ¶ 316; Chinkin Test., Tr. Vol. 2-B, 17:8-18.

V. RUSH ISLAND'S EXCESS POLLUTION IS BEST REMEDIATED BY DECREASING EMISSIONS AT THE NEARBY LABADIE ENERGY CENTER

358. Ameren's violation of the Clean Air Act at Rush Island has resulted in more than 162,000 tons of excess SO_2 pollution through 2016. That amount is expected to grow to 275,000 tons by the time Rush Island finally complies with the PSD program. FOF ¶ 210-11.

359. Accordingly, Plaintiffs seek an injunction requiring Ameren, over time, to reduce pollution from its nearby Labadie plant in an amount equal to Rush Island's total excess emissions. By reducing future SO_2 emissions from the Labadie plant, Ameren can, ton for ton, remedy the harm it caused by failing to install pollution control technology that should have been installed in 2007 and 2010.

360. The Labadie plant is located near Labadie, Missouri, about 35 miles west of St. Louis. The plant consists of four units, each of which can generate about 600 megawatts of electricity, about as much as Rush Island's units can generate. Integrated Resource Plan (Pl. Ex. 1247), at USTREXR0006246 to 6247. Ameren plans to retire the four Labadie units in 2036 and 2042. Michels Test., Tr. Vol. 5-B, 18:20-23, Michels Dep., Aug. 14, 2018, Tr. 14:1-23, 109:21-110:13.

361. Dr. Staudt looked at multiple options for reducing future SO_2 emissions from the Labadie plant: natural gas conversion, wet FGD, dry FGD, DSI, and DSI with the addition of a fabric filter.

362. All these options are technically and practically achievable at Labadie. Staudt Test., Tr. Vol. 1-B, 102:11-103:6. The capital costs range from $55 million for DSI on all four

Labadie units to about $1 billion for wet FGD on all four units. Staudt Test., Tr. Vol. 1-B, 102:15-103:11. The operating costs range from $31 million/year for DSI with a fabric filter to a high but variable operating cost for a natural gas conversion. Id. at 103:12-20. The operating costs for DSI without a fabric filter would be about $53 million/year. Id. at 105:19-20. Natural gas conversion would have the highest emissions reductions, virtually eliminating SO_2 emissions. After that, wet FGD would achieve the greatest reductions, followed by dry FGD, DSI-FF, and DSI. The higher the reductions, the faster the remediation. Staudt Test., Tr. Vol. 1-B, 104:1-17.

363. The reduction capabilities of installing DSI without a fabric filter on all four units and wet FGD on two units are relatively close. It would take about the same amount of time to offset the excess pollution with these two technologies. Assuming, on the high side, annual uncontrolled emissions of about 38,000 tons per year, DSI on all four units would remove 19,000 tons per year and offset the excess within about 14 or 15 years, while wet FGD on two units would remove 17,000 tons per year and offset the excess in a little over 16 years. Staudt Test., Tr. Vol. 1-B, 106:23-107:11, 108:2-7.

364. The cost-effectiveness of the two options is also relatively similar: $4300/ton for wet FGD on two units compared to $3100/ton for DSI on four units. Id. at 107:12-15.

365. DSI could be installed in 18 months, more quickly than wet FGD. Staudt Test., Tr. Vol. 1-B, 106:8-20, Tr. Vol. 2-A, 16-17; Snell Test., Tr. Vol. 4-B, 30:17-31:6.

a. Reducing Future Pollution from Labadie Will Remediate the Harm from Rush Island for the Same Populations and to the Same Extent

366. The harm from Ameren's excess SO_2 emissions was imposed on tens of millions of people living in the communities impacted by Rush Island's pollution. As a result, these populations experienced increased risks of adverse health effects, including increased risk of

premature mortality. Schwartz Test., Tr. Vol. 3-A, 82:14-83:4, 110:10-22.

367. The linear concentration-response relationship for $PM_{2.5}$ exposure means that, in the range of concentrations studied, any incremental decrease in exposure produces a positive impact on public health. FOF ¶ 263; see also Schwartz Test., Tr. Vol. 3-A, 48:3-50:13.

368. Reducing pollution from Labadie by an amount equal to Rush Island's excess emissions will reduce the risk of adverse health effects and premature mortality in the exposed population by an amount equal to the increased risk from Rush Island's excess emissions. Schwartz Test., Tr. Vol. 3-A, 20:23-21:8, 110:10-22.

369. The populations that will benefit from these reductions are almost identical to those who were harmed by Rush Island's excess pollution. As a result, there is a particularly tight factual nexus between remedy and harm. This tight nexus is demonstrated by Dr. Schwartz's 2009 risk assessment. For most coal-fired power plants, the assessment showed significant variability in the health impacts of emissions depending on where each ton was emitted. Schwartz Test., Tr. Vol. 3-A, 88:9-89:12. However, Ameren's Rush Island and nearby Labadie plants had nearly identical health impacts per ton of SO_2, because they impact roughly the same populations. Schwartz Test., Tr. Vol. 3-A, 110:24-111:23, 116:23-118:4.

370. Chinkin's CAMx modeling confirms this close nexus. Chinkin modeled the benefits of installing pollution control options at Labadie in the same way he studied the impacts of Rush Island's excess pollution. This modeling shows that the two plants have similar pollution-impact profiles, affecting the same populations and to the same extent. Chinkin Test., Tr. Vol. 2-B, 31:21-33:5, 36:16-37:22.

371. Chinkin's CAMx modeling indicated that scrubber technology operated at two of Ameren's Labadie units would reduce SO_2 pollution by about the same amount in the same

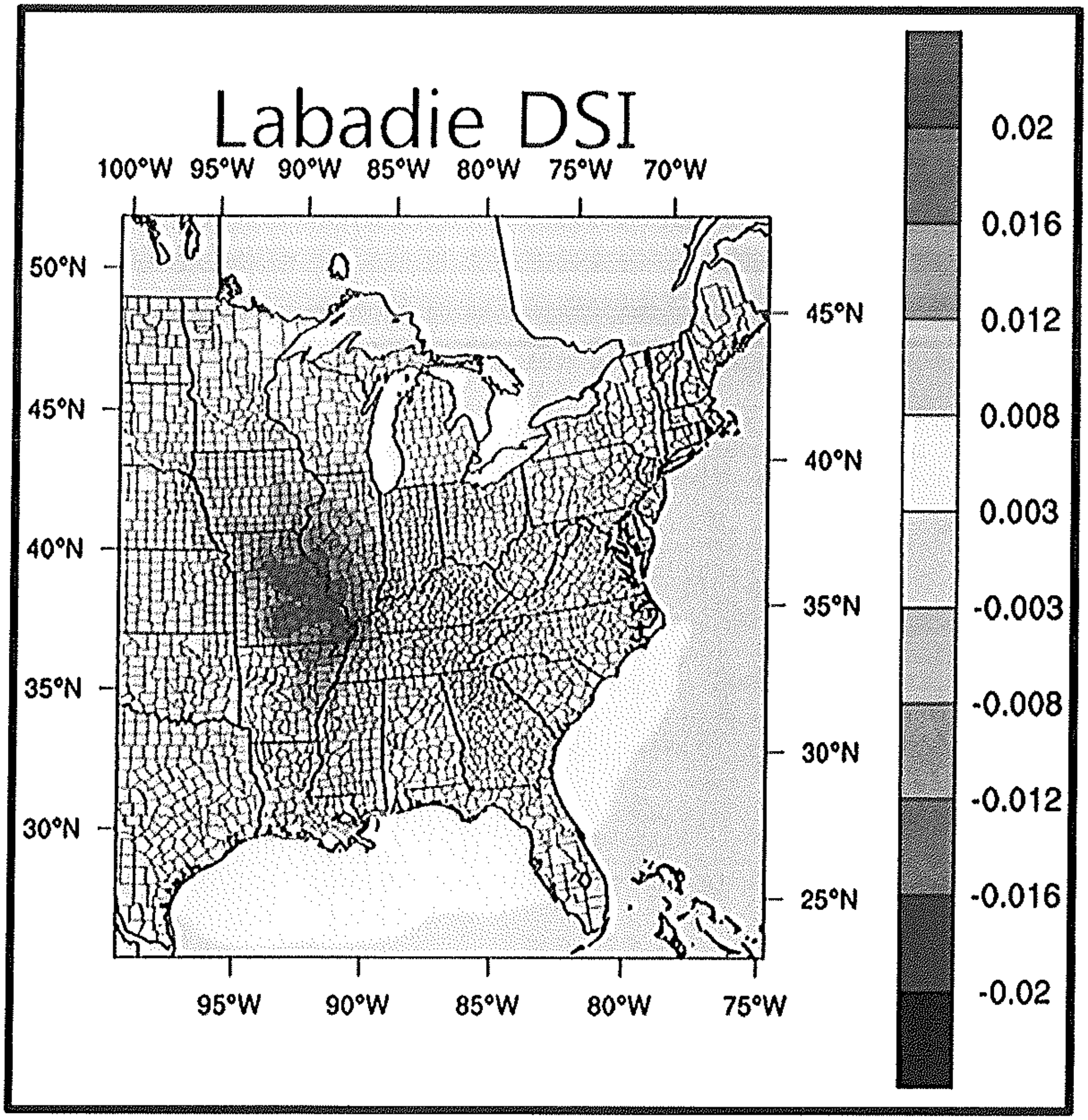
geographic region as Rush Island's excess pollution. Based on 2011 data, this control technology would have a maximum average annual impact of 0.054 $\mu g/m^3$ (compared to 0.057 $\mu g/m^3$ for Rush Island's excess pollution), and a maximum daily downwind impact on $PM_{2.5}$ concentrations of 2.44 $\mu g/m^3$ (compared to 2.25 $\mu g/m^3$). Chinkin Test., Tr. Vol. 2-B 33:6-34:12; Model Results Map (Pl. Ex. 1362).

372. Similarly, the CAMx modeling shows that DSI technology operated at all four of Ameren's Labadie units would reduce SO_2 pollution by about the same amount in the same geographic region as Rush Island's excess pollution, as shown in Figure 7. Chinkin Test., Tr. Vol. 2-B, 34:20-36:5 Schwartz Test., Tr. Vol. 3-A, 111:24-112:8.

373. I find that reducing emissions SO_2 pollution from Ameren's Labadie plant will, on a ton-for-ton basis, benefit the same populations—and to the same extent—that suffered the harm from Rush Island's excess pollution. This finding is based on both the reduced form modeling prepared by Dr. Schwartz in his published 2009 risk assessment, as well as the CAMx modeling prepared by Chinkin for this case.

374. Ameren did not present evidence or testimony challenging Chinkin's conclusion that the SO_2 pollution from the Labadie Energy Center affects downwind $PM_{2.5}$ concentrations to the same scope and degree as the SO_2 pollution from the Rush Island facility.

Figure 7



Pl. Ex. 1362.

b. Society Will Benefit If Ameren Offsets Its Excess Emissions

375. The societal benefits associated with offsetting Ameren's excess pollution are substantial. Reducing the pollution from Labadie in an amount equal to Rush Island's excess emissions will result in an equal amount of avoided health effects, including premature mortality,

in the same population. Schwartz Test., Tr. Vol. 3-A, 20:23-21:8, 110:10-22.

376. These benefits have substantial economic value. In his 2009 risk assessment, Dr. Schwartz quantified the social cost Rush Island and Labadie's pollution, as well as the pollution of 405 other coal-fired power plants. In this study, Dr. Schwartz applied standard, peer-reviewed values used by public health professionals and the EPA to estimate economic benefits of pollution reduction. Schwartz Test., Tr. Vol. 3-A, 112:10-116:22. Based that study, Dr. Schwartz estimated the social benefits from remedying Rush Island's excess emissions would far surpass the costs of any control technology used. Compare Schwartz Test., Tr. Vol. 3-A, 116:23-118:4 with Def. Exs. IB & IC and FOF ¶ 362 (Labadie costs).

377. Chinkin's CAMx-derived benefits estimates are even higher than the results of the 2009 risk assessment, confirming that the benefits of remediating Rush Island's excess pollution exceed the costs. Compare Schwartz Test., Tr. Vol. 3-A, 118:16-24 with Def. Exs. IB & IC and FOF ¶ 362.

c. Ameren's Surrendering of Pollution Allowances Would Not Remedy Harms to the Populations Affected by Rush Island's Excess Emissions

378. Ameren offered to surrender SO_2 emission allowances under the Cross-State Air Pollution Rule (CSAPR) as mitigation for Rush Island's excess pollution. See Ameren Trial Brief, ECF Doc. 1071, at 13-15. CSAPR is a market-based program issued under the Good Neighbor Provision of the Clean Air Act and designed to reduce air pollution from upwind states to the benefit of downwind states. Knodel Test., Tr. Vol. 1-A, 100:10-16, 102:16-20; see 42 U.S.C. § 7410(a)(2)(D)(i).

379. Under CSAPR, which went into effect in 2015, the EPA establishes an SO_2 emission budget for each state. Knodel Test., Tr. Vol. 1-A, 100:10-101:17, 102:21-23. Each state then allocates allowances to individual units, with each allowance authorizing the source to

emit one ton of pollution. Knodel Test., Tr. Vol. 1-A, 101:22-102:8.

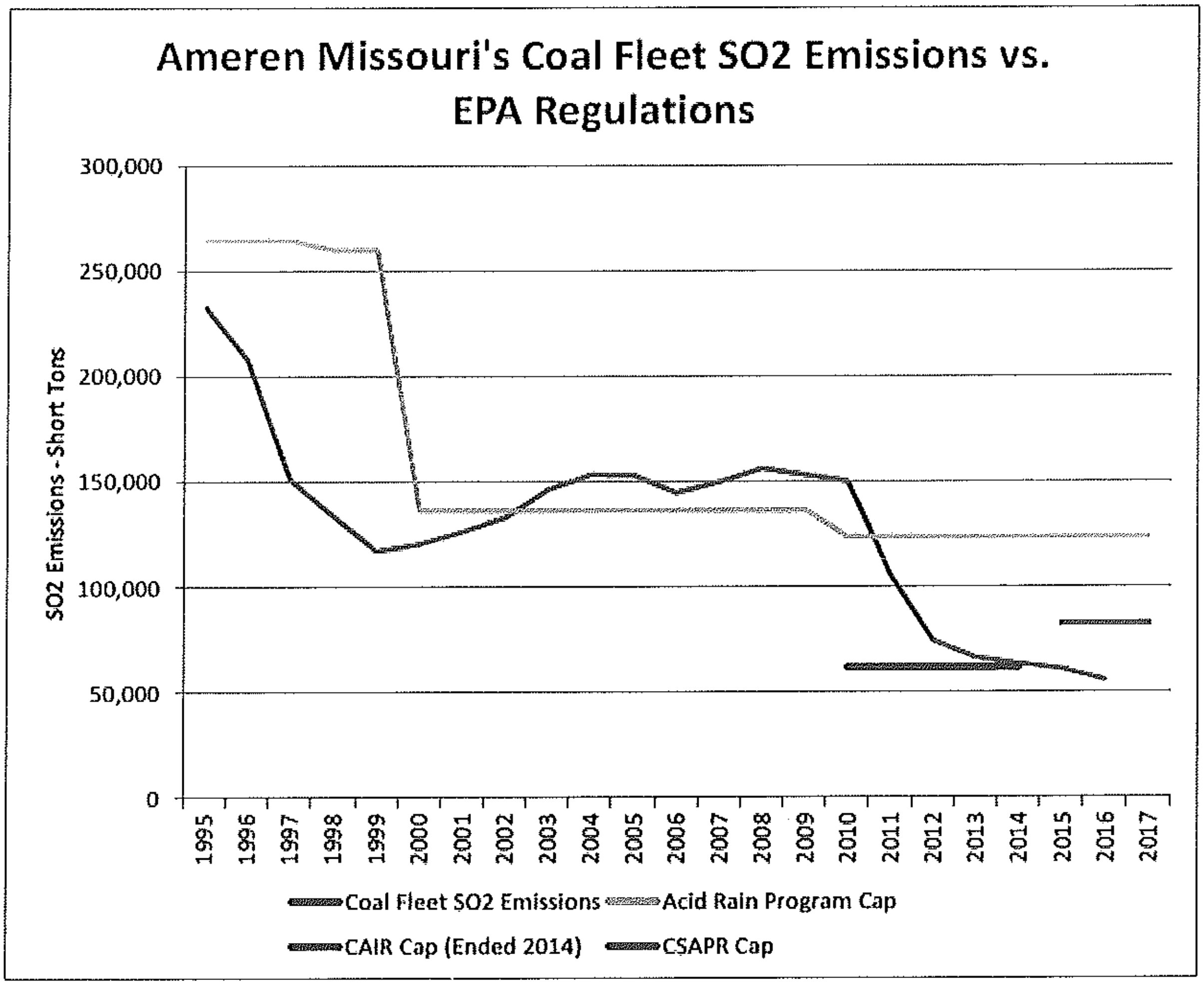
380. Allowances are freely tradable among regulated units, brokers, and other parties. (Harvey Decl. at 18.) During each year of the CSAPR programs, each regulated unit must monitor and report its SO_2 emissions. Shortly after the end of the year, the unit must surrender one eligible "allowance" for each ton of its reported emissions for the year. Id. If a utility does not use its allowances in a given period, it can carry over the unused allowances. The utility may either sell the allowances to another source in the same trading region or use the carryover allowances itself. Knodel Test., Tr. Vol. 1-A, 102:4-15, 102:24-103:3.

381. Missouri is part of Group 1 of the CSAPR SO_2 allowance trading program. Group 1 consists of 16 states, including those as far away as Wisconsin, Michigan, New York, Virginia, and North Carolina. Michels Test., Tr. Vol. 5-B, 12:19-13:23.

382. The Parties stipulated that, as of the beginning of 2019, Ameren held 237,184 CSAPR SO_2 allowances. ECF No. 1077-1 at 3; Pre-Trial Hearing Tr. 31:18-32:3 (Ameren counsel agreeing to use the United States' number); Michels Test., Tr. Vol. 5-B, 14:2-5.

383. In its 2017 Integrated Resource Plan, Ameren presented a graph (reproduced here as Figure 8) showing that its fleetwide SO_2 emissions are below the cap established by CSAPR, and that the allowance surplus is increasing each year:

Figure 8



Def. Ex. PV, at PV_5; Michels Test., Tr. Vol. 5-B, 14:8-15:5.

In this graph, the blue line represents Ameren's emissions limit based on its annual allocation of CSPAR allowances. Id. The red line represents the tons of SO_2 emitted from the entirety of Ameren's coal fleet in Missouri. The green and purple lines represent Ameren's respective limits for the Acid Rain Program and the Clean Air Interstate Rule (CAIR), the predecessor to CSAPR. As shown in Figure 8, the CAIR program had lower emissions limits for Ameren's fleet of power plants than any other program shown. Ameren never met the more challenging emissions limitations of CAIR, although its fleetwide emissions decreased during the CAIR program. By the time the CAIR program ended in 2014, Ameren's fleetwide emissions were about equal to the CAIR limit and substantially lower than the new CSAPR emissions limit.

384. Generally, power plant owners and operators have met the CSAPR limit by large margins. As of the end of 2016, Group 1 sources had banked 2,924,713 SO_2 allowances. EPA Report, "2016 Program Progress: Cross-State Air Pollution Rule and Acid Rain Program," (Pl. Ex. 1442).

385. The price for Group 1 SO_2 allowances is currently "very low" according to Ameren's trial expert economist. Celebi Test., Tr. Vol. 5-B, 72:9-11. Each allowance is about $2.50 under current market prices. Knodel Test., Tr. Vol. 1-A, 107:18-21.

386. Ameren did not present evidence or an argument demonstrating that surrendering allowances would actually decrease emissions. In its proposed findings of fact, Ameren stated that:

> Ameren currently relies on the use of CSAPR allowances to comply at Rush Island. For the period when CSAPR began in 2015 through 2018, Ameren has been allocated an average of 21,477 allowances per year, and has exceeded those allowances in several years. (Michels, Tr. Vol. 5-B, 7:14-8:4.) Based on these trends, it is reasonable to assume that Rush [I]sland's emissions may exceed allowances in the future as well.

Ameren's Proposed Findings of Fact, ECF No. 1110 at ¶277.

387. The cited testimony does not support Ameren's assertions. Michels, Tr. Vol. 5-B, 7:14-8:4. Instead, the testimony demonstrates that Rush Island has exceeded its allowances in only one year (2017), and over the past four years, Rush Island has accumulated 9,625 net allowances. Over its entire fleet, Ameren has accumulated 237,184 net allowances during the same period. ECF No. 1077-1at 3; Pre-Trial Hearing Tr. 31:18-32:3 (Ameren counsel agreeing to use the United States' number); Michels Test., Tr. Vol. 5-B, 14:2-5.

388. From CSAPR's effective date in 2015 through 2018, Rush Island has had the following allowances and actual emissions:

a. 2015: 24,310 allowances and 18,253 tons of emissions,

b. 2016: 24,237 allowances and 17,379 tons of emissions,

c. 2017: 18,686 allowances and 22,167 tons of emissions,

d. 2018: 18,675 allowances and 18,484 tons of emissions.

389. Ameren did not present evidence to demonstrate that CSAPR emissions limitations would become more difficult to meet. Instead, Ameren presented evidence that it would gain surplus credits for six years after the retirement of its Meramec Energy Center. Michels, Tr. Vol. 5-B, 8:16-20. These surplus credits would make CSAPR easier to meet.

390. Nor did Ameren present any evidence that, by trading allowances, it would actually decrease emissions in the same geographic area impacted by Rush Island and Labadie.

391. Ameren could trade its surplus allowances to power plants in Wisconsin, Michigan, New York, Virginia, or North Carolina. Michels Test., Tr. Vol. 5-B, 12:19-13:23.

392. The evidence does not support Ameren's assertion that surrendering its CSAPR emissions allowances would lead to actual emissions reductions remedying the harm to the populations impacted by Rush Island's excess emissions.

VI. ADDITIONAL EQUITABLE FACTORS SUPPORT THE REQUESTED REMEDIES

a. Liability Standards Were Well Understood in the Industry

393. I have already concluded that a reasonable power plant operator would have known that the modifications undertaken at Rush Island Units 1 and 2 would trigger PSD requirements. I have also concluded that Ameren's failure to obtain PSD permits was not reasonable. Ameren Missouri, 229 F.Supp.3d at 915-916, 1010-14.

394. After the liability trial in this case, I found that at the time of the Rush Island modifications, "the standard for assessing PSD applicability was well-established." It was also

"well-known" that the types of unpermitted projects Ameren undertook risked triggering PSD requirements. Id. at 915.

395. Despite these findings, Ameren now seeks to avoid PSD permitting by arguing that, if it knew about the consequence of its actions, it would have never triggered PSD in the first place. At trial, Ameren expert Campbell testified that Ameren could have used several options to avoid New Source Review (NSR) requirements. According to Campbell, Ameren would have used one of those "avoidance" options, if only it had known that the Rush Island modifications might be found to trigger PSD. Campbell Test., Tr. Vol. 4-A, 135:2-5. Campbell's avoidance options included canceling the projects, reducing the projects emissions without a permit, or reducing the projects emissions with a "minor permit." Campbell Test., Tr. Vol. 4-A, 49:7-19. The parties have referred to Campbell's opinions on this subject as his "PSD avoidance" theory.

396. Assuming they were viable, Ameren did not take any of the options identified by Campbell. Instead, Ameren proceeded with the projects without obtaining the required permits.

397. Campbell admitted that his PSD avoidance theory relies on an assumption that Ameren did not appreciate the risks of violating NSR when it undertook the largest modification in plant history. Campbell Test., Tr. Vol. 4-A., 136:5-9. Campbell did not talk to any Ameren employees about whether they ascertained the risks of violating NSR. Nor did Campbell talk to any Ameren employees about whether they would have taken or been able to take any of the avoidance options that he presented during his testimony. Id. 136:19-137:15.

398. Ameren's documents indicate that Ameren was aware of the possibility that NSR would be triggered at Rush Island. For example, on May 1, 2009, Ameren met with engineering firm Black & Veatch to review contracting strategies and to allow Black & Veatch to

"understand internal AmerenUE drivers." May 13, 2009 Conference Memorandum (Pl. Ex. 1111), at AM-REM-00319195. Included among the "Questions for thought" discussed at that meeting was "What is the tolerance for risk?" Id. at AM-REM-00319198, 319222. The Conference Memorandum summarizing the discussion of that question identified that "NSR is likely the biggest potential issue." Id. at 319199. Addressing a question about cash flow for any FGDs at Rush Island, the May 2009 Conference Memo identified that "NSR or EPA will likely be the driver to shift the schedule early." Id.

399. A June 2010 presentation to Ameren's Corporate Project Oversight Committee (CPOC) similarly identified "New Source Review" as one of several Clean Air Act "driving forces for additional control equipment" that Ameren was monitoring. See June 1, 2010 CPOC Presentation, Scrubber Technology Assessment, Rush Island Plant (Pl. Ex. 1099), at AM-REM-00288980; see also Ameren Rule 30(b)(6) Dep., Nov. 7, 2017, Tr. 59:25-60:10.

400. A February 2010 CPOC presentation identified NSR as among the relevant environmental concerns facing Rush Island. Specifically, the presentation identified NSR's "permitting and control requirements for new sources and existing sources that undergo 'major modifications.'" See February 5, 2010 Project Review Board Presentation—Rush Island FGD (Pl. Ex. 1100), at AM-REM-00289009, 011.

401. Campbell also testified that Ameren could avoid PSD by restricting operations. This opinion is similarly unsupported. To avoid PSD by restricting operations, a source can obtain a permit known as a synthetic minor permit. A synthetic minor permit limits a source to operate below significance thresholds under the PSD program. Knodel Test., Tr. Vol. 1-A, 67:5-14, 97:25-98:7.

402. Ameren did not apply for a synthetic minor permit prior to undertaking the

modification of Unit 1 in 2007 nor the modification of Unit 2 in 2010. Knodel Test., Tr. Vol. 1-A, 67:15-20; MDNR Rule 30(b)(6) Dep., Aug. 10, 2018, Tr. 137:5-9.

403. Ameren's director of corporate analysis, the official in charge of resource planning, testified that he was not aware of any instance where Ameren voluntarily restricted the operations of Rush Island. Michels Test., Tr. Vol. 5-B, 4:19-20, 5:1-9; Michels Dep., Aug. 14, 2018, Tr. 156:13-17.

404. Owners of baseload plants such as Rush Island generally avoid limiting plant operations, which are designed to run as much as possible. Staudt Test., Tr. Vol. 1-B, 20:16-24, 97:13-23; see also Ameren Missouri, 229 F. Supp.3d at 917 (Liability Findings ¶ 6 (Rush Island units are "baseload units" that "generally operate every hour they are available to run"), ¶ 7 ("The Rush Island units are among Ameren's most cost-effective units and carry much of the system load."), ¶ 59 (Rush Island units gain "economic advantage … by burning cheaper coal then their competitors")).

405. Dr. Staudt testified that he was not aware of any instance in which the owner of a baseload power plant like Rush Island accepted a limitation on operations in the way that Campbell suggests. Staudt Test., Tr. Vol. 2-A, 13:23-14:12. ("[T]hat doesn't happen very often, or I'm not sure if it's ever happened on a electric-generating unit.").

406. Despite its expert testimony, Ameren did not present any company witness or documents suggesting the pursuit of a synthetic minor permit was a realistic possibility, or ever considered for Rush Island.

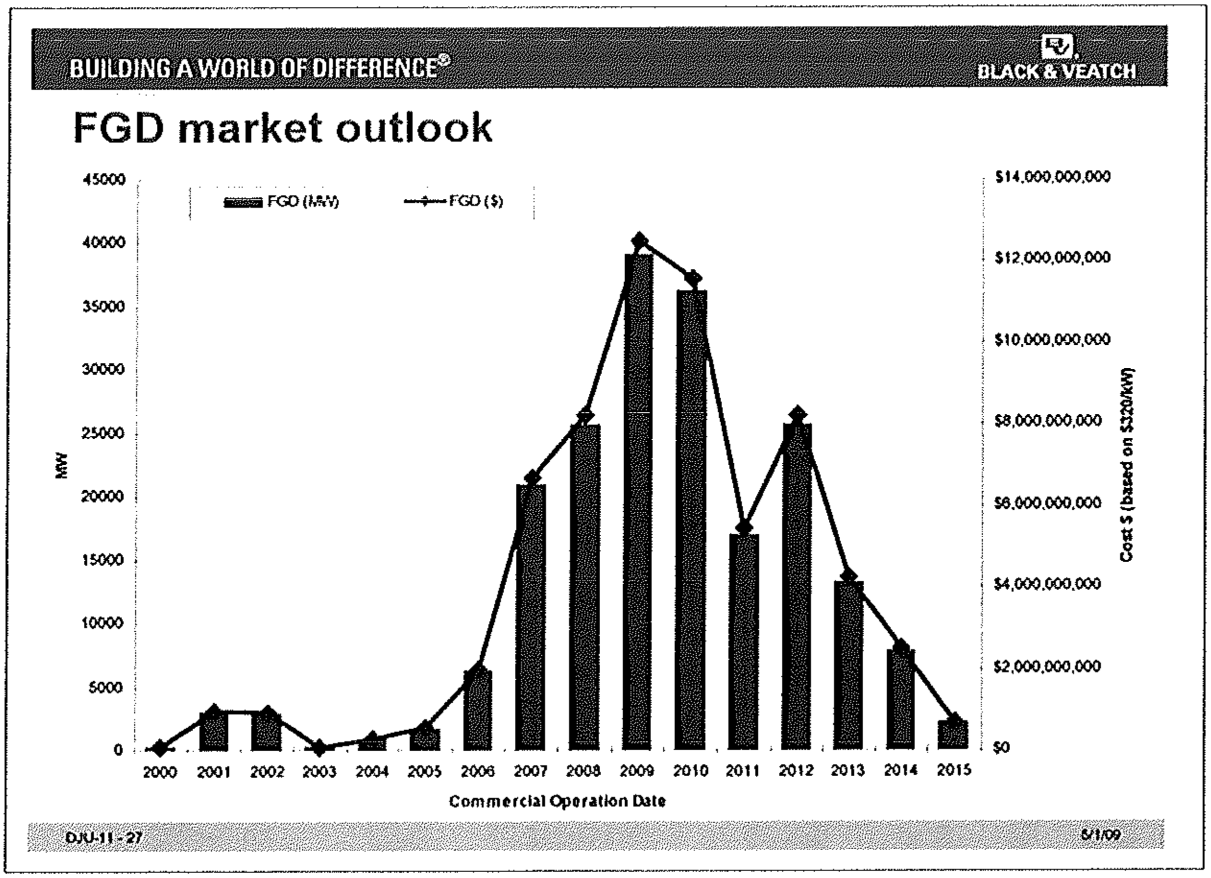
407. While Rush Island began burning lower sulfur coal after its modifications, Ameren has not accepted a permit limit at that level. Nothing currently requires Rush Island to burn lower sulfur coal. Staudt Test., Tr. Vol. 2-A, 17:5-16; Knodel Test., Tr. Vol. 1-A, 67:25-

68:19, 69:18-20.

b. Ameren Has Benefitted from Delaying Compliance at Rush Island

408. Between 2007 and 2010 was a period of peak market demand for the installation of scrubbers in the electric utility industry, as illustrated by Figure 9.

Figure 9



Pl. Ex. 1111, at AM-REM-00319231.

409. Ameren avoided this period of peak market demand to its benefit, as discussed in internal company documents. Staudt Test., Tr. Vol. 1-B, 28:3-31:1; Ex. 1111, at AM-REM-00319199, 231; Ameren's April 2011 Presentation for MPSC, Ex. 1009, at AM-02225216 (Ameren's business strategy "[a]llows Ameren Missouri to defer capital investments on environmental retrofits" and "delay its construction needs to avoid the likely timeframe of

greatest environmental retrofit construction.")

410. Ameren's internal documents also make clear that Ameren has understood for many years the possibility that scrubbers would be required as a result of NSR violations at Rush Island. Ex. 1009, at AM-02225205 ("New Source Review lawsuit by EPA may require flue gas desulfurization (FGD) systems or scrubbers at Rush Island."), and AM-02225216 (2011 fuel switch strategy "[a]llows Ameren Missouri additional time to complete its detailed engineering design should scrubbers ultimately be required.");

411. Today, the scrubber market is "slow" and there would be lots of "very eager suppliers" to get Ameren's business. That means not only that Ameren benefitted from the delay, but also that an FGD could be installed much more quickly today because the resources are more available. Staudt Test., Tr. Vol. 1-B, 32:2-33:3.

412. By delaying wet FGD scrubbers for more than ten years, Ameren also sold more power from Rush Island than it would have had it complied with the law. Operating a scrubber changes the dispatch cost of a unit (the cost that unit needs to break even in the market). Celebi Test., Tr. Vol. 5-B, 68:18-69:18. Because the unit's dispatch cost will increase, it may run less. The unit will also sell less energy to the grid because some of its energy is needed to power the scrubber itself. Celebi Test., Tr. Vol. 5-B, 68:18-70:15.

413. The sources that installed scrubbers when required have been at a competitive disadvantage to Rush Island. In contrast, by not installing scrubbers in 2007 and 2010, Ameren benefited from the ability to spend capital on other items or issue dividends.

c. Ameren Admits It Can Afford to Comply With the Requested Remedies

i. Ameren Has Abundant Financial Resources

414. Ameren Missouri and Ameren Corporation are "financially strong." Kahal Test.,

Tr. Vol. 2-A, 53:11-19, 59:23-60:5 (discussing the strength of Ameren's financial reports). Ameren Corporation is the sole owner of Ameren Missouri. Kahal Test., Tr. Vol. 2-A, 55:3-25. Ameren has strong credit ratings, access to capital on favorable terms, and can access far more capital than it needs for its current capital spending plans. Kahal Test., Tr. Vol. 2-A, 69:25-70:5.

415. Each year, Ameren reports financial information for Ameren Corporation and Ameren Missouri to the Securities and Exchange Commission (SEC). Kahal Test., Tr. Vol. 2-A, 56:9-16. In its latest Form 10-K, Ameren submitted the financial information contained in Table 2 for the calendar year 2018.

Table 2. Ameren Corporation and Ameren Missouri 2018 Financial Information

	Ameren Corporation	Ameren Missouri
Assets	$27,215,000,000	$14,291,000,000
Operating Revenue	$6,291,000,000	$3,589,000,000
Net Income	$815,000,000	$478,000,000
Shareholder Dividends	$451,000,000	$375,000,000
Capital Spend	$2,336,000,000	$914,000,000
Operating Cash Flow	$2,170,000,000	$1,260,000,000

Ameren 2019 10-K (Pl. Ex. 1340), at USTREXR0003003, 3055, and 3057.

416. Ameren also reports financial information to the Federal Energy Regulatory Commission (FERC) in a document called the FERC Form 1. Ameren reported the following financial data in its FERC Form 1s for the years 2012 through 2017.

Table 3: Ameren Corporation 2012-2017 Financial Information (dollars)

	Net Income	**Capital Spending**	**Dividends**	**Cash Flow**
2012	420,000,000	611,000,000	400,000,000	995,000,000
2013	399,000,000	668,000,000	460,000,000	1,135,000,000
2014	394,000,000	770,000,000	340,000,000	943,000,000
2015	356,000,000	631,000,000	575,000,000	1,239,000,000
2016	360,000,000	751,000,000	355,000,000	1,161,000,000
2017	326,000,000	786,000,000	362,000,000	1,018,000,000
Average	376,000,000	703,000,000	415,000,000	1,082,000,000

Pl. Exs. 1331-36; see Rule 1006 Summary of FERC Form 1s (Pl. Ex. 1388).

417. In the SEC Form 10-K and FERC Form 1s:

a. ***Assets*** refers to total property owned by the company and provides a sense of the company's size.

b. ***Operating revenue*** is the total amount the company receives from its services.

c. ***Net income*** means the after-tax profits of the business.

d. ***Shareholder dividends*** refers to the money paid to the owners of the company. Ameren Corporation has individual public shareholders, while Ameren Missouri is wholly owned by Ameren Corporation. Therefore, all Ameren Missouri's dividends go to Ameren Corporation.

e. ***Capital spend*** means the total capital spending.

f. ***Operating cash flow*** refers to the net funds that the company earns after expenses such as operating and maintenance spending, taxes, interest, and other costs. Throughout the period, the cash flow roughly equals the total of capital spending and dividends, indicating that the company is using its cash to fund capital projects with internally generated revenue and paying the rest in dividends.

Kahal Test., Tr. Vol. 2-A, 57:16-59:22, 63:10-64:12.

418. Ameren has three main options for financing capital projects. It can use revenues from its operations, obtain funds from debt markets, or issue new common stock (through the parent company). Kahal Test., Tr. Vol. 2-A, 66:21-67:24.

419. Ameren's stock has performed "extremely well" over the past five years. Kahal Test., Tr. Vol. 2-A, 60:8-17. Ameren's Form 10-K indicates that the parent company's stock price grew by more than 16% per year from 2013 to 2018. Ameren 2019 10-K (Pl. Ex. 1340), at USTREXR0003002; Kahal Test., Tr. Vol. 2-A, 60:8-61:6. This growth was considerably larger

than indexes reflecting the electric utility industry or the broader stock market. Id. Ameren's stock performance means that the company would have access to equity markets, if needed, to finance capital projects. Kahal Test., Tr. Vol. 2-A, 60:8-61:6.

420. In February 2019, Ameren announced a $6.3 billion capital spending program for the next five years. Ameren Feb. 15, 2019 Press Release (Pl. Ex. 1341). This program represents an increase in spending from the recent past, when capital spending averaged about $700 million per year. Kahal Test., Tr. Vol. 2-A, 64:13-65:21; Ameren Feb. 15, 2019 Press Release (Pl. Ex. 1341).

421. Ameren's strong credit ratings allow it to access debt markets on very favorable terms. Kahal Test., Tr. Vol. 2-A, 65:22-66:20. The corporate credit ratings for both Ameren Corporation and Ameren Missouri are at the top end of the triple B range, while the secured debt for Ameren Missouri is rated medium single A. Kahal Test., Tr. Vol. 2-A, 65:22-66:20.

ii. Ameren Agrees It Can Finance the Requested Relief

422. Ameren can afford to finance the pollution controls at issue in this case. Kahal Test., Tr. Vol. 2-A, 53:11-54:12. Ameren presented no evidence to the contrary. Instead, Ameren's lead counsel stated at trial that Ameren "can afford anything this Court orders." Ameren Closing Argument, Tr. Vol. 6, 34:12-13.

423. The annual capital cost of installing FGD at Rush Island is only about half as large as Ameren's average annual dividend in recent years. Installing FGD at both Rush Island units would result in about $200 million per year in capital costs over the four-year construction period plus an estimated $27 to $38 million in operating and maintenance costs once the FGD systems begin operating. Kahal Test., Tr. Vol. 2-A, 71:5-12; Callahan Dep., Nov. 8, 2017, Tr. 195:5-12. Ameren's average dividend payment to its parent company is about $415 million per

year and its operating cash flow is more than $1 billion. See Rule 1006 Summary of FERC Form 1s (Pl. Ex. 1388, summarizing Pl. Ex. 1331 through 1336). Compared to these metrics, the wet FGD operating costs "are a very small number." Kahal Test., Tr. Vol. 2-A, 71:5-22.

424. Plaintiffs also presented evidence of several pollution control options at Labadie, including FGD and DSI to offset the excess emissions from Rush Island. Dr. Staudt estimated that the capital cost of FGD at two Labadie units would be $465 million with $29 million in annual operating costs. Staudt Test., Tr. Vol. 1-B, 105:12-106:24; see also Kahal Test., Tr. Vol. 2-A, 71:5-22. Dr. Staudt also estimated that installing DSI at all four Labadie units would mean a capital cost of $55 million and annual operating costs of $53 million. Staudt Test., Tr. Vol. 1-B, 104:21-105:11.

425. These costs are a small fraction of Ameren's $6.3 billion capital plan for the next five years and its $1.1 billion annual operating cash flow. Kahal Test., Tr. Vol. 2-A, 64:13-65:21; Rule 1006 Summary of FERC Form 1s (Pl. Ex. 1388, summarizing Pl. Ex. 1331-1336).

426. The EPA's expert Matthew Kahal testified that Ameren could afford to implement any of the mitigation options identified by Dr. Staudt for Labadie or Rush Island. Kahal Test., Tr. Vol. 2-A, 71:23-72:1, 78:10-17. This testimony was not challenged on cross or by any Ameren witnesses.

iii. The Projected Ratepayer Impact of the Requested Relief Is Less Than Ameren's Yearly Rate Increases

427. As of 2016, Ameren Missouri had 1.2 million customers. Celebi Test., Tr. Vol. 5-B, 26:16-20.

428. Ameren is a regulated monopoly. Kahal Test., Tr. Vol. 2-A, 51:12-19. When Ameren incurs costs that are not being recovered by its rates, it can seek a rate increase from the Missouri Public Service Commission. Kahal Test., Tr. Vol. 2-A, 51:12-52:4. The Public Service

Commission reviews the request and determines whether any rate increase is appropriate to allow Ameren to recover its costs. Kahal Test., Tr. Vol. 2-A, 51:12-52:4.

429. In the ratemaking process, Ameren receives a profit (known as the rate of return) on capital spending. Kahal Test., Tr. Vol. 2-A, 68:24-69:19; Celebi Test., Tr. Vol. 5-B, 42:24-43:8 (noting inclusion of rate of return). The rate of return is set by the Missouri Public Service Commission. Kahal Test., Tr. Vol. 2-A, 68:24-69:24. In recent years, the rate of return for Missouri utilities has been about 9.5%. Kahal Test., Tr. Vol. 2-A, 68:24-69:24.

430. Expert witnesses for both parties calculated how much installing pollution controls could affect the rates paid by Ameren customers if Ameren seeks to recover those costs from ratepayers. See Kahal Test., Tr. Vol. 2-A, 72:21-25; Celebi Test., Tr. Vol. 5-B, 66:11-19.

431. Ameren could choose not to recover those costs from its ratepayers. The Public Service Commission could also elect not to allow full cost recovery, especially if it determines the costs are the result of Ameren's decision not to comply with the Clean Air Act. Kahal Test., Tr. Vol. 2-A, 77:7-78:6; Celebi Test., Tr. Vol. 5-B, 66:11-67:19.

432. The EPA's expert Matthew Kahal testified that wet FGD at Rush Island would result in an increase in customer rates of about 2.8% over 20 years (assuming the Missouri Public Service Commission allows full rate recovery). Kahal Test., Tr. Vol. 2-A, 74:22-75:1. Ameren's expert Dr. Metin Celebi found that FGD at Rush Island would increase customer rates by 2.4%.[11] Kahal Test., Tr. Vol. 2-A, 80:23-82:4.

433. For DSI at the Labadie station, Kahal testified that the controls could result in an increase to customer rates of between 0% and 2% over 14 years. Kahal Test., Tr. Vol. 2-A, 77:7-

[11] Despite his expert opinions, Dr. Celebi did not testify about the individual percentage increases due to the scrubbers at Rush Island and DSI at Labadie. Kahal read his expert disclosure report and testified about the contents of that report. Celebi Test., Tr. Vol. 5-B, 64:21-65:9.

79:12. Dr. Celebi calculated a 1.4% rate increase if Ameren sought to recover the costs of implementing DSI from consumers. Kahal Test., Tr. Vol. 2-A, 81:25-82:1.

434. Overall, Kahal estimated that installing FGD at both Rush Island units and DSI at all four Labadie units would increase customer rates from 2.8 to 4.8%, while Dr. Celebi estimated that those controls would increase rates by 3.8%. Kahal Test., Tr. Vol. 2-A, 80:23-82:4; Celebi Test., Tr. Vol. 5-B, 64:21-65:9.

435. Rate increases in that range are in keeping with Ameren's typical rate changes from year to year. Dr. Celebi testified that Ameren's rates increased 5.4% from 2016 to 2017, and that Ameren's 2017 Integrated Resource Plan predicted that rates would increase 2.9% per year over the period from 2018 to 2037. Celebi Test., Tr. Vol. 5-B, 65:15-66:10.

436. The rates Ameren charges its customers are well below the national average. In 2016, Ameren's rates were 14% lower than the national average. Kahal Test., Tr. Vol. 2-A, 72:4-20; Celebi Test., Tr. Vol. 5-B, 57:15-24. Even with the rate increases estimated by Kahal or Dr. Celebi, Ameren customers' rates would still be around 10% lower than the national average. Kahal Test., Tr. Vol. 2-A, 82:6-15. Ameren's rates are also at or below the median rates for utilities in both Missouri and in surrounding states. Celebi Test., Tr. Vol. 5-B, 82:2-83:14.

437. In December 2017, a change in the tax laws reduced Ameren's income tax rate, resulting in a 6.1% decrease in customer rates. Kahal Test., Tr. Vol. 2-A, 82:16-83:2, 83:15-23; Ameren Presentation, "Building a Brighter Energy Future," Feb. 14, 2019 (Pl. Ex. 1337) at USTREXR0002371; Celebi Test., Tr. Vol. 5-B, 84:2-8. The potential rate increases predicted by Dr. Celebi and Kahal are smaller than the rate decrease resulting from the tax law changes. Celebi Test., Tr. Vol. 5-B, 84:2-16.

iv. Ameren's Average Estimates of Rate Increase Are Misleading

438. At trial, and in its proposed findings of fact, Ameren asserted that the costs of installing FGD at Rush Island and DSI at Labadie would be disproportionate to the harm of its excess emissions.

439. Ameren's expert, Dr. Celebi, conducted rate impact analyses for controls that might be installed on Rush Island and Labadie. Celebi Test., Tr. 5-B 62:3-63:10. He analyzed that the annual average total cost for wet FGD at Rush Island and DSI at Labadie would be $196 million per year, for a total of $4.1 billion over the entire period. He then estimated a per customer cost of $3,422.

440. Dr. Celebi's per customer estimates are unrepresentative of the typical customer's experience, because he does not differentiate based on residential, commercial, or industrial users. A three-bedroom home does not use the same amount of electricity, nor pay the same electricity bill, as a department store or an aluminum smelter. When residential, commercial, and industrial ratepayers are lumped together, the larger sources have a disproportionate influence on the total electricity use and the average cost of electricity, per customer. Ameren could have accommodated these differences by differentiating residential, commercial, and industrial ratepayers or, at the very least, calculating a median value, but it did not.

441. Additionally, in part, Dr. Celebi presented his results as an average per-customer cost over twenty years of operation. When presenting these results, Dr. Celebi often failed to indicate whether his estimates were in 2016 dollars, 2025 dollars, or some other years' dollars. See, e.g., id. at 62:19-23, 63:8-10. Because the value of money changes over time due to, for example, inflation, Dr. Celebi's failure to provide the reference year makes his testimony more ambiguous.

442. I find that Ameren's average per customer rate increase estimates in dollars do not reflect the typical customer's experience.

CONCLUSIONS OF LAW

As I noted in the introduction to this opinion, my conclusions of law from the liability phase significantly influence my findings of fact and conclusions of law in the remedies phase. In the liability phase, I found that Ameren violated the Clean Air Act by making major modifications that increased SO_2 emissions at Rush Island without obtaining the proper Prevention of Significant Deterioration (PSD) program permit and installing the Best Available Control Technology (BACT). Sulfur dioxide (SO_2) has been regulated under the Clean Air Act for 50 years. Once emitted, most SO_2 converts into fine particulate matter ($PM_{2.5}$), a pollutant known to cause increased risks of premature mortality, heart and lung disease, and other adverse health effects. Modern pollution controls can dramatically reduce SO_2 emissions, saving lives in the process.

While the rest of the electric industry made great strides in reducing SO_2 pollution, Rush Island lagged behind, rising steadily in the ranks to become one of the country's largest sources of SO_2. That pollution contributed to $PM_{2.5}$ levels across much of the Eastern United States, a range extending from Texas and Minnesota to the Atlantic Ocean. The emissions were allowed because Rush Island was grandfathered into the Clean Air Act Amendments of 1977. Rush Island lost its grandfathered status when Ameren conducted major modifications of the plant, redesigning and rebuilding essential parts of its two boilers. These major modifications increased Rush Island's emissions, based on Ameren's own operating data, and Ameren should have expected the increase.

Now, in the remedies phase, the EPA seeks to bring Ameren's Rush Island facility into compliance with the law and to remediate the harm from the more than 162,000 tons—and counting—in excess SO_2 that Rush Island emitted after Ameren failed to obtain a PSD permit there. Specifically, the EPA seeks an order requiring Ameren to (1) apply for a PSD permit at Rush Island, (2) propose wet FGD as the BACT in its Rush Island permit application, (3) meet an emissions limitation of 0.05 lb SO_2/mmBTU, and (4) reduce emissions at Labadie on a ton-per-ton basis to remedy the more than 162,000 excess SO_2 emissions released by Rush Island.

Once Ameren installs BACT at Rush Island, it should capture nearly 99% of SO_2 emissions there. By that time, Rush Island will have emitted nearly 275,000 tons of excess pollution, impacting $PM_{2.5}$ concentrations across the Eastern United States. Ameren must reduce pollution released into those areas. Accordingly, the EPA presented evidence on control measures that Ameren could implement at its nearby Labadie Energy Center in order to remediate the excess emissions. The pollution from that facility affects the same communities—and to the same degree—as Rush Island's pollution on a ton-per-ton basis. Therefore, efforts to reduce Labadie's pollution would be closely tailored to remedy the harm created by Rush Island's excess emissions.

Ameren presents seven arguments against the relief the EPA requests at Rush Island and Labadie. First, Ameren argues that it should be allowed to obtain a minor permit, instead of the statutorily-required PSD permit. According to Ameren, if it had known better, it would have pursued other, less expensive compliance options than PSD permitting. I need not entertain this hypothetical or speculate what might have been. Ameren made a major modification that lengthened the life of, and increased emissions at Rush Island. It cannot now undue these modifications or regain its grandfathered status. Ameren must obtain a PSD permit.

Second, Ameren argues that the Missouri Department of Natural Resources (MDNR) should determine the Best Available Control Technology for Rush Island. I have already discussed this argument in my order denying Ameren's motion for summary judgment. United States v. Ameren Missouri, 372 F. Supp. 3d 868, 873 (E.D. Mo. 2019). At summary judgment, Ameren did not demonstrate, as a matter of law, that I do not have authority to determine what Ameren must propose as BACT. Id. In this case, I am not issuing a permit, replacing the notice and comment process, or otherwise altering the nature of the PSD permitting process. Consistent with my authority to restrain violations and "require compliance" with the Clean Air Act, the relief in this case merely orders Ameren to submit an application that proposes wet FGD as BACT. 42 U.S.C. § 7413(b)(3).

Third, Ameren argues that, if I do determine BACT, I should order the installation of the least effective control technology, DSI without a fabric filter. DSI is about half as effective as scrubber technology, and it has never been accepted as BACT for a coal-fired electric generating unit. Ameren would like the BACT analysis to settle on the "least expensive option" capable only of "moderate" emissions reductions. Deciding BACT based primarily on a cost-benefit analysis would itself be in conflict with the Clean Air Act, which requires emissions limits "based on the maximum degree of reduction" available. 42 U.S.C. § 7479(3).

Fourth, Ameren argues that the eBay factors do not support the EPA's requested relief. Based on my analysis of the eBay factors, I conclude that the EPA's requested remedy is narrowly tailored to the harm suffered, addresses irreparable injury that could not be compensated through legal remedies, serves the public interest, and is warranted when considering the balance of hardships in this case.

Fifth, Ameren argues that any relief ordered at Labadie would constitute a penalty waived by the EPA before the liability trial. The installation of DSI at Labadie is an equitable remedy that is narrowly tailored and does not penalize Ameren. DSI's capital costs are minimal, and when Ameren has fully accounted for Rush Island's excess emissions, it may choose to discontinue use of its DSI system. Ameren may also choose to install a more capital-intensive technology if it decides to do so, but I will not require that Ameren does so.

Sixth, Ameren argues that Sierra Club v. Otter Tail Power Co., an Eighth Circuit case concerning the statute of limitations for suing to remedy a PSD violation, essentially gives Ameren immunity for all the excess pollution it released after failing to obtain a PSD permit for Rush Island. See 615 F.3d 1008, 1011 (8th Cir. 2010). Ameren's reliance on Otter Tail is misplaced. The statute of limitations did not expire before the United States commenced this case against Ameren, and I do not find in this case that Ameren's operation without a permit is an ongoing violation. The "excess emissions" or "excess pollution" references throughout this opinion describe the pollution that Rush Island has emitted in excess of what it would have released had Ameren installed BACT as required by the PSD program.

Finally, Ameren argues that it should be able to surrender allowances from a distinct regulatory program that could otherwise be traded to plants in Wisconsin, Michigan, New York, Virginia, or North Carolina. Ameren presented no evidence at trial to demonstrate that surrendering allowances would actually decrease emissions and $PM_{2.5}$ concentrations in the communities affected by Rush Island. Therefore, this proposal is not narrowly tailored to remedy the harm suffered.

Pollution from Rush Island is regulated for a reason, and Rush Island remains one of the largest sources of SO_2 in the country. Applied to the record evidence, the broad scientific consensus dictates the conclusion that the $PM_{2.5}$ that resulted from the excess SO_2 pollution at Rush Island has harmed—and continues to inflict harm on—the public in the form of premature mortality and myriad other adverse health effects.

To remedy its violations, Ameren must obtain the necessary PSD permit for the facility, implement the best available control technology, and undertake emissions reductions at its Labadie plant commensurate with Rush Island's volume of excess pollution.

I. THE CLEAN AIR ACT REQUIRES THE BEST AVAILABLE CONTROL TECHNOLOGY FOR MODIFIED POWER PLANTS IN PSD AREAS

The 1970 Clean Air Act (CAA) was designed in part to "speed up, expand, and intensify the war against air pollution in the United States with a view to assuring that the air we breathe throughout the Nation is wholesome once again." H.R. Rep. No. 91-1146, at 1 (1970), reprinted in 1970 U.S.C.C.A.N. 5356, 5356; Wis. Elec. Power Co. v. Reilly, 893 F.2d 901, 909 (7th Cir. 1990) (quoting legislative history). One primary purpose of the statute is "to protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." 42 U.S.C. § 7401(b)(1).

Not satisfied with the results achieved under the 1970 statute, Congress added the New Source Review program to the Act in 1977 to ensure that additional requirements were imposed on new and modified sources of air pollution. New York v. EPA, 413 F.3d 3, 10 (D.C. Cir. 2005). The PSD component of NSR was "aimed at giving added protection to air quality" while fostering economic growth in a manner consistent with preservation of existing clean air resources. Envtl. Def. v. Duke Energy Corp., 549 U.S. 561, 567 (2007) (noting that "NSPS . . . did too little to "achiev[e] the ambitious goals of the 1970 Amendments"); 42 U.S.C. § 7470. In areas that already meet the NAAQS, the 1977 amendments required BACT on new and modified sources that would otherwise increase pollution. Hawaiian Elec. Co. v. EPA, 723 F.2d 1440, 1447 (9th Cir. 1984) ("Congress found that it was important to reduce pollution levels below those mandated by the standards and that the best means of doing so was to require the installation of BACT on all sources which would otherwise increase pollution."). Pursuant to the PSD program, modification of a major source is prohibited unless, among other requirements:

> (1) a permit has been issued for such proposed facility in accordance with this part setting forth emission limitations for such facility . . .
>
> (3) the owner or operator of such facility demonstrates . . . that emissions from construction or operation of such facility will not cause, or contribute to, air pollution in excess of [among other things] any . . . national ambient air quality standard [NAAQS] in any air quality control region . . . [AND]
>
> (4) the proposed facility is subject to the best available control technology for each pollutant subject to regulation . . . .

42 U.S.C. § 7475(a); see also id. §7479(2)(C) (explaining that modification of a source constitutes "construction" with respect to the requirement to obtain a permit). Among the other five requirements listed in this section, modification of a source is prohibited unless the owner (1) obtains a PSD permit, (2) installs BACT at the facility, and (3) demonstrates that, even when BACT is installed, permitted emissions from that facility will not violate the NAAQS.

II. THE EBAY STANDARD GOVERNS INJUNCTIVE RELIEF

The liability phase of this case established that Ameren violated the Clean Air Act when it modified Rush Island "without obtaining the required permits [and] installing best-available pollution control technology." United States v. Ameren Missouri, 229 F. Supp. 3d 906, 914 (E.D. Mo. 2017). The question presented now is what to do about Ameren's violations.

Section 113(b) of the Clean Air Act authorizes district courts to "restrain such violation[s], to require compliance, . . . and to award any other appropriate relief" where a source owner or operator "has violated or is in violation of" statutory or regulatory prohibitions. 42 U.S.C. § 7413(b). Courts have jurisdiction to craft "complete relief in light of the statutory purposes;" that jurisdiction is "not to be denied or limited in the absence of a clear and valid legislative command." Mitchell v. Robert De Mario Jewelry, 361 U.S. 288, 291-92 (1960); see also Weinberger v. Romero-Barcelo, 456 U.S. 305, 313 (1982) (courts enjoy the entire range of their historic equitable powers to craft relief unless Congress placed limitations on those powers "in so many words or by necessary and inescapable inference").

When considering injunctive relief, a court evaluates whether

> (1) [the plaintiff] has suffered irreparable injury; (2) . . . remedies available at law, such as monetary damages, are inadequate to compensate for the injury; (3) . . . considering the balance of hardships between the plaintiff and defendant, a remedy in equity is warranted; and (4) . . . the public interest would not be disserved by a permanent injunction.

eBay Inc. v. MercExchange, L.L.C.: 547 U.S. 388, 391 (2006).

In addition to the eBay factors, several principles guide the crafting of remedies in a case like this. First, the ordered relief must enforce the statutes created by Congress:

> If Congress has prohibited certain behavior, I do not have discretion to determine "whether enforcement is preferable to no enforcement at all." United States v. Oakland Cannabis Buyers' Coop., 532 U.S. 483, 497 (2001). In these circumstances, my discretion is limited to evaluating how equitable considerations "are affected by the selection of an injunction over other enforcement mechanisms." Id.

Ameren Missouri, 372 F. Supp. 3d 868, 877.

Courts cannot "override Congress' policy choice, articulated in a statute, as to what behavior should be prohibited." Oakland Cannabis Buyers' Coop., 532 U.S. 483, 497 (2001). A remedy should grant "complete" relief to fulfill the statute's purposes. C.f. Mitchell, 361 U.S. at 296 (noting "little room for . . . discretion not to order" equitable reimbursement and that a court either proceeding under general equity powers or the Fair Labor Standards Act has authority to order "legal relief[] necessary to do complete justice between the parties.").

Next, "[a]n injunction must be tailored to remedy specific harm shown." Rogers v. Scurr, 676 F.2d 1211, 1214 (8th Cir. 1982). The injunction should be "no more burdensome to the defendant than necessary to provide complete relief to the plaintiffs." Califano v. Yamasaki, 442 U.S. 682, 702 (1979). Where, as here, the United States seeks to enforce a public interest statute, a court places "extraordinary weight . . . upon the public interests" because the "suit involve[es] more than a mere private dispute." United States v. Marine Shale Processors, 81 F.3d 1329, 1359 (5th Cir. 1996) (citing Virginian Ry. v. Sys. Fed'n No. 40, AFL, 300 U.S. 515, 552 (1937)).

Additionally, where an injunction will remediate environmental harm, courts have considered "(1) whether the proposal 'would confer maximum environmental benefit,' (2) whether it is 'achievable as a practical matter,' and (3) whether it bears 'an equitable relationship to the degree and kind of wrong it is intended to remedy.'" United States v. Deaton, 332 F.3d 698, 714 (4th Cir. 2003) (quoting a standard articulated in United States v. Cumberland Farms of Conn., Inc., 826 F.2d 1151, 1164 (1st Cir.1987) and echoed in United States v. Sexton Cove Estates, Inc., 526 F.2d 1293, 1301 (5th Cir. 1976)).

III. AMEREN MUST MAKE RUSH ISLAND COMPLIANT BY OBTAINING A PSD PERMIT WITH EMISSIONS LIMITATIONS BASED ON WET FGD

The PSD program's BACT requirement is a "technology-forcing" standard that is meant to "stimulate the advancement of pollution control technology," a central goal of the 1977 Amendments. Wis. Elec. Power Co. v. Reilly, 893 F.2d 901, 909 (7th Cir. 1990) ("The legislative history suggests and courts have recognized that in passing the Clean Air Act Amendments, Congress intended to stimulate the advancement of pollution control technology."). The BACT requirement codified at 42 U.S.C § 7475(a)(4) is the cornerstone of the PSD program. It advances both Congress's public protection and technology-driving aims. Accordingly, my remedies determination is based on a careful examination of what constitutes BACT for Rush Island.

a. BACT Sets Emissions Limitations Based on the Maximum Degree of Pollution Reduction Achievable

As defined by Congress in the Clean Air Act, BACT is an "emissions limitation based on the maximum degree of reduction of each pollutant subject to regulation." 42 U.S.C. § 7479(3); see also Sierra Club v. Otter Tail Power Co., 615 F.3d 1008, 1011 (8th Cir. 2010). Determining BACT is a case-by-case endeavor that incorporates consideration of "energy, environmental, and economic impacts and other costs." 42 U.S.C. § 7479(3); 40 C.F.R. § 52.21(b)(12) (further defining BACT). While BACT is determined on a case-by-case basis, "the permitting authority's analysis must in all circumstances give effect to the purpose of BACT, which is to promote the use of the best technologies as widely as possible." In re Gen. Motors, Inc., 10 E.A.D. 360, 364 (E.A.B. 2002).[12] As noted by the Ninth Circuit, BACT requires use of "the most current, state-of-the-art pollution controls" available. Grand Canyon Trust v. Tucson Elec. Power Co., 391 F.3d 979, 983 (9th Cir. 2004). "[F]ailure to consider all available control alternatives in a BACT analysis constitutes clear error," unless the control alternative would require the evaluator to "redefine the source." Helping Hand Tools v. U.S. Envtl. Prot. Agency, 848 F.3d 1185, 1194 (9th Cir. 2016).

In practice, BACT follows a "top-down" approach used by the EPA and MDNR to ensure that the most effective technology is actually selected. FOF ¶ 77. The Supreme Court has explained the top-down process as providing:

> that all available control technologies be ranked in descending order of control effectiveness. The PSD applicant first examines the most stringent—or "top"—alternative. That alternative is established as BACT unless the applicant demonstrates, and the permitting authority in its informed judgement agrees, that technical considerations, or energy, environmental, or economic impacts justify a

[12]The Environmental Appeals Board (EAB) is the final decision-maker on administrative appeals arising under environmental statutes administered by EPA, including the Clean Air Act. See Sierra Club v. Wisconsin DNR, 787 N.W.2d 855, 867 n.6 (Wis. App. 2010).

conclusion that the most stringent technology is not "achievable" in that case.

Alaska, Dep't of Envtl. Conservation v. EPA, 540 U.S. 461, 475-76 (2004) (quoting EPA's Draft New Source Review Workshop Manual, Oct. 1990 [Pl. Ex. 1190] ("NSR Manual") at B2); see also Chipperfield v. Mo. Air Conserv. Comm'n, 229 S.W.3d 226, 239-40 (Mo. Ct. App. 2007). "So fixed is the focus on identifying the 'top', or most stringent alternative, that the analysis presumptively ends there. . . ." In re Northern Mich. Univ. Ripley Heating Plant, 14 E.A.D. 283, 294 (E.A.B. 2009). The top option constitutes BACT unless something unique about the plant prevents it from using the same "top" controls.[13] Id.

The top-down method consists of five steps: (1) identify all applicable control technologies; (2) remove any technically infeasible controls; (3) rank feasible controls by effectiveness; (4) determine if the most effective option is achievable considering the energy, environmental and economic impacts; and (5) select a BACT emissions limitation. Pl. Ex. 1190 [NSR Manual] at AM-REM-00544123-MDNR; see also FOF ¶ 74.

b. Industry Experience and Ameren's Own Analyses Show FGD Technology Is Economically and Technically Feasible at Rush Island

The parties do not dispute the outcome of the first three steps in the BACT analysis.[14] As the parties agree, there are four available control technologies, all of which are technically feasible for Rush Island. FOF ¶¶ 180-81. As ranked in descending order of effectiveness, these

[13] The Ninth Circuit has stated that "the burden of proof [is] on the 'applicant to justify why the proposed source is unable to apply the best technology available.'" Citizens for Clean Air v. U.S. EPA, 959 F.2d 839, 845 (9th Cir. 1992) (quoting NSR Manual). To meet that burden, the source must "demonstrate that the technology is technically or economically infeasible." Id.; see also FOF ¶ 76. If the "top" control is eliminated in Step 4, the next most effective technology is considered, and so on, until the most effective remaining option is selected as BACT. Alaska, Dep't of Envtl. Conservation v. U.S. E.P.A., 298 F.3d 814, 822 (9th Cir. 2002), aff'd sub nom. Alaska Dep't of Envtl. Conservation v. E.P.A., 540 U.S. 461 (2004).

[14] While Dr. Staudt included natural gas conversion in his BACT analysis, Dr. Staudt and the EPA agree with Ameren that natural gas conversion is not an appropriate technology for consideration. Tr. Vol. 2-A, 21:6-17, 22:23-23:18.

are:

(1) Wet FGD technology (sometimes called a "wet scrubber")
(2) Dry FGD technology (sometimes called a "dry scrubber")
(3) DSI implemented in parallel with a fabric filter
(4) DSI implemented as a stand-alone control

FOF ¶ 113. Based on these options, the next question is whether the "top" control—wet FGD technology—should be eliminated as not "achievable" after an evaluation of its energy, environmental, or economic impacts. The great weight of evidence presented at trial shows wet FGD is achievable.

Over the last forty years, about 200,000 megawatts of coal-fired electric generating capacity have been fitted with FGD technology. See Figure 1; FOF ¶ 14. FGD scrubbers are currently installed on hundreds of coal-fired electric generating units, including about 84% of the coal-fired electric generating capacity in the United States. See FOF ¶ 16. While other plants adopted FGD technology en masse, Rush Island has lagged behind. In 2007, the Rush Island plant ranked 154th in the nation in SO_2 emissions. Ten years later, it was the tenth-most SO_2 polluting plant in the nation. FOF ¶ 18.

Ameren suggested at trial that FGD technology is more appropriate for new plants as opposed to existing plants. Ameren's suggestion is contradicted by the evidence. Of the more than 170,000 MW of coal-fired electric generating capacity now controlled with wet FGD, about 120,000 MW are retrofitted units. See Figure 2; FOF ¶ 17. About three quarters (90,000 MW) of that retrofitted generating capacity has been installed between 2005 and 2015. Figure 2, FOF ¶ 17.

The emissions reductions achievable by FGD do not depend on whether the technology is built with new plant or retrofitted on an existing one. FOF ¶ 162. The prevalence of FGD at both new and existing units indicates that FGD is achievable at Rush Island. As the EPA noted in the NSR Manual: "In the absence of unusual circumstance, the presumption is that sources within the same source category are similar in nature, and that cost and other impacts that have been borne by one source of a given source category may be borne by another source of the same source category." Pl. Ex. 1190 [NSR Manual] at AM-REM-00544146-MDNR; FOF ¶ 79.

Ameren has provided no evidence of an unusual circumstance at Rush Island that is relevant to the BACT determination. FOF ¶ 219. Ameren's BACT expert Colin Campbell testified that Rush Island's status as an existing plant not otherwise required to install BACT constitutes an unusual circumstance. Id. However, as shown in Figure 2, more FGD-controlled generating capacity exists at retrofitted, existing plants than at new plants. See also FOF ¶ 17.

Based on its own studies, Ameren has no evidentiary basis to rule out FGD in Step 4. At trial, Ameren only briefly mentioned energy or environmental impacts of wet FGD. Specifically, Ameren's expert Snell discussed the auxiliary power consumed by FGD systems, which reduced power output to the grid. FOF ¶ 190. Snell also mentioned wastewater costs and mercury controls. FOF ¶ 192. However, Ameren did not explain how these energy and environmental impacts made wet FGD unachievable. Nor did Ameren suggest that these environmental impacts are different from the kinds of impacts experienced at other pulverized coal-fired power plants. See NSR Manual (Pl. Ex. 1190), at AM-REM-00544146-MDNR; Staudt Test. Vol. 1-B, at 63:14-64:6.

Around the time Ameren was rebuilding Rush Island Unit 2, Ameren was also studying how and whether FGD might be installed at Rush Island. Ameren's engineering studies, undertaken over a period of years at a cost of about $8 million, concluded that wet FGD was both economically and technically feasible at Rush Island. The engineering studies determined that wet FGD was the best option for the plant to control SO_2. FOF ¶ 29-31.

The economic impacts of implementing wet FGD do not render the technology unachievable. The EPA's expert Dr. James Staudt estimated, based on Ameren's engineering studies, that the direct capital costs of implementing wet FGD technology at Rush Island would be $582 million in 2016 dollars. FOF ¶ 124. That total translates to an "average" cost-effectiveness of $3,854 per ton of SO_2 removed. FOF ¶ 225. Even according to Campbell's testimony, this value is well below MDNR's threshold for acceptable average cost effectiveness. Id., n.7. Ameren did not present any evidence or testimony demonstrating that $3,854 per ton was too high or out-of-line with the average cost effectiveness incurred by other electric utilities with FGD.[15] Id. In fact, Ameren's own engineering study concluded that the cost of wet FGD at Rush Island would be consistent with industry benchmarks. FOF ¶ 226. MDNR and other agencies have concluded that both wet and dry FGD are economically acceptable for pulverized coal-fired power plants. For all these reasons, there is no basis for excluding FGD technology from the BACT assessment at Step 4, whether based on energy, environmental, economic impacts or other costs.

The last step of the BACT analysis (Step 5) involves determining an achievable emission rate based on the chosen wet FGD technology. As with Steps 1 through 3, there is no material dispute about what the achievable emission rates would be for wet FGD at Rush Island. FOF ¶¶ 229-31. Wet FGD has been widely adopted over the years, and its performance continues to improve. Wet FGD's emissions rates have steadily fallen. See Figure 3; FOF ¶ 221. By 2016, the top 50% of FGD-equipped plants averaged a 12-month emission rate of 0.058 lb/mmBTU, and the top 20% of FGD-equipped plants averaged a 12-month emission rate

[15] Ameren's BACT expert Campbell testified that he reached no conclusions on whether the average cost-effectiveness of wet FGD would be considered unacceptable in this case. FOF ¶ 225.

of 0.024 lb/mmBTU. See Id. These numbers have fallen by more than 20% between 2008 and 2011 and by another 20% or more between 2011 and 2016. See Figure 3. Ameren's engineering studies echo the broader trend of increasing effectiveness. In the first two phases of its study, Ameren identified its Rush Island FGD design-rate as 0.06 lb/mmBTU. FOF ¶ 33. In late 2010, Ameren lowered the target design-rate of its planned scrubbers to 0.04 lb/mmBTU. FOF ¶ 52.

Based on a reasonable compliance margin, Dr. Staudt testified that BACT for the Rush Island units at the time of the illegal modification would have been 0.08 lb/mmBTU for Unit 1 and 0.06 lb/mmBTU for Unit 2, both on a 30-day rolling average. FOF ¶ 202-03. The record showed these rates were reasonable given the technological capabilities at those times and consistent with the nearly two-dozen contemporaneous BACT determinations at similar facilities. FOF ¶ 100-105. Ameren presented no evidence at trial to dispute that these emissions rates were achievable. Ameren's expert Campbell even testified that 0.05 lb/mmBTU was achievable. FOF ¶ 231. If applied today, the evidence shows that wet FGD could meet a 30-day rolling-average emissions limitation no less stringent than 0.05 lb/mmBTU. FOF ¶ 233.

c. Ameren's Arguments Against PSD Permitting Mischaracterize Case Law, Ameren's Permitting Options, and the Nature of BACT

Ameren presents three arguments to avoid permitting under the PSD program. First, Ameren argues it need not install BACT because it would have sought less costly ways avoid PSD permitting had it known its major modifications would trigger PSD obligations. Second, Ameren argues that I should not make any BACT determination as part of my ruling, because that decision is appropriately left to the permitting authority MDNR. Third, Ameren argues that DSI—a far less-effective (and less costly) control technology than wet FGD—should be considered BACT at Rush Island. None of these three arguments is persuasive.

i. As a Major Stationary Source That Performed Major Modifications, Ameren Must Obtain a PSD Permit, Not a "Minor Permit"

Ameren argues that had it known its modifications would trigger PSD obligations, it might have sought a synthetic minor permit. With a minor permit, a source can limit its emissions below a threshold that would trigger PSD requirements. FOF ¶ 401. At trial, Ameren's expert Campbell testified in support of this theory. See Campbell Test., Tr. Vol. 4-A, 49:9-24, 80:20-83:7.

This argument is not supported by law. First, it requires speculation about what actions Ameren might have taken, rather than an examination of what actions Ameren actually took. By statute and regulation, once Ameren undertook major modifications, Ameren was required to comply with BACT. Rush Island Units 1 and 2 are modified facilities; they cannot obtain "minor" permits for their "major modifications." To find otherwise would require me to ignore the statue and regulations. See 42 U.S.C. § 7475(a)(1), (4); 40 C.F.R. § 52.21(j)(3) (any "major modification shall apply best available control technology"); 40 C.F.R. § 52.21(r)(1) (any source that modifies without permit approval is subject to enforcement); United States v. Ohio Edison Co., 276 F. Supp.2d 829, 850 (S.D. Ohio 2003) (a "modification triggers permitting requirements under the CAA as well as the duty to install pollution controls."). The statute and the regulations set forth "without exception" that all major modifications are subject to CAA requirements. Oregon Envtl. Council v. Oregon Dep't of Envtl. Quality, No. 91-13-FR, 1992 WL 252123, *22-23 (D. Or. Sept. 24, 1992).

NSR requirements apply to all major modifications, including those illegally constructed. The United States District Court for the District of Oregon explained:

> The [State Implementation Plan] does not exempt a source of pollutants from the new source review requirements simply because the 'major modification' was constructed prior to the issuance of a requisite permit. Moreover, if such an

> exemption were allowed, a windfall would be created for those major new or modified sources that disregarded the SIP-mandated requirements.

Oregon Envtl. Council v. Oregon Dep't of Envtl. Quality, 1992 WL 252123, at *23. Other district and appellate courts have made similar rulings. See, e.g., United States v. Midwest Generation, 720 F.3d 644, 646 (7th Cir. 2013) (modifying plant without a permit is a "risky strategy" because, if challenged, the plant may need "to undertake a further round of modifications to get the permit"); United States v Cinergy Corp., 618 F.Supp.2d 942, 961-62, 965 (S.D. Ind. 2009) (holding that the only compliance alternative "was to apply for the necessary permits or shut down the units"); United States v. Louisiana-Pacific Corp., 682 F. Supp. 1141, 1166 (D. Colo. 1988) ("requirements of the [PSD] program have been met only upon receipt of PSD permits").

Ameren "must suffer the consequences of the action it chose to take—even if these, or some of these, might have been avoided had it taken a different course of action." United States v. Westvaco Corp., 2015 WL 10323214, at *8 (Md. Feb. 26, 2015). Ameren's "initial failure to comply with the requirements of the Clean Air Act" should not "now inure to its benefit." New York v. Niagara Mohawk Power Corp., 263 F. Supp. 2d 650, 663 (W.D.N.Y. 2003). It cannot now obtain a minor permit as a means of avoiding PSD permitting. Ameren must come into compliance with the law by obtaining a PSD permit and meeting BACT emissions limitations.

Even if Ameren's argument that it should be allowed to apply for a minor permit had merit, it is unsupported by the evidence. The facts that run contrary to Ameren's assertion that it would have applied for a minor permit include:

- The PSD standards were clear long before Ameren undertook the Rush Island modifications. FOF ¶¶ 393-394.
- Ameren did not present any company witness or document suggesting the pursuit of

a synthetic minor permit was a realistic possibility. FOF ¶ 406.

- Ameren's director of corporate analysis testified that he was not aware of any instance where Ameren voluntarily restricted the operations of Rush Island. FOF ¶ 403, and
- Restricting Rush Island's operations would have been inconsistent with the purposes of the modifications. FOF ¶ 404.

Ameren did not present evidence of any baseload power plant operator restricting a facility's operations in the manner Ameren now claims in hindsight it would have. Because they are the cheapest generating sources and so reliably dispatched, utilities like Ameren hesitate to put operating or fuel limitations on their baseload plants. Cinergy, 618 F. Supp. 2d 942, 947 (S.D. Ind. 2009) (quoting testimony of Cinergy witness). Ameren's post hoc PSD-avoidance argument runs contrary to the facts in this case and is not supported by the law.

ii. None of Ameren's Arguments or Evidence Prevent Me From Ordering Ameren to Propose Wet FGD as BACT

In its proposed conclusions of law, Ameren renews its argument from summary judgment that I cannot and should not make a BACT determination. According to Ameren, I should leave any BACT determination to the permitting authority MDNR, respecting its notice and comment process. As I noted in my order denying summary judgment, Plaintiffs have not asked me to write and issue a permit. Ameren Missouri, 372 F. Supp. 3d 868, 873, Instead, Plaintiffs request that I order Ameren to propose wet FGD as BACT in the permit application Ameren submits to MDNR. This requested relief does not violate any of the principles raised by Ameren in its motion for summary judgment. Id. Additionally, the cases Ameren previously cited in its motion for summary judgment do not support its argument that I cannot order Ameren to propose wet FGD as BACT. Id. (citing Westvaco, 2015 WL 10323214, at *11 (D. Md. Feb. 26, 2015) ;

Cinergy, 618 F. Supp. 2d 942, 955 (S.D. Ind. 2009). Ameren does not present any other citations or evidence to support this argument.

I conclude that I am able to order Ameren to propose wet FGD as BACT.

iii. Ameren's Arguments for the Least Effective Control Technology, DSI, Contradict the Nature and Definition of BACT

Ameren argues that DSI, a technology that removes about 50% of SO_2 emissions, constitutes BACT for Rush Island. DSI is about half as effective as FGD and has never been accepted as BACT for coal-fired electric generating units. FOF ¶ 167. Ameren prefers DSI because it is less costly overall and per-ton than other control technologies. However, BACT does not permit a source to install the most cost-effective technology. The plain language of the statute requires emissions limits "based on the maximum degree of reduction" available. 42 U.S.C. § 7479(3).

To support its position, Ameren argues that FGD technology should have been excluded at Step 4 of the BACT analysis because of its "economic impacts." The costs Ameren cites are not based on any unique physical or operational characteristics of Rush Island. Ameren was unable to identify any material feature that distinguishes Rush Island from the rest of the industry or electric market. Ameren's argument is premised entirely on its expert Campbell's economic analysis. That analysis was inconsistent with BACT permitting practices and Campbell's own past guidance, and I give Campbell's testimony little weight. FOF ¶¶ 134-40.

In BACT permitting, two cost metrics are often consulted, (1) average cost-effectiveness, and (2) incremental cost-effectiveness. FOF ¶¶ 82-83. The EPA's expert Dr. Staudt calculated average cost-effectiveness for wet FGD at Rush Island and determined the costs were achievable. FOF ¶ 199. Dr. Staudt made his calculations according to the standard overnight cost methodology. FOF ¶ 124.

In their calculations, Ameren's experts included costs that are traditionally excluded from BACT analyses for consistency and comparison's sake. Ameren's expert Snell admitted that his cost estimates were not developed for the purpose of a BACT analysis. FOF ¶ 128. Ameren's expert Campbell still included Snell's cost estimates in his incremental cost-effectiveness comparison. Incremental cost-effectiveness considers the per-ton change in cost of reducing SO_2 pollution using two compared technologies. Based on that comparison, Campbell eliminated wet FGD from his BACT analysis. Ameren's experts offered no opinions on the average cost-effectiveness of wet FGD.[16]

According to Campbell, the incremental cost-effectiveness of wet FGD compared to DSI exceeds a threshold used by MDNR in BACT determinations. FOF ¶ 141. This explanation misstates how incremental cost-effectiveness analysis usually operates in reality. Measuring incremental cost may be useful when evaluating control options ranked next to each other with similar control efficiencies. FOF ¶ 83. Campbell did not compare incremental technologies, he compared one of the most effective control technologies with one of the least. FGD technology can remove 95% or more of SO_2 emissions, while DSI can remove only 50%. These differences in effectiveness are not incremental.

"[W]here a control technology has been successfully applied to similar sources in a source category, an applicant should concentrate on documenting significant cost differences, if any, between the application of the control technology on those other sources and the particular source under review." Pl. Ex. 1190 [NSR Manual] at AM-REM-00544148-MDNR. Ameren's analyses do not provide any distinguishing characteristic of wet FGD implementation at Rush Island that makes the technology unachievable or significantly more costly than other similar

[16] Ameren's sole reliance on incremental cost-effectiveness to eliminate wet FGD while ignoring average cost-effectiveness is inconsistent with a proper top-down analysis. FOF ¶ 84.

sources.

Ameren's main attempt to differentiate Rush Island from other plants depends on a false distinction between new plants and existing, retrofitted plants. Specifically, Ameren points out that the New Source Performance Standards (NSPS) do not apply to existing plants such as Rush Island. However, the NSPS emission rate does not fundamentally change the BACT methods or results. FOF ¶¶ 87-89; Ameren Missouri, 2019 WL 1384631, at *3 (citing Columbia Gulf at *4). Instead, the NSPS emission rate serves as a "floor" for any BACT determination; BACT at any facility cannot be less stringent that the NSPS for that source category. 42 U.S.C. § 7479(3). Ameren's new-versus-existing plant distinction does not demonstrate that Rush Island is so unusual as to make wet FGD unachievable.

d. SO_2 BACT For Rush Island Was Wet FGD Technology at the Time of the Modifications and Remains So Today

The parties do not dispute what control technologies are available to reduce SO_2 emissions, whether those technologies could be implemented at Rush Island, or their relative effectiveness: wet FGD is the most effective control technology, and it is technically and economically feasible at Rush Island. The parties disagree, however, about whether wet FGD is achievable "taking into account energy, environmental, and economic impacts and other costs." 42 U.S.C. § 7479(3). Based on the evidence presented at trial, wet FGD is achievable when taking into account these factors. FOF ¶¶ 184-88, 200.

Although the specific emission rate may vary somewhat, FGDs are the best available SO_2 controls at coal-fired power plants. Chipperfield v. Mo. Air Conserv. Comm'n, 229 S.W.3d 226, 240 (Mo. Ct. App. 2007) ("In general, pulverized coal-fired boilers burning low-sulfur coal, such as Powder River Basin ("PRB") coal, may use dry FGD, while boilers burning high-sulfur coals, such as eastern bituminous coal, must use wet FGD."); Cinergy, 618 F.Supp.2d 942, 955

("BACT would require a scrubber that removed 99% of the SO_2"). The evidence presented at trial does not provide any support for the proposition that FGD technology, the "top control" for SO_2 removal, should be ruled-out based on "energy, environmental, and economic impacts" associated with its application. As a result, I conclude the following:

(1) At all times pertinent to this case, BACT for SO_2 pollution at Rush Island would have been determined based on the application of wet FGD technology.

(2) At the time of the Unit 1 major modification in 2007, BACT for SO_2 pollution would have required a 30-day rolling-average emissions rate of no more than 0.08 lb/mmBTU. FOF ¶ 208.

(3) At the time of the Unit 2 major modification in 2010, BACT for SO_2 pollution would have required a 30-day rolling-average emissions rate of no more than 0.06 lb/mmBTU. Id.

(4) At present, BACT for SO_2 pollution at Rush Island requires a 30-day rolling-average emissions rate of no more than 0.05 lb/mmBTU. FOF ¶ 213.

e. The eBay Factors Require Rush Island to Comply with PSD Permitting and BACT Emissions Limitations

The United States asks this Court to order Ameren to apply for a PSD permit within 90 days from the issuance of a final order, and to implement BACT no later than four and one-half years from this Court's order. A balancing of the eBay factors confirms that an injunction directing Ameren to propose wet FGD as BACT at Rush Island is an appropriate method to end Ameren's violation of the PSD program at Rush Island.

When considering injunctive relief, I evaluate whether:

> (1) [the plaintiff] has suffered irreparable injury; (2) . . . remedies available at law, such as monetary damages, are inadequate to compensate for the injury; (3) . . . considering the balance of hardships between the plaintiff and defendant, a remedy in equity is

> warranted; and (4) . . . the public interest would not be disserved by a permanent injunction.

eBay Inc. v. MercExchange, L.L.C.: 547 U.S. 388, 391 (2006).

Ameren concedes the first two factors of the eBay standard are "in essence satisfied" in this case. (Def. Closing Arg., Tr. Vol. 6, 33:23-25 ("And I agree with the Government that the first two factors are - the eBay factors are in essence satisfied.")). Ameren argues, however, that the costs of pollution controls, borne by Ameren and passed onto ratepayers, weight the balance of hardships and public interest prongs in Ameren's favor.

i. The Communities Downwind of Rush Island Have Been Irreparably Injured

Environmental harm, "by its nature . . . is often permanent or at least of long duration, i.e., irreparable." Amoco Prod. Co. v. Gambell, 480 U.S. 531, 545 (1987); see also, United States v. Production Plated Plastics, Inc., 762 F. Supp. 722, 729 (W.D. Mich. 1991) (violations of an environmental statute usually result in irreparable injury); Ohio Valley Envt'l Coalition v. U.S. Army Corps of Engineers, 528 F. Supp.2d 625, 630 (S.D. W.Va 2007) ("because to damage the environment is often irreversible, this harm is frequently justification for a restraining order or an injunction"). I have closely reviewed the evidence presented at trial concerning harms the public has suffered because of the excess SO_2 emissions resulting from Ameren's failure to obtain a permit. Based on that evidence, I conclude that Ameren's failure to obtain a permit caused irreparable damage.

At trial, the EPA presented voluminous data demonstrating that Rush Island's excess emissions have increased the risk of heart attack, asthma attack, stroke, and premature death in downwind communities. FOF ¶¶ 251-53. Dr. Schwartz testified at length about the concentration-response relationship between $PM_{2.5}$ concentrations and premature mortality. Dr.

Schwartz and Lyle Chinkin also explained how SO_2 converts to $PM_{2.5}$, and the mechanisms by which $PM_{2.5}$ can cause harm. Id.; ¶¶ 240, 305-07.

In contrast, Ameren's experts Dr. Valberg and Dr. Fraiser testified contrary to the scientific consensus on $PM_{2.5}$'s human health impacts. Dr. Fraiser contradicted the scientific consensus that that $PM_{2.5}$ is a no-threshold pollutant that causes increased mortality on a linear basis.[17] Dr. Fraiser also offered opinions that were outside her area of expertise. FOF ¶¶ 274-75. Dr. Valberg's testimony in other cases and regulatory matters, on the same topics as were before me, has frequently been rejected by the EPA and courts. FOF ¶¶ 281-84.

Rush Island's excess emissions have created harmful $PM_{2.5}$ that has increased the risk of human health impacts in downwind communities. FOF ¶ 265. The EPA's independent modeling efforts estimated that the excess emissions have contributed to hundreds of premature deaths. FOF ¶ 338, Table 1. These environmental and human health impacts demonstrate irreparable injury from Rush Island's PSD violation. Cinergy, 618 F. Supp. 2d at 964 (finding irreparable harm from "significant health and environmental effects in the form of $PM_{2.5}$" resulting from excess SO_2). The first eBay factor is satisfied.

ii. Legal Remedies Are Inadequate to Remedy the Harm

Damages are inadequate to address the harm from excess emissions at Rush Island. See Def. Closing., Tr. Vol. 6, at 33:23-25; Gambell, 480 U.S. at 545 (explaining that environmental harm "can seldom be adequately remedied by money damages"). The facts of the case demonstrate that money damages would be inadequate here. Because of Rush Island's excess emissions, an increased risk of disease and premature mortality extends across thousands of miles of the Eastern United States. The public and environmental nature of the harm render

[17] Dr. Fraiser admitted, however, that the NAAQS do not guarantee zero risk. FOF ¶ 273.

monetary awards ineffectual: There is no individual to compensate. The additional risks of disease and premature mortality are spread across the population of the Eastern United States. Legal remedies alone cannot address the harm.

iii. The Balance of Hardships Weighs in Favor of an Injunction Ordering Ameren to Install Wet FGD at Rush Island

This opinion contains extensive discussion of the harm the downwind communities are suffering due to Ameren's decision to ignore the statutory requirement that it install pollution controls at the modified Rush Island. The Plaintiffs are suing to enforce a statute enacted to reduce the kind of harm Ameren's excess pollution has created, and they would suffer great hardship if I allow Ameren to continue to operate Rush Island without BACT. Meanwhile, an injunction ordering Ameren to comply with the Clean Air Act and install BACT imposes a relatively minor hardship on Ameren. Ameren will have to install at Rush Island the same pollution controls that power utility companies—including Ameren—must install at facilities across the country.

Ameren admits that it can "afford anything this Court orders." Def. Closing Arg., Tr. Vol. 6, 34:13. At the same time, Ameren expresses concern that its customers will bear the costs of compliance in the form of rate increases. Ameren asserts that the average customer will have to pay thousands more dollars over 20 years to reimburse Ameren for its capital expenditures.

This alleged hardship does not tip the balance in Ameren's favor. The costs of pollution controls are a cost of doing business; the Clean Air Act struck that balance when it mandated BACT measures for new and modified sources. See Introduction supra. Moreover, nothing in this order requires Ameren to recover the costs of compliance and remediation from its ratepayers. Ameren does not need to submit the costs as reimbursable, and the Missouri Public Service Commission has the discretion to allow only partial cost-recovery or to bar recovery because the costs result from Ameren's Clean Air Act violations. FOF ¶ 431.

Even if the control costs are passed onto ratepayers in their entirety, the resulting rate increase would be within the range of recent rate increases. FOF ¶¶ 435. On this point, Ameren presented conflicting, unrepresentative, and mischaracterized cost estimates. FOF ¶¶ 439-442. For example, one of Ameren's methods calculated average cost increase estimates and assumed that the cost of installing pollution controls will apply equally to all customers, regardless of whether they are residential, commercial, or industrial. FOF ¶ 440. This method over-estimates the costs that most of its customers, especially residential customers, will bear. Id.

In contrast, the EPA presented cost estimates on a percentage basis, and compared them with Ameren's recent cost increases. According to the EPA, the total cost of installing FGD at Rush Island and DSI at Labadie would lead to rate increases between 2.8 and 4.8%. FOF ¶ 434. Ameren also presented evidence using this methodology and calculated a similar percentage increase of 3.8%. Id. Of course, the Rush Island portion of these rate increases would have been borne by the ratepayers ten years ago had Ameren complied with the law.

For context, these projected increases are less than the most recent annual increase levied by Ameren (5.4%), as well as the rate decrease that was triggered by the 2017 federal tax law (6.1%). FOF ¶¶ 435, 437. Regardless of whether Ameren is allowed by the PSC and ultimately passes on the costs of compliance to customers, Ameren can readily finance and install wet FGD at Rush Island while staying profitable.

iv. Compliance at Rush Island Serves the Public Interest

The United States brought this civil action to enforce a public interest statute. The United States has clearly established that it is in the public interest for Ameren to comply with the Clean Air Act.

Ameren's argument to the contrary depends entirely on the costs it asserts this injunction will impose on rate-payers. As I discuss above in Section VI.c.iii, the estimated cost increases are modest. The estimated value of the benefit to the public is much larger than estimated costs to Ameren. FOF ¶¶ 375-77.

f. Ameren's Arguments That Rush Island's Excess Pollution Was Not Harmful Are Not Convincing

To influence the eBay analysis, Ameren argues that Rush Island's excess SO_2 pollution was either harmless as a matter of law (because of certain regulatory thresholds), or harmless as a matter of fact (based on the testimony of Ameren's toxicology experts). These arguments do not withstand scrutiny.

i. The National Ambient Air Quality Standards (NAAQS) Do Not Establish a Safe Threshold For SO_2 Pollution

Ameren's claim that the NAAQS render PSD requirements unnecessary is contradicted by the plain language and history of the PSD program and the NAAQS. Congress enacted the PSD program to address pollution occurring in areas already meeting the public health protections set forth in the NAAQS. C.f. TVA v. Hill, 437 U.S. 153, 194 (1978) ("[I]t is … the exclusive province of the Congress not only to formulate legislative policies and mandate programs and projects, but also to establish their relative priority for the Nation.").

The NAAQS predate the PSD program and exist to protect public health and welfare. 42 U.S.C. § 7409(b). The process of setting the NAAQS does not require the EPA to "definitively identify pollutant levels below which risks to public health are negligible." American Trucking Ass'n v. EPA, 283 F.3d 355, 369-70 (D.C. Cir. 2002). When it makes NAAQS determinations, "EPA does not purport to set the NAAQS at a level which would entirely preclude negative health outcomes." North Carolina v. TVA, 593 F. Supp. 2d 812, 822 n.6 (W.D.N.C. 2009), rev'd on other grounds 615 F.3d 291 (4th Cir. 2010). As even Ameren's expert Dr. Fraiser agrees, the NAAQS do not set a black-and-white threshold below which $PM_{2.5}$ poses no risk to human health. FOF ¶ 273.

The EPA's years of implementing the Clean Air Act and the PSD program also contradict Ameren's argument. The EPA has emphasized *ad nauseum* that there is no known safe threshold below which incremental increases in $PM_{2.5}$ exposure do not create incremental increases in risk to human health and welfare. 78 Fed. Reg. 3086, 3098, 3118-19, 3148 (Jan. 15, 2013); Final Integrated Science Assessment (Dec. 2009) at 2-12, 2-25 & 6-75 [Pl. Ex. 1209]; 71 Fed. Reg. 61144, 61158 (Oct. 17, 2006); 62 Fed. Reg. 38652, 38670 (July 18, 1997).

The EPA's scientific determinations mirror the broad consensus of the world's public health authorities. The great weight of the evidence demonstrates that $PM_{2.5}$ has a linear concentration-response function down to concentrations well below the NAAQS. See FOF ¶¶ 266-272. The overwhelming weight of evidence supports that $PM_{2.5}$ is a no-threshold pollutant, meaning it can pose risks to human life and health at any concentration level. See, e.g., 78 Fed. Reg. 3086, 3092, 3119 (Jan. 15, 2013) (citing Lead Industries v. EPA, 647 F.2d at 1156 n.51); FOF ¶¶ 256-62.

Ameren is not the first company to argue that the NAAQS set thresholds that shield against or limit PSD obligations. Hawaiian Electric (HECO) maintained before the Ninth Circuit that the EPA could not "impose emission restrictions that are more stringent than necessary to protect NAAQS" in a PSD permit. Hawaiian Electric v. EPA, 723 F.2d 1440, 1446-47 (9th Cir. 1984). The Ninth Circuit rejected the argument. After recounting the legislative history and examining the statute's text, the court concluded, "it is absurd for HECO to maintain that EPA may not, through a PSD permit, require pollution controls which yield air quality better than

NAAQS." Id. Similarly, I will not ignore the harm from Rush Island's excess emissions merely because these excess emissions were released in an attainment area with $PM_{2.5}$ levels below the NAAQS.

ii. The "Significant Impact Levels" Do Not Determine the Meaningfulness of Human Health Impacts

Similar to its NAAQS assertions, Ameren argues that pollution impacts below the EPA's "significant impact levels" (or SILs) are harmless. Ameren points out that the EPA has established a SIL of annual $PM_{2.5}$ impacts of 0.2 $\mu g/m^3$ for some areas. This value is almost four times higher than the highest impact of Rush Island's excess emissions when averaged over an entire year. SILs are not a valid means of determining the significance of downwind health effects. Instead, SILs are a regulatory tool for assessing whether a source's emissions might exceed NAAQS despite the installation of BACT. See FOF ¶¶ 342-48. Ameren's use of the SILs as a benchmark for its excess pollution is not supported by pertinent law or relevant fact.

Clean Air Act Section 165(a)(3) requires operators looking to implement a major modification to demonstrate that the pollution from the modified facility will not cause or contribute to a downwind NAAQS exceedance. 42 U.S.C. § 7475(a)(3). The EPA established the SILs to be screening tools aimed at identifying which facilities might lead to NAAQS exceedances. Pl. Ex. 1205 [Guidance on Significant Impact Levels] at USTREXR0003853-3855. But "[t]he SIL values identified by the EPA have no practical effect unless and until permitting authorities decide to use those values in particular permitting actions." Id. at 3-4.

Just as the NAAQS do not establish a "zero-risk" threshold under which pollution is safe, the SILs do not establish a level below which there is no risk of harm from a facility's pollution. The SILs are, at bottom, a compliance demonstration tool, helping permit applicants and permitting authorities determine whether additional air quality modeling of a proposed source is needed. They provide NAAQS modeling guidance for the PSD permitting process.

The EPA's practice of assessing the benefits of Clean Air Act regulations further supports this legal analysis. The EPA models the effects of pollution concentration reduction by amounts well below the SILs, including the effects of changes less than 0.01 $\mu g/m^3$. FOF ¶ 348. Ameren's SILs argument does not overcome the wealth of evidence demonstrating that Rush Island's emissions led to irreparable harm that should be remedied.

iii. Ameren's Reliance on Scientific Uncertainty Is Misguided and Its Reliance on Fringe Toxicological Evidence Is Unpersuasive

Finally, Ameren asserts there is too much uncertainty about any harm from its excess emissions to justify the expense associated with installing scrubbers. Ameren's counsel argued in closing that "[t]here are uncertainties at every stage of the causal relationship that plaintiffs must prove." Def. Closing., Tr. Vol. 6, at 34:19-21. Ameren complains that Plaintiffs do "not identify[] or even predict[] any person's real-world death." ECF No. 1068 at 4. This argument mischaracterizes the level of scientific certainty needed and displayed in this case. There is widespread consensus among public health agencies and scientists that $PM_{2.5}$ causes adverse health effects, including cardiovascular effects such as heart attacks and strokes, respiratory effects such as asthma attacks, and premature mortality. FOF ¶¶ 251-54.

Ameren's reliance on individualized uncertainty misconceives the case. This is not a toxic tort case. The Clean Air Act curbs harm borne by a population, not a single person. By enacting the Clean Air Act, Congress sought "to protect public health and welfare from any actual or potential adverse effects" from air pollution. 42 U.S.C. § 7470(1) (emphasis added). Public health regulation evaluates and communicates risk, not diagnoses or proximate causes of any one individual's health problems or death. Numerous epidemiological studies reviewed by the experts in this case have shown that increases to SO_2 and $PM_{2.5}$ concentrations increase the risk to the public of lung disease, heart disease and premature mortality. FOF ¶¶ 260-62.

Further, Ameren overstates and misconstrues the nature of uncertainties presented in the EPA's modeling. There is no question that $PM_{2.5}$ increases the risk of premature mortality. Instead, the primary uncertainties in the EPA's case relate to specific quantifications of that risk. In his analyses, Dr. Schwartz laid no claim to absolute precision. On the contrary, Dr. Schwartz carefully documented the uncertainty in his risk assessments by providing peer-reviewed, 95% confidence intervals that bounded the certainty of his estimates. FOF ¶¶ 331, 335. Taken together, Dr. Schwartz's two assessments show that Rush Island's excess pollution has substantially harmed public health and welfare.

Next, Ameren insists that, though epidemiology can show correlation, it can never establish causation. Sulfate $PM_{2.5}$ is only one component of a mixture that Ameren believes should be isolated for rigorous epidemiological or toxicological analysis. Ameren's toxicologists argue that there is no toxicological literature that establishes the poisonous dosage of $PM_{2.5}$ or sulfate. This argument incorrectly interprets the relevant scientific literature. The scientific consensus is that $PM_{2.5}$ exposure is harmful at all relevant exposure levels. This consensus is not based exclusively on epidemiological research. See, e.g., FOF ¶ 259; see also generally Pl. Ex. 1209 [NAAQS ISA] (considering, among other things, "controlled human exposure studies" and "toxicological studies"). It also derives from the findings of toxicologists and medical practitioners endeavoring to settle on a coherent, cross-discipline understanding of the relationship between health effects and changes in ambient $PM_{2.5}$ concentrations. FOF ¶ 259. Ameren's attempts to inject uncertainty into the broad scientific consensus do not undermine the wealth of evidence demonstrating human health impacts due to sulfate-created $PM_{2.5}$ particles.

Finally, the structure of the Clean Air Act itself disposes of Ameren's argument.

Congress made clear in passing the Clean Air Act that when a source "increases the amount of any air pollutant," it must be subject to NSR (among other requirements). See, e.g., 42 U.S.C. § 7411(a)(4). Even in attainment areas with low $PM_{2.5}$ concentrations, the Clean Air Act requires facilities like Rush Island that undergo major modifications to install BACT. See 42 U.S.C. § 7475(a)(3). Regardless of whether Ameren is correct about the harm $PM_{2.5}$ causes at low concentrations, the Clean Air Act grants courts jurisdiction to provide "appropriate relief" to remedy Ameren's violation. See 42 U.S.C. § 7413(b)(3).

IV. LABADIE MUST REDUCE EMISSIONS COMMENSURATE WITH THE EXCESS EMISSIONS RELEASED BY RUSH ISLAND

a. The eBay Factors Support the EPA's Requested Injunctive Relief at Labadie

Injunctive relief at Rush Island will bring the plant into compliance with the PSD program, ending the release of excess SO_2 emissions and $PM_{2.5}$ there. However, BACT measures at Rush Island will not redress the harm from the last ten years. A balancing of the eBay factors leads me to conclude that injunctive relief is necessary at Labadie in order to remediate Rush Island's excess emissions.

i. The Same Irreparable Injury Analysis of Rush Island's Excess Emissions Applies to Labadie

The record establishes that in the last ten years, Rush Island's release of more than 162,000 tons of excess SO_2 pollution has increased the risk of adverse health effects, including premature mortality. The EPA's experts quantified these effects at trial. FOF ¶ 376-77. Dr. Schwartz testified at length about the concentration-response relationship between $PM_{2.5}$ concentrations and premature mortality. Dr. Schwartz and Lyle Chinkin also explained how SO_2 is transported from Rush Island across the country, its conversion to $PM_{2.5}$, and the mechanisms by which $PM_{2.5}$ can cause harm. These environmental and human health impacts demonstrate irreparable injury from Rush Island. Cinergy, 618 F. Supp. 2d at 964.

ii. Legal Remedies Are Inadequate to Remedy the Harm

Ameren admits there is no adequate remedy at law to address the environmental harm documented in this case. Def. Closing., Tr. Vol. 6, at 33:23-25. Because the environmental harm and health risks are spread across the population of the Eastern United States, there is no one person or discrete group of people to compensate. I find that an "economic award would not sufficiently compensate" for injuries and the increased risk of harm resulting from Ameren's failure to obtain a PSD permit at Rush Island. Franklin County Power, 546 F.3d at 936; see also Westvaco, 2015 WL 10323214, at *9 (D. Md. Feb. 26, 2015); Cinergy, 618 F. Supp. 2d at 961.

iii. Plaintiffs Suffer the Balance of the Hardships

The balance of hardships for equitable relief at Labadie compares well with the balance of hardships at Rush Island. On one hand, Rush Island's excess emissions have created a widespread risk of harm to public health. On the other hand, accounting for those excess emissions requires some cost on Ameren's part. The costs of pollution reductions at Labadie are well within Ameren's financial capabilities. FOF ¶¶ 440-444. Implementing DSI on the four Labadie units would cost $55 million dollars in capital investment and then $53 million a year in operating costs. FOF ¶ 362. Ameren did not present any evidence that paying these costs would cause it any hardship. On the contrary, Ameren Missouri's FERC Form 1 filings reveal it has an exceptionally strong and profitable financial standing. FOF ¶¶ 415-16. If the Missouri Public Service Commission does not allow Ameren to seek reimbursement for the cost of implementing DSI, Ameren can readily finance it with a fraction of the annual dividends it has issued in recent years. See FOF ¶¶ 415 Table 2, 416 Table 3.

iv. Pollution Reductions at Labadie Serve the Public Interest

An award of injunctive relief at Labadie to account for Ameren's excess emissions serves the public interest. This remedy protects life and health through full enforcement of the protections Congress set forth in the permitting scheme of the Clean Air Act. The cost of remediating the harm from Rush Island's excess emissions pales in comparison to the public health benefit. Using standard, peer-reviewed estimates, Dr. Schwartz estimated the monetary value of social benefits that would accrue from offsetting Rush Island's excess emissions. The benefits of emissions reductions would far surpass any financial costs Ameren will face. FOF ¶¶ 375-76. Remediating the harm from non-compliance also reduces any economic advantage Ameren gained by violating the law, placing it on more equal footing with companies that have complied with the Clean Air Act.

b. Reducing Pollution from Nearby Labadie Is Relief Narrowly Tailored to Remedy the Harm from Ameren's Violations.

To remediate the harm from Rush Island's excess pollution, the EPA requests that Ameren reduce SO_2 emissions from its Labadie plant in an amount equal to Rush Island's excess emissions. The goal of this requested relief is to reduce $PM_{2.5}$ concentrations for the same population that experienced increased $PM_{2.5}$ concentrations and increased risk of adverse health effects due to Rush Island's failure to obtain a PSD permit.

Ameren argues that because Labadie is "totally innocent," and Ameren has not violated the Clean Air Act there, my order that Ameren install pollution controls at Labadie is an "extreme remedy" that constitutes a penalty. On the contrary, the remedy is based on straightforward equitable principles and the authority I have under the Clean Air Act "to restrain" violations, "to require compliance," and "to award any other appropriate relief." 42 U.S.C. § 7413(b). I have the authority to "order a full and complete remedy" for the harm caused by Ameren's violations, "and in doing so may go beyond what is necessary for compliance with the statute" at Rush Island. United States v. Cinergy, 582 F. Supp. 2d 1055, 1060-61 (S.D. Ind. 2008).

This relief is narrowly tailored "to remedy specific harm shown." Rogers v. Scurr, 676 F.2d 1211, 1214 (8th Cir. 1982). There is a tight geographic nexus between the harms Rush Island caused and the benefits gained through reducing Labadie's emissions. Pollution from Labadie affects the same communities as those affected by Rush Island, and to the same degree. FOF ¶ 369. Accordingly, any efforts undertaken to reduce at Labadie pollution would correspond ton-for-ton with the harm caused by Rush Island's excess emissions. Pl. Exs. 1362 & 1364; FOF ¶¶ 368, 373. Controlling Labadie's emissions offers a rare opportunity to right Ameren's wrong on the same terms.

This relief also respects the persuasive factors considered by other courts evaluating environmental remedies. Specifically, reducing emissions at Labadie (1) "would confer [the] maximum environmental benefit," allowed, (2) is "achievable as a practical matter," and (3) bears "an equitable relationship to the degree and kind of wrong it is intended to remedy." United States v. Deaton, 332 F.3d 698, 714 (4th Cir. 2003).

First, this order achieves the maximum possible environmental benefit in this case. When Ameren reduces emissions at Labadie commensurate with the excess emissions from Rush Island, Ameren will have put the public in the place it would have been absent Ameren's Clean Air Act violation. Second, there is no dispute that commonly available pollution controls (DSI, FGD) are achievable as a practical matter. No obstacle stands in the way of DSI or FGD being installed on Labadie. FOF ¶ 362. Finally, the remedy bears an equitable relationship to Rush Island's excess emissions because of the tight geographical link between Rush Island's emissions and Labadie's emission. Ameren's ton-for-ton reductions at Labadie will lower the risks of premature mortality and disease in the same communities impacted by Ameren's Rush Island violations.

c. DSI Installation at Labadie Is Not a Penalty

At trial, Ameren argued that any injunction against its Labadie plant would constitute a penalty, which the EPA waived when it moved to strike its jury demand. As I ruled at the time, "[w]hen relief 'goes beyond remedying the damage caused to the harmed parties by the defendant's action,' [ ] it is properly viewed as punitive and therefore legal in nature." U.S. v. Ameren Missouri, No. 4:11 CV 77 RWS, 2016 WL 468557, at *1 (E.D. Mo. Feb. 8, 2016) (quoting Johnson v. S.E.C., 87 F.3d 484, 488 (D.C. Cir. 1996)). Ameren correctly notes that I cannot issue injunctive relief that would constitute a penalty. However, Ameren's application of that legal principle to the facts of this case is incorrect. By ordering emissions reductions up to, but not surpassing, the excess emissions from Rush Island, I am ordering relief that goes exactly to "remedying the damage caused to the harmed parties by the defendant's action." Id.

To further ensure that any relief at Labadie does not surpass the damage caused by Rush Island, I will order Ameren to base its relief at Labadie on DSI control technology. The capital costs of DSI without a fabric filter are a small fraction of the capital costs of any other control technology. While FGD installation at two units may cost more than $500 million, DSI installation on Labadie's four units would cost only $55 million. FOF ¶ 424. Operating DSI without a fabric filter on all four Labadie units would cost about $53 million per year. Id. As a result, the overall expense of DSI comes predominantly from operating expenses. Ameren can therefore install DSI on Labadie's four units, operate DSI for as many years as necessary to remediate Rush Island's excess emissions, and terminate its use of DSI without suffering significant lost capital assets. Installing DSI—or some more effective pollution control technology—at Labadie provides the relief necessary to remedy the harm from Rush Island without penalizing Ameren.

By the time Rush Island implements BACT measures and comes into compliance with PSD, the facility will have emitted nearly 275,000 excess tons of SO_2. FOF ¶ 211. The record shows Ameren has multiple options to reduce Labadie's emissions by the same amount. If they are implemented soon, these measures will reduce SO_2 pollution by as much as 250,000 tons before 2036, the year two of the four Labadie units are slated for retirement. Installing DSI at Labadie will reduce SO_2 pollution in the area commensurate with the volume of Rush Island's excess emissions, and will benefit the same communities burdened by the harm caused by the violations. I will order Ameren to begin operating Labadie with DSI, or a more effective pollution control, beginning no later than three years after this order.

V. AMEREN'S FAIR NOTICE ARGUMENT FAILS

Ameren argues that I should not order injunctive relief at either Rush Island or Labadie because the EPA did not provide fair notice of its regulatory interpretations of the Clean Air Act. Fair notice is an administrative law concept that "preclude[s] an agency from penalizing a private party for violating a rule without first providing adequate notice of the substance of the rule." Howmet Corp. v. E.P.A., 614 F.3d 544, 553 (D.C. Cir. 2010) (quoting Satellite Broad. Co., Inc. v. FCC, 824 F.2d 1, 3 (D.C.Cir.1987). When evaluating whether this constitutional requirement has been met, courts determine whether a regulated party "would be able to identify, with 'ascertainable certainty,' the standards with which the agency expects parties to conform." Id. at 5353-54 (quoting Gen. Elec. Co. v. U.S. E.P.A., 53 F.3d 1324, 1329 (D.C. Cir. 1995), as corrected (June 19, 1995)). The "ascertainable certainty" standard does not require an agency to define how a given regulation applies to every set of facts. That function is served by adjudication. See United States v. Cinemark USA, Inc., 348 F.3d 569, 580 (6th Cir. 2003) ("An agency's enforcement of a general statutory or regulatory term against a regulated party cannot be defeated on the ground that the agency has failed to promulgate a more specific regulation.") (citing SEC v. Chenery Corp., 332 U.S. 194, 201 (1947)).

Courts also consider "whether the regulated party received, or should have received, notice of the agency's interpretation in the most obvious way of all: by reading the regulations." Howmet Corp. v. E.P.A., 614 F.3d at 553 (quoting Gen. Elec., 53 F.3d 1324, 1329). The regulations at issue concern the EPA's definition of "projected actual emissions." The regulations provide instructions in how regulated entities should determine projected actual emissions. Specifically,

> the owner or operator of the major stationary source:
> (a) Shall consider all relevant information, including but not limited to, historical operational data, the company's own representations, the company's expected business activity and the company's highest projections of business activity, the company's filings with the State or Federal regulatory authorities, and compliance plans under the approved State Implementation Plan; and
> (b) Shall include fugitive emissions to the extent quantifiable, and emissions associated with startups, shutdowns, and malfunctions

40 C.F.R. § 52.21(b)(41)(ii). The regulations also allow a "demand growth exclusion" where owners and operators

> Shall exclude . . . that portion of the unit's emissions following the project that an existing unit could have accommodated during the consecutive 24-month period used to establish the baseline actual emissions under paragraph (b)(48) of this section and that are also unrelated to the particular project, including any increased utilization due to product demand growth

Id. § 52.21(b)(41)(ii)(c).

Ameren argues that the EPA failed to give notice of how it applies these two subparagraphs to the facts of any given case. Ameren also argues that "on its face" the "all relevant information" standard in 40 C.F.R. § 52.21(b)(41)(ii)(a) fails to provide "ascertainable certainty."

These arguments are unconvincing. The regulation in question is not "baffling and inconsistent" or "unclear" in the way that courts have found other regulations subjected to fair notice challenges. E.g. Gen. Elec., 53 F.3d at 1330. Instead, the regulation provides a clear, if flexible standard: owners and operators of major stationary sources "[s]hall consider all relevant information . . . ." 40 C.F.R. § 52.21(b)(41)(ii). Immediately after this standard, the regulation provides examples of specific factors that should be considered, including "historical operational data, the company's own representations, the company's expected business activity and the company's highest projections of business activity, the company's filings with the state or federal regulatory authorities, and compliance plans under the approved State Implementation Plan." Id. The EPA evaluated these same factors when presenting evidence before me that Ameren's projected emissions had increased. Ameren Missouri, 229 F. Supp. 3d at 946-71. Ameren had fair notice of how "projected annual emissions" should be determined under § 52.21(b)(41)(ii).

Ameren also objects to the EPA's application of the demand growth exclusion. The demand growth exclusion applies when a power plant's projected emissions increases are caused by an increase in system-wide demand growth. Ameren argues that the EPA only considered plant-specific, rather than system-wide, demand growth. Ameren also objects to a "restaurant" metaphor that the EPA used to explain temporal demand for electricity generation.[18]

[18] At the liability phase of the trial, the EPA used a restaurant metaphor to explain the relationship between a baseload power plant and system-wide electricity demand. Specifically, the EPA suggested that a baseload power plant is analogous to a high-demand restaurant that has no available seating during the lunch and dinner rushes. Increased demand for meals during these times does not increase the number of meals served at the restaurant. The EPA presented this metaphor for argumentative purposes only. This metaphor does not reveal any new aspect of the regulations at hand. As a result, there is no "fair notice" issue at stake.

In making these arguments, Ameren mischaracterizes how the EPA applied the demand growth exclusion. The EPA did not evaluate market demand at Rush Island. Instead, the EPA evaluated Rush Island's relationship to system-wide demand. Specifically, the EPA presented evidence that Rush Island is a baseload power plant that runs as frequently as possible. Ameren Missouri, 229 F. Supp. 3d at 972-73. This means that Rush Island's own generating capacity and maintenance needs, rather than demand, determine when it is operated. Id. at 975. Because Ameren mischaracterizes the EPA's approach to the demand-growth exclusion, its fair-notice argument fails.

Finally, Ameren argues that the EPA failed to give fair notice that it would use an actual emissions standard—as opposed to a projected emissions standard—when determining whether Ameren made a major modification at Rush Island. According to Ameren, Missouri's 2007 State Implementation Plan only referred to a pollution source's "potential to emit." After the liability phase trial, I found that both Rush Island's projected and actual emissions increased due to its major modifications. Id. at 952-54, 956-58. Ameren does not argue any fair notice issue concerning the "projected emissions" aspect of the regulation. If projected emissions were the only criteria to determine major modifications, then Ameren would still be liable for major modifications at Rush Island. Consequently, there is no fair notice issue at stake. Ameren's fair notice arguments fail and do not provide a reason to deny the EPA's requested injunctive relief.

CONCLUSION

In the 1977 Clean Air Act Amendments, Congress struck a balance. The Act allowed then-existing power plants to continue emitting high levels of pollution until their owners made major modifications at those plants. At that point, they would have to apply for a PSD permit and meet reduced emissions requirements. For thirty years, Ameren benefitted from this policy, operating Rush Island without the need to apply for a PSD permit. When Ameren decided to make major modifications to expand Rush Island's capacity, Ameren refused to play by the rules Congress set. It did not apply for the required PSD permit, and in so doing skirted PSD's requirement to install the best available technology to control the pollution Rush Island emits.

To remedy its violation of the Clean Air Act, Ameren must now apply for a PSD permit for Rush Island within ninety days, propose wet FGD as BACT in its permit application, and implement BACT no later than four and one-half years from this order. However, to stop there would be to abet Ameren's Clean Air Act violation and to ignore the public harm that violation has caused. Mindful of my authority to grant other appropriate injunctive relief under the Clean Air Act, I cannot ignore that harm.

In addition to the relief I order at Rush Island, I will also order Ameren to reduce its pollution at Labadie in an amount equal to Ameren's excess emissions at Rush Island. Ameren may choose whether it will achieve the reductions by installing DSI or some other more effective pollution control at Labadie. This is not a penalty for Ameren's violation of the Clean Air Act; it is an attempt to put the Plaintiffs in the place they would have been had Ameren complied with PSD program requirements from the start. The ton-for-ton reduction at Labadie directly remediates the public harm Ameren has caused and reverses the unjust gain Ameren has enjoyed from its violation of the Clean Air Act at Rush Island.

Accordingly,

IT IS HEREBY ORDERED THAT Defendant Ameren shall apply for a Prevention of Significant Deterioration permit for the Rush Island Energy Center within ninety days of the date of this Order. Ameren must propose wet flue-gas desulfurization as the technology-basis for its Best Available Control Technology proposal.

IT IS FURTHER ORDERED THAT Defendant Ameren shall operate Rush Island Units 1 and 2 in compliance with an emissions limit that is no less stringent than 0.05 lb SO_2/mmBTU on a thirty-day rolling average within four and one half years of the date of this Order.

IT IS FURTHER ORDERED THAT Defendant Ameren shall install a pollution control technology at least as effective as dry sorbent injection at the Labadie Energy Center within three years from the date of this Order. That technology shall remain in use at Labadie until Ameren has achieved emissions reductions totaling the same amount as the excess emissions from Rush Island, as defined in this Order, through the time Ameren installs BACT at Rush Island.

IT IS FURTHER ORDERED THAT I will retain jurisdiction over this case until Ameren has fully implemented the remedies set forth in this Order.

RODNEY W. SIPPEL
UNITED STATES DISTRICT JUDGE

Dated this 30th day of September, 2019.

UNITED STATES DISTRICT COURT
EASTERN DISTRICT OF MISSOURI
EASTERN DIVISION

UNITED STATES OF AMERICA,	)	
	)	
Plaintiff,	)	
	)	
vs.	)	Case No. 4:11 CV 77 RWS
	)	
AMEREN MISSOURI,	)	
	)	
Defendant.	)	

MEMORANDUM OPINION AND ORDER

"'Why don't you go up to the Range?' somebody said to me.
'The air is pure, and they have the best water on earth.'"

- W.P. Kinsella
Shoeless Joe

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INTRODUCTION

Plaintiff the United States of America, acting at the request of the Administrator of the United States Environmental Protection Agency ("EPA"), filed this suit against defendant Ameren Missouri ("Ameren") on January 12, 2011. The United States alleges that Ameren committed various violations of the Clean Air Act, 42 U.S.C. § 7401 *et seq.*, the Missouri State Implementation Plan, and Ameren's Rush Island Plant Title V Permit when it allegedly undertook major modifications at its Rush Island Plant in Festus, Missouri without obtaining the required permits. For the reasons that follow, I conclude the United States has established that Ameren violated the Clean Air Act and its operating permit by carrying out the Rush Island projects without obtaining the required permits, installing best-available pollution control technology, and otherwise meeting applicable requirements.

The modern Clean Air Act was passed in 1970 in order "'to speed up, expand, and intensify the war against air pollution in the United States with a view to assuring that the air we breathe throughout the nation is wholesome once again.'" *United States v. Duke Energy Corp.* ("*Duke Energy 2010*"), No. 1:00 CV 01262, 2010 WL 3023517, at *2 (M.D.N.C. July 28, 2010) (quoting H.R. Rep. No. 91-1146, at 1 (1970), reprinted in 1970 U.S.C.C.A.N. 5356). By 1977, Congress had determined that earlier programs "did too little" to achieve air quality goals and added the New Source Review program ("NSR"), including the Prevention of Significant Deterioration ("PSD") provisions at issue in this case. *See Envtl. Def. v. Duke Energy Corp.*, 549 U.S. 561, 567-68 (2007) ("*Duke Energy 2007*"); *New York v. EPA*, 413 F.3d 3, 12-13 (D.C. Cir. 2005). The PSD program is designed to *prevent* significant increases in pollution, an objective built into the very name of the program. *United States v. Ameren Missouri ("Ameren SJ Decision")*, Case No. 4:11 CV 77 RWS, 2016 WL 728234, at *13 (E.D. Mo. Feb. 24, 2016).

The program is designed to prevent future significant increases in pollution, in part, by requiring major-emitting facilities to employ state-of-the-art pollution controls.

When it enacted the PSD program, Congress required all new major-emitting facilities to comply with PSD requirements by installing state-of-the-art pollution controls at the time of construction. Recognizing the expense and burden of installing such controls, however, Congress did not require facilities then in existence to immediately install pollution controls. Rather, Congress allowed these facilities to continue to operate without installing such controls on the condition that if they ever modified their facilities, they would calculate the impact of those modifications, report the planned modifications to the EPA, obtain the requisite permits, and install the required pollution control technologies at that time. PSD rules apply to "major modifications," which occur when there is a "physical change" or change in the method of operation of a major stationary source that would significantly increase net emissions. *See Ameren SJ Decision*, 2016 WL 728234, at *4. An increase of 40 tons or more per year of sulfur dioxide ("SO_2"), the pollutant discussed in this case, is "significant" under the regulations. 40 C.F.R. § 52.21(b)(23)(i).

Congress enacted these modification provisions to ensure that facilities that were grandfathered into the program would not be allowed "perpetual immunity" from PSD's requirements. *Ala. Power Co. v. Costle*, 636 F.2d 323, 400 (D.C. Cir. 1979). Under the PSD program:

> [O]ld plants [are treated] more leniently than new ones because of the expense of retrofitting pollution-control equipment. But there is an expectation that old plants will wear out and be replaced by new ones that will be subject to the more stringent pollution controls that the Clean Air Act imposes on new plants. One thing that stimulates replacement of an old plant is that aging produces more frequent breakdowns and so reduces a plant's hours of operation and hence its output.

United States v. Cinergy Corp., 458 F.3d 705, 709 (7th Cir. 2006).

Ameren's Rush Island plant includes two coal-fired electric generating units, Units 1 and 2. These units went into service in 1976 and 1977 and were grandfathered into the PSD program. Neither unit has air pollution control devices for SO_2. The Rush Island plant currently emits about 18,000 tons of SO_2 per year. The Rush Island units are big sources of pollution, so even small performance improvements or increases in unit availability can lead to a 40-ton increase in SO_2. It only takes an availability improvement of 0.3% or an additional 21 hours of operation at full power for the Rush Island units to emit more than 40 tons of SO_2.

By 2005, some of the major boiler components in Units 1 and 2 were causing problems that forced Ameren to frequently take the units out of service and made the units underperform, reducing the amount of electricity Ameren could generate and sell from the units. Ameren decided to fix these problems by replacing the problem components with new, redesigned components. Courts in PSD enforcement actions have long recognized that "[i]f the repair or replacement of a problematic component renders a plant more reliable and less susceptible to future shut-downs, the plant will be able to run consistently for a longer period of time," burning more coal and emitting more pollution. *United States v. Ala. Power Co.*, 730 F.3d 1278, 1281 (11th Cir. 2013); *see also United States v. Ohio Edison*, 276 F. Supp. 2d 829, 834-35 (S.D. Ohio 2003). When these conditions occur, as they did here, they trigger a utility's obligation to conduct PSD review, secure the appropriate permits, and install required pollution controls.

This standard for assessing PSD applicability was well-established when Ameren planned its component replacement projects for Units 1 and 2. Ameren's testifying expert conceded that the method used by the United States' experts—which showed that Ameren should have expected the projects to trigger PSD rules—has been "well-known in the industry" since 1999.

But Ameren did not do any quantitative PSD review for the project at Unit 1 and performed a late and fundamentally flawed PSD review for Unit 2. And Ameren did not report its planned modifications to the EPA, obtain the requisite permits, or install state-of-the-art pollution controls. Instead, Ameren went ahead with the projects, spending $34 to $38 million on each unit to replace the problem components. It executed these projects as part of "the most significant outage in Rush Island history," taking each unit completely offline for three to four months. Ameren's engineers justified the upgrade work to company leadership on the basis that the new components would eliminate outages and the investment would be returned in recovered operations.

The evidence shows that by replacing these failing components with new, redesigned components, Ameren should have expected, and did expect, unit availability to improve by much more than 0.3%, allowing the units to operate hundreds of hours more per year after the project. And Ameren should have expected, and did expect, to use that increased availability (and, for Unit 2, increased capacity) to burn more coal, generate more electricity, and emit more SO_2 pollution.

Now that the projects have been completed, the evidence shows that Ameren's expected operational improvements actually occurred. Replacement of the failing components increased availability at both units by eliminating hundreds of outage hours per year. Unit 2 capacity also increased. Ameren's employees have admitted that those availability increases would not have happened but for the projects. As a result of the operational increases, the units ran more, burned more coal, and emitted hundreds of tons more of SO_2 per year.

In response to these projects, the United States filed this suit against Ameren, alleging that Ameren violated the Clean Air Act, the Missouri State Implementation Plan, and Ameren's

Rush Island Plant Title V Permit by performing major modifications on Units 1 and 2 without obtaining the required permits, installing state-of-the-art pollution control technology, or otherwise complying with applicable requirements.

Previously, in ruling on the parties' summary judgment motions, I set out several of the legal standards at issue in this case. *See Ameren SJ Decision*, 2016 WL 728234, at *13 (ruling on the parties' various motions for partial summary judgment and evidentiary motions); *United States v. Ameren Missouri*, 158 F. Supp. 3d 802, 804 (E.D. Mo. 2016) (denying Ameren's motion for full summary judgment). I held a twelve day non-jury trial beginning on August 22, 2016. The parties filed post-trial briefs and proposed findings of fact and conclusions of law on September 30, 2016 and argued outstanding evidentiary issues that were raised at trial. On October 12, 2016, the parties filed responses to each other's post-trial briefs.

After consideration of the testimony given at trial, the exhibits introduced into evidence, the parties' briefs, and the applicable law, I make the following findings of fact and conclusions of law, which largely adopt those proposed by the United States. As discussed below, I conclude the United States has established that Ameren should have expected, and did expect, the projects at Rush Island to increase unit availability (and, for Unit 2, to increase capacity), which enabled Ameren to run its units more, generate more electricity, and emit significantly more pollution. The United States has also established that Ameren actually emitted significantly more pollution as a result of the projects. Ameren has failed to establish that either the routine maintenance or demand growth defenses apply to shield it from liability. As a result, I conclude that the United States has established by a preponderance of the evidence that Ameren violated the PSD and Title V provisions of the Clean Air Act.

FINDINGS OF FACT

I. BACKGROUND CONCERNING THE DEFENDANT, THE RUSH ISLAND PLANT, AND THE APPLICABLE REGULATIONS

A. The Defendant

1. Defendant Ameren Missouri is a Missouri corporation. Defendant's incorporated name is Union Electric Company, but Defendant conducts business under the name Ameren Missouri. Answer to Third Amended Complaint ("Answer"), at ¶ 10 (ECF No. 250); Joint Stipulations of Fact ("Joint Stip."), at ¶ 1 (ECF No. 743).

2. As a corporate entity, Ameren is a "person" within the meaning of the Clean Air Act Section 302(e), 42 U.S.C. 7602(e) and 10 C.S.R. 10-6.020(2). Answer, at ¶ 11; Joint Stip., at ¶ 2.

3. At all times relevant to this case, Ameren has been the owner and/or operator of the Rush Island Plant in Festus, Jefferson County, Missouri. Answer, at ¶¶ 12, 57; Joint Stip., at ¶ 3.

B. The Rush Island Coal-Fired Power Plant

4. The Rush Island coal-fired power plant ("Rush Island Plant") consists, in part, of Units 1 and 2, which are coal-fired electric generating units. Rush Island Units 1 and 2 went into commercial service in 1976 and 1977, respectively. Answer, at ¶¶ 13, 59; Joint Stip., at ¶ 4.

5. The Rush Island units were originally designed to have an approximately 30-year life. Testimony of U.S. Power Plant Expert Bill Stevens, Trial Transcript Volume ("Tr. Vol."), 1-B 50:24-51:4, 69:4-11. The components of large units like the Rush Island units typically have a life of between 30 and 40 years. Stevens Test., Tr. Vol. 1-B 81:19 – 82:1.

6. The Rush Island units were designed as baseload units, meaning they generally operate every hour that they are available to run. Design Data Report (Pl. Ex. 297), at AUE-00022523, 22526; Testimony of Retired Ameren Vice President Charles Naslund, Tr. Vol. 6-A, 55:4-7; Anderson Dep., Dec. 4, 2013, Tr., 63:21 – 64:6; Pope Dep., Sept 20, 2013, Tr. 121:18 – 122:11; Testimony of U.S. Utility System Modeling Expert Dr. Ezra Hausman, Tr. Vol. 4-B, 26:15-10; Testimony of EPA Engineer Jon Knodel, Tr. Vol. 1-A, 75:16 – 75:24; 76:21–76:25.

7. The Rush Island units are among Ameren's most cost-effective units and carry much of the system load. Retired Ameren executive vice president Charles Naslund described the units as "two workhorses." Naslund Test., Tr. Vol. 6-A, 50:3-12.

8. Burning coal at Rush Island Units 1 and 2 generates combustion gases containing sulfur dioxide ("SO_2"). The SO_2 gases at Rush Island Units 1 and 2 are passed through a smokestack directly to the atmosphere, as neither unit has air pollution control devices for SO_2. Testimony of U.S. Emissions Expert Ranajit Sahu, Tr. Vol. 5, 43:9 – 44:24; Knodel Test., Tr. Vol. 1-A, 73:7 – 73:9.

9. The Rush Island plant currently emits about 18,000 tons per year of SO_2. Knodel Testimony, Tr. Vol. 1-A, 73:16 – 73:18. If Ameren operated scrubbers at Rush Island that achieved emissions reductions comparable to other plants in the region that currently operate scrubbers, SO_2 emissions would be reduced to several hundred tons per year. Knodel Test., Tr. Vol. 1-A, 108:3 – 108:5.

C. Facts Concerning General Applicability of the Prevention of Significant Deterioration Program

10. The Clean Air Act's New Source Review ("NSR") program consists of a Prevention of Significant Deterioration ("PSD") program and a Nonattainment New Source

Review program. The PSD program applies in areas that are in attainment with the National Ambient Air Quality Standards ("NAAQS") for a particular pollutant or are unclassifiable. 42 U.S.C. §§ 7471, 7475. Knodel Test., Tr. Vol. 1-A, 52:11 - 53:4.

11. The Rush Island Plant is located approximately 50 miles south of St. Louis, Missouri, in the southern tip of Jefferson County, which is currently designated as in nonattainment with the NAAQS for SO_2. Knodel Test., Tr. Vol. 1-A, 53:8 – 53:15 At the time of the 2007 and 2010 projects at issue in this case, Jefferson County was classified as in attainment with the NAAQS for SO_2. Answer, at ¶ 19.

12. At all times relevant to this case, the Rush Island Plant has been a fossil-fuel fired steam electric plant of more than 250 million British thermal units per hour heat input, and has had the potential to emit more than 100 tons per year of SO_2. The Rush Island Plant is a "major emitting facility" as defined by 42 U.S.C. § 7479(1), and a "major stationary source" as defined by 40 C.F.R. § 52.21(b)(1) and 42 U.S.C. § 7602(j). Answer, at ¶¶ 58, 59; Knodel Test., Tr. Vol. 1-A, 53:16 – 54:1.

13. Rush Island Units 1 and 2 are each a "major emitting facility" as defined by 42 U.S.C. § 7479(1), a "major stationary source" as defined by 40 C.F.R. § 52.21(b)(1), and an "electric utility steam generating unit" as defined by 40 C.F.R. § 52.21(b)(31). Joint Stip., at ¶ 5.

14. At the time of the 2007 and 2010 projects, the applicable EPA-approved Missouri PSD regulations were found in the 2003 version of 40 C.F.R. § 52.21, as incorporated into Missouri Rule 10 C.S.R. 10-6.060. Before a major source of air pollution located in such an area designated as in attainment with the NAAQS undergoes a "major modification," the owner or operator of the source must obtain a PSD permit that imposes emission limits. *See* January 21,

2016 Memorandum and Order (ECF No. 711); 40 C.F.R. § 52.21(a)(2), (j); 71 Fed. Reg. 36,486 (June 27, 2006).

15. The PSD regulations define "major modification" as "any physical change … that would result in" a significant net emission increase in actual emissions from a major stationary source. *See* January 21, 2016 Memorandum and Order (ECF No. 711); 40 C.F.R. § 52.21(a)(2)(i).

16. Under the PSD regulations, a "physical change" does not include "routine maintenance, repair and replacement." 40 C.F.R. § 52.21(a)(2)(iii).

17. Under the PSD regulations, a "significant" increase in SO_2 is 40 tons per year. 40 C.F.R. § 52.21(b)(23)(i).

D. Notice of the Violations Alleged in the Complaint

18. The EPA issued a Notice of Violation on January 26, 2010, and issued amended Notices of Violation on October 14, 2010 and May 27, 2011. The Notices of Violation identified, *inter alia*, the alleged violations arising from the 2007 and 2010 major modifications of Rush Island Units 1 and 2 that are at issue in this case. Answer, at ¶ 6; Joint Stip., at ¶ 6.

19. The Notices of Violation were provided to Ameren and the State of Missouri, in accordance with 42 U.S.C. § 7413(a). Answer, at ¶ 6; Joint Stip., at ¶ 7.

20. The United States filed its original Complaint on January 12, 2011 (ECF No. 1), an Amended Complaint on June 28, 2011 (ECF No. 36), a Second Amended Complaint on October 30, 2013 (ECF No. 165), and a Third Amended Complaint on April 24, 2014 (ECF No. 249). The Amended Complaint, Second Amended Complaint, and Third Amended Complaint alleged, *inter alia*, violations arising from the 2007 and 2010 major modifications of Rush Island

Units 1 and 2 that are at issue in this case, and were filed more than 30 days after notice of the violations was provided as required by 42 U.S.C. § 7413(a). Joint Stip., at ¶ 8.

21. The United States provided notice of the commencement of this action to the State of Missouri, as required by 42 U.S.C. § 7413(b). Knodel Test., Tr. Vol. 1-A, 87:4 - 87:23.

II. FACTS CONCERNING THE 2007 AND 2010 BOILER UPGRADES AT RUSH ISLAND UNITS 1 AND 2

22. The major modifications in this case arise from construction projects undertaken by Ameren in 2007 and 2010 at Rush Island Units 1 and 2. The 2007 major modification occurred at Rush Island Unit 1 during a major boiler outage that began on February 17, 2007 and ended on May 28, 2007. The 2010 major modification occurred at Rush Island Unit 2 during a major boiler outage that began on January 1, 2010 and ended on April 9, 2010. Stevens Test., Tr. Vol. 2-A, 24:9 -24:15; 2007 Post Outage Report (Pl. Ex. 34), at AM-02252210; 2010 Post Outage Report (Pl. Ex. 46), at AM-02739973.

A. The Boiler Components at Issue and Their Role in Burning Coal to Generate Electricity

23. Rush Island Units 1 and 2 each include a large boiler where coal is burned to convert water into steam. The boilers are comprised of a number of major components, including the economizers, reheaters, lower slope panels, and air preheaters at issue. The economizer, reheater, and lower slope panels are each comprised of bundles of steel tubes designed to carry high-temperature, high-pressure steam to the turbines. Altogether, the boilers in large coal-fired units like those at Rush Island are constructed of hundreds of miles of tubing. Exposing the steel tube bundles in the major boiler components to the heat from burning coal converts water into steam. The steam is sent to the turbines, including a high pressure turbine, an intermediate pressure turbine, and a low pressure turbine. The turbines spin a generator, which

produces electricity. Unlike the tubular boiler components, the air preheater does not consist of steel tube bundles; it consists of metal heat exchanging surfaces that preheat additional air used for combustion of coal in the boiler. Stevens Test., Tr. Vol. 1-B, 55:9 - 55:13, 57:13 - 61:6; *see also* Welcome to Rush Island Plant Presentation (Pl. Ex. 35), at AM-02253169-173.

24. The Rush Island boiler house is approximately 270 feet tall from the ground to the rooftop. Stevens Test., Tr. Vol. 1-B, 95:10-16. Each boiler is approximately 230 feet tall. Stevens Test., Tr. Vol. 1-B, 95: 10-18; Welcome to Rush Island Presentation, (Pl. Ex. 35), at AM-02253171. Each furnace is approximately 60 feet wide and 50 feet deep. Stevens Test., Tr. Vol. 1-B, 96:2-5.

25. The specific boiler components at issue in the major modifications are the economizer, reheater, lower slopes, and air preheaters that were replaced at Rush Island Unit 1 in 2007, and the economizer, reheater, and air preheaters that were replaced at Rush Island Unit 2 in 2010. Knodel Test., Tr. Vol. 1-A, 81:9 - 82:8; Stevens Test., Tr. Vol. 1-B, 46:2-12.

26. The Rush Island economizers are located in the convection section of each boiler. Stevens Test., Tr. Vol. 2-A, 29:11-24. The purpose of the economizer, which is the first tubular heat exchanging component in the boiler, is to take heat from the hot gases in the boiler and transfer it to high pressure boiler feedwater. When it leaves the economizer, the water is close to turning into steam. It then flows to a steam drum before being circulated through waterwall tubes that form the walls of the boiler furnace, and on to a section of the boiler known as the superheating section, before being sent as steam to the high pressure turbine. Stevens Test., Tr. Vol. 1-B, 58:12 – 60:6.

27. Each economizer at Rush Island Unit 1 and 2 weighed approximately 600 tons. Stevens Test., Tr. Vol. 2-A, 34:22 – 35:7. The original Unit 1 and Unit 2 economizers had

identical designs. They each had two banks – an upper and a lower bank – with 276 assemblies per bank, and had a spiral-finned design, with a staggered arrangement. The diameter of each tube was 1.75 inches. Stevens Test., Tr. Vol. 2-A, 29:25 - 30:18; Specification No. EC-5491 (Pl. Ex. 10), at AM-00080276; Ameren's Response to Request for Admission ("RFA") Nos. 362, 364, 365, 367 (ECF. No. 785-1).

28. The Rush Island reheaters are located at the top of each boiler's furnace. Stevens Test., Tr. Vol 2-A, 41:14-42:13. The purpose of the reheater is to reheat steam after it has passed through the high pressure turbine, before being sent back to the intermediate and low pressure turbines. Stevens Test., Tr. Vol. 1-B, 60:7 – 60:17.

29. The original Rush Island reheaters each had a front section and a rear section. The front section had 72 side-by-side assemblies, each of which was over 50 feet tall. The front assemblies were spaced on ten inch centers. The original front section had a sloped bottom, which created a close clearance between the bottom of the reheaters' front section and each boiler's nose. The rear section had 145 assemblies, each of which was around 26 feet tall. Both the front and rear reheater sections were spaced, not platenized, meaning there was no material that connected one tube to the next. Stevens Test., Tr. Vol. 2-A 42:2 - 43:2; Specification No. EC-5491 (Pl. Ex. 10), at AM-00080428; RFA Nos. 386, 387, 389, 390.

30. Rush Island's lower slope tubes are part of the waterwall tubes and are located in the bottom of the furnace area of the boiler. Stevens Test., Tr. Vol. 1-B, 61:15-24, Tr. Vol. 2-A, 51:2 -51:19.

31. In addition to the economizers, reheaters, and lower slopes, the other primary boiler components at issue in this case are the air preheaters, which help warm combustion air entering the boiler. Forced draft ("FD") fans are used to push combustion air into the boiler, and

before entering the furnace the cold combustion air passes through the lower portion of the air preheater. Once in the furnace, the air mixes with pulverized coal and creates flue gas which heats the water and steam in the boiler tube components. Among other things, the flue gas contains tiny particles of ash known as flyash. Stevens Test., Tr. Vol. 1-B, 57:13 – 58:11; Tr. Vol. 2-A, 56:21-57:11.

32. The hot flue gas resulting from coal combustion flows up through the furnace and then from the back pass of the boiler down through the top of the air preheater, before going to the electrostatic precipitator and then being sucked out by induced draft ("ID") fans and sent up the stack. During this process, the air preheater rotates, allowing the hot flue gas exiting the boiler to warm up the forced draft air that is entering the boiler. Stevens Test., Tr. Vol. 2-A 13:10-14, 56:21-58:8; Testimony of U.S. Power Plant Expert Robert Koppe, Tr. Vol. 3-A, at 16:16-17:2.

33. Rush Island Units 1 and 2 each have two air preheaters. Each air preheater is approximately 40 feet tall and is located approximately 100 feet from ground level. Stevens Test., Tr. Vol. 2-A 13:10-14, 67:21-68:5. Each air preheater weighed at least a couple hundred tons. Stevens Test., Tr. Vol. 2-A 59:3-6.

34. The original Rush Island air preheaters were Ljungstrom regenerative air preheaters. Specification No. EC-5491 (Pl. Ex. 10), at AM-00080275. Each original air preheater had three layers: a hot layer, an intermediate layer, and a cold layer. RFA Nos. 329, 332. Each layer was made up of air preheater baskets of various sizes. There were 216 hot end baskets, and each basket was 42 inches thick. There were 216 intermediate end baskets, and each basket was 16 inches thick. RFA No. 333, 334. There were 24 cold end baskets, and each basket was 12 inches thick. Stevens Test., Tr. Vol. 2-A 57:12 - 58:21; RFA No. 335.

35. Because the tubes that comprise the economizers, reheaters, and lower slopes are in constant contact with flue gas and/or combusting coal, these tubes are subject to deterioration over the life of the boiler and eventually develop leaks, which require repair or replacement. When the tubes degrade and the walls become too weak, the high pressure steam or water can burst through, resulting in a boiler tube leak. Large leaks require a unit to shut down while the portion of the tube that ruptured is repaired, which typically lasts two to three days. Koppe Test., Tr. Vol. 3-A, at 14:16-15:9; Stevens Test., Tr. Vol. 1-B, 65:15 - 66:7.

36. Typically, the length of tube replaced when fixing a boiler tube leak would be on the order of several feet of tube. Stevens Test., Tr. Vol. 1-B, 79:4 - 79:19. Such repairs would be part of the day-to-day responsibility of plant maintenance staff and would involve no design changes to the component. Stevens Test., Tr. Vol. 1-B, 65:15 – 66:15, 69:4 – 69:11.

37. Similarly, on occasion some cold end air preheater baskets might need to be replaced due to corrosion. Stevens Test., Tr. Vol. 2-A, 58:14-21.

38. It is well known in the industry that a well-designed section of new boiler tubes should have almost no leaks at all for the first 20 years, before the tubes eventually begin to wear out and start to fail. Koppe Test., Tr. Vol. 3-A 50:11-50:16; Vasel Dep., Aug. 15, 2013, Tr. 131:11-132:24 (Ameren was not expecting any tube leaks with the new economizer).

39. In light of the harsh conditions in which they operate, boiler components typically have a finite design life of between 20 to 40 years of operation. Stevens Test., Tr. Vol. 1-B 83:5-15. At that point, routine maintenance may no longer be sufficient to maintain desired operations, and an alternate approach may be required to optimize and extend the life of the unit. Vol. 1-B, Stevens Test., 82:2-20.

40. As a result, if a utility like Ameren wants to operate a boiler like the Rush Island boilers beyond 25 to 35 years, one strategy would be to replace the major boiler components, including the reheater. Stevens Test., Tr. Vol. 1-B 83:5-21, 84:5-6. Likewise, an economizer should be expected to last approximately 35 years and lower slope tubes should be expected to last approximately 40 years. Stevens Test., Tr. Vol. 1-B 83:22-84:4, 84:7-8. Ameren's expert witness, Mr. Jerry Golden, similarly testified that the typical life of a reheater is about 30 years, the typical life of an economizer is about 35 years, and the typical life of a lower furnace is about 40 years. Golden Test., Tr. Vol. 8-A, 18:2 – 18:11.

41. Life extension activities historically have been considered in the utility industry to be different than typical maintenance activities. The distinction was explained by Mr. Stevens, and is also discussed in an authoritative engineering text published by Babcock and Wilcox known as the "Steam Book." Stevens Test., Tr. Vol. 1-B 76:7 – 76:16, 78:4-7, 80:6-17.

42. According to the Steam Book, prior to the 1980s, it was assumed that older plants would be torn down to make room for newer, larger, more efficient units, and it was common to retire plants after 35 to 40 years of service. That assumption changed when utilities began to engage in life extension activities. The concept of "Life Extension and Upgrades" is discussed in a chapter in the Steam book by that name, while routine maintenance is discussed separately. Golden Test., Tr. Vol. 8-A, 32:16-33:8; Stevens Test., Tr. Vol. 1-B, 78:4-79:3.

43. The Steam Book describes a case-study involving the replacement of an economizer as a "life extension" project. In that life extension case study, a staggered economizer at a coal-fired generating unit was experiencing pluggage and gas flow resistance, resulting in erosion and tube failures. It was replaced with a new, redesigned, in-line

economizer, which alleviated the operational problems and allowed for higher availability and reliability. Stevens Test., Tr. Vol. 1-B 84:19-87:19.

44. By contrast, typical maintenance activities on coal-fired fired boilers are those done on a day-to-day basis to keep the power plant running in its current condition. Such typical maintenance includes things like replacing small sections of tubing, not replacing entire boiler components. Stevens Test., Tr. Vol. 1-B 64:15-66:15; 77:23-78:3, 78:20-79:19, 80:6-12.

45. Similarly, Ameren's Work Order Procedure Manual defines routine maintenance activities as those that "relate to work performed regularly by Ameren employees or contractors on an ongoing basis in the customary and normal course of business to operate or maintain facilities and equipment." Ameren Work Order Procedure (Pl. Ex. 7), at AM-00066968; Stevens Test., Tr. Vol. 1-B 71: 15-72:7. Such routine activities are not subject to the requirements of Ameren's Work Order Procedures. Pl. Ex. 7, at AM-00066960, 66968; Stevens Test., Tr. Vol. 1-B 72:9-14; Moore Dep., Sept. 16, 2014, Tr. 22:11-22.

46. Ameren's Administrative Design Control Manual provides that any activity that changes "any design or operating feature of the plant that is described by drawings or other design documents" is not considered routine maintenance. Ameren Administrative Procedure Design Control Manual (Pl. Ex. 495), at AM-0223699; Stevens Test., Tr. Vol. 2-A, 70:24-71:2.

B. Operational Problems Leading up to the 2007 and 2010 Boiler Upgrades

47. The Rush Island Units were originally designed to burn Southern Illinois Bituminous Coal. Rush Island Resurfacing Study (Pl. Ex. 20), at AM-00499384; Stevens Test., Tr. Vol. 1-B, 100:24 -101:4, Tr. Vol. 2-A, 92:10-92:15. Around 1990, Rush Island began to burn coal from the Powder River Basin in Wyoming, known as PRB coal. Stevens Test., Tr. Vol. 1-B, 101:5-14. By 1995, the Rush Island units were burning 100 percent PRB coal. Stevens

Test., Tr. Vol. 1-B, 101:15-20; Meiners Test., Tr. Vol. 7-A, 102:10-12; Meiners Dep., April 8, 2014, Tr. 237:9-238:11; Specification No. EC-5491 (Pl. Ex. 10), at AM-00080275; Project Approval Package (Pl. Ex. 3), at AM-00072837.

48. Ameren chose to switch to PRB coal, which has less sulfur, in order to comply with the Clean Air Act's separate "Acid Rain" rules. As Ameren explained in an internal 1992 Acid Rain "Compliance Strategy" document, "a significant advantage of a fuel switch strategy is that it delays an irreversible decision to construct scrubbers." Report from Union Electric: Compliance Strategy, Clean Air Act Amendments (Pl. Ex. 798), at AUE-00020365; Knodel Test., Tr. Vol. 1-A, 102:16-21.

49. The Acid Rain rules are part of a program under Title IV of the 1990 Clean Air Act Amendments designed to reduce by about 50% precursors of acid rain, or acid deposition, from coal-fired power plants. These pollutants include SO_2 and nitrogen oxides. Knodel Test., Tr. Vol. 1-A, 55:13-19; *see* 42 U.S.C § 7651 *et seq.*

50. According to retired Ameren senior vice president Charles Naslund, PRB coal is the cheapest fuel option for the Rush Island plant, and Ameren has the cheapest fuel costs in the regional transmission area, known as the Midcontinent Independent System Operator ("MISO") area. "So when I bid in my units, basically my units are always picked up pretty much baseload because I'm the cheapest." Naslund Dep., Sept. 18, 2014, Tr. 144:17 – 145:7; Knodel Test., Tr. Vol. 1-A, 104:22-105:09. The economic advantage provided by burning cheaper coal than their competitors means Rush Island Units 1 and 2 run a higher percentage of the time. Naslund Test., Tr. Vol. 6-A, 48:7-49:3.

51. Although PRB coal was cheaper and had less sulfur, it differed in other important characteristics, including having a lower heating value and higher moisture content, meaning that

more coal needed to be burned to achieve the same output from the units. Stevens Test., Tr. Vol. 1-B, 101:21-102:15; Pope Dep., Sept. 20, 2013, Tr. 71:18-72:9. Because the Rush Island plant was not designed for coal with these characteristics, Ameren knew that switching to PRB would eventually cause operational problems at the units. Meiners Dep., April 8, 2014, Tr. 237:9-238:1; Pope Dep., Sept. 20, 2013, Tr. 73:12-74:12. For instance, Ameren's Acid Rain Compliance Strategy specifically identified the fact that "the low heat content and the higher moisture of these coals generally result in operational problems that reduce capability." Report from Union Electric: Compliance Strategy, Clean Air Act Amendments (Pl. Ex. 798), at AUE-00020397.

52. The anticipated problems from switching to PRB coal for which the units were not designed were realized, causing related operational problems across the entire boiler. These problems worsened over time, and by the mid-2000's, these components were also suffering from additional operational problems due to age-related deterioration, including tube leaks in the boiler components. Fred Pope, Rush Island's former General Manager of Engineering and Technical Services, said Ameren took interim measures to "defer as long as we could the potential component replacements that…we anticipated would eventually come as the result of individual components reaching the end of their life, and we recognized that when that occurred, we would…..adjust the design of those components…to accommodate western coal." Pope Dep., Sept. 20, 2013, Tr. 73:12-74:11.

53. As described further below, these operational problems included boiler tube leaks, slagging, fouling, and plugging, which adversely affected the economizers, reheaters, lower slopes, and air preheaters. These problems, which were extensively described in Ameren's documents, forced each of the units to be completely shut down (in outages) for periods of time,

or to have their electricity generation limited to less than full power (derated) for periods of time. Stevens Test., Tr. Vol. 1-B 102:16-102:24, 105:18-105:20, 107:6 - 109:13; Tr. Vol. 2-A, 7:16-8:20, 59:7-60:22, 63:22-65:7; Koppe Test., Tr. Vol. 3-A, 14:5-15; *see* Project Approval Package (Pl. Ex. 1), at AM-0072580 (noting "tube leaks" and "load reductions due to flyash pluggage" at Unit 1), 72585 (recounting that "switch to 100% PRB coals has caused flyash pluggage" and noting boiler tube leaks at Unit 1), 590 (describing need for Unit 1 replacements following switch to PRB coal); Project Approval Form (Pl. Ex. 2), at AM-00072829 (noting "tube leaks" and "load reductions due to flyash pluggage" at Unit 2); Project Approval Package (Pl. Ex. 3), at AM-00072831 & 837 (same statements for Unit 2); Project Approval Package (Pl. Ex. 6), at AM-00072912 (describing "major boiler modifications" at both units to address components "experiencing an increase in tube leaks" and planned redesigns for PRB coal); July 15, 2005 Email (Pl. Ex. 45) at AM-0266037, 38 (noting derates due to "permanently plugged" air preheaters); September 18, 2009 Memo (Pl. Ex. 26), at AM-00954160 (Unit 2 air preheaters "have continued to foul"); October 15, 2009 Memo (Pl. Ex. 23), at AM-00926322-323 (describing problems in Unit 2 reheater and economizer following switch to PRB coal); Specification No. EC-5491 (Pl. Ex. 10), at AM-00080276-279 (describing problems in Unit 1 and 2 boiler components); Presentation re: Justification for Projects (Pl. Ex. 28), at AM-00966724-725, 731-736, 740-742, 745, 750-753 (describing problems in components).

1. Boiler tube leaks

54. As discussed above, boiler tube leaks occur in tubular components such as economizers, reheaters, and lower slopes, and large leaks require a unit to shut down for repairs which typically last two to three days. FOF 35.

55. The rates of boiler tube failures are generally unlike the failure rates that may occur in other equipment in a boiler. Other boiler equipment tends to have failure rates that stay constant with time as long as the utility keeps up with its maintenance. But as boiler tube components degrade and reach the end of their useful life, their failure rates increase with time and become repetitive given the miles of deteriorated tubing, any inch of which can fail. As the component reaches the end of life, the failures will keep increasing even though the utility repairs specific leaks. Koppe Test., Tr. Vol. 3-A, 52:8-54:15.

56. The Rush Island Units were experiencing boiler tube leaks in the years leading up to the 2007 and 2010 major boiler outages, particularly in the three boiler tube components at issue in this case. Koppe Test., Tr. Vol. 3-A 14:5-15. As Ameren's documents described the situation for the Rush Island plant as of 2005, "[t]here were a total of 10 reheat leaks in the reheaters in 2004 alone" along with "a total of 4 economizer tube leaks" and "12 lower slope tube leaks." Project Approval Package (Pl. Ex. 3), at AM-00072837; *see also id.* at AM-00072831 (noting problems that were "causing tube leaks" in the lower slopes and that "[t]here have been tube leaks in the economizer sections and reheater pendants"); Project Approval Package (Pl. Ex. 1), at AM-00072585, 72590 (identical document for Unit 1); 2008 State of the System Presentation (Pl. Ex. 15), at AM-00196730-735 (presentation identifying lost megawatt-hours from boiler tube leaks at both units).

2. Slagging and fouling

57. Slagging is the accumulation of liquid ash on the walls of the furnace and on components that are located at the top of the furnace, including superheaters and reheaters. Slag condenses or solidifies, eventually becoming like rock or concrete. Slag can bridge between tubes causing plugging, which limits flow through the unit. Slag can also fall down through the

furnace, causing tube leaks in the lower slope tubes. Stevens Test., Tr. Vol. 1-B, 104:23 – 105:17; Tr. Vol. 2-A, 51:02-52:25

58. Slag buildup on the reheaters would fall to the bottom of the furnace, causing damage to the lower slope tubes. Stevens Test., Tr. Vol. 2-A 44:1-21; Presentation re: Justification for Projects (Pl. Ex. 28), at AM-00966735; Specification No. EC-5491 (Pl. Ex. 10), at AM-00080278; Boll Dep., Sept. 5, 2014, Tr. 68:11-70:5. The slag falls caused "a vast number of gouges" on the lower slope tubes, which would often require a unit shutdown to repair. Pl. Ex. 28, AM-00966722, at 745. The slag falls at the Rush Island units were at times as large as an automobile. Stevens Test., Tr. Vol. 2A, 54:2-14; Boll Dep., Sept. 5, 2015, Tr. 69:22-70:5. In addition, the lower slope tubes were experiencing problems related to 30 years of exposure to liquid ash and molten slag. Stevens Test., Tr. Vol. 2-A 51:20 – 52:25, 54:2 – 14; Pl. Ex. 28, at AM-00966745; Project Approval Package (Pl. Ex. 1), at AM-00072585; Project Approval Package (Pl. Ex. 3), at AM-00072831.

59. Before the 2007 major boiler outage, Ameren undertook efforts to repair the tube leaks caused by falling slag. For instance, Ameren would pad-weld over areas eroded by flowing slag and would replace leaking sections of tubes. However, because the buildup of slag was a recurring problem that was not being controlled adequately, problems continued. Stevens Test., Tr. Vol. 2-A 54:15-55:8.

60. Fouling is the deposit of solid particles of ash on heat transfer surfaces. When fouling builds up on itself, it can plug the gas flow path between boiler tubing, limiting gas flow across the component, and through the unit. Fouling also leads to higher velocity gas flows through the areas that are not plugged, which causes erosion and tube failures. Stevens Test., Tr. Vol 1-B, 102:16-103:23, Tr. Vol. 2-A, 32:7-32:23.

3. Pluggage

61. Pluggage at Rush Island Units 1 and 2 occurred in the reheaters and economizer boiler tube components and in the air preheaters. Pluggage in boiler tube components occurs when ash material bridges the spaces between tubes, limiting gas flow. Stevens Test., Tr. Vol. 1-B, 103:24 - 104:4, 104:16 - 104:22. Ash also accumulates on the air preheater surfaces, restricting flue gas flow through the air preheaters and reducing the unit's output. Stevens Test., Tr. Vol. 2-A 59:7 - 60:22; July 15, 2005 Email (Pl. Ex. 45), at AM-0266037, 38; September 18, 2009 Memo (Pl. Ex. 26), at AM-000954160; Koppe Test., Tr. Vol. 3-A, 14:11-14:15, 17:5-17:11.

62. Ameren's documents specifically identified the switch to PRB coal as the reason for increased flyash pluggage and load reductions. Project Approval Package (Pl. Ex. 1), at AM-00072585 ("The switch to 100% PRB coals has caused flyash pluggage in the reheater and economizer. The pluggage in the existing staggered economizer has caused load reductions."); Rush Island Resurfacing Study (Pl. Ex. 20) at AM-00499388 ("changing fuels resulted in economizer performance problems…and maintenance problems…"); Bosch Dep., June 12, 2014, Tr. 38:25 – 39:7; *see also* July 15, 2005 Email (Pl. Ex. 45) at AM-0266037, 38 (noting derates due to "permanently plugged" air preheaters).

63. Mr. Koppe and Mr. Stevens explained that the boiler components were all suffering from the same underlying pluggage problem that collectively contributed to limiting air and gas flow through the boiler, thus reducing the amount of coal that could be burned. Stevens Test., Tr. Vol. 1-B, 108:13-109:13; Koppe Test., Tr. Vol. 3-A, 28:7-14, 29:2-8; see also Koppe Test., Tr. Vol. 4-A, at 46:23-47:18 (discussing the cumulative effect of the air preheaters,

reheater, and economizer pressure differentials on overall pressure drop throughout the boiler and its impact on the ID fans).

64. Jeff Shelton, an Ameren trial witness, similarly testified that because they all collectively contribute to the problem, the air preheaters, economizer, and reheater have to be looked at together when considering the effects of pluggage on the unit's ability to generate. Shelton Test., Tr. Vol. 10-A, 106:13-24.

65. Pluggage in the economizer with PRB ash was exacerbated by the original economizer's staggered alignment design, which created a torturous flow path for the flue gas and ash. Together with the switch to PRB coal, the economizers' staggered alignment also resulted in erosion, thinning, and tube leaks. Stevens Test., Tr. Vol. 2-A 30:19 - 32:14, 33:9-22, 40:11-19.

66. Ameren attempted to remedy the problems in the economizer through soot blowing and off-line cleanings, but these efforts did not solve the problem. Pluggage and erosion kept occurring, and the end of the economizers' lives were approaching. Stevens Test., Tr. Vol. 2-A 32:7-23.

67. The original design of the reheaters also exacerbated pluggage due to PRB coal. The spacing of the reheaters, along with the use of PRB coal, led to pluggage of the gas lanes through the reheaters. Contemporaneous documents indicated that "fouling is a daily concern," that pluggage occurred in certain areas of the reheater across the entire boiler width, and that shotguns and dynamite needed to be used to remove the pluggage. Stevens Test., Tr. Vol 2-A, 43:3-45:13; Presentation re: Justification for Projects (Pl. Ex. 28), at AM-00966735.

68. Ameren attempted to address the problems with the reheaters through cleanings, including soot blowing, and even dynamite. Strubberg Dep., Nov. 5, 2013, Tr. 162:7-19, 174:9-

23. However, because of end of life considerations, it became necessary to replace the reheaters. Stevens Test., Tr. Vol. 2-A, 44:22 – 45:13, 47:20-24.

69. The original air preheaters also consistently experienced pluggage. With the switch to PRB coal, ash accumulated on the air preheater surfaces and built up on itself. Ultimately, the pluggage also led to an end-of-life situation for the air preheaters. Stevens Test., Tr. Vol. 2-A 59:7 – 60:22. As an internal Ameren email stated, "It sounds like we have to live with the load limitations on RI due to fan capacity limits. Is there anything else we should look at, or as Jon suggests, is this beyond recovery due to the permanently plugged air heaters." July 15, 2005 Email (Pl. Ex. 45), at AM-0266037; Cardinale Dep., July 31, 2014, Tr. 84:3 – 21 (air preheater fouling was "permanent"); *see also* September 18, 2009 Memo (Pl. Ex. 26), at AM-000954160 (noting continued air preheater fouling).

70. The specific mechanisms by which pluggage from PRB coal restricted air and gas flow and limited boiler operation were explained by Mr. Koppe. As noted previously, each boiler's FD fans push air in through the air preheaters where it is warmed up before it enters the furnace areas of the boiler. Koppe Test., Tr. Vol. 3-A 16:16-20. The very hot gases then flow up through all of the boiler tube components and back through the other side of the air preheaters, through the precipitator, and then are sucked out by ID fans, before going out the stack. Koppe Test., Tr. Vol. 3-A 16:20-17:2. When pluggage gets bad enough, it is no longer possible to push enough air into the furnace to burn as much coal as could otherwise be burned. That reduces the amount of coal that is burned, which reduces the amount of steam that is generated, which reduces the amount of electricity that is produced. Koppe Test., Tr. Vol. 3-A, 17:3-11.

71. Pluggage limited the amount of coal that could be burned in several ways. First, pluggage impacted the pressure differentials (also known as "delta P") across the air preheater and economizer, which limited air and gas flow and reduced the amount of coal that could be burned. As discussed above, the hot gases flow through the boiler as air is pushed into the boiler by FD fans and pulled by ID fans. The amount of air pushed into the furnace has to be in balance with the amount of gas that goes out of the furnace. As a component gets plugged, it takes more pressure to push the gas through it. The "delta P" represents the change in pressure from the inlet to the outlet of the various boiler components. When the pressure drop gets too high, the amount of gas flow out of the furnace must be reduced, which requires reducing the amount of air coming into the furnace, which reduces the amount of coal the boiler can burn. Koppe Test., Tr. Vol. 3-A, 17:12-18:21.

72. Second, pluggage also impacted the FD and ID fans. As pluggage got worse, the ID fans, which create a vacuum to suck air out of the boiler, had to work harder and harder to pull air, and eventually got to the point where they were "fan-limited" and could not suck any more without damaging equipment. Cardinale Dep., July 31, 2014, Tr. 103:17-205:17. So the ID fans had to reduce power, which also reduced the amount of coal that could be burned. Koppe Test., Tr. Vol. 3-A., 19:18-20:16.

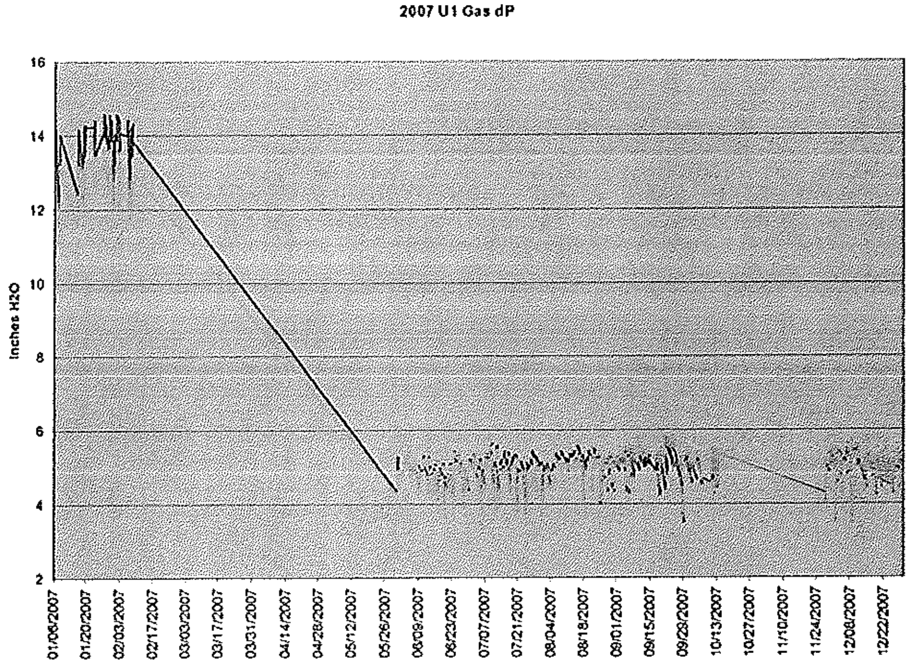
73. As the air preheaters plugged up more and more, the FD fans also had to work harder and harder to get air into the boiler. Bosch Dep., June 12, 2014, Tr. 38:25 – 40:11. Eventually the FD fans were maxed out and they could not push any more air, which limited the amount of coal that could be burned. Bosch Dep., June 12, 2014, Tr. 39:19 – 40:11. This typically happened in the summertime. Koppe Test., Tr. Vol. 3-A, at 20:17-21:11; Koppe Test., Tr. Vol. 4-A 44:13-23 ("on the rare occasions when I have before seen units limited by FD fans,

it is because the pluggage has gotten so severe in the summer months the FD fans use up all their margin and can't push any more air"); Birk Dep., Sept. 24, 2013, Tr. 194:7-16; *see also* July 2005 email, Pl. Ex. 45 (discussing "permanently plugged air heaters" and noting that the units "run out of FD fans when ambient temps come up in the summer months").

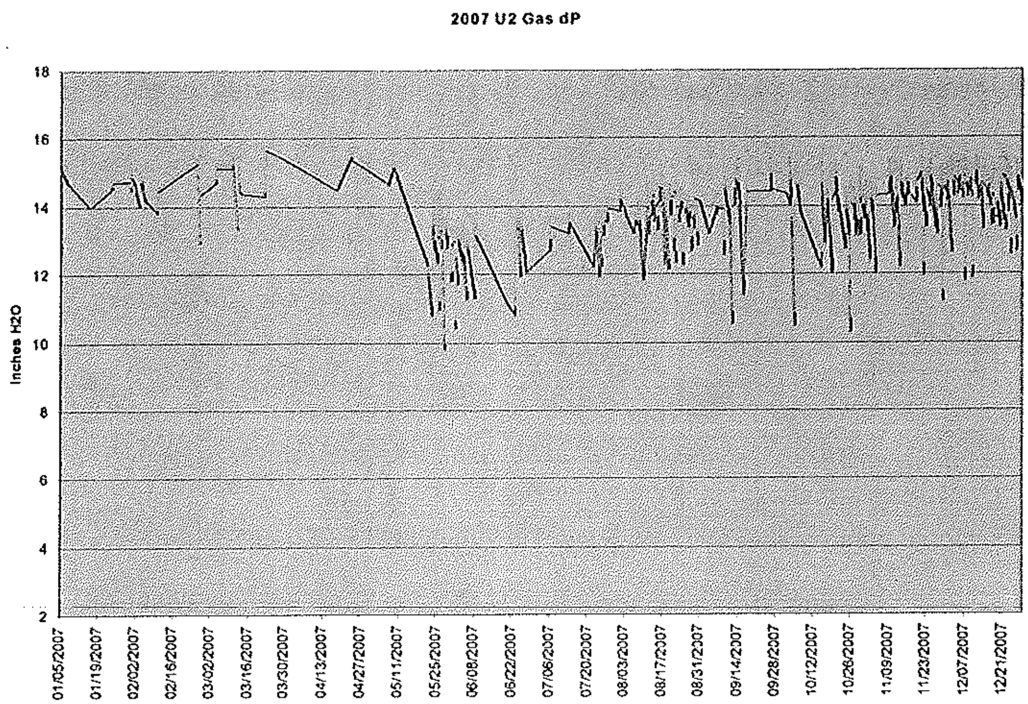
74. In the short term, Ameren coped with pluggage by shutting the units down periodically to conduct high-pressure washes to try to clean out some of the pluggage. Koppe Test., Tr. Vol. 3-A 22:3-12.; Stevens Test., Tr. Vol. 2-A, 59:7-22; Cardinale Dep., July 31, 2014, Tr. 41:15-43:10. This ameliorated the problem somewhat, but it did not solve it. Koppe Test., Tr. Vol. 3-A 22:3-12. The pressure drop would improve somewhat following a cleaning, but "much of the deposits in the air heater were so hard that they couldn't be removed even with a high-pressure wash." *Id.* at 25:12-21; Stevens Test., Tr. Vol. 2-A, 66:8-23; Cardinale Dep., July 31, 2014, Tr. 84:3-21.

75. Evidence of these problems was specifically discussed in company presentations to Ameren executives and memorialized in documents such as the 2008 "State of the System" report. 2008 State of the System (Pl. Ex. 15), AM-00196593, at AM-00196898-923; Meiners Test., Tr. Vol. 7-B, 58:20-59:8 (State of the System presentations were an opportunity to review the performance of plant equipment with Ameren executives). For instance, the 2008 State of the System report included a graphical representation of the high differential pressure problems caused by pluggage, showing very high differential pressure ranging from 12 to over 14 inches of water pressure at the beginning of 2007 at both Unit 1 and Unit 2. The two graphs are found in Pl. Ex. 15, at AM-00196909-10:

2007 U1 Gas dP



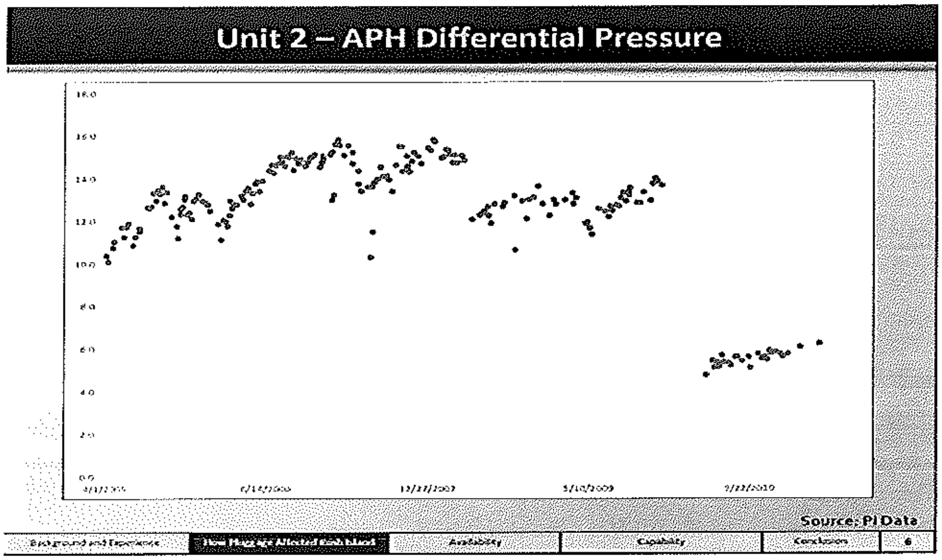
2007 U2 Gas dP



76. At Unit 1, the graphs indicate that differential pressure at Unit 1 dramatically dropped from about 14 inches of water pressure in early 2007 down to 4 to 6 inches of water pressure after the Unit 1 air preheaters were replaced in the Spring of 2007. Pl. Ex. 15, at AM-00196909. At Unit 2, the graph shows the permanence of the pluggage. As compared to the dramatic improvement achieved at Unit 1 due to the boiler component replacements, the Unit 2 graph shows only a very small improvement in differential pressure (from 14 down to 12 inches) following a washing of Unit 2 in the Spring of 2007, which almost immediately crept back up to 14 inches. Pl. Ex. 15, at AM-00196910. Koppe Test., Tr. Vol. 3-A, at 23:15 – 26:3.

77. The differential pressures described in the 2008 State of the System report before the boiler components were replaced were extremely high and caused load reductions. Koppe Test., Tr. Vol. 3-A, at 24:12-25:4. Ameren's trial witnesses Joseph Sind and Andrew Williamson referred to such differential pressures as "extremely high" and indicative of "high pluggage." Sind Test., Tr. Vol. 9-B, at 26:16 – 18 (air preheater differential pressures above even 11 inches are "extremely high"); Williamson Test. Tr. Vol. 9-B, at 44:4-11 (air heater differential pressure of 15 inches indicates "high pluggage").

78. Mr. Koppe's analysis of the company's operational data showed that the same high differential pressures reported in the 2008 State of the System report plagued Unit 2 throughout the years leading up to the 2010 major boiler outage. As Mr. Koppe's review of Ameren's data demonstrated, Unit 2's differential pressure at full load ranged between 10 and 16 inches of water in the years leading up to the projects, before dramatically improving following the 2010 major boiler outage. Koppe Test., Tr. Vol. 3-A 25:22-27:17 (discussing Koppe demonstrative 6).



79. Rush Island's operational data was also compiled in periodic full load tests, which Ameren generally performed on a weekly basis in order to determine the maximum output the unit could achieve at that time. Koppe Test., Tr. Vol. 3-B, 35:17-36:4. During full load tests, the unit tries to generate as much output as it can. Sind Test., Tr. Vol. 9-B, at 30:1-7; Williamson Test., Tr. Vol. 9-B, 42:11-20 (former Rush Island Superintendent of Operations testifying that he reviewed full load tests on a regular basis so he could understand what the capability of the units were); *see also* November 2007 email (Pl. Ex. 130), at AM-02635983 (Rush Island performance engineer James Bosch discussing full load test results after being asked to determine the "capacity" of Unit 1).

80. Plaintiff's Exhibit 928 is a compilation of these full load tests at Unit 2. In addition to reporting actual data such as pressure differentials, each full load test included a row for a possible narrative description of what was limiting load at the time. *See* Pl. Ex. 928, at Spreadsheet Cell B.2 ("Load Limited by"). In addition to the consistently high reported differential pressures, the full load tests performed during the PSD baseline period for Unit 2 (March 2005 to April 2007) are replete with examples where Ameren engineers went out of their

way to indicate in the narrative description of the load test reports that load was limited by the pluggage that is at issue in this case.[1]

81. Ameren also specifically quantified the generation losses due to the boiler components in company presentations. For instance, the 2008 State of the System presentation attributes 185,286 megawatt-hours of lost production at Unit 2 in 2007 to the air preheaters, as compared to only 15,197 megawatt-hours during that same year at Unit 1, which was the year the air preheaters were replaced at Unit 1. 2008 State of the System (Pl. Ex. 15), at AM-00196900.

82. Ameren trial witness David Strubberg conceded that the reported Unit 1 losses were smaller due to the replacement of the air preheaters. Strubberg Test., Tr. Vol. 8-A, 80:12-81:22 (discussing excerpt of presentation in Pl. Ex. 14). Similarly, a July 2006 email from Mr. Strubberg concerning the potential risks of postponing the Unit 1 major boiler outage estimated an approximately 35 MW load reduction due to pluggage. Strubberg Test., Tr. Vol. 8-A, 90:11-91:10.

83. The pluggage at Unit 2 continued to get worse in the years leading up to the 2010 major boiler outage. As ash plugged up the economizer or air preheater, some of it could be removed relatively easily. But a hard layer of ash deposit would form on the surfaces that could

[1] *See* Pl. Ex. 928, at Cell O.2 ("FD Fan Capacity"), W.2 ("ID FAN SUCT PS"), Y.2 ("ID Fan suction press"); AJ.2 ("ECON PLUGGAGE ID FAN SUCT). AK.2 ("Due to pluggage in boiler, it limits ID fan suction pressure"); AL.2 ("limited by the ID fan suction pressure…Boiler is plugged"); AO.2 ("ID suction Supht [sic] plugged Econ plugged"); AP.2 ("ID Fan Suction (Plugged Boiler)"); AQ.2 ("ID Fan Suction (Plugged Boiler)"), BD.2 ("02 blr pluggage"), BF.2 ("FD FANS"); BV.2 ("APH Pluggage"), BW.2 ("APH Pluggage"), BX.2 ("APH Pluggage"), BY.2 ("APH Pluggage"), BZ.2 ("ID Fan Suction Pressure"), CA.2 ("ID FAC SUCTION PRESS."), CC.2 ("ID Fan Suction"); CE.2 ("Blr Pluggage"), CH.2 ("APH Pluggage), CI.2 ("Suction Press."), CJ.2 ("APH Pluggage"), CK.2 ("APH Pluggage"), CN.2 ("ID Fan Suction Pressure"), CO.2 ("APH Pluggage"), CP.2 ("ID suc press Blr & APH's plugged"), CQ.2 ("APH Pluggage"), CR.2 ("ID FAN SUCT"), CS.2 ("APH Pluggage"), CT.2 ("Aph Pluggage"), CU.2 ("APH Pluggage"), CV.2 ("ID fan suction pressure").

not be removed "short of going in with a chisel and chiseling it out inch by inch. So as time went on, the thickness of these hard layers increased and that means that even after washing these components, the pressure drops were still very high." Koppe Test., Tr. Vol. 3-B, 20:1 – 21:7. This inability to remove the load limitations with high pressure washes was specifically identified in project justification documents for Unit 2. An Ameren memo reported: "A high pressure wash can restore some of the pressure loss, but the gains are dimensioning [sic] with an ever increasing accumulation of hardened fly ash." September 18, 2009 Memo (Pl. Ex. 26), at AM-000954160.

84. By 2008, pluggage of the Unit 2 air preheaters had gotten so bad that Ameren had to install a bypass as a temporary measure to allow gas to get around the pluggage. Koppe Test., Tr. Vol. 3-B, 21:8-21:19; Caudill Test., Tr. Vol. 10-B, 40:25-41:7; Cardinale Dep., July 31, 2014, Tr. 103:17-105:17 ("What they did on Unit 2, put in a pipe bypass around the air preheater because they really had serious pluggage problems."). The effect of the bypass would be to increase the electrical output of the unit and decrease its efficiency. Koppe Test., Tr. Vol. 3-B, 21:25 – 22:10; Cardinale Dep., July 31, 2014, Tr. 43:1-45:10 ("certainly bypassing the air preheater is not something you want to do"). Out of all the plants that Mr. Koppe has assessed throughout his career, he has never seen another example of such a bypass being installed. Koppe Test., Tr. Vol. 3-B, 21:20 – 21:24.

85. The effects of pluggage were also well-documented in other contemporaneous documents. Ameren described the pluggage at Unit 2 in a letter it sent to EPA's Clean Air Markets Division in 2008, "Unit 2 generation has been limited to approximately 90 percent of normal load since the middle of 2007 due to gas flow restrictions in the air preheater." April 7, 2008 Letter (Pl. Ex. 934), at AM-00015890-MDNR. When shown the document at trial, Ameren