

EPA-SAB-xx-xxx

The Honorable Michael S. Regan
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, D.C. 20460

Subject: Transmittal of the Final Science Advisory Board Report: *Review of the Science Supporting the Proposed Rule Titled, New Source Performance Standards for Greenhouse Gas Emissions From New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions From Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule (RIN 2060–AV09).*

Dear Administrator Regan,

The Environmental Research, Development, and Demonstration Authorization Act of 1978 (ERDDAA) requires the Environmental Protection Agency (EPA) to make available to the Science Advisory Board (SAB) proposed criteria documents, standards, limitations, or regulations provided to any other Federal agency for formal review and comment, together with relevant scientific and technical information on which the proposed action is based. The SAB may then make available to the Administrator, within the time specified by the Administrator, its advice, and any comments on the adequacy of the scientific and technical basis of the proposed action. Thus, the SAB is submitting the attached regulatory review report on the scientific and technical basis of the proposed rule titled *New Source Performance Standards for Greenhouse Gas Emissions From New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions From Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule (RIN 2060–AV09)* (GHG Power Plant Rule) published in the Federal Register on May 23, 2023.

On May 23, 2023 EPA proposed under section 111 of the Clean Air Act emission standards for new or modified or reconstructed fossil-fuel fired electricity generating units along with emission guidelines for existing fossil fuel fired electricity generating units in the United States. The proposal sets limits, and provides guidelines, on the atmospheric emission of carbon dioxide. The proposal applies to fossil fuel fired electricity generating units including new gas-fired combustion turbines, existing coal, oil and gas-fired steam generating units, and certain existing gas-fired combustion turbines. The EPA evaluated technologies, costs, energy requirements, performance, and other statutory factors, consistent with the “traditional” approach to establishing standards under section 111 of the clean air act. The SAB elected to

1 conduct a review of the science and technology considerations underlying the EPA proposal at a
2 public meeting held on June 23rd, 2023.

3
4 In conducting this review, the SAB followed the engagement process for review of science
5 supporting EPA decisions outlined in the memo of February 28, 2022, signed by the Associate
6 Administrator in the Office of Policy, the Deputy Assistant Administrator for Science Policy in
7 the Office of Research and Development, and the Director of the Science Advisory Board Staff
8 Office. A workgroup of SAB members reviewed the proposed rule and workgroup members
9 responded to charge questions, developed by the group, on topics in the proposed rule. The
10 workgroup took the lead in SAB deliberations on the science supporting the proposed rule at a
11 public meeting of the Chartered SAB held on February 29th, 2024. The SAB's advice and
12 comments on the science supporting the proposed rule are provided in the enclosed regulatory
13 review report.

14
15 The SAB acknowledges the unprecedented and challenge of achieving ambitious emission
16 reduction targets in a dynamic technological and regulatory environment. However, the SAB
17 finds that the greenhouse gas (GHG) emission reductions that would be achieved by the
18 proposed rule are insufficient to align the United States electricity sector's emissions with
19 established national goals, and that the use of both natural gas and hydrogen as fuels to
20 generate electricity have atmospheric consequences that may not be accounted for in the rule.
21 The SAB recommends that the EPA:

- 22 • consider substantial increases in the stringency of the proposed rule to align the
- 23 outcomes with the Administration's goals and develop the ability to rapidly and
- 24 realistically assess a wide variety of alternative measures and innovative technologies;
- 25 • incorporate a more accurate understanding of methane emissions from natural-gas
- 26 value chains into future benefit analyses, as required under the revised Greenhouse Gas
- 27 Reporting Rule; and
- 28 • form a working group that will update the definition of low-GHG hydrogen regularly as
- 29 technological and industrial capabilities evolve.

30
31 The SAB appreciates the opportunity to provide comments on the science supporting the
32 proposed rule. We look forward to receiving the Agency's response.

33
Sincerely,

Chair
EPA Science Advisory Board

34
35 Enclosure:

NOTICE

This report has been written as part of the activities of the EPA Science Advisory Board, a public advisory committee providing extramural scientific information and advice to the Administrator and other officials of the Environmental Protection Agency. The Board is structured to provide balanced, expert assessment of scientific matters related to problems facing the Agency. This report has not been reviewed for approval by the Agency and, hence, the contents of this report do not represent the views and policies of the Environmental Protection Agency, nor of other agencies in the Executive Branch of the Federal government, nor does mention of trade names or commercial products constitute a recommendation for use. Reports of the EPA Science Advisory Board are posted on the EPA website at <https://sab.epa.gov>.

The SAB is a chartered federal advisory committee, operating under the Federal Advisory Committee Act (FACA; 5 U.S.C. 10). The committee provides advice to the Administrator of the U.S. Environmental Protection Agency on the scientific and technical underpinnings of the EPA's decisions. The findings and recommendations of the Committee do not represent the views of the Agency, and this document does not represent information approved or disseminated by EPA.

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DRAFT Science Advisory Board Report: *New Source Performance Standards for Greenhouse Gas Emissions From New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions From Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule (RIN 2060–AV09)*

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ACRONYMS AND ABBREVIATIONS

1		
2		
3	ACS	American Community Survey
4	BENMAP-CE	Environmental Benefits Mapping and Analysis Program-
5		Community Edition
6	BSER	Best System of Emission Reduction
7	CAA	Clean Air Act
8	CAMx	Comprehensive Air Quality Model with Extensions
9	CCS	carbon capture and sequestration
10	CASAC	Clean Air Scientific Advisory Committee
11	CH ₄	methane
12	CO ₂	carbon dioxide
13	DoE	U.S. Department of Energy
14	EGU	Electricity Generating Unit
15	EJ	Environmental Justice
16	EPA	U.S. Environmental Protection Agency
17	ERDDAA	Environmental Research, Development, and Demonstration
18		Authorization Act of 1978
19	GHG	greenhouse gas
20	GHGRP	Greenhouse Gas Reporting Program
21	GHG Reporting Rule	Greenhouse Gas Reporting Rule: Revisions and Confidentiality
22		Determinations for Petroleum and Natural Gas Systems
23	Gt	Gigatonne
24	GW	Gigawatt
25	GWP	Global Warming Potential
26	HAP	Hazardous Air Pollutant
27	IPCC	Intergovernmental Panel on Climate Change
28	ISA	Integrated Science Assessment
29	IWG	Greenhouse Gas Monitoring and Measurement Interagency
30		Working Groupkg kilogram
31	kg/h	kilogram per hour
32	MMT	million metric tons
33	MOE	margin of error
34	MW	Megwatt
35	NAAQS	National Ambient Air Quality Standards
36	NASEM	National Academies of Science, Engineering and Medicine
37	NDC	Nationally Determined Contribution (of greenhouse gas
38		reductions)
39	NSPS	New Source Performance Standards
40	PM	Particulate Matter
41	RIA	Regulatory Impact Assessment
42	SAB	EPA Science Advisory Board
43	SC-GHG	Social Cost of Greenhouse Gases

Science Advisory Board (SAB) Draft Report (February 1, 2024) Do Not Cite or Quote --This draft is a work in progress, does not reflect consensus advice or recommendations, has not been reviewed or approved by the chartered SAB and does not represent EPA policy.

1	TCEQ	Texas Commission on Environmental Quality
2	TRL	Technology Readiness Level
3	TWh	Terawatt-hours
4	UNFCCC	United Nations Framework Convention on Climate Change
5	USGCRP	U.S. Global Change Research Program
6	VOC	volatile organic compound

1. INTRODUCTION

As part of its statutory duties, the EPA Science Advisory Board (SAB) may provide advice and comments on the scientific and technical basis of planned EPA regulatory actions pursuant to the Environmental Research, Development, and Demonstration Authorization Act of 1978 (ERDDAA). ERDDAA requires the EPA to make available to the SAB proposed criteria documents, standards, limitations, or regulations, together with the relevant scientific and technical information on which the proposed action is based. Based on this information, the SAB may provide advice and comments. Thus, the SAB has reviewed the scientific and technical basis of the proposed rule titled *New Source Performance Standards for Greenhouse Gas Emissions From New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units; Emission Guidelines for Greenhouse Gas Emissions From Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule (RIN 2060–AV09)* (GHG Power Plant Rule) published in the Federal Register on May 23, 2023.¹

In 2009 EPA concluded that the emission of greenhouse gases, including carbon dioxide, endangers public health and welfare. This conclusion is consistent with the international scientific consensus and is strongly supported by a growing body of scientific evidence. By establishing performance standards and providing emission guidelines in the proposed rule reviewed here, the EPA is attempting to reduce a significant quantity of GHG emissions from new and existing fossil-fuel fired electricity generating units. The EPA under the authority granted by section 111 of the Clean Air Act evaluated the scientific and technological feasibility of several emission reduction approaches, and considered other factors, such as cost, to develop the proposal being reviewed.

In conducting this review, the SAB followed the engagement process for review of science supporting EPA decisions outlined in the memo of February 28, 2022, signed by the Associate Administrator in the Office of Policy, the Deputy Assistant Administrator for Science Policy in the Office of Research and Development, and the Director of the Science Advisory Board Staff Office. The SAB met on June 23, 2023, and elected to review the scientific and technical basis of the proposed rule. A workgroup of SAB members was assembled to review the proposed rule, and a subset of workgroup members responded to charge questions developed by the group on topics of interest in the proposed rule. The SAB Workgroup consisted of Drs. David Allen (chair of the Workgroup), Susan Anenberg, Tami Bond, Jayajit Chakraborty, Steven Hamburg, David Keiser, Jonathan Samet, and Drew Shindell. The workgroup took the lead in SAB deliberations

¹ New Source Performance Standards for Greenhouse Gas Emissions from New, Modified, and Reconstructed Fossil Fuel-Fired Electric Generating Units: Emission Guidelines for Greenhouse Gas Emissions from Existing Fossil Fuel-Fired Electric Generating Units; and Repeal of the Affordable Clean Energy Rule, Federal Register, Vol. 88, No. 99, page 33240, Tuesday, May 23, 2023. [Available at: <https://www.federalregister.gov/documents/2023/05/23/2023-10141/new-source-performance-standards-for-greenhouse-gas-emissions-from-new-modified-and-reconstructed>]

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- 1 on the science supporting the proposed rule at a public meeting of the Chartered SAB held on
- 2 February 29th, 2024.
- 3

2. SAB ADVICE AND COMMENTS ON THE PROPOSED RULE

2.1. Overview and Relevance.

2.1.1 Charge Question 1: Comment on the United States' commitment to limiting climate change, how cumulative greenhouse gas (GHG) emissions affect climate, the pace needed for greenhouse gas reductions, and the role of the electric-power generating system in achieving those reductions.

United States commitments

The United States is a party to the United Nations Framework Convention on Climate Change (UNFCCC); the objective of the UNFCCC is to stabilize “greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system.”² The United States is also a party to the Paris Agreement, which identifies the levels to be achieved:

Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change;

These temperature targets are aligned with EPA’s requirement to protect the health and well-being of Americans. Within both the UNFCCC and the Paris Agreement, the nation has committed to the principle of “common but differentiated responsibilities and respective capabilities,” in which countries possessing advanced technology lead in combating climate change. As do all parties to the Paris Agreement, the United States produced its own Nationally Determined Contribution (NDC), or intended actions to mitigate climate impacts, in April 2021.

Earth-system considerations

Cumulative emissions of CO₂ – that is, the total of emissions over history - are closely linked to global temperature change, and the carbon budget, consistent with a given warming level, is readily estimated. Through 2019, the world emitted around 2560 gigatonnes (Gt) CO₂ through 2019 (IPCC, 2022). The total worldwide remaining carbon budget for allowable emissions from 2020 onwards to meet 2 °C or 1.5 °C Paris targets is quite limited: just 500 Gt CO₂ for a 50% probability of keeping below 1.5 °C (IPCC, 2022). Global emissions are currently around 40 Gt CO₂ per year (IPCC, 2022), meaning that between 2020-2022 alone, humanity used around 120 Gt CO₂ of the small remaining budget. Large portions of the remaining carbon budget are

² United Nations Framework Convention on Climate Change, United Nations, 1992; [Available at: https://unfccc.int/sites/default/files/convention_text_with_annexes_english_for_posting.pdf]

emitted each year, so the time frame for reductions to near-zero becomes shorter. After updating contributions from non-CO₂ drivers of climate change, such as methane, and accounting for the last few years of emissions, the carbon budget remaining after January 2023 is only about 250 Gt CO₂ for a 50% probability of keeping below 1.5 °C (Lamboll et al., 2023). Such a small budget would be exhausted by the end of 2028 if emission remain at current levels. The share of the small allowable future budget allocated to the United States is small if the worldwide total is divided up according to current emission levels, current population or a combination of those (Raupach et al., 2014; Tavoni et al., 2015). The United States share becomes even smaller or vanishes entirely if historical emissions are taken into account.

No single timeframe can be assigned to any specific transition in any single country, as future climate will be set by total emissions from all sectors and all countries. However, specific timelines are widely reported in the scientific literature for many of the main features of the energy transition. The electricity generation sector plays an important role in keeping emissions within carbon budgets. It is the easiest sector to decarbonize based on the availability of low or zero carbon technology, societal acceptance of alternatives, and cost considerations (de Coninck et al., 2018). Scenarios in which emissions are successfully kept within carbon budgets generally decarbonize this sector rapidly and completely (Clarke et al., 2022). Scenarios that keep warming within the Paris Agreement's ambitious 1.5 °C target include a virtually complete phaseout of unabated coal-fired power by 2030 and achievement of net-zero emissions throughout the electricity sector by 2035 in developed countries.

In the United States, the electricity generation sector was responsible for about 31% of CO₂ emissions in 2022 (DoE, 2022). For several reasons, rapid and deep reductions in emissions from this sector are critical to meet climate goals. Reductions in emissions from the electricity generation sector are critical because of: (1) this sector's substantial current emissions, (2) the availability of existing options to eliminate emissions from the sector, many of which have lower costs than maintaining current systems, and (3) the need to electrify the bulk of current non-power sector fossil fuel end uses, such as transport and heating, that will increase electricity demand and would therefore otherwise increase the share of the electricity generation sector's CO₂ emissions (Clarke et al., 2022).

Energy-system considerations

Fossil fuels serve three purposes in today's energy system: they are sources of available energy; they store energy and release power when needed; and they serve as carriers that transport stored energy to the location of end-use. This combustion and subsequent release of products increases carbon dioxide in the atmosphere when carbon is a component of the fuel. The system of energy provision entails selecting not only energy sources but also the storage and conveyance of useful energy. An energy source may be extracted in one place (e.g., a coal mine); processed to a suitable quality in another location and combusted in yet another (a power plant). Each transformation, and each transportation, entails some losses of energy and fuel mass. Notably, the simple combustion of any fuel to produce electricity is a transformation

1 with typical efficiencies of 35-50%. Greenhouse-gas emissions from an energy system are set by
2 choices of source, storage, and carrier; and the end-use to which they are matched. System
3 efficiency is optimized by minimizing the number of transformations and the distance over
4 which carriers are distributed.

5
6 In the current United States regulatory environment, the EPA does not have jurisdiction over
7 the entire energy system. Specifically, in *West Virginia vs. EPA* (U.S. Supreme Court Docket 20-
8 1530, February 2022),³ the United States Supreme Court ruled that Congress did not task the
9 EPA with “balancing the many vital considerations of national policy implicated in the basic
10 regulation of how Americans get their energy.” The Court specifically addressed the issue of
11 generation-shifting, averring that the mix of energy sources was not within the EPA’s purview.
12 In *West Virginia*, the Court stopped short of limiting the EPA to “measures that improve the
13 pollution performance of individual sources, such that all other actions are ineligible to qualify
14 as the [Best System of Emission Reductions].” But the Court did encourage such a focus,
15 pointing out that “EPA has acted consistent with such a limitation for the first four decades of
16 the [Clean Air Act]’s existence.”

17
18 An implication of the *West Virginia* ruling is that in developing New Source Performance
19 Standards under the authority of the Clean Air Act, the EPA is precluded from taking advantage
20 of energy-system features external to individual electricity generating units (EGUs), including
21 generation shifting as well as other energy innovations being spurred by the threat of climate
22 change. The SAB infers that the limited authority granted to EPA also carries with it a limited
23 responsibility for certain outcomes. In meeting national GHG emission goals and climate
24 commitments, the EPA must be viewed as just one partner among federal agencies, States,
25 industrial concerns, and the American public. Specifically, debating the projections of
26 technological advance provided by the Department of Energy and other relevant agencies is
27 likely not within the EPA’s jurisdiction. Measures to reduce costs might occur within regional
28 markets or an entire grid system, but participation in such cost optimization is not to be
29 expected addressed within individual rules promulgated by the Agency. EGU operators have
30 freedom of choice with regard to energy generation, storage, and distribution options outside
31 the boundaries of their facilities. However, these factors are exogenous to EPA’s rule-making
32 for power plants.

33
34 The SAB finds that the regulatory focus on individual facilities limits the EPA to three
35 technological options for reducing GHG emissions from EGUs: (1) improving plant efficiency so
36 that less fuel is required per kilowatt-hour output, known as heat rate improvements; (2)
37 combusting the same fuel, but removing carbon from the exhaust with carbon capture and
38 sequestration (CCS); or (3) using fuels with a lower carbon content, accomplished by
39 emphasizing natural gas or firing or co-firing with low-carbon fuels such as hydrogen or
40 changing fuels entirely to a zero carbon option. Many efficiency gains have already been
41 realized (Memorandum included in the proposed rule docket authored by Sargent & Lundy

³ <https://www.supremecourt.gov/docket/docketfiles/html/public/20-1530.html>

Chicago, IL dated March 2023⁴), and the proposed rule assumes that the Best System of Emission Reduction (BSER) includes all possible heat rate improvements. The proposed rule introduces the latter two options as alternatives to complete the BSER.

2.2. Overview of the Regulatory Impact Analysis

2.2.1 Charge Question 2: Comment on the modeling framework employed by EPA for the overall analysis of costs, impacts, and benefits

The SAB reviewed the tools used by EPA to estimate changes in emissions, the costs of those changes, and the impacts of emissions and reduced emissions as presented in the Regulatory Impact Assessment. These tools are listed in Table 1. Overall, the SAB finds that the tools selected for analysis have been peer reviewed and are the best models available to the EPA. In the case of the computational general equilibrium model SAGE, a new tool was developed and peer reviewed following recommendations from the SAB in 2015. A novel aspect of the SAGE model analysis, which had not yet emerged at the time of that the SAB peer review, is the addition of hydrogen as an energy carrier and storage medium.

The SAB commends the EPA for transparency in modeling and in sharing intermediate results, such as required electricity and hydrogen consumption within the power sector provided in the supplemental Regulatory Impact Assessment (RIA; EPA supplemental notice of proposed rulemaking published November 20th, 2023 in the *Federal Register* 88 FR 80682⁵). Such intermediate results aid public understanding in addition to the SAB's review.

Table 1: EPA Tools Used in the Estimation of Costs and Health Benefits

EPA Tool	Use	Peer-Review
SAGE Computational General Equilibrium Model	Simulates inputs and outputs in nationwide economy by sector	Peer review conducted in 2022
Integrated Planning Model (IPM)	Estimate emission reductions from individual electrical generating units based on policy changes; linked to SAGE	Peer review conducted in 2019 with EPA response in 2022
CAMx version 7.10	Model changes in ozone and PM _{2.5} concentrations from	Peer review in 1997 when developed

⁴ Document can be accessed at <https://www.regulations.gov/document/EPA-HQ-OAR-2023-0072-0018>

⁵ Available at: <https://www.federalregister.gov/documents/2023/11/20/2023-25580/new-source-performance-standards-for-greenhouse-gas-emissions-from-new-modified-and-reconstructed>

	the rule	
Particulate Matter Source Apportionment Technology (PSAT) tool	Estimate contributions to PM _{2.5} from groups of emission sources	Component of CAMx
Anthropogenic Precursor Culpability Assessment (APCA) tool	Estimate contributions to ozone from groups of emission sources	Component of CAMx
BENMAP-CE	Estimate counts of mortality and morbidity events; Monetize the benefits of reducing the numbers of morbidity and mortality events	Previous peer review and SAB review in progress

2.3. Achieving Greenhouse Gas Reduction Targets

2.3.1 Charge Question 3. Comment on whether the proposed rule is likely to achieve greenhouse gas reduction targets from the power generation sector that are consistent with national commitments and international goals and treaties.

Magnitude and pace of reductions

The United States' NDC, communicated under Article 4 of the Paris Agreement, commits to reduce economy-wide GHG emissions by 50-52% by 2030. Recognizing that the electricity sector is the most amenable sector for rapid decarbonization, the Biden Administration set forth a goal of net zero electricity sector emissions by 2035 as a critical component of meeting the 2030 NDC and a longer-term transition to net-zero CO₂ emissions (The White House, 2021).

The United States' NDC and electricity sector emission goals are consistent with analyses of the global transition required to keep planetary temperatures below low warming targets. For example, the United Nations Climate Solidarity Pact calls for the electricity sector to reach net zero emissions by 2035 and for coal-fired power to be phased out by 2030 in developed countries (UN, 2023). Similarly, the electricity sector achieves net zero emissions in advanced economies by 2035 in the Net Zero Emissions scenario from the International Energy Agency (IEA, 2022).

These transitions are clearly much faster than the proposed timelines for net zero electricity and CO₂ emission reductions from coal-fired EGUs in the proposed rule. The requirement of 40% natural gas co-firing for coal plants, starting in 2030, results in a 16% decrease in CO₂ intensity; an alternative is operating through Dec. 31, 2034 with no reduction in CO₂ emissions

1 if run with a capacity factor of no more than 20%, or operating through Dec. 31, 2031 with no
2 reduction of CO₂ emissions at any capacity factor. By capacity, more than half, 118 gigawatts
3 (GW), of the United States' coal EGUs (212 GW) have announced plans for retirement by 2040,
4 implying that those units would be permitted to release 84-100% of current emissions through
5 the end of their operations, which could be as late as 2039.

6
7 Similarly, for power plants using natural gas, nearly complete co-firing with H₂ is required only
8 in 2038 for large and frequently-operating plants, while intermediate-load gas EGUs are
9 required to co-fire with only 30% co-firing from 2032 onwards. Smaller, frequently-used gas
10 fired power plants, and large but infrequently-used gas plants, are not covered by the existing
11 rule and hence could contribute substantial emissions in the future. In the absence of negative
12 emission deployment within the electricity sector, the continued emissions permitted by the
13 proposed rule from coal- and especially gas-fired power plants past 2035 are inconsistent with
14 the 100% carbon-free electricity goal in the United States' NDC.

15
16 EPA's analysis⁶ shows that the proposed rule would make a very modest contribution toward
17 the NDC's proposed elimination of GHGs from this sector. The baseline projection does show a
18 decrease in EGU emissions of more than 50% by 2035-2040 relative to 2028 and by 76-81%
19 relative to 2005. However, emissions during 2035-2040 are still projected to range from 500-
20 600 million metric tons CO₂ per year. Compared with baseline projections, the proposal would
21 reduce emissions from EGUs by only about 7-8% in 2035 and 2040. EPA projects a 76%
22 decrease from 2005 to 2035 in the baseline analysis, and a 78% decrease over the same time
23 period when the proposed rule is applied.

24
25 Detailed analyses of the transitions required to meet the United States' NDC have been
26 published in the peer-reviewed scientific literature. A "central case" deep decarbonization
27 scenario for the United States illustrates the pace of the energy transition required to achieve
28 net zero CO₂ emissions by 2050 (Williams et al., 2021). In that scenario, natural-gas fired
29 electricity generation decreases from about 1800 terawatt-hours (TWh) (about 43% of
30 generation) in 2023 to 700-800 TWh (about 10%) in 2040. In contrast, EPA's analysis of this rule
31 projects that it would only decrease unabated gas to 1063 TWh in 2040.

32
33 Other scenarios examined in that study include low land use, delayed electrification, and 100%
34 renewables; those rely on even less energy from unabated natural gas in 2050 – roughly 100-
35 300 TWh versus ~350 TWh in the central case (values in 2040 were not reported), suggesting
36 the 2040 decrease in the central case may be on the low side across NDC consistent scenarios.
37 Coal-fired power is phased out by 2030 across all pathways examined in this study, with less
38 than 1% of current generating capacity left in 2030, again a faster pace than the EPA's modeling
39 of the effects of this rule.

40

⁶ Table 3 in Memorandum on Additional Modeling Analysis EPA-HQ-OAR-2023-0072-0237 available at:
<https://www.regulations.gov/document/EPA-HQ-OAR-2023-0072-0237> last accessed February 1, 2024.

Global projections, including those reported in the Intergovernmental Panel on Climate Change (IPCC) AR6 Synthesis Report: Climate Change 2023, (IPCC, 2023), are consistent with the Williams et al. (2021) study. Unabated coal decreases by about 70-80% worldwide by 2030 in scenarios consistent with reaching 1.5 °C (Allen et al., 2018; Clarke et al., 2022). The IPCC AR6 states that “To limit warming to 2 °C or lower, and without new builds, existing coal plants will need to retire 10 to 25 years earlier than the historical average operating lifetime” (Clarke et al., 2022). Therefore, in order to meet stated climate goals, the U.S. would need to retire its relatively old fleet of unabated coal-fired power plants faster than planned and faster than in other countries to meet low warming targets and its NDC.

Another consideration is that of lock-in, or capital investments that favor generation with specific fuels. While the use of natural gas fuel can be useful in meeting moderate GHG emission reduction goals, its continued use is consistent with short-term, but not longer-term goals (e.g., Riesz et al., 2015; De Sisternes et al., 2016). IPCC AR6 states: “If investments in coal and other fossil infrastructure continue, energy systems will be locked into higher emissions, making it harder to limit warming to well below 2 °C.” (Clarke et al., 2022). While GHG emissions from both coal and natural gas can be mitigated with CCS or hydrogen co-firing, investing in technologies that burn fossil fuel carries the implication that mitigation technologies, which are still emerging, will work perfectly and ultimately obtain a zero-emission power sector (Elliston et al., 2014) or that low warming targets will not be achieved.

A final concern relates to the total carbon budget, which is the quantity relevant to temperature change and risk from climate change. Most existing scenario projections include decreases in emissions beginning in 2021 (e.g., Williams et al., 2021; Clarke et al., 2022), while emissions have continued at a high rate from 2020-2023. Thus, achieving carbon targets would necessitate even faster reductions than those in most existing scenarios.

The SAB is concerned about the continuation of allowable GHG emissions under this rule, since the time required to implement responsive regulations is long compared to both the required pace of transition and compared to the rate of technological development. The SAB encourages EPA to consider increases in the stringency of the proposed rule, including requirements for co-firing with hydrogen earlier than 2038 for large and frequently used gas-fired power plants; expansion of the rule to cover smaller, frequently used gas-fired power plants; and more rapid timescales for implementing emission controls for coal-fired units retiring between 2030 and 2040.

Finding: The SAB finds that GHG emission reductions that would be achieved by the proposed rule are insufficient to align the United States electricity sector’s emissions with national goals. Given the importance of this sector in leading the way towards net-zero GHG emissions, it is very likely that the proposed rule is inconsistent with Paris Agreement targets. In 2035 and 2040, the rule appears to have a small influence on baseline electricity-sector CO₂ emissions. The rule also lacks provisions to recognize the importance of total carbon budgets in achieving temperature targets.

Recommendation: The SAB recommends that EPA should consider substantial increases in the stringency of the proposed rule, to align the outcomes with the Administration’s goals and the nation’s Nationally Determined Contribution to meeting climate targets.

Value-Chain Measurement and Accounting

Both methane, a primary component of natural gas, and hydrogen can be unintentionally released to the atmosphere during production, storage, transportation and use. Use of these gases to produce energy causes emissions not only at the point of transformation, but along the entire value chain. It is important to ensure that these “value-chain” emissions are considered in evaluations of climate impact.

Methane emissions from production are large in some regions, enough so that they alter the net effect of electricity-generation schemes when included in analysis. For example, the apparent climate benefits of replacing fossil-fuel generated electricity with electricity generated with hydrogen produced from natural gas combined with carbon capture and storage may be offset or even eliminated (Howarth and Jacobson, 2021; Bauer, et al., 2022; Ocko and Hamburg, 2022).

Understanding this potential problem is complicated by uncertainties in quantification. Current inventories of natural gas value chain methane emissions in the United States consistently underestimate emissions when compared to empirical measurements (Alvarez et al., 2018). The Inflation Reduction Act of 2022 included a requirement to revise the Greenhouse Gas Reporting Program (subpart W) as it relates to oil and gas reporting, requiring that reports be based on empirical data and be accurate.⁷

Hydrogen. While hydrogen is not included in the list of greenhouse gases currently considered by the EPA, its indirect effects on climate are significant. The hydrogen molecule is much smaller than other molecules, and is therefore more likely to escape from pipes and other infrastructure than methane (Swain and Swain, 1992). Hydrogen is also highly reactive in the atmosphere. Its three known mechanisms of indirect impact on climate are: reacting with hydroxyl radical that reduces hydroxyl radical concentrations in the troposphere and leads to increased methane residence times; formation of tropospheric ozone; and formation of stratospheric water vapor (Paulot et al., 2021). Hydrogen is estimated to have a global warming potential (GWP) of 37 over 20 years and 12 over 100 years (IPCC, 2023; Sand et al., 2023; Derwent, 2023). For comparison, methane has a 20-year GWP of 81-83 and a 100-year GWP of 27-30 (IPCC,2023). Thus, value-chain hydrogen emissions can offset at least some of the climate benefits of shifting from fossil fuel to hydrogen energy systems, particularly during the first few decades after the switch is implemented (Ocko & Hamburg, 2022). The indirect climate impacts

⁷ Reviewed by the SAB January 17, 2024 report EPA-SAB-24-004 is available https://sab.epa.gov/ords/sab/f?p=114:0:13875130647045:APPLICATION_PROCESS=REPORT_DOC:::REPORT_ID:1125

of methane emissions are considered in EPA's use of IPCC GWPs, and it would be inconsistent to ignore comparable impacts from hydrogen.

One of the challenges of recognizing and quantifying hydrogen emissions is the lack of empirical data on emissions from existing infrastructure. Estimates of hydrogen emissions from existing value chains vary by two orders of magnitude although no empirical data are currently available (Esquivel-Elizondo et al., 2023). Technology is emerging to make fast-response, high-precision measurements required to characterize value-chain emissions, but these measurements have not yet been made.

Time horizon. Using the 100-year GWP, which is EPA's default standard, inaccurately represents the near-term implications of fuel switching (Ocko et al., 2017) because hydrogen and methane are short-lived climate pollutants.

Finding: The SAB finds that both methane (natural gas) and hydrogen have emissions and atmospheric consequences that are not accurately accounted for in current greenhouse analyses of climate impacts.

Recommendations: The SAB recommends that EPA incorporate more accurate estimates of methane emissions from natural-gas value chains into future climate benefit determinations and cost-benefit analyses. Such improvements appear to be required under the Inflation Reduction Act through improvements to the Greenhouse Gas Reporting Rule.

The SAB also recommends that EPA support or promote research on the air-quality, climate and health impacts of hydrogen leakage, including improvements in detection technology for hydrogen. An understanding of unintended atmospheric consequences of hydrogen usage should be incorporated into future climate benefit determinations and cost-benefit analyses.

2.4. Mitigation Analysis

2.4.1 Charge Question 4. The Regulatory Impact Analysis (RIA) describes two pathways to meet the Best System of Emission Reduction (BSER): carbon capture and sequestration (CCS) of 90% by 2035 or hydrogen co-firing of 30% by 2032 with an increase to 96% by 2038. Comment on whether EPA's analyses of GHG emission reduction associated with these technologies are reasonable, appropriate, and based on the most current understanding of costs and feasibility. Also comment on whether adequate consideration has been given to unintended impacts of these technologies.

Carbon Capture and Sequestration

Financial Costs. The potential benefits and costs of the use of CCS in industry vary considerably due to the diversity of industrial processes; Kearns et al. (2021) provide a recent review. The EPA relies on current data showing that costs are high but are coming down. For example, Giannaris et al. (2020) suggest a CCS cost of 47 U.S. dollars per tonne of CO₂ for a 90% capture power generation plant based on learnings from the Saskpower Boundary Dam pilot. The EPA relies on this work as well as an analysis by the Global CCS Institute and operating data from several operating CCS retrofits in the United States or Canada (88 FR 33254). The proposed rule acknowledges that at present only a small number of full-scale CCS power plants have been built, so that analysis of costs and cost projections rely on limited data from the energy sector. There is much more cost data from the industrial sector, which contributes to projections of cost decreases due to technological innovation and learning. The SAB notes that the 2015 rules already require CCS for new coal, with higher cost estimates than those in the current rule.

Storage limitations. A challenge with all CCS strategies is construction of gathering and transport networks for CO₂. Transport and sequestration cost estimates are included, based on U.S. Department of Energy (DoE) reports that most United States units are within 80 km of plausible storage locations (88 FR 33347). This seems to be a reasonable approach.

The United States has the potential for storage of several trillion tons of CO₂ (Kearns et al, 2017), as compared with emissions of about 1 billion tons per year from the power generation sector. The number of CCS storage facilities in the United States is growing rapidly, with planned projects nearly doubling between 2022 and 2023 (Global CCS Institute, 2023). Thus, use of CCS is not limited by capacity, but rather by the rate of infrastructure development and refinement.

Finding: The SAB finds that cost estimates provided by the EPA for carbon capture and storage are reasonable given the emerging state of technology development.

Societal Costs. Societal costs for CCS are discussed in the RIA in a qualitative sense as potentially important issues (section 4). Some impacts include ammonia emissions that cause air-quality degradation (Jablonka et al., 2023; Waxman et al., 2023). Data on the range of societal impacts is quite limited due to the lack of experience with CCS. Effects of CCS on drinking water are subject to separate rules, as geologic sequestration of CO₂ is regulated by the EPA through the Underground Injection Control Program under the Safe Drinking Water Act. Nonetheless, the Agency should include estimates of the social costs of drinking water-related impacts in the analysis of this rule.

Recommendation: Recognizing the limited history available to characterize widespread CCS operation, the SAB recommends support for monitoring societal impacts to identify risks and costs.

Hydrogen co-firing

Hydrogen cost and production capacity. The current proposed rule anticipates that the combination of the Bipartisan Infrastructure Law and the Inflation Reduction Act will help spur the development of low-GHG hydrogen.⁸ This aspiration is consistent with DoE’s National Clean Hydrogen Strategy and Roadmap⁹ (hereinafter Hydrogen Roadmap). Modeling for the RIA treats hydrogen as a fuel that “is available at affected sources at a delivered cost of \$1/kg under the baseline, and at a delivered cost of \$0.5/kg in years when the second phase of the proposed New Source Performance Standards (NSPS) is assumed to be active.” The first cost target is consistent with the Hydrogen Roadmap, which seeks “\$1 per 1 kg within 1 decade” after 2021. DoE’s *Hydrogen Roadmap* production targets are 10 million metric tons (MMT) per year by 2030 and 20 MMT by 2040. One MMT of hydrogen, if combusted in a turbine of 60% efficiency, would produce about 24 TWh of electricity. Thus, EPA’s projection of 42 TWh of hydrogen co-firing in 2040¹⁰ consumes a small fraction of the projected production. This fraction in outlying years is broadly consistent with DoE’s vision that hydrogen would be applied in the power generation sector as part of a “second wave” of hydrogen deployment (Fig. 41, *Hydrogen Roadmap*).

However, EPA’s projection of 283 TWh co-firing in the intermediate year of 2035 is a cause for concern. It would consume almost all the projected hydrogen production capacity during a critical time when DoE’s strategy might be directing that production toward other well-matched uses such as steel and cement production. In an economy-wide computable general equilibrium model, competition for this inexpensive hydrogen resource would normally have been simulated, but the limited representation of hydrogen as a fuel with a fixed cost may have allowed modeled consumption to occur without this natural limitation. The influence of this assumption might be explored with sensitivity analyses that use different, plausible costs of hydrogen.

Recommendation: The SAB recommends that costs of the proposed rule as estimated in the RIA should include realistic uncertainties in the price of available hydrogen throughout Phases I, II and III. These cost uncertainties should reflect potential competition for hydrogen as a limited resource.

Upstream emissions for hydrogen production.

Major pathways to producing hydrogen include reforming of carbon-based fuels and electrolysis with power from renewable sources. Essentially all hydrogen in use today is fossil-

⁹ [U.S. National Clean Hydrogen Strategy and Roadmap \(energy.gov\)](https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf) [Available at: <https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf>]

¹⁰ Integrated Proposal Modeling and Updated Baseline Analysis, Memo to the Docket, July 7, 2023; Table 11. [Available at: <https://www.regulations.gov/docket/EPA-HQ-OAR-2023-0072/document?filter=memo%20>]

fuel derived, produced by steam reforming of methane. Carbon intensities range from 0.3-0.8 kg CO₂eq/kg H₂ for electrolysis using renewable energy to 20-25 kg CO₂eq/kg H₂ for hydrogen from reforming coal (Incer-Valverde et al, 2023; Fell et al., 2023). Thus, the origin of hydrogen is extremely important in ensuring that net greenhouse gas reductions occurred.

EPA proposes a definition of “low-GHG hydrogen” that conforms to the lowest-emitting production identified in the United States Tax Code 45.V, which provides tax credits for clean hydrogen:

The EPA is proposing that hydrogen qualifies as low-GHG hydrogen if it is produced through a process that results in a GHG emission rate of less than 0.45 kilograms of CO₂ equivalent per kilogram of hydrogen (kg CO₂e/kg H₂) on a well-to-gate basis^{11,12}.

The SAB supports the commitment to define low-GHG hydrogen, which is an important step to constrain GHG impacts arising from an increase in hydrogen production and use. The SAB also supports the emission limitation proposed by the EPA, i.e., 0.45 kg CO₂eq/kg H₂, a value that is coordinated with the envisioned national hydrogen system. The SAB further supports the definition of low-GHG hydrogen in terms of GHG emissions rather than production pathway or “color,” which allows flexibility as technological pathways develop. Finally, the SAB recognizes that producers, end-users, and federal agencies will face important challenges in certifying that the hydrogen used to meet regulatory standards is indeed produced with low GHG emissions.¹³

The SAB has concerns about GHG-relevant emissions downstream of production. The “well-to-gate” definition of GHG emissions is appropriate for assessing production. However, for estimating impacts of fuel usage, a “well-to-wheels” (i.e., production to end-use) definition is more common because it includes the environmental effects of transport and delivery between locations of production and of use.

Finding: The SAB affirms the necessity of a low-GHG hydrogen definition in the proposed rule and recommends that this definition appear before references to that term within the rule.

¹¹ “The term “lifecycle greenhouse gas emissions” shall only include emissions through the point of production (well-to-gate), as determined under the most recent Greenhouse gases, Regulated Emissions, and Energy use in Transportation model (commonly referred to as the “REET model”) developed by Argonne National Laboratory.” - USC 45V “Credit for Production of Clean Hydrogen” 45V.c.1.B

¹² The agency writes, “We also note the model does not track upstream emissions associated with the production of the hydrogen (or any other modeled fuels such as coal and natural gas), nor any incremental electricity demand associated with its production.” (3-13)

¹³ See, for an example discussion the blog post from Bergman, Prest, and Palmer (2022) from Resources for the Future: <https://www.resources.org/common-resources/how-can-hydrogen-producers-show-that-they-are-clean/>.

Recommendation: The SAB strongly recommends formation of a working group that will update the definition of low-GHG hydrogen regularly as technological and industrial capabilities evolve. The EPA should also support discussions about certification of low-GHG hydrogen based on a value-chain definition rather than a “well-to-gate” definition alone.

Readiness of turbine technology for co-firing hydrogen.

Adapting turbines to hydrogen co-firing requires addressing several issues, including the higher flame speeds of hydrogen which may require combustor redesign (Emerson et al., 2020) and additional NO_x production. Manufacturers and researchers are actively working on turbine design to address these issues. Co-firing from 5% to 25% volume has been demonstrated in several projects, and there are current examples of utility companies preparing to co-fire hydrogen. Some major turbine manufacturers advertise their products as compatible for co-firing up to 100% hydrogen by volume. Such high rates of hydrogen co-firing have been tested but do not currently appear in long-term practice.

Technology improvement and utility demonstration are necessary steps toward widespread adoption. These measures may not be sufficient to provide confidence in adopting novel technology for all EGUs, as some may be more committed to sustained and reliable operation than to pushing a technological envelope. It is not easy to assess confidence in the current state of maturity from news reports and manufacturers’ web sites, as these resources do not provide a complete assessment of remaining challenges and prevalence of trouble-free operation. However, Technology Readiness Levels (TRLs) are commonly employed to communicate technology maturity by other federal agencies (DoE, 2011), and advancement along the TRL scale provides confidence to other adopters as technologies begin to penetrate the user base. Without assessing the specific TRL of any technology, it is the SAB’s assessment that the TRL of 25% hydrogen co-firing is far more advanced than the TRL of 96% co-firing, and that this difference may be currently acceptable as 96% co-firing is not envisioned until Phase III. To retain a commitment to the Phase III rates of co-firing, progress along a scale similar to the TRL ladder should be monitored as the eight-year revision of the NSPS approaches.

Readiness of distribution system to transport hydrogen.

Hydrogen might be distributed through natural-gas pipelines, which require no infrastructure change because they already exist at EGUs operating natural-gas turbines. Concerns regarding hydrogen transport by pipeline include embrittlement of pipeline material, hydrogen leakage, and safety (Melaina et al., 2013; Topolski et al., 2022; Kappes and Perez, 2023). There has been practical experience delivering hydrogen content up to about 15-20% by volume. At higher fractions, both plastic pipelines, depending on the material, and steel pipelines can undergo embrittlement by reacting with hydrogen. Advanced materials are being developed but would require replacing existing infrastructure.

Finding: The SAB finds uncertainties in the timing of hydrogen technology readiness, but recognizes these uncertainties as characteristic of a rapidly emerging technological field. As the rule is revisited and alternatives are discussed in the public domain, the SAB suggests communication of alternatives using Technology Readiness Levels.

Energy system considerations.

Hydrogen is envisioned to play an important role as a storage medium and carrier of energy (Figure 2). However, hydrogen is not an energy source; its chemical energy must be generated in some, and low-GHG options for that generation are currently limited to electricity from renewable sources. The “round-trip” efficiency - from electricity to hydrogen to turbine-generated electricity - is less than 50%, sometimes much lower, depending upon the technology employed (Escamilla et al., 2022). Given this loss, the proposed co-firing with hydrogen for stationary sources is of greatest value when it provides energy storage to achieve load matching.

On a purely scientific basis, the SAB would recommend an approach to hydrogen utilization that optimized costs and end-use matching throughout the entire energy system. However, the SAB acknowledges that this rule must be restricted to measures that can be deployed by individual EGUs, and confirms that hydrogen co-firing is one of a limited set of such alternatives.

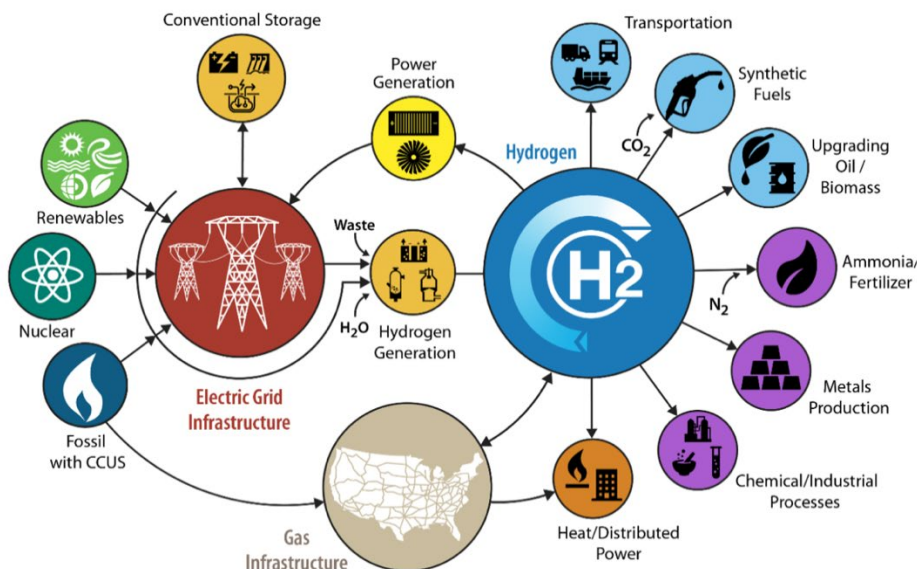


Figure 1. U.S. Department of Energy’s “H2@scale” initiative to enable decarbonization.

Reproduced from the *U.S. National Clean Strategy and Roadmap*.

(<https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf>)

Overall evaluation

The SAB acknowledges the unprecedented nature of stipulating regulations to achieve ambitious emission targets within two decades, with available tools set by a dynamic technological and regulatory environment. The SAB affirms that this challenge lies within the EPA's requirement to protect human health and the environment. The SAB commends EPA for its prior investment in integrated tools that aid in analysis and forecasting. Nevertheless, these tools are not yet adequate to adjust to the rapidly changing environment, leaving a gap in EPA's ability to assess alternatives with responsiveness. For example, modeling conducted for the RIA was not yet able to represent competition for hydrogen within the economy, and it is not apparent how emerging technology, its capacity, or its readiness would be incorporated into ongoing assessments of the best system of emission reduction. The projected persistence of carbon emissions from the electricity-generating sector remains a fundamental barrier to the delivery of the United States' commitments to protecting climate and requires continual attention.

Recommendation: The SAB strongly recommends that EPA develop, or support research to develop, the ability to rapidly and realistically assess how a wide variety of alternative measures and innovative technologies may affect overall greenhouse-gas emissions.

Further, the SAB strongly recommends that EPA engage in continuous use of these tools to explore emerging opportunities and developing limitations. That is, EPA should conduct analysis proactively to lay a foundation for future rules, rather than reactively in response to proposed rules.

2.5. Benefit Calculations

2.5.1 Charge Question 5. Comment on whether the climate and health benefits in the rule and associated technical support documents are appropriately estimated and bounded.

Social Cost of Greenhouse Gases

To assess climate benefits associated with the proposed rule, EPA utilizes Greenhouse Gas Monitoring and Measurement Interagency Working Group (IWG) estimates of the social costs of greenhouse gases (SC-GHG) in accordance with Executive Order 13990 of January 20, 2021. That order reinstated the IWG after it was disbanded in 2017 and required interim SC-GHGs within 30 days¹⁴. The estimates used in this proposed rule rely on interim estimates of the

¹⁴ <https://www.federalregister.gov/documents/2021/01/25/2021-01765/protecting-public-health-and-the-environment-and-restoring-science-to-tackle-the-climate-crisis>

1 social cost of carbon, methane, and nitrous oxide that were subsequently developed and
2 reported by the IWG in February 2021. EPA notes that, “while likely an underestimate, [these]
3 are the best currently available GHG-estimates”¹⁵. EPA noted that the IWG was working to
4 update the SC-GHG estimates through a rigorous peer-review process, public comment
5 solicitation, and review of the scientific literature.

6
7 In November 2022, EPA published a supplemental notice of proposed rulemaking, “Standards
8 of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for
9 Existing Sources: Oil and Natural Gas Sector Climate Review”.¹⁶ To support this notice, EPA
10 conducted a regulatory impact analysis(RIA). In this RIA, the agency used the interim values of
11 the SC-GHGs for the primary benefit-cost analysis. EPA focused on estimates of damages from
12 methane. The agency also included a sensitivity analysis that used draft SC-GHG estimates
13 based on the latest available science and economics. These new estimates are described in a
14 technical report from EPA, “Report on the Social Cost of Greenhouse Gases: Estimates
15 Incorporating Recent Scientific Advances.”¹⁷ These updated SC-GHG values are more evidence-
16 based and comprehensive, compared with the IWG interim values. The EPA retained the use of
17 the updated SC-GHG values in the EPA’s final oil and gas performance standards published in
18 December 2023.

19
20 The EPA noted, and the SAB agrees, that the IWG recommended values are likely to be
21 underestimates. The updated values that EPA finalized in December 2023 are substantially
22 higher, reflecting several additions and updates to the methodology to better reflect current
23 scientific understanding, aligned with recommendations from the National Academy of
24 Sciences, Engineering, and Medicine’s “Valuing Climate Damages” report (NASEM 2017). For
25 example, health impacts of extreme temperature are included in the updated SC-GHG
26 estimates and not in the IWG values. A recent analysis by EPA scientists shows that adverse
27 health impacts contribute more than any other quantified sector to damages from climate
28 change in the United States, driven largely by mortality from climate-driven changes in extreme
29 temperature and air quality (Hartin et al., 2023). Other changes made in the EPA’s updated SC-
30 GHG estimates include updates to the discounting approach, socioeconomic projections,
31 climate models, damage functions, and increased transparency. While the estimates are not
32 directly comparable due to differences in the discount rate approach applied, the new value of
33 \$190 per ton CO₂ at a discount rate of 2% is more than three and a half times higher than the
34 IWG’s recommended value of \$51 per ton CO₂ at a discount rate of 3%, with a rate of 2% being
35 closest to the recommendation of the recent revisions to OMB’s circular A-4.

36
37 In May 2023, an external review panel completed a final report on the methodology behind
38 EPA’s updated SC-GHG estimates. The committee reviewed the use of a modular approach to
39 the methodological update, socioeconomic and emissions module, climate module, damages
40 module, discounting module, and other issues including distributional impacts. While the report

¹⁵ See section XIV.D. of the proposed rule.

¹⁶<https://www.epa.gov/environmental-economics/scghg>

¹⁷ https://www.epa.gov/system/files/documents/2022-11/epa_scghg_report_draft_0.pdf

included only individual reviewer comments and not consensus across the panel, the reviewer comments taken together indicate the panel’s assessment that the new estimates were well-designed and executed and represent a significant advance and improvement over the IWG 2021 interim values.

Finding: The SAB finds that the analyses of climate impacts due to emission changes are scientifically sound in general.

Recommendation: The SAB recommends that the EPA apply their updated SC-GHG estimates to value the climate benefits of the current rule, acknowledging an external review panel’s finding that the updated SC-GHG estimates are more comprehensive, transparent, and evidence-based.

Additional impacts.

As with most evaluations of climate impacts, and all those relying upon the United States government’s valuations for the social cost of greenhouse gases, the analyses neglect many effects of climate change that are clearly important but are difficult to quantify reliably. These neglected impacts include the economic effects of precipitation changes, the effects of extreme weather events, change in the spread of infectious diseases, and changes in ecosystem services, among many others (EPA, 2022).

Even if EPA’s SC-GHG estimates were applied to estimate climate damages, the societal benefits of reducing CO₂ emissions would still be underestimated because even the updated SC-GHG estimates exclude many pathways by which climate change worsens public health. For example, the estimates exclude impacts of climate change on mortality and morbidity from climate-sensitive wildfire smoke, dust, ozone, and extreme weather. The scientific evidence linking climate change to these impacts is strong (Turnock et al., 2023; Hayden and Mahin, 2022, Hayden et al. 2023; West et al. 2023). If these damage pathways were included, the SC-GHG values would almost certainly be larger, leading to larger estimates of the societal benefits of this proposed rule.

In addition, the SC-GHG methodology in general is unable to account for how different population subgroups would be impacted by climate change damages, often referred to as “climate injustice.” Climate damages differ among individuals, communities, and population sub-groups. For example, the EPA’s “Climate Change and Vulnerability in the United States: A Focus on Six Impacts” report describes the degree to which four socially vulnerable populations – based on income, educational attainment, race and ethnicity, and age – may be disproportionately exposed and at risk to damages from climate change (EPA, 2021). Further, EPA has acknowledged the importance of climate equity as part of the overall aim of environmental justice (EPA, 2023) and is now administering the new Environmental and Climate Justice Community Change Grants Program using funds from the Inflation Reduction Act. The current SC-GHG methodology (both used for the IWG recommended values in 2021 and the

EPA November 2022 values) applies a single value of damages with no geographic dimension that could potentially account for disparate impacts to certain communities or population subgroups. The external review panel for the EPA's November 2022 SC-GHG estimates did not comment extensively on the exclusion of climate injustice and disparate vulnerability to climate damages in the current SC-GHG approach.

Recommendation: The SAB recommends that the EPA note the limitations of the SC-GHG approach and the application to estimate the societal benefits of reduced greenhouse gas emissions in this proposed rule. The SAB further recommends that EPA consider how public health and equity impacts can be more appropriately and comprehensively captured in future SC-GHG updates.

Health Benefit Analysis

The calculation of health benefits of the proposed rule, and the monetization of those benefits, is based on peer-reviewed assessments and models used widely by the EPA. . The EPA's calculation of health benefits is based on the impact of the rule on particulate matter (PM_{2.5}) and ozone, while acknowledging that emissions reductions would affect other pollutants, e.g., hazardous air pollutants. Figure 2 describes the components of the benefit analysis for PM_{2.5}. Three scenarios are modeled: the proposed best system of emissions reductions (BSER), a less stringent alternative, and a more stringent option. The calculations extend across the years 2024-2042 with snapshots provided for 2028, 2030, 2035, and 2040.

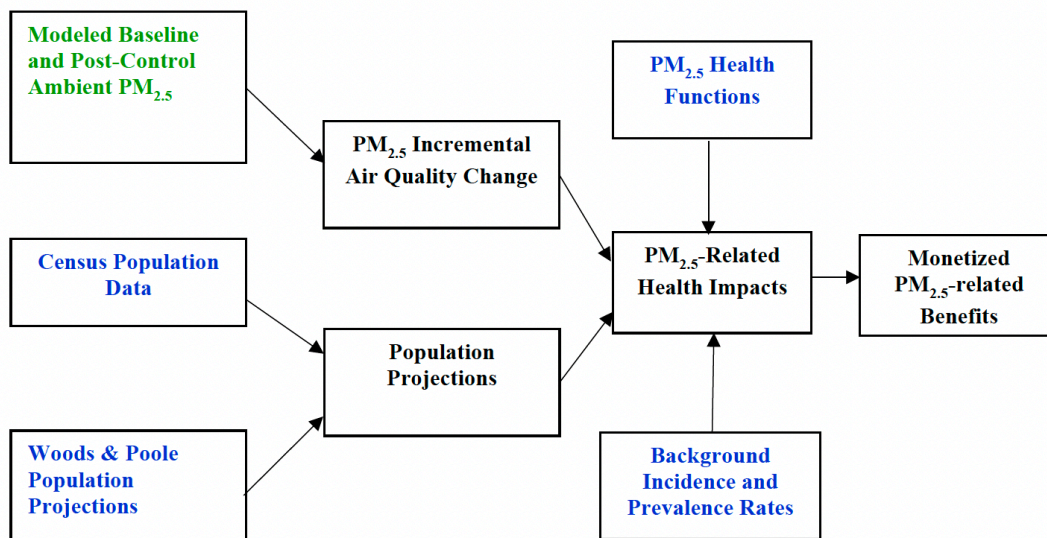


Figure 2. Data Inputs and Outputs for the BenMAP-CE Model.

The core data sets for the modeling are described in Figure 2 and their origins are well documented: the U.S. Census, population projections from Woods & Poole, and the baseline incidence and mortality rates in the BENMAP-CE model, which are documented in Table 12 of

the Technical Support Document for the 2022 PM National Ambient Air Quality Standards (NAAQS) Reconsideration Proposal RIA. The air quality changes in PM_{2.5} and ozone were obtained via simulations in the Comprehensive Air Quality Model with Extensions (CAMx) using scenarios of emissions reductions. Additionally, source apportionment was performed for 2026 to estimate the contributions to ozone from NO_x emissions and to PM_{2.5} from NO_x, SO₂, and primary PM_{2.5} emissions. Initial inputs to these models were generated from the Integrated Planning Model, which projects changes in emissions from electricity generating units based on policy changes.

With these inputs, BENMAP-CE was used to estimate the health impacts of the changes in modeled pollutant concentrations resulting from the rule under the three scenarios of emissions reductions. The outcomes considered in BENMAP-CE are based on Integrated Science Assessments (ISAs) for PM and ozone and include those for which the evidence was classified as either causal or likely to be causal. The Clean Air Scientific Advisory Committee (CASAC) provides intensive peer review for the ISAs. For these outcomes, a standard health outcome function was utilized that incorporated risk coefficients from epidemiological investigations. The resulting counts were then monetized using BENMAP-CE. Sources of uncertainty and variability are listed. Monte Carlo simulation was used to characterize random sampling error and a number of assumptions made were addressed qualitatively around potential uncertainties.

The SAB assessed whether agency's approach to estimating health benefits of the rule followed established best practices. As a summary response, the SAB's evaluation is affirmative on the question of utilization of best practices in the context of EPA peer-reviewed tools and approaches. As shown in Figure 2, the EPA used well-documented and appropriate data inputs and peer-reviewed models for estimating the rule's effect on air pollution concentrations—PM_{2.5} and ozone. In selecting health outcomes for BENMAP-CE, the EPA used the peer-reviewed ISAs for ozone and PM_{2.5}. Table 1 lists these peer-reviewed building blocks for the health benefit analysis. Additionally, as noted, the ISAs for PM and ozone were the basis for identifying the health outcomes considered in BENMAP-CE. The tools listed in the table have undergone peer review by the EPA SAB or through other mechanisms.

One element not included in the RIA is evaluation of the health impacts of hydrogen utilization. The Agency recognizes the potential for increases nitrogen oxide, a harmful GHG and local air pollutant, from the co-firing of hydrogen.¹⁸ However, the potential increase in nitrogen oxide, and its societal harms are not modeled in the current RIA. If hydrogen is to become a major component of the nation's energy system, health analyses will need to represent its emissions and their influence on air contaminants.

A more comprehensive description of the overall framework for estimation of the health benefits would be helpful to the reader. The descriptions are somewhat disconnected across

¹⁸ See 3-34 of the RIA and TSD for Hydrogen (<https://www.regulations.gov/document/EPA-HQ-OAR-2023-0072-0059>).

the RIA and the Executive Summary should be revised to do a better job of describing how the various components and data sets are utilized and integrated. The handling of uncertainty should be bolstered to more fully explore the assumptions and attendant uncertainties covered on pages 4-38 and 4-39 of the RIA. An expanded discussion should address how the uncertainties covered by the assumptions made could affect the magnitude and direction of the estimates of health benefits.

With regard to sources of uncertainty, 95% confidence intervals are estimated using the Monte Carlo simulations. The qualitative description of uncertainty (pages 4-38 and 4-39 of the RIA) describes assumptions made with only brief and superficial consideration of the magnitude and direction of the resulting uncertainties.

Finding: The SAB finds that the RIA and supporting documents adequately describe the approach taken by EPA in estimating health benefits. The estimation uses peer-reviewed tools that reflect the state-of-practice for benefit estimation.

Recommendation: The SAB recommends improvement of the RIA by providing a more comprehensive description of the overall framework for estimation, including how assumptions made could affect the magnitude and direction of the estimates of health benefits.

The SAB further recommends that the EPA support research on the atmospheric impacts of hydrogen co-firing, with the goal of representing the influence of this change in technology on air pollutants and their impacts on health.

While the health benefit analysis uses the EPA's standard approach to benefit quantification using BenMAP and to valuation of those benefits, the SAB has recently completed a review of both Benefits Methodology generally and BenMAP specifically (EPA SAB report EPA-SAB-24-003¹⁹). That review provides suggestions for improvements and updates to the health benefit analysis. Some of those suggestions relate to better characterizing the uncertainty range of future projections, for example by including a range of demographic scenarios. These changes would not be likely to greatly affect the values in the RIA but would partly address the recommendations of the SAB in response to the previous charge question.

The SAB's review of BenMap and Benefits Assessment provided other recommendations that might affect the values put forth in the RIA. The SAB recommended that the EPA (1) expand its approach to health benefit analyses to include the use of exposure-response data from outside North America such as meta-analyses that include broader coverage, (2) include additional health impact endpoints, (3) develop more comprehensive measures by expanding its cost of

¹⁹ available at:

https://sab.epa.gov/ords/sab/f?p=114:0:14473944488630:APPLICATION_PROCESS=REPORT_DOC:::REPORT_ID:1124

illness estimates to include a wider range of averted medical and nonmedical costs and apply estimates of willingness-to-pay associated with those risks based on a criteria-driven review of the literature using the benefits transfer framework, (4) update the valuation methodology to rectify internal inconsistencies in the application of income adjustments over time, and (5) use more recent valuation of a statistical life estimates. The review also recommended that EPA include the effects of air pollution exposure on both labor productivity and human capital, which are not currently included in either climate or health benefit analyses.

Recommendation: The SAB recommends that the Agency update the RIA for the proposed rule to incorporate the recommendations from the Benefits Methodology and BenMAP review panel, as much as possible. The SAB notes that updating the RIA would be valuable since it was only performed for parts of this proposed rule rather than for the rule in its entirety.

Uncertainties in Health and Climate Benefits

Figure 2 outlines the framework for estimating the monetary benefits of reducing the adverse effect of PM_{2.5} and ozone. The modeled changes in pollutant concentrations under the three scenarios are estimated with CAMx and combined with a risk function, derived from epidemiological investigations, to calculate the changes in attributable numbers of events using BENMAP-CE. The cost estimates are based on use of willingness to pay figures derived from the literature.

The Technical Support Document for the 2022 PM NAAQS Reconsideration Proposal RIA provides the documentation for estimating monetized benefits and provides descriptions of contributors to uncertainty. Chapter 6 provides a qualitative listing of various contributors to uncertainty. Nineteen separate items are listed, some with multiple components. While the list is comprehensive, the TSD does not attempt to systematically characterize the potential directions or magnitudes of the uncertainties.

Monte Carlo simulation is used to generate 95% confidence intervals around the estimates of health benefits and also for the monetized health benefits. The RIA includes sensitivity analyses for the long-term effects of PM_{2.5} on mortality, using risk estimates from two different epidemiological studies (Pope et al., 2019; Wu et al., 2020). The tables include the confidence intervals generated by the Monte Carlo simulation for both the counts of reduced (or increased) morbidity and mortality events and also monetized benefits.

This approach to setting out sources of uncertainty and their consequences results in an incomplete presentation of the actual ranges of values associated with the estimates of morbidity and mortality events and the cost benefits. The confidence intervals inherently understate the true range of values consistent with the uncertainties in the input data. Errors in the exposure estimates are not propagated into the calculation of health and cost benefits. The tables should provide an appropriate caveat concerning interpretation of the 95% confidence

intervals, acknowledging that they capture only one contributor to uncertainty—stochastic variation.

There are also substantial uncertainties in the analysis of climate benefits, in addition to the methodological differences addressed previously between updates of the SC-GHG by the IWG and the prior estimates. One example is the role of persistent effects, by which economic damages in one year influence long-term growth. Though such impacts are difficult to constrain from empirical data, some studies attempting to incorporate such persistent effects on economic growth find much larger social cost values (e.g., Wang and Teng, 2023 and references therein). Such values could also be explored in characterizing climate damage uncertainties.

Recommendation: The SAB recommends a more complete explication of uncertainties with more depth in the discussion of the qualitative analysis. The RIA could state the potential directionality of some of the sources of uncertainty, e.g., measurement error, as well as the potential magnitude of the range of uncertainty. The SAB recognizes that consideration of the aggregate consequences of the sources of uncertainty may not be possible.

2.6. Distributional Issues and Environmental Justice

2.6.1 Charge Question 6. Please comment on the scientific and technical adequacy of EPA's environmental justice analysis relating to distributed and cumulative impacts. Address both the baseline environmental justice analysis, and the analysis of projected conditions after the rule is implemented. Does the analysis support actions and future rules to achieve environmental justice?

Distributed costs and benefits

The EPA's environmental justice (EJ) analysis presented in Section 6 (Environmental Justice Impacts) of this Regulatory Impact Analysis document is generally sound and adequately detailed. This EJ analysis is primarily distributional in scope and focuses on evaluating: (1) the proximity of affected facilities to potentially vulnerable populations for consideration of local pollutants affected by these rules (Section 6.4 of the RIA); and (2) the distribution of PM_{2.5} and ozone concentrations in the baseline and changes due to the three scenarios modeled (the proposed best system of emissions reductions, a less stringent alternative, and a more stringent option) across different socio-demographic groups based on race, ethnicity, poverty status, employment status, health insurance status, age, sex, educational attainment, and degree of linguistic isolation (Section 6.5 of the RIA). The EJ analysis does not address distributed benefits.

In its evaluation, EPA conducted a qualitative assessment of climate impacts, demographic proximity analysis, and quantitative analyses of resulting changes in PM_{2.5} and ozone with respect to EJ impacts. In addition, EPA described its process for meaningful involvement in the development of the proposed rule. For health, the analyses focus on proximity to sources and

exposure concentrations while not quantifying disease burden. The RIA also does not address costs and benefits in relation to specific EJ considerations.

The qualitative assessment of climate impacts

The qualitative assessment of climate impacts on human health is cursory and does not specifically address the consequences of the proposed rule. Instead, the RIA draws on previous reports by the Agency, including the U.S. Global Change Research Program (USGCRP) Climate and Health special report (USGCRP, 2016) and the 2021 report on Climate Change and Social Vulnerability in the United States (EPA, 2021). The RIA makes no direct connections between findings of these previous assessments of the literature and consequences of the proposed rule specifically.

The use of various discount rates as a sensitivity analysis for future cost valuations represents the state-of-the-art way to address intergenerational justice in the economics literature and is standard practice in evaluation of climate impacts using the social cost of greenhouse gases (EPA, 2022). The analyses incorporate low values of discount rate to reflect impacts on future generations. However, the lowest value used here is 3%, which is relatively high and likely undervalues cost impacts on future generations. Other discount rates should be considered that are either lower or declining over time.

Distributional impacts

The geographically distributed impacts of climate change are not well characterized by the methods used to value climate impacts due to the limited spatial resolution of the primary analyses supporting the development of the social cost of greenhouse gases (EPA, 2022).

The demographic proximity analysis was performed for all plants with at least one coal-fired unit greater than 25 MW without retirement or gas conversion plans before 2030 that would be affected by these proposed rulemakings. It also separately evaluated subsets of coal plants that are potentially subject to the proposed rule. The analysis focused on census blocks within a 10km and a 50km radius of each facility and provided descriptive statistics using census block group data from the Census' American Community Survey 5-year averages for 2016 to 2020. Demographic characteristics addressed include race, ethnicity, age, education level, poverty status, and linguistic isolation. This proximity analysis does not address health hazards or risks arising from these facilities and affecting the populations within these nearby communities.

The quantitative analysis of PM_{2.5} and ozone was done at a 12-km resolution that might be sufficient for these pollutants and this emission sector because of tall smokestacks at the plants and the resulting dispersion of emissions. Analysis focuses on concentration impacts, but if the concentration estimates were integrated with disease rates in the populations to characterize burden, disparities could be larger than manifest in the analyses based on concentration alone because of heterogeneity of underlying disease rates across populations. Health impacts

associated with these pollutants are discussed only qualitatively. The findings are presented with a variety of heat maps that summarize a great deal of data, although some of the figures, e.g., those showing data for individual states, are difficult to use because of the mass of data and small font sizes. The focus on PM_{2.5} and ozone omits other important pollutants that communities are rightfully concerned about, particularly hazardous air pollutants. However, concentrations of these pollutants are more difficult to model and the RIA acknowledges their importance and also their absence from the analysis.

The geographic proximity analyses are based on census block demographic characteristics drawn from the Census' American Community Survey (ACS) data. In addition to using the census block group variables from the ACS survey, EPA could examine impacts for disadvantaged communities identified by the Climate and Economic Justice Screening Tool. This approach would provide a complementary EJ based geographical classification schema.

Overall, the analysis of potential EJ concerns is consistent with key questions and analytical approaches outlined in the EPA's *Environmental Justice Technical Guidance* (EPA, 2015). The methodology is appropriate, and results are explained with sufficient clarity. Caveats and limitations associated with proximity analysis and exposure modeling are also discussed. Some issues, however, require further clarification and consideration.

Proximity analysis

The proximity-based EJ analysis of proposed rule changes was based on the comparing percentages of the population in specific socio-demographic categories (i.e., race/ethnicity, low-income, education, and linguistically-isolated) residing within 10 km and 50 km radii of relevant coal plants, respectively, to their corresponding national averages. While this approach is easy to understand and interpret, it may not represent the most effective or valid approach for measuring disproportionate impacts. A more appropriate approach is to estimate and compare the percentage of each socio-demographic group inside these proximate areas (within 10 km and 50 km of relevant coal plants) to their respective percentage in areas outside (rest of the contiguous United States), as recommended in several published EJ studies. Using the overall United States percentage for comparison leads to double-counting of communities, since the national percentage for any variable includes areas both inside and outside the 10 km and 50 km radii around coal plants. The percentage difference or ratio of percentages (inside vs. outside areas proximate to coal plants) for each scenario should provide a more accurate metric for comparing or evaluating distributive EJ implications.

Significance

For both proximity and exposure analysis, no statistical tests of significance are included to support the numerical results. Inferences drawn from specific tables in Section 6 of the Regulatory Impact Analysis (e.g., page 6/16: "meaningful EJ exposure concerns are not likely created or exacerbated by the rule for the population groups evaluated, due to the small

difference in magnitudes of PM_{2.5} concentration reductions across demographic groups”) are not reliable, unless appropriate statistical significance tests (e.g., two-sample tests of means or proportions) are conducted to determine if any of the observed percentage differences are significantly different from zero.

Indigenous identification

Although American Indians are included as a socio-demographic variable for evaluating potential EJ concerns in the proximity analysis, this classification may not be adequate to capture adverse and disproportionate impacts on Native Americans or Indigenous communities nationally. A better and more appropriate approach would be to examine the nature and extent of spatial overlap between the areas proximate to relevant power plants (i.e., within 10 km and 50 km) and boundaries of federally-designated tribal lands. Geographic boundaries of tribal areas that can be used to estimate this overlap are available in census data²⁰

Low-income identification

Low-income individuals are defined for this analysis as those within an annual income either equal to or twice the federal poverty line, which is not adequate for a national-scale evaluation of potential EJ concerns. The federal poverty level measure is identical across the United States (except for Alaska and Hawaii) and does not account for the significant differences in the cost of living across and within regions. The use of a single value for the entire nation may result in a mischaracterization of income from the EJ perspective, as both upward and downward biases are possible. For example, the poverty guideline of \$52,992 for a family of four living in New York compared to a small county in the Midwest or Central United States is not an equal comparison. There are alternative measures that should be considered to inform low-income measurement, including 80% of the area median income, an indicator of wealth such as home ownership rate, median home value, or a weighted income calculation. Any income-based measure deserves more scrutiny because of its impact on all aspects of a person’s quality of life, from nutrition to health care to education.

Uncertainty:

For socio-demographic variables examined in the proximity and exposure analyses (Section 6 of the RIA), data are obtained from the United States Census Bureau’s American Community Survey (ACS) five-year estimates. These ACS estimates are surrounded by uncertainty, which are quantified through the margin of error (MOE). The magnitude of the MOE is typically considerable for estimates obtained at the census block group level, and particularly higher in rural areas with lower population counts. To mitigate against measurement errors and derive reliable proportional estimates, researchers have suggested removal of census enumeration

²⁰ <https://www.census.gov/cgi-bin/geo/shapefiles/index.php?year=2022&layergroup=American+Indian+Area+Geography> .

units (i.e., tracts or block groups) with small population counts from their analysis, and/or using census units where MOE of the estimates are relatively low. Although the EJ analysis presented here uses census block groups and tracts, data quality problems with the ACS socio-demographic data (e.g., missing values and higher MOE) are not acknowledged and it is unclear if appropriate techniques were used to address data uncertainty and related errors.

Procedural justice

Procedural environmental justice, also referred to as participatory environmental justice, focuses on the presence or absence of meaningful involvement of residents to influence government and industry decisions affecting their communities. In this context, meaningful involvement means that: (1) people have an opportunity to participate in decisions about activities that may affect their environment and/or health; (2) the public's contribution can influence the regulatory agency's decision; (3) community concerns are considered in the decision making process; and (4) decision makers will seek out and facilitate the involvement of those potentially affected.

Based on the information provided in EPA-HQ-OAR-2023-0072 (*Federal Register* Vol. 88, No. 99: page 33247-8), the EPA engaged adequately with EJ organizations and representatives of communities potentially impacted by various forms of pollution from the power sector, as part of its pre-proposal outreach to stakeholder. This feedback and analysis was considered by the EPA in its development of these proposals. Issues that require further clarification and consideration are:

- No details are provided about what efforts and steps were used to contact and ensure participation of all potentially affected residents, as well as underserved and vulnerable communities.
- Insufficient information is included about the criteria used to consider, evaluate, and/or address stakeholder input.
- It is unclear whether related briefings, meetings, and discussions were conducted only in English, and how or whether community residents speaking other languages were included.

Recognition justice

Justice as recognition is conceptualized in terms of which individuals, social groups, and communities are included, respected, and valued and which are not (Schlosberg, 2007). In the context of this analysis of potential EJ concerns, there are two vulnerable groups that were not included:

- People with disabilities, a highly disadvantaged group that has been documented to face unique barriers and challenges. President Biden's Executive Order 14096 on *Revitalizing Our Nation's Commitment to Environmental Justice for All*²¹ identifies people with disabilities as a population group that should be considered as part of the definition of EJ and related

²¹ Available at: <https://www.govinfo.gov/content/pkg/FR-2023-04-26/pdf/2023-08955.pdf>

1 analyses. In recognition of this updated definition, the EPA should consider adding disability
2 status to the list of vulnerable and/or overburdened populations that are examined in this
3 distributive justice analysis and for procedural justice considerations.

4 Native American or Indigenous communities have not also been adequately included, despite
5 the inclusion of American Indian as a demographic variable for proximity and exposure
6 analyses. Specifically, the EJ analyses presented here does not examine the extent to which
7 federally-designated tribal areas will be impacted by these rules.

8
9 **Finding: The SAB finds that the environmental justice evaluation accompanying the proposed**
10 **rule is advanced beyond analyses of many prior rules. However, some important factors**
11 **necessary for a complete analysis of environmental justice are not yet incorporated.**

12
13 **Recommendation: The SAB acknowledges that it has recently undertaken a self-initiated**
14 **project on advancing environmental justice in rulemaking. The SAB recommends t the**
15 **shortcomings identified here be addressed in developing the guidance that will shape future**
16 **analyses.**
17

3. SUMMARY OF FINDINGS AND RECOMMENDATIONS

The SAB finds that GHG emission reductions that would be achieved by the proposed rule are insufficient to align the United States electricity sector's emissions with national goals. Given the importance of this sector in leading the way towards net-zero GHG emissions, it is very likely that the proposed rule is inconsistent with Paris Agreement targets. It appears that in 2035 and 2040, the rule will have a small influence on baseline electricity-sector CO₂ emissions. The rule also lacks provisions to recognize the importance of total carbon budgets in achieving temperature targets.

The SAB finds that both methane (natural gas) and hydrogen have emissions and atmospheric consequences that are not accurately accounted for in current greenhouse analyses of climate impacts.

The SAB finds that cost estimates provided by the EPA for carbon capture and storage are reasonable given the emerging state of technology development.

The SAB affirms the necessity of a low-GHG hydrogen definition in the proposed rule and recommends that this definition be included before references to that term within the rule.

The SAB finds uncertainties in the timing of hydrogen technology readiness but recognizes that these uncertainties are characteristic of a rapidly emerging technological field. As the rule is revisited and alternatives are discussed in the public domain, the SAB suggests communication of alternatives using Technology Readiness Levels.

The SAB finds that, in general, the analyses of climate impacts due to emission changes are scientifically sound.

The SAB finds that the Regulatory Impact Analysis and supporting documents adequately describe the approach taken by EPA in estimating health benefits. In developing the estimation of health benefits, the EPA has used peer-reviewed tools that reflect the state-of-practice for benefit estimation.

The SAB finds that the environmental justice evaluation accompanying the proposed rule is advanced beyond analyses of many prior rules. However, some important factors necessary for a complete analysis of environmental justice are not yet incorporated.

The SAB's recommendations are as follows:

EPA should consider substantial increases in the stringency of the proposed rule, to align the outcomes with the Administration's goals and the nation's Nationally Determined Contribution to meeting climate targets.

The SAB recommends that EPA incorporate a more accurate understanding of methane emissions from natural-gas value chains into future climate benefit determinations and cost-benefit analyses. This update is required under the revised Greenhouse Gas Reporting rule.

The SAB also recommends that EPA support or promote research on the air-quality, climate and health impacts of hydrogen leakage, including improvements in detection technology for hydrogen. This understanding of unintended atmospheric consequences of hydrogen usage should be incorporated into future climate benefit determinations and cost-benefit analyses.

Recognizing the limited history available to characterize widespread carbon capture and storage operation, the SAB recommends support for monitoring societal impacts to identify risks and costs.

The SAB recommends that costs of the proposed rule as estimated in the RIA include realistic uncertainties in the price of available hydrogen throughout Phases I, II and III. These cost uncertainties should reflect potential competition for hydrogen as a limited resource.

The SAB strongly recommends formation of a working group that will update the definition of low-GHG hydrogen regularly as technological and industrial capabilities evolve. The EPA should also support discussions about certification of low-GHG hydrogen based on a value-chain definition rather than a “well-to-gate” definition alone.

The SAB strongly recommends that EPA develop, or support research to develop, the ability to rapidly and realistically assess how a wide variety of alternative measures and innovative technologies may affect overall greenhouse-gas emissions.

Further, the SAB strongly recommends that EPA engage in continuous use of tools to explore emerging opportunities and developing limitations. That is, EPA should conduct analysis proactively to lay a foundation for future rules, rather than reactively in response to proposed rules.

The SAB recommends that the EPA apply the updated Social Cost of Greenhouse Gas estimates to value the climate benefits of the current rule, acknowledging the external review panel’s finding that the updated SC-GHG estimates are more comprehensive, transparent, and evidence-based.

The SAB recommends that the EPA note the limitations of the SC-GHG approach and its application to estimate the societal benefits of reduced greenhouse gas emissions in this

1 proposed rule. The SAB further recommends that EPA consider how public health and equity
2 impacts can be more appropriately and comprehensively captured in future SC-GHG updates.

3
4 The SAB recommends improvement of the RIA by providing a more comprehensive description
5 of the overall framework for estimation, including how assumptions made could affect the
6 magnitude and direction of the estimates of health benefits.

7
8 The SAB further recommends that the EPA support research on the atmospheric impacts of
9 hydrogen co-firing, with the goal of representing the influence of this change in technology on
10 air pollutants and their impacts on health.

11
12 The SAB recommends that the Agency update the RIA for the proposed rule to incorporate the
13 recommendations provided in the SAB review of BenMAP and EPA's Benefits Methodology, as
14 much as possible. The SAB notes that updating the RIA would be valuable since it was only
15 performed for parts of this proposed rule rather than for the rule in its entirety.

16
17 The SAB recommends a more complete explication of uncertainties with more depth in the
18 discussion of the qualitative analysis. The RIA could state the potential directionality of some of
19 the sources of uncertainty, e.g., measurement error, as well as the potential magnitude of the
20 range of uncertainty. The SAB recognizes that consideration of the aggregate consequences of
21 the sources of uncertainty may not be possible.

22
23 The SAB notes that it has recently undertaken a self-initiated project on advancing
24 environmental justice in rulemaking. The SAB recommends that the shortcomings identified
25 here be addressed in developing the guidance that will shape future environmental justice
26 analyses.

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