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***Electricity Sector Impacts of the
Inflation Reduction Act:
Assessment of Projected CO₂
Emissions Reductions from
Changes in Electricity Generation
and Use:
Peer Review***

Final Report

Prepared for

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PEER REVIEW SUMMARY REPORT

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1. Introduction

The U.S. Environmental Protection Agency (EPA), Climate Change Division (CCD), contracted with RTI International for an independent external letter-style peer review of the draft final report: *Electricity Sector Emissions Impacts of the Inflation Reduction Act: Assessment of Projected CO₂ Emission Reductions from Changes in Electricity Generation and Use*, prepared by EPA. This report is in response to the Low Emissions Electricity Program (LEEP) of the Inflation Reduction Act (IRA), which requires EPA to assess “... the reductions in greenhouse gas emissions that result from changes in domestic electricity generation and use that are anticipated to occur on an annual basis through fiscal year 2031.” The report is referred to throughout this peer review as the “IRA emissions draft report.”

EPA’s peer review guidelines specify that all influential scientific and technical work products shall undergo independent peer review per specific agency protocols. RTI was tasked with managing an independent external peer review process to evaluate the IRA emissions draft report. EPA’s goal for this peer review was to ensure the use of the highest quality science in its predictive assessments. By so doing, EPA seeks to assure its stakeholders that this analysis has been conducted in a rigorous, appropriate, and defensible way.

The peer reviewer selection process for the IRA emissions draft report involved identifying six expert peer reviewers who were available to participate in the peer review, including preparing individual written peer review comments during a specific time frame. In recruiting these expert peer reviewers, RTI evaluated the qualifications of peer reviewer candidates, conducted a thorough conflict of interest (COI) screening process, and independently selected the peer reviewers. RTI then provided management and oversight of the independent external peer review process. RTI produced this report that documents the peer review process and summarizes the peer reviewer comments for the Charge Questions.

The following sections provide background on the draft report, describe RTI’s process for identifying and selecting expert peer reviewers for this peer review, and provide EPA’s scope for the peer review of the IRA emissions draft report, the selection and communication with peer reviewers, and summaries of comments from the reviewers.

1.1 Background on IRA Emissions Draft Report

The IRA was implemented in August 2022 to address climate change, inflation, and clean energy in the United States. This act addresses innovation and greenhouse gas (GHG) mitigation across multiple economic sectors. From the executive summary of the report:

The Inflation Reduction Act of 2022 (IRA) aims, in part, to transform energy production and consumption in ways that reduce the risks of climate change and improve environmental quality, while simultaneously spurring investment that create economic opportunities. With a comprehensive system of economic incentives estimated at nearly \$400 billion¹, the Act aims to support the development and use of clean energy. The IRA

¹ Congressional Budget Office, 2022. Final score from September 7 (<https://www.cbo.gov/publication/58455>). Summary estimate of climate and energy provisions calculated by the Committee for a Responsible Federal Budget is \$391 billion (<https://www.crfb.org/blogs/cbo-scores-ira-238-billion-deficit-reduction> ).

aims to reduce emissions by incentivizing both the generation of low-cost, low-emission electricity and its efficient use in buildings, transportation, and industry.

EPA sought peer review of the IRA emissions draft report to ensure emissions changes and economic impacts of the IRA are based on state-of-the-art assumptions, data, and models. For the transportation, buildings, and industry sectors, EPA wanted at least one qualified reviewer and at least two reviewers were desired for the electricity and general chapters.

1.2 Identification and Selection of Expert Peer Reviewers

The peer reviewer selection process involved identifying three subject matter experts (SMEs) who were available to participate in the peer review, including preparing individual written comments, during a specific time frame. In recruiting the peer reviewers, RTI evaluated the qualifications of peer reviewer candidates, conducted a thorough COI screening process, and independently selected the peer reviewers. These activities are discussed in more detail below.

1.2.1 Identification of SMEs

In late May 2023, EPA tasked RTI with finding qualified peer reviewers and provided RTI with a short list of desired reviewers. RTI independently selected peer reviewers who collectively had the background and proven expertise for the following areas:

- Knowledge on the literature and methods for estimating emissions from domestic electricity generation due to incentives and programs in the IRA, economic activity, and related policies, and
- Knowledge on the literature and methods for estimating changes in emissions in the power, transportation, industry, and buildings sectors from the use of electricity as well as other incentives and programs in the IRA, economic activity, and related policies.

The SMEs were identified through EPA recommendation, literature and internet searches of scientific journals, professional societies, universities, and government agencies. RTI worked to identify SMEs representing a range of sectors affected by the IRA and covered in the IRA emissions report.

RTI contacted a total of 34 people, of whom eight were interested in participating, provided their CV/resume (or bio), and were also available during the anticipated peer review time frame. RTI researched readily available information about the eight interested individuals for relevant experience and demonstrated expertise in the subject matter of the IRA emissions draft report, as demonstrated by educational degrees attained, research and work experience, publications, awards, and participation in relevant professional societies. RTI requested a signed Conflict of Interest Form from the available reviewers. Initially, only five reviewers were to be selected, but one reviewer was away, and it was uncertain whether they would be able to complete the review in the desired time. To that end, a sixth reviewer was identified and secured to ensure that EPA would have comments for all sectors in the allotted time.

1.2.2 Peer Reviewer Candidates

From the interested individuals who completed the COI Form, RTI included all of them to result in identifying six candidate peer reviewers who best met the required fields of expertise for this peer

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review. The names and affiliations of the six candidate peer reviewers, as well as a summary of their qualifications, are provided in Table 1.1.

Table 1.1. IRA emissions Peer Reviewers

Name	Affiliation	Academic Degrees	Area of Expertise
Aaron Bergman, PhD	Resources for the Future	- PhD, Princeton University, Physics (2003) - BS, Yale University, Physics & Mathematics (1998)	Power & General
John Bistline, PhD	Electric Power Research Institute	- PhD, Stanford University, Management Science and Engineering, (2013) - MS, Stanford University, Mechanical Engineering, (2010) - BS, Carnegie Mellon, Mechanical Engineering and Engineering and Public Policy (2008)	Power & General
Eliot Crowe	Lawrence Berkeley National Laboratory	Bachelor's, University of Plymouth, Industrial Design, (1995)	Buildings
Bri-Mathias Hodge, PhD	University of Colorado, Boulder	- PhD, Purdue University, Chemical Engineering, (2010) - MS, Åbo Akademi University, Chemical Engineering (2005) - BS, Carnegie Mellon University, Chemical Engineering (2004)	Industry
Jared Langevin, PhD	- U.S. Department of Engineering, Office of Energy Efficiency and Renewable Energy - Lawrence Berkeley National Laboratory	- PhD, Drexel University, Engineering, (2014) - Bachelor of Architecture, Carnegie Mellon University, (2008)	Buildings
Yuanrong Zhou	International Council on Clean Transportation	- MA, Columbia University, Climate and Society (2015) - BS, University of Toronto, Environmental Biology (2014)	Transportation

1.2.3 Conflict of Interest Screening Process

RTI conducted COI screening for the six candidate peer reviewers who best met the required fields of expertise (see Table 1.1) to ensure that the SMEs had no COI or appearance of the lack of impartiality. The COI screening was conducted in accordance with EPA's Peer Review Handbook and involved each SME completing a COI questionnaire (COI Form) to determine if they were involved with any other work and/or organizations that might create an actual, potential, or perceived COI for this peer review. Section 5 provides the COI Form and Non-Disclosure Agreement (NDA) for this peer review. Completed COI Forms were received from each candidate peer reviewers.

Although some of the candidate peer reviewers disclosed previous or current research funding in related fields, it was RTI's opinion that such research funding opportunities and relationships with

research funding agencies and organizations would not likely pose an actual or potential COI. SMEs with expertise in areas related to this peer review are likely to engage in obtaining research funding and conducting related research or similar project activities, and those disclosures were included on their COI Forms.

1.2.4 Selection of Peer Reviewers

RTI evaluated each peer reviewer candidate's credentials to select the six reviewers that collectively cover the areas of expertise needed for this peer review, have no actual or potential COI or appearance of the lack of impartiality, and were available to complete the peer review within the desired time frame.

RTI completed the Peer Review Materials Package with the Charge Questions developed by EPA and delivered to the six reviewers listed in Table 1.1.

1.3 Scope of Peer Review

EPA approved the scope of this peer review as defined by RTI for the IRA emissions draft report to focus the peer review process effectively on the Charge Questions (see Section 2). The peer reviewers were directed to keep their written peer review comments within the EPA scope, as defined below:

The scope of this letter-style peer review is technical in nature, reviewing the methods, data quality, data sources, underlying assumptions, and the overall strengths and limitations of the study. EPA is especially interested in comments that focus on the validity or scientific merit of the methodology and that identify any significant weaknesses in the scientific information from the methodology.

- Peer reviewers should focus on providing comments on the technical nature of the report, and its consistency with the state of current science as you understand it. The peer reviewers should evaluate the analysis used to develop the proposed methods and the suitability of those methods to estimate sales, pre-buy, and other impacts for use in policy analysis.
- Peer reviewers should also focus on the clarity and completeness of the presentation in the draft report. Because the review is technical in nature, the peer reviewers should not focus on editorial style.

1.4 Organization of Report

This peer review report is comprised of five sections, as listed below:

- **Section 1** describes the process for this independent external letter-style peer review.
- **Section 2** presents the Charge Questions sent to each of the peer reviewers for comments.
- **Section 3** includes the summary of the peer reviewer comments.
- **Section 4** consists of the individual peer reviewer comments.
- **Section 5** provides a sample of the COI Form for this peer review.

2. Charge Questions

The objective of this external letter-style peer review was to obtain written peer review comments from individual experts to conduct an independent external peer review and evaluate the IRA emissions draft report to (1) ensure the use of the highest quality science in EPA’s predictive assessments; and (2) for EPA to assure its stakeholders that this analysis was conducted in a rigorous, appropriate, and defensible way. RTI charged each peer reviewer with evaluating the IRA emissions draft report and responding to the Charge Questions presented in Table 2.1.

Table 2.1. Charge Questions

1. Are the writing level and graphics appropriate for an educated but general audience including stakeholders and decision-makers?
2. Do the text, figures, and tables in the sector specific chapters clearly communicate the modeling results? If not, please provide recommendations for improvement. Note that Appendix G contains additional figures and alternative figure styles.
3. Does the executive summary provide sufficient context to understand the synthesized results?
4. Does the introductory chapter clearly explain the purpose of the report and provide appropriate context for the sector chapter results?
5. Does the introductory chapter adequately explain the overall analytic framework of the project?
6. Are the inputs and scenarios clearly explained and documented in the introduction? If not, please provide recommendations for improvement.
7. Is the cited literature accurately represented?
8. Are there any additional relevant data sources that are not included but could be incorporated into this analysis?
9. The analysis presented in this report is multi-faceted, using results from several sophisticated multi-sector and single-sector energy-economy models. Is the use of a multi-model approach, incorporating multi-sector and power sector models, appropriate to estimate the potential effects of the energy- and climate-related provisions of the IRA? If not, please suggest other approaches.
10. Does the report provide an assessment of reductions in greenhouse gas emissions that result from changes in domestic electricity generation and use due to the Inflation Reduction Act of 2022 that are anticipated to occur on an annual basis through fiscal year 2031?
11. Is the draft report missing important findings or messages based on your review?
12. Do you have any recommendations for any key research that could be discussed but is not mentioned? Do you have recommendations for future updates to the report that EPA should consider?

3. Summary of Peer Reviewer Comments

This section provides a summary of the peer reviewers' comments, concerns, and suggestions regarding the Charge Questions (see Section 2). Peer reviewers received a randomly assigned number and their responses are anonymized here. but the individual peer reviewer's final written comments can be found in Section 4. Questions vary in breadth of scope of the Report and reviewer responses vary by length depending on their respective section and sector. To that end, some questions, e.g., Question 2 have detailed, lengthy responses while others are shorter.

1. Are the writing level and graphics appropriate for an educated but general audience including stakeholders and decision-makers?

Reviewers generally find the writing style clear and appropriate for a general audience. Reviewer 5 suggests adding a call-out box or text explaining each of the models used and what purpose they serve and explanatory text that models are not predictive but are meant for insight, results are conditional on scenario assumptions, and model ensembles are not statistical distributions. Reviewer 6 agrees that more context for the models, assumptions, and limitations would make it more accessible to a general audience. The distinction between EPA- and non-EPA-supported models is useful for understanding model results and conclusions.

Some reviewers are of the opinion that the graphics and some of the context provided are overly lengthy to the point where readers might not engage. This can prevent decision-makers from fully reading and acting on the information provided. Conversely, Reviewer 2 finds the number and style of charts to be appropriate for a general audience.

2. Do the text, figures, and tables in the sector specific chapters clearly communicate the modeling results? If not, please provide recommendations for improvement. Note that Appendix G contains additional figures and alternative figure styles.

The peer reviewers generally believe that the graphics are well done, and the visualizations are clear, with some suggestions. Reviewer 5 suggests adding a measure of central tendency in addition to range for model results. Reviewer 4 notes a conflicting definition of industry sector scope on pages 11 and 19 on whether non-combustion industrial process emissions are included.

Reviewer 3 believes that several of the graphs with multiple trend lines are too messy and difficult to compare. They note that change from baseline is the most useful information, and trend lines or dots for median bars do not add additional information. They suggest adding a chart just for changes in emissions. They also suggest breaking out direct and indirect emissions from end-use sectors as this can show double counting of emission reductions. They note that electrification in particular can lead to short-run increase in emissions, depending on efficiency and carbon intensity of the grid. Indirect end-use emissions changes in some end-use sectors can be the result of a given model's abatement in the power sector. This reviewer suggests showing electricity consumption in addition to direct emissions to more clearly capture the impact of efficiency and electrification than indirect emissions.

In reference to Figure ES.2 on page 12, Reviewer 5 suggests adding a sentence on how power sector emissions are allocated across sectors. For Table ES.1 on page 12, Reviewer 5 suggests adding a sentence explaining the motivation to use median instead of mean, and Reviewer 4 recommends adding percentage reduction in addition to absolute reduction. Reviewer 4 notes that the reported CO₂ emission values differ between Figure 1.1 (5,695 Mt and 4,615 Mt in 2005 and 2021, respectively) and Figure 1.2 (6,132 Mt and 5,032 Mt in 2005 and 2021, respectively). Reviewer 4

notes that Figure 1.1 is the sum of direct and indirect emissions from sectors but differs from economy-wide totals from the EPA Greenhouse Gas Inventory (GHGI) in Figure 1.2. This same reviewer also notes that there are discrepancies in in the combined case Figure 1.4. Reviewer 6 notes that the distinction between models in Figure 1.4 is too subtle and can raise more questions than it answers. Reviewer 3 comments that Figure 2.4 does not show clearly whether generation is going up or down for given models and should be revised. Reviewer 3 also suggests stacking columns for each model for Figure 2.5. This same reviewer notes that the 45U credit is responsible for increases in existing nuclear power plants, so it could represent an increase over retirements in the baseline but not an increase over historical levels, which is not clearly explained on page 42. They also comment that the call-out boxes related to Environmental Justice and SF6 do not reflect modeling results. Reviewer 6 agrees that the call-out boxes add unnecessary length and seem out of place in the context of model results. This reviewer suggests reducing the length of these text boxes. They also comment that Figures 3.1, 4.1, and 5.1 do not convey new information that has not been provided by percentages.

Reviewer 4 notes that in Figure 3.1, no indirect transportation emissions are shown and suggests adding a note that it is very low but non-zero. Reviewer 4 also notes Figure 3.2 would benefit from a description of what is included in the “other” category and whether it includes domestic or international air transportation.

Reviewer 4 wonders why the Clean Hydrogen Production Tax Credit (45V) is only included in industry and not transportation, even though hydrogen Production Tax Credits (PTC) could be used as transportation fuel. They note that IRA incentives for biofuels and sustainable aviation fuels are included for both transportation and industry sectors. Reviewer 4 notes that the definition of pipeline emissions on page 56 is vague and cites EPA’s “US Transportation Sector Greenhouse Gas Emissions 1990-2021” for more context. Finally, Reviewer 4 notes some discrepancies in results of tables and figures between the Executive Summary and Conclusion chapters and the chapter on transportation and the spreadsheet. For example, reported transportation emissions for 2005 are different on pages 52 (1,874 Mt) and 79 (1,863 Mt). Reviewer 4 attributes these differences in values to whether the total emissions inventory is based on the sum of direct and indirect emissions. Reviewer 4 also notes differences in No IRA and IRA scenarios, noting different values reported on pages 59 and 79 and calculations based on numbers reported in the Executive Summary and Conclusion. They conclude that it would be useful to have figures or tables with the breakout of different fuels in 2021 and future IRA and No IRA scenarios. These figures could demonstrate where emission reductions occur and where further support might be needed.

Reviewer 1 finds the Buildings chapter figures to clearly demonstrate results of IRA impacts from economy-wide models. They note that the text could benefit from more interpretation of key drivers of the range of results and cite assumptions made in the appendix. To that end, they comment that the Table 4.1 description of drivers of change across different scenarios is too generic. Reviewer 1 also suggests adding a high-level comparison of building-specific and multi-sector results and a discussion on potential reasons for differences between them. Also regarding Table 4.1, Reviewer 2 notes that the No IRA scenario is missing, and the table placement is confusing and could lead the reader to believe the table findings refer to a different study.

Reviewer 2 questions why 2005 is chosen as the base year and notes that in choosing this reference year, much of the reported data are communicating aggregate totals of modeling results plus the historical CO₂ emissions. At the end of Section 4.1, Reviewer 2 suggests resources from Institute for Market Transformation (IMT) to contextualize the benchmarking policies mentioned. Reviewer 2

also suggests adding more context on what is considered “energy and building management” and could more specifically mention building commissioning, energy management and information systems (EMIS), and advanced building controls. This reviewer also recommends adding a definition for “efficient electrification” and whether it applies to heating, ventilation, and air conditioning (HVAC) and domestic hot water equally. This reviewer also suggests acknowledging horsepower (HP) limitations in cold climates. They suggest clarifying that in paragraph 3 of page 67, building owners can “invest in certified green power” is out of scope of the analysis, if that is the case. Reviewer 2 also recommends adding a separate bar chart to show reductions captured in Figure 4.2. As it is, the median reductions in the figure title are difficult to discern.

Regarding Figure 4.3, Reviewer 2 notes that more context is needed for the initial input assumptions for additional measures. The text describing the figure focuses on heat pumps and HVAC for heating, but the figure legend shows “HVAC/Env” and “Other.” They also note discrepancy in the pessimistic scenario of Figure 4.3 compared to Table 4.1 comparisons to 2019. This reviewer recommends explanatory text for why the pessimistic scenario is so low and any reported reductions for such small emissions can be misleading. Finally, Reviewer 2 notes that the Buildings chapter describes key uncertainties but leaves out the key uncertainty of rate of electrification of power supply in achieving CO₂ reductions from efficient electrification of buildings and the uncertainty of whether newly installed equipment will be operated and efficiently maintained over the long term.

3. Does the executive summary provide sufficient context to understand the synthesized results?

Reviewers generally find the Executive Summary to be clear and concise. Reviewer 3 notes that the Executive Summary provides a lot of context but needs a clearer statement of results. Reviewer 5 finds the Executive Summary to provide a good overview of the overall motivation and findings. Reviewer 5 does suggest adding text in the Executive Summary on page 8 that the fiscal cost estimate is over a 10-year budget window and this is based on the initial estimate of fiscal impacts from the Congressional Budget Office (CBO) and subsequent analyses by Credit Suisse, Goldman, and Brookings indicate that impacts may be larger by 2032 and beyond.

Reviewer 5 suggests clarifying the sentence on page 8 of the report, “This report uses the most up-to-date modeling tools to show how the IRA’s provisions to spur investments in clean energy technologies, promote domestic manufacturing and well-paying jobs reduce emissions of greenhouse gases (GHG) in a growing economy.” This reviewer also suggests clarifying on page 9, “Second, modeling certain IRA provisions, such as the structure of investment tax credits, is uncertain because the impact of the provisions will depend on decisions that are not yet final,” to indicate what these decisions are based on, whether Treasury guidance, firms related to building-specific assets, use of bonus credits, or something else.

Reviewer 5 recommends adding some additional caveats to the first paragraph of page 9 that models do not explicitly capture recent inflationary drivers that might offset some IRA cost reductions and that models might not include some barriers and bottlenecks to quicker adoption including scaling up of supply chains, infrastructure build-out, or deploying brand-new emerging technologies, etc. On page 10, Reviewer 5 wonders why the ranges are reported in CO₂ rather than all GHGs and how the ranges might be affected. This reviewer also notes discrepancy between the lowest emissions range reported from the Bistline et al. (2023) study of 33% to 40% and the 35% to 43% in the IRA emissions report.

On the other hand, Reviewer 1 suggests that the Executive Summary contains arguably too much context about approach and limitations. They suggest presenting key takeaways and results first, followed by details and context on the modeling approach and motivation.

Reviewer 2 reiterates concern that 2005 is chosen as a base year without explanation or context. Reviewer 2 notes that the median lines and distribution marks in Figure ES.1 make it visually confusing. They note that alternatives placed in Appendix G are even more confusing. Reviewer 2 suggests removing bars and dots and just indicate medians on the main ES.1 chart. For Figure ES.2, they suggest highlighting the numerical difference between 2035 IRA and No IRA scenarios as this is an important insight in the text. This could be represented in a bar chart to compare percentage reduction values. For Figure 1.1, this reviewer suggests adding a value for transportation indirect emissions since it is not visible in the chart. On page 33, in the “Market Failures” section, they suggest adding that many commercial properties can exhibit split incentive risks and so-called “green lease” structures are one strategy for addressing that risk. Finally, they suggest clarification for the “Market Barriers and Transitions” section on page 34 on the high relative costs.

Reviewer 6 notes that the medians overlap for IRA and No IRA scenarios in multi-sector emission reductions, as shown in Figure ES.2. It would be helpful, they note, to have the base of the Executive Summary focus on “internal” models with only a brief comparison against “external” models.

4. Does the introductory chapter clearly explain the purpose of the report and provide appropriate context for the sector chapter results?

Reviewer 3 recommends shortening the introductory chapter. This reviewer suggests removing the call-out boxes as they are ancillary to the report. Reviewer 6 agrees that the call-out boxes are not directly relevant and recommends shortening them. Reviewer 6 recommends a call-out box similar to the “Overcoming Deployment Challenges” explaining the limitations of the modeling paradigms used in this report. This text box or section can refer to Appendix B for more details. Reviewer 3 also notes that in the generation section, the reported factor of 5 increase is not consistently used in the section. In the text it refers to credits from wage and apprenticeship requirements as bonus credit, but Reviewer 3 notes it generally refers to additional credits for domestic content, etc. This reviewer also notes that on page 18, natural gas and methane are used interchangeably, but natural gas contains other compounds as well. Reviewer 3 also notes that the description of the National Energy Modeling System (NEMS) should be made more consistent on page 21. More generally, U.S. nationally determined contributions (NDC) and other publicly stated climate goals could be provided to contextualize economy-wide results.

Reviewer 5 suggests adding more context of uncertainty of total support from 2022 through 2031 in the Executive Summary on page 14. In the electricity chapter on the bullet point discussion on risk aversion, they suggest mentioning financing.

Reviewer 5 also suggests that footnote 15 on page 15 should be moved to the text to provide more explicit detail on specific provisions. This reviewer also suggests updating footnote 23 on page 19 to show that the Bistline et al. (2023) paper has been published in *Science* and is no longer forthcoming. Other footnotes recommended by Reviewer 5 are (1) on page 26 to explain that CO₂ emissions in 2005 are gross emissions, not accounting for sequestration from land and (2) on page 31 to include a citation footnote.

Reviewer 3 suggests changing the colors in Table 1.1 to accommodate colorblind readers. In the Industry header on page 17, Reviewer 5 suggests adding 45Q.

Reviewer 1 comments that the text describing the purpose of the report, the key provisions of the IRA, and scope and approach in the introductory chapters are well-written and straightforward. This reviewer notes it would be useful to explain the rationale behind including sector-specific analysis for the building sector but not for other end-use sectors. This explanation could prime the reader on the relationship between the multi-sector and buildings-specific modeling and results.

Reviewer 2 recommends adding examples of “economic opportunities available” that are mentioned in the first paragraph of the Introductory chapter. They also note that section 1.2.1 mentions 2031 as the target year, but analysis and interpolation is between 2030 and 2035 and 2031 values were not reported on. Reviewer 2 suggests adding a citation on page 13 for the sentence beginning, “Recent research suggests pathways for reducing...” and that the Scout model should be cited as both a Lawrence Berkeley National Labs (LBNL) and National Renewable Energy Laboratory (NREL) tool. For greater clarity, Reviewer 2 suggests rephrasing, “...transportation accounted for 38% of direct plus indirect emissions from electricity consumption” to direct emissions plus indirect emissions from electricity consumption.

5. Does the introductory chapter adequately explain the overall analytic framework of the project?

Reviewer 3 notes that EPI-EI and SCOUT are accounting tools and not models. Reviewer 4 notes that descriptions of the models in sections 1.2.1. and 1.2.2 can be confusing. The models are organized by origin and sector type, but it is not clear which external models are power sector or multi-sector models until page 24. Furthermore, Reviewer 4 notes difference in the number of multi-sector models reported in the Executive Summary and section 1.3.2. This reviewer suggests clearly outlining each model’s format (multi-sector, power or building sector), whether it is EPA or external, and whether emissions are economy-wide or sector-specific for clarity and consistency. Furthermore, Reviewer 4 suggests providing more clarity on what is meant by an EPA-supported model and how NREL’s Regional Energy Deployment System (ReEDS) is categorized.

Reviewer 1 reiterates that including explanation for building-specific models as well as multi-sector results and analysis could be useful. The sector-specific modeling reads as divorced from the larger analysis for buildings.

Reviewer 6 notes that readers’ unfamiliarity with various models can be confusing, especially since some “external” models produce conflicting or counter-intuitive results. Including some of these “external” models can distract from the main messaging, as exemplified in Figure 2.6.

6. Are the inputs and scenarios clearly explained and documented in the introduction? If not, please provide recommendations for improvement.

Reviewers 3 and 4 both suggest clarifying the optimistic and pessimistic scenarios in the text more. Reviewer 4 notes that adding which assumptions change can provide useful context.

Reviewer 5 recommends adding more context in the appendices for interested readers as well as a figure on capital cost assumptions of key electric sector technologies and a figure on fuel prices over time. Reviewer 4 suggests providing more context on which federal and state policies are taken into consideration. Reviewer 4 also notes that on page 22, NEMS-OP, ReEDS, and USREP-ReEDS include IRA and Bipartisan Infrastructure Law (BIL), but it is not stated whether other models also include BIL in their IRA scenarios, which could mean model results could not easily be compared. The text does not indicate what is internal modeling and whether this is EPA-supported modeling.

Reviewer 4 also notes that the technology Cost section on page 22 could benefit from clarification on annual technology baseline (ATB) costs across scenarios and resource classes as well as technology costs for renewables only. Another comment is that an explanation for why CO₂ pipeline, injection, and storage infrastructure doubles in the Technology Constraints section would provide useful context. Regarding economic growth scenarios, it is not clear which energy prices are adjusted and how or which energy is being included and Reviewer 4 suggests further clarifications. Reviewer 4 suggests adding further explanation on attribution of emissions across different sectors, possibly in the form of a graph or figure.

Reviewer 1 notes that the primary scenarios, No IRA and IRA, are straightforward to understand. However, the coverage of sensitivities is less clear. This reviewer notes that it is not clear how sector-specific sensitivities fit into broader set of sensitivities and some sensitivities interact with each other. They comment that the text would benefit from more explicit technology cost assumptions for the “Optimistic” and “Pessimistic” scenarios. Reviewer 6 agrees with this analysis and adds that more comparison for “internal” and “external” models and their findings can provide useful context in the text. Reviewer 6 suggests separating the two types of models to help the reader more clearly understand the distinction in model results.

7. Is the cited literature accurately represented?

Reviewer 5 finds the cited literature appropriate. Reviewer 4 notes the citation of the GCAM model can be misleading that the Center for Global Sustainability (CGS) developed GCAM when it was developed by Joint Global Change Research Institute (JGCRI) of Pacific Northwest National Labs (PNNL). Similarly, it is not clear if the [Integrated Planning Model’s] IPM-EPA or IPM-NRDC are interchangeable or are different models. They note model descriptions and documentation can vary, even if models have the same fundamental aspects. Reviewer 4 notes these differences appear in figures in Appendix F, as well.

Reviewer 1 comments some minor misrepresentations in the buildings study published by LBNL and the Brattle Group. They note more methodological information from that study can be used to provide more context for building-specific analysis. They also suggest noting that the LBNL and Brattle Group study is a preprint that has undergone subsequent review and revision and to include updated published information if available. For the Buildings chapter, Reviewer 2 notes that footnotes 100 and 101 in reference to “studies have estimated that benchmarking can increase energy efficiency by over 2% annually and around 7% if it occurs consistently over three years” is a slight mischaracterization because benchmarking is not an energy saving measure in and of itself but rather it supports energy efficiency improvements.

Reviewer 4 compares model results from the Bistline et al. (2023) paper and notes some model results are the same (e.g., MARKAL-NETL) while others are different (e.g., EPS-EI). They note that the differences between different reports are likely not calibrated, which can lead to incorrect interpretation of model results.

Reviewer 6 notes that the literature seems under-cited in the text.

8. Are there any additional relevant data sources that are not included but could be incorporated into this analysis?

Reviewer 5 notes other IRA analysis reports from Goldman Sachs and Credit Suisse that could be included. They also suggest at minimum a qualitative discussion of sector-specific reports, for example, literature related to 45V credits for hydrogen could include Ricks et al. (2023)

“Minimizing emissions from grid-based hydrogen production in the United States.” Reviewer 3 is unaware of any additional relevant data sources.

Reviewer 4 recommends adding Slowick et al. (2023), an ICCT study on the impact of IRA on EV and zero-emission vehicles.

Reviewer 1 notes there are very few extant analyses of both residential and commercial buildings. This reviewer cites Berrill et al. (2022), Goldstein et al. (2020), and Vahidi (2021) as potential additional context for the levels of emissions reductions in the buildings sector. (For the full citations, please see Reviewer 1’s individual comments in Section 4.1.)

Reviewer 6 believes fewer comparisons to other data sources could make for easier for the authors to draw conclusions based on “internal” models.

9. The analysis presented in this report is multi-faceted, using results from several sophisticated multi-sector and single-sector energy-economy models. Is the use of a multi-model approach, incorporating multi-sector and power sector models, appropriate to estimate the potential effects of the energy- and climate-related provisions of the IRA? If not, please suggest other approaches.

Reviewers generally find the various model approaches to be appropriate and useful. Reviewer 3 notes that multi-model and single-model approaches are well-established methods of policy analysis, but accounting models such as SCOUT are less appropriate for projections. Reviewer 5 notes that multi-model approaches are appropriate for the research questions and the approach can help disentangle structural uncertainty and parametric uncertainty to ensure robust findings. This reviewer notes it would be ideal to complement this discussion with harmonized scenarios and single-model sensitivities to determine the influence of parametric uncertainties, but the level of effort might not be worth the value added.

Reviewer 1 suggests more context on the differences between multi-sector model results and building-specific model results. It would help transparency and confidence to show a more focused and granular look at the buildings sector does not yield dramatically different results to multi-sector analyses. They also note it would be helpful to emphasize the opportunity and need to link sector-specific models with multi-sector frameworks in future iterations. Reviewer 6 agrees with the assessment that more explicit delineation of EPA-supported and non-EPA-supported models before page 20 of the report. This reviewer suggests moving external model results to an appendix.

10. Does the report provide an assessment of reductions in greenhouse gas emissions that result from changes in domestic electricity generation and use due to the Inflation Reduction Act of 2022 that are anticipated to occur on an annual basis through fiscal year 2031?

Reviewers 2, 3, and 5 say yes. Reviewer 5 notes that future comparisons after 2031 is important as future effects can influence earlier emissions and energy system outcomes. Reviewer 1 agrees that the report provides the necessary information and context to understand sector-specific changes and that future emissions beyond 2031 are useful context. Reviewer 1 notes limitations in multi-sector modeling with demand-side factors being less granular than supply-side representation. Reviewer 1 notes that the inclusion of sector-specific models is important to check the robustness of multi-sector models’ buildings results and highlights additional buildings-specific sensitivities of interest.

Reviewer 4 disagrees because only CO₂ emissions are addressed, not other GHGs. Reviewer 4 also believes that modeling results show more than just electricity changes and that sector-specific IRA

incentives could lead to GHG reductions as well. They note that the scope might be better described as changes in CO₂ from IRA provisions and not result from changes in domestic electricity generation. Reviewer 6 agrees with Reviewer 2 that the use of 2005 as a reference year without context can be misleading, especially for showing percentage reductions in the Executive Summary. While this reviewer acknowledges the reason for 2005 as a base year, they suggest comparison to 2021 might be more informative about the impact of the IRA in the context of the minimum values in Table ES.1.

11. Is the draft report missing important findings or messages based on your review?

Reviewer 3 notes that there is a misleading conflation of electrification and efficiency in the report. This reviewer notes that as the grid becomes cleaner, electrification can lead to abatement even if it is not efficient. Reviewer 5 believes regional disaggregation would be useful to illustrate differences in responses to IRA incentives. Reviewer 1 agrees with Reviewer 5's suggestion for regional disaggregation and adds that it would provide useful context for understanding emissions through 2035. At minimum, they suggest acknowledging the limitation of scope and degree of varying underlying national data in section 1.2 if there is no data at regional resolution.

Reviewer 4 notes that the reported emissions savings in the transportation sector reported in the conclusion is made out to be large, but the appendix data shows only 2.6% change in emissions from IRA to No IRA in 2030 and 1.4% in 2050, which somewhat contradicts the findings. They also comment that it would be beneficial to include some explanatory text as to why the transportation sector has significantly lower emissions reduction compared to the building and industrial sectors. Reviewer 4 also suggests that changes in specific fuel sources between the No IRA and IRA scenarios is missing for context. In particular, petroleum and natural gas trends vary widely in 2030 and 2035 across scenarios, but it is not explained why. Finally, Reviewer 4 suggests adding more explanatory text for differences in trend lines between IRA and No IRA scenarios in general. Reviewer 2 generally finds the report successful in communicating key findings across a wide breadth and complex subjects. This reviewer notes that the text could emphasize building-related efforts through energy efficiency and efficient electrification as key enablers for power sector reductions as there is a risk that energy consumers may deprioritize energy efficiency if they believe energy generation will be decarbonized. The IRA emissions report can reinforce the fact that reducing demand is a way to maintain demand at a low level where power suppliers can effectively decarbonize.

Reviewer 6 points out that one downside to multi-sector analyses is that individual scenarios are underexplained. Several model runs indicate steady or increasing emissions in the No IRA scenarios after 2025, which can influence the percentage reduction in IRA scenarios. Some figure captions, such as that of Figure 1.3 regarding MARKA-NETL address this, they acknowledge. Reviewer 6 also suggests adding in the call-out box "Promising Technological Innovation" that not only is long-duration energy storage developing rapidly, but it is also poorly represented by the models used in the analysis because of their non-sequential representations. This text box could also mention limitations of representing distributed generation in the types of models used.

12. Do you have any recommendations for any key research that could be discussed but is not mentioned? Do you have recommendations for future updates to the report that EPA should consider?

Reviewer 3 suggests future updates include the best available industrial sector modeling as this is an active area of model development. Reviewer 5 recommends regional deep dives and more information on the impacts of individual provisions and uncertainties about implementation. Reviewer 4 suggests more detailed emissions reduction results by sector, such as, light-duty, medium-duty, and aviation in the transportation sector. This can identify sectors that might need additional policy support. Reviewer 4 also suggests including other GHGs and notes that CO₂ and GHG are used interchangeably frequently in the IRA emissions report, which can lead to confusion. Including other gases is important as several gases have much higher global warming potential (GWP) than CO₂. This reviewer also suggests adding a figure or table for the projected grid mix by model and discuss the results. Finally, Reviewer 4 comments it would be beneficial to sector competition for electricity. This increased competition could place pressure on grid balancing, especially for renewables. It is unclear if any barriers are included and what the impacts, prioritization, and solutions could be if electricity were not able to meet end-sector demands.

For recommendations for future updates EPA should consider, Reviewer 1 suggests highlighting the opportunity for linking demand projections from building-specific analysis with multi-sector modeling to harmonize projections in the Buildings chapter. Reviewer 1 notes that capabilities to do this are being pursued by the Department of Energy (DOE) through the DECARB Initiative. They note that an updated IRA emissions report could be a key use case for those improved modeling capabilities. Reviewer 2 wonders if data inputs used for the report's analysis hold up equally for underserved communities, addressing equity concerns mentioned in the IRA emissions report and suggests elaborating on this. This reviewer also suggests that follow up on long-term energy management and maintenance practices for building technologies would be important as the report currently does not mention any assumptions related to performance degradation, ongoing building commissioning or performance monitoring. There is research documenting performance degradation in the absence of active efforts to maintain or manage technologies that could be included.

Reviewer 6 suggests more mechanistic explanation of why the models consistently do not choose "emerging technologies" that have specific IRA components, such as carbon capture and storage (CCS) and nuclear power, in the "Overcoming Deployment Challenges" call-out box. This could be a place to discuss sensitivities that provide valuable context.

4. Individual Peer Reviewer Comments

This section provides the individual peer reviewer comments, presented in no particular order.

4.1 Reviewer 1

1. Are the writing level and graphics appropriate for an educated but general audience including stakeholders and decision-makers?

In general, the document is well-written and organized and the graphics successfully convey the key information to the reader. I appreciate that the sections of the document that I reviewed are largely free of technical jargon that would not be readily understood by a general audience. I have provided a few suggestions on specific graphics in the document where I believe there are a few legibility issues.

2. Do the text, figures, and tables in the sector specific chapters clearly communicate the modeling results? If not, please provide recommendations for improvement. Note that Appendix G contains additional figures and alternative figure styles.

Figure 4.2 in the buildings chapter clearly conveys IRA impacts from the economy-wide models in a consistent format to other chapters, which helps with legibility. The text explains the key takeaway numbers well, though it could provide further interpretation of key drivers of the range of results and link to the Appendix assumptions Table (C2) in so doing. I also reviewed Table C2 and suggested a few places where assumptions could be clarified.

The buildings chapter is unique in its inclusion of a sector-specific analysis on top of the multi-sector analysis and there are a few ways that the communication of the latter could be improved. First, the text could further detail key assumptions of the sector-specific scenarios, as Table 4.1 reads as overly generic about the drivers of change across the different scenarios. Second, the chapter could include more comparisons of the assumptions and high-level results of the multi-sector models and the buildings-specific model and briefly discuss potential reasons for differences between the two. Finally, the chapter could further highlight the future opportunity to link the demand projections from the building-specific analysis with the multi-sector modeling, to harmonize the projections and insights.

3. Does the executive summary provide sufficient context to understand the synthesized results?

The summary does provide sufficient context for understanding but perhaps provides too much context about approach and limitations before getting into the key results. In my comments on the document, I suggest moving the key takeaways up towards the beginning of the summary, followed by the additional methodological details. The reader would benefit from understanding the key takeaways first and then reading on for details and context about the modeling approach and motivation.

4. Does the introductory chapter clearly explain the purpose of the report and provide appropriate context for the sector chapter results?

The text that outlines the purpose of the report, key provisions of the IRA, and the scope and approach of the modeling is well written and straightforward to follow. While in general the introduction sets up the remaining sector-specific results well, it could do more to explain the rationale behind including an additional sector-specific analysis for the building sector (but not the

other end-use sectors), and could more effectively prime the reader on the relationship between the multi-sector and buildings-specific modeling and results. Please see a few comments along these lines in the document.

5. Does the introductory chapter adequately explain the overall analytic framework of the project?

The explanation of the analytic framework is adequate overall; however, per the previous comment the use of the sector-specific models for electricity and buildings in the context of the broader, multi-sector results and analysis could be explained more effectively. As it stands, the sector-specific modeling reads as divorced from the larger analysis and this is particularly true for the buildings analysis, which, for example, is missing in the summary of model coverage in Table 1.1 and in several of the Appendix tables.

6. Are the inputs and scenarios clearly explained and documented in the introduction? If not, please provide recommendations for improvement.

The two primary scenarios – IRA and No IRA – are documented in the introduction and are straightforward to understand. The subsequent coverage of sensitivities is a bit more muddled for a few reasons: 1) per my comment in the text, it's not clear where sector-specific sensitivities, particularly those explored in the buildings-specific modeling, fit into this broader set of sensitivities, and 2) some of these sensitivities seem to intersect – for example, wouldn't the "Constr" sensitivity factor into a "Pessimistic" IRA implementation? Similarly, is an IRA "Optimistic" implementation consistent with the assumption of "Advanced" technology costs in the combined scenario? More context is needed concerning how the sensitivity cases were designed, and specifically, how these sensitivities address interactive effects across key inputs to the modeling.

7. Is the cited literature accurately represented?

There are a few places where I suggested adding or clarifying sources to increase the transparency of results and/or support key claims in the text. In the buildings chapter, the representation of the LBNL/Brattle study, which provides much of the basis for the EPA-specific buildings analysis, is generally accurate save for a few minor issues that I have noted in my comments on the document. There are also a number of opportunities to pull more methodological information out of that study to provide greater context for the buildings-specific modeling that EPA supported, as I noted in my comments in the document.

One key suggestion is to highlight the nature of the available citation on the LBNL/Brattle study as a preprint that has undergone subsequent review and revision. If possible, the citation and numbers from the final publication could also be used (available August 2023), provided that the timing works with the EPA revision and publication schedule.

8. Are there any additional relevant data sources that are not included but could be incorporated into this analysis?

For now, there are still very few existing analyses of the full building sector (residential and commercial buildings) that provide extensive enough data to be included in this work. There are a few publications that may be useful for comparing and contextualizing the levels of emissions reductions that this report estimates for buildings (note that two of these are residential-focused):

- P. Berrill et al. "Decarbonization pathways for the residential sector in the United States". Nature Climate Change 12.8 (2022), pp. 712–718. <https://doi.org/10.1038/s41558-022-01429-y> 

- E. Vahidi et al. “Regional Variation of Greenhouse Gas Mitigation Strategies for the United States Building Sector”. Applied Energy 302 (Nov. 2021), p. 117527. <https://doi.org/10.1016/j.apenergy.2021.117527> 
- B. Goldstein, D. Gounaridis, and J. P. Newell. “The carbon footprint of household energy use in the United States”. Proceedings of the National Academy of Sciences 117.32 (2020), pp. 19122–19130. <https://doi.org/10.1073/pnas.1922205117> 

9. The analysis presented in this report is multi-faceted, using results from several sophisticated multi-sector and single-sector energy-economy models. Is the use of a multi-model approach, incorporating multi-sector and power sector models, appropriate to estimate the potential effects of the energy- and climate-related provisions of the IRA? If not, please suggest other approaches.

Yes, I believe that this is an appropriate approach for representing the energy- and climate-related provisions of the IRA. I also understand the intent of including the single-sector electricity and building models to provide further context; however, I believe in the case of the buildings model, which was the focus of my review, the report could do more to highlight differences in assumptions and results between the sector-specific and multi-sector modeling. This will improve the transparency of and confidence in multi-sector results for the building sector by showing that a more focused and granular look at the sector does not produce dramatically different results to the higher-level, multi-sector analysis. It would also be helpful to further emphasize the opportunity and need to directly link and/or harmonize the more resolute, sector-specific models with the multi-sector framework in future iterations of this kind of analysis.

10. Does the report provide an assessment of reductions in greenhouse gas emissions that result from changes in domestic electricity generation and use due to the Inflation Reduction Act of 2022 that are anticipated to occur on an annual basis through fiscal year 2031?

Yes, the report provides this assessment along with the necessary context to understand key drivers and sector-specific attributions of the changes. The report provides results through 2035, which goes beyond the scope of this charge but is useful in illustrating longer-term trends in the modeling, as the authors explain in the document.

The supply-side representation (“generation”) appears more sophisticated and granular than that of the demand-side (“end use”) in the multi-sector models that inform the report’s key findings, which reflects limitations in the multi-sector modeling configuration and capabilities that could be addressed in future updates. For now, the inclusion of additional sector-specific modeling for buildings helps to check the robustness of the multi-sector models’ buildings results and point to additional buildings-specific sensitivities of interest.

11. Is the draft report missing important findings or messages based on your review?

While I understand that the focus of this report is national, the report could do more to highlight the regional implications of the modeled changes in energy and emissions through 2035. Presumably at least the internal EPA data are reported in a format that allows for regional breakouts of emissions reductions, but if this is not possible, I suggest at least including a paragraph or two in the discussion of analysis scope or limitations (section 1.2) about the regional resolution in the underlying data and the degree to which national findings would be expected to vary by region (as well as which regions could expect to see the smallest/largest relative changes in emissions, if possible.)

12. Do you have any recommendations for any key research that could be discussed but is not mentioned? Do you have recommendations for future updates to the report that EPA should consider?

EPA could consider supporting future updates to the report that incorporate improved endogenous representation of specific IRA provisions in the modeling frameworks (as noted, several provisions are not yet finalized in terms of implementation and are also challenging to represent precisely in models) and to improve linkages and/or harmonization between the sector-specific models (e.g., the building and power sector models, or the sector-specific models and cross-sectoral models like GCAM.) Capabilities to support the latter are currently being pursued by DOE (e.g., through the DECARB Initiative that is run through the Strategic Analysis Program) and updates to the IRA emissions report could be a key use case for those improved modeling capabilities.

4.2 Reviewer 2

1. Are the writing level and graphics appropriate for an educated but general audience including stakeholders and decision-makers?

Yes. The report is clearly written, and the charts are clear and appropriate (more specific comments on charts below). I also like that there are not too many charts, which could create confusion/overwhelm for a general audience.

2. Do the text, figures, and tables in the sector specific chapters clearly communicate the modeling results? If not, please provide recommendations for improvement. Note that Appendix G contains additional figures and alternative figure styles.

BUILDINGS CHAPTER

A contextual comment: it is not clear in the report why 2005 is chosen as a reference year. In choosing this reference year, much of the reported data is not just communicating the modeling results, but rather the aggregate total of modeling results plus the historical CO₂ emissions trends. With that said, the tables and figures do clearly communicate the difference in modeling IRA effects compared to “No-IRA” effects.

End of Section 4.1 mentions benchmarking policies, could be a place to cite this resource from IMT: <https://www.imt.org/resources/map-u-s-building-benchmarking-policies/> .

Section 4.3, first paragraph, mentions “energy and building management”- these are quite generic in nature, you could be more specific and mention building commissioning, energy management & information systems (EMIS), and advanced building controls.

Also in Section 4.3, the term “efficient electrification” is used without a definition. Unclear if “efficient electrification” just means heat pumps, and whether that applies to HVAC and domestic hot water equally. Also, this paragraph doesn’t acknowledge HP limitations in cold climates.

Also in Section 4.3, one paragraph notes that building owners can “invest in certified green power” – suggest making clear that this is outside of the scope of the data analysis (if that is the case).

Figure 4.2. Figure title says “median additional reductions of 26% and 38% respectively” – this is very hard to discern from the chart; consider putting this on a separate bar chart.

Table 4.1 placement is confusing. It is placed after a paragraph about a different study, which might lead the reader to erroneously assume the table relates to that study. The table is also missing input values for the “No IRA” scenario that is mentioned in the paragraph after the table.

Figure 4.3 is confusing. The text prior to the figure is focused on modeling heat pumps for HVAC and water heating, but Figure 4.3 legend shows “HVAC/Env” (envelope?), and “Other.” Need some explanation of the input assumptions for these additional measures. It is also curious that the pessimistic scenario shows a barely visible improvement from energy efficiency and electrification, even though Table 4.1 shows that this scenario is a significant step up from the 2019 reference values. The charts in 4.3 may be reasonable but I suggest adding some text to explain why the pessimistic case is so low; a description of the “reference” values in Figure 4.3 may explain this. It would be helpful to distinguish the reference values used in Figure 4.3 with the “EIA AEO 2022 Reference Case” mentioned in Table 4.1. Also, in the Figure 4.3 title, the phrase “Energy efficiency and electrification both contribute to an 50% decrease in emissions from 2005 in the Pessimistic Scenario” is misleading, since that chart is showing virtually no contribution to any achieved CO₂ reductions.

The end of the buildings chapter describes 2 key uncertainties. The rate of electrification of power supply is a key uncertainty in achieving the CO₂ reductions from efficient electrification of buildings but is not mentioned. Also, the uncertainty around whether newly installed equipment will be operated and maintained efficiently over the long term (mentioned earlier in the chapter) is another uncertainty factor not mentioned.

3. Does the executive summary provide sufficient context to understand the synthesized results?

The Executive Summary is clear and concise and provides sufficient context to understand the results. One general concern (already noted in my response to question 2) is the lack of explanation for why 2005 is used as the main reference year for all results. Additional specific comments on figures/tables below:

Figure ES1: The addition of median lines and distribution marks to the right of the main chart is a bit confusing visually. I find the alternatives in Appendix G more confusing. Suggestion: Remove the bars/dots piece to the right of ES-1, and just indicate the medians on the main ES-1 chart (as bold dots of 2 different colors?). The chart already gives an impression of distribution, so all you need is to indicate the medians.

Figure ES-2: The Figure title states “The buildings sector shows the greatest decline in total CO₂ emissions in 2035 between the No IRA and IRA scenarios” – If this is considered an important insight, it could be expressed numerically, e.g., Indicate median percentage reduction by 2035, to have a single number to quote? This could also be presented in the form of a bar chart comparing percentage reduction values.

Table ES-1: This data may be more easily understandable as a chart.

4. Does the introductory chapter clearly explain the purpose of the report and provide appropriate context for the sector chapter results?

The introductory chapter provides clear context and explanation of the report’s purpose. More specific comments below:

The first paragraph of Introductory chapter mentions “economic opportunities available” - examples and/or a citation may provide helpful context for the reader.

Bottom of section 1.2.1 mentions 2031 target year and interpolation between the 2030 and 2035 modeled results, but I did not find any actual 2031 values in the report. Suggest clarifying whether this was actually done.

First paragraph on p13 mentions “Recent research suggests pathways for reducing...” – suggest adding a citation.

1.2.2 (Models cited or used) – Scout is indicated as an NREL tool, should be LBNL/NREL (per this [public presentation](#))

1.3.1: The phrase “...transportation accounted for 38% of direct plus indirect emissions from electricity consumption” is confusing. Would be clearer to say direct emissions plus indirect emissions from electricity consumption.

Figure 1.1: May be helpful for Figure title to mention a value for transportation indirect emissions, since they are not visible on the chart.

“Market Failures” sub-section, p33, mentions split incentives, and gives an example of “some multifamily housing units.” Suggest adding that many commercial properties also exhibit split

incentive risks, and you could also note that so-called “green lease” structures are one strategy for addressing that risk.

“Market Barriers and Transitions,” page 34, includes a bullet titled “High relative costs...”, but the body of that bullet suggests that costs are only “perceived” as being high. Needs clarification.

5. Does the introductory chapter adequately explain the overall analytic framework of the project?

The introductory chapter does a good job of explaining the overall analytical approach and models used in developing the report.

6. Are the inputs and scenarios clearly explained and documented in the introduction? If not, please provide recommendations for improvement.

Inputs and scenarios are sufficiently explained in the introduction; I have no suggestions for edits.

7. Is the cited literature accurately represented?

Footnotes 100 and 101 (p69) are tied to text that says, “studies have estimated that benchmarking can increase energy efficiency by over 2% annually and around 7% if it occurs consistently over three years.” I would consider this a slight mischaracterization, in that benchmarking is not an energy saving measure in and of itself. You might say that benchmarking supports/drives energy efficiency improvements, or that buildings that are benchmarked see energy efficiency improvements.

Aside from this very minor observation, and the earlier mention of attribution of the Scout tool to both LBNL and NREL, I did not see any other citations with issues.

8. Are there any additional relevant data sources that are not included but could be incorporated into this analysis?

The report includes a comprehensive array of relevant data sources; no additional sources are suggested.

9. The analysis presented in this report is multi-faceted, using results from several sophisticated multi-sector and single-sector energy-economy models. Is the use of a multi-model approach, incorporating multi-sector and power sector models, appropriate to estimate the potential effects of the energy- and climate-related provisions of the IRA? If not, please suggest other approaches.

Yes, I believe the multi-faceted approach is appropriate for addressing the target questions around IRA impacts.

10. Does the report provide an assessment of reductions in greenhouse gas emissions that result from changes in domestic electricity generation and use due to the Inflation Reduction Act of 2022 that are anticipated to occur on an annual basis through fiscal year 2031?

I believe the report meets that stated objective; I also believe the report makes a reasonable case for presenting results that extend to 2035.

11. Is the draft report missing important findings or messages based on your review?

Considering the extremely wide breadth and complexity of the report’s objectives, the report is successful in presenting important findings and key messages in a concise way.

A key message that could be emphasized more: Building-related efforts through energy efficiency and efficient electrification are key enablers for power sector emission reductions. In my opinion, there is a risk that energy consumers may deprioritize energy efficiency if they believe that generation will be decarbonized. This report presents an opportunity to reinforce the fact that reducing demand is a way to maintain demand at a low level where power suppliers can effectively decarbonize.

12. Do you have any recommendations for any key research that could be discussed but is not mentioned? Do you have recommendations for future updates to the report that EPA should consider?

The report mentions objectives to address equity and underserved communities, which is an opportunity for further key research. For example, are the data inputs used for this report's analysis hold up equally for underserved communities?

Research into the actual long term energy management and maintenance practices for the subject building technologies would be another topic worthy of further follow up. The report does not mention assumptions around performance degradation, periodic/ongoing building commissioning, ongoing performance monitoring/analytics, etc., though there is plenty of research documenting performance degradation in the absence of active efforts to maintain/manage technology.

4.3 Reviewer 3

1. Are the writing level and graphics appropriate for an educated but general audience including stakeholders and decision-makers?

Yes, for the writing level. The graphics are too complicated. The report is also much too long. In particular, it includes extraneous information about abatement opportunities that do provide context, but the added length reduces the probability that anyone – particularly decision-makers – will read this. I would consider dropping most of that material – which is available from many other sources – and focusing on the modeling results.

2. Do the text, figures, and tables in the sector specific chapters clearly communicate the modeling results? If not, please provide recommendations for improvement. Note that Appendix G contains additional figures and alternative figure styles.

I very much empathize with the authors on the difficulty of presenting this much data in a coherent format. Unfortunately, I do not believe that they have succeeded. In particular, the charts are a mess of lines, and it is not possible to match the baseline and policy cases from an individual model. The dots and median bar in the text do not add additional information. While policy makers are often rightly concerned with the absolute level of emissions, from a modeling point of view, the change from the baseline is the most useful category. The charts in the appendix include this, which is an improvement. I would consider instead showing a chart with just the changes, labeled as emissions reductions. Perhaps the absolute levels could be summarized as an envelope with a median line.

I am generally not a fan of combining indirect and direct emissions from end-use sectors since it double-counts the electric sector emissions. I would show direct emissions separately to emphasize the direct emissions reductions, which are independent of the evolution of the power grid. In particular, electrification can lead to a short-run increase in emissions depending on efficiency and the carbon intensity of the grid, a point not noted in the text. The results shown in various chapters for end-uses including indirect emissions may reflect the degree of abatement in the power sector for a given model rather than the modeling of changes in the end-use sector. Without distinguishing direct emissions, the reader cannot understand what is modeled to occur in an end-use sector. Showing electricity consumption in addition to direct emissions is a much clearer metric for the impact of efficiency and electrification than indirect emissions.

Figure 2.4 should also be revised, at a minimum to add lines. As is, one cannot tell whether generation is going up or down in given models as the range of points includes both possibilities.

The right-hand part of figure 2.5 may be better a set of stacked columns for each model.

On p. 42, it states that the 45U is responsible for increases in nuclear generation. The 45U credit is only for existing plants, however, so it could represent an increase over retirements in the baseline, but not an increase over historical levels. This isn't clear in the text.

In chapter 2, the Environmental Justice and SF₆ boxes, while both important, do not reflect any modeling results.

The industrial section has almost no analysis of the modeling results.

3. Does the executive summary provide sufficient context to understand the synthesized results?

The ES provides a lot of context. It needs a clearer statement of results.

4. Does the introductory chapter clearly explain the purpose of the report and provide appropriate context for the sector chapter results?

Consider shortening. The boxes, for example, are ancillary to the purpose of the report and could be removed.

In the generation section, the report refers to the factor of 5 increase in credits from wage and apprenticeship requirements as bonus credits – in my experience, that generally refers to the additional credits for domestic content, etc. The factor of 5 is not treated consistently in this section.

In the gases section on p. 18, it equates natural gas with methane, but methane is the largest component of natural gas, which contains other compounds.

In the model descriptions on p 21, the NEMS descriptions should be made consistent.

Table 1.1 is impossible to decipher for someone with colorblindness.

Economy-wide results could be put in context of US NDC and other publicly stated climate goals.

5. Does the introductory chapter adequately explain the overall analytic framework of the project?

Yes. It may be worth pointing out the EPI-EI and SCOUT are accounting tools and not models.

6. Are the inputs and scenarios clearly explained and documented in the introduction? If not, please provide recommendations for improvement.

The optimistic and pessimistic scenarios need more explanation in the text rather than just being in the appendix.

7. Is the cited literature accurately represented?

Didn't check.

8. Are there any additional relevant data sources that are not included but could be incorporated into this analysis?

Not that I am aware of.

9. The analysis presented in this report is multi-faceted, using results from several sophisticated multi-sector and single-sector energy-economy models. Is the use of a multi-model approach, incorporating multi-sector and power sector models, appropriate to estimate the potential effects of the energy- and climate-related provisions of the IRA? If not, please suggest other approaches.

Multi-model and single model approaches are longstanding and well-established methods of analyzing policies. This paper also includes two accounting models, particularly the use of the SCOUT model in the buildings chapter, which are less appropriate. These are tools for scenario analysis and should not be used for projections.

10. Does the report provide an assessment of reductions in greenhouse gas emissions that result from changes in domestic electricity generation and use due to the Inflation Reduction Act of 2022 that are anticipated to occur on an annual basis through fiscal year 2031?

Yes.

11. Is the draft report missing important findings or messages based on your review?

In the section on the industry sector, the limitations of most models for this sector should be discussed and emphasized.

Throughout the report, there is a pairing of electrification and efficiency that is misleading. For example, the report discussed “efficient electrification”, but electrification need not be efficient, and even inefficient electrification can lead to abatement, particularly as the grid becomes cleaner.

12. Do you have any recommendations for any key research that could be discussed but is not mentioned? Do you have recommendations for future updates to the report that EPA should consider?

Most of these models do not reflect the industry sector or hydrogen well. This is an active area of model development and future updates should include the best available industrial sector modeling.

4.4 Reviewer 4

1. Are the writing level and graphics appropriate for an educated but general audience including stakeholders and decision-makers?

Yes. The writings and figures are clear and straightforward for general audience to follow.

2. Do the text, figures, and tables in the Executive Summary and Introductory chapters clearly communicate the modeling results? If not, please provide recommendations for improvement. Note that Appendix G contains additional figures and alternative figure styles.

In Table ES.1, it would be helpful to also provide the percentage reduction in addition to the absolute reduction values. It would also be helpful to present the sector specific reductions, both in percentage and absolute values.

Economy-wide CO₂ emissions in Figure 1.1 are 5695 and 4615 Mt CO₂ in 2005 and 2021, which differ from that in Figure 1.2 – 6132 and 5032 Mt CO₂ in 2005 and 2021. The economy-wide CO₂ emissions in Figure 1.1 is the sum of the direct and indirect emissions from industry, building, and transportation sectors. Does this sum really reflect economy-wide CO₂, given that it is lower than the total CO₂ emissions from the national inventory (EPA-GHGI) that was used in Figure 1.2? Please clarify in the report or use different terms to describe them.

Figure 1.4 on page 30: under IRA implementation scenarios, how come the highest estimate of optimistic is higher than the highest estimated of moderate? Under the combined case, why there are two mod and two op-adv results, while only one pass-adv result of each model?

Page 11 of the Executive Summary says, “Industry also includes non-combustion industrial process emissions and indirect emissions from the direct combustion of fossil fuel related to the extraction, processing and transportation of that fuel, which are outside the scope of this report.” However, page 19 of the sector definition says “Importantly, industry also includes non-combustion-related industrial process emissions (e.g., from cement).” The scope of work described in different sections needs to be consistent.

Same as Figure 1.1, there is no indirect emissions for transportation shown in Figure 3.1. By looking at the spreadsheet, it probably is too small to be shown on the graph. I think it probably needs some notes on (1) it’s not zero indirect emissions; and (2) the reason for this extremely low emission.

Figure 3.2 needs a note on what the “other” category represents. In addition, for aviation and shipping, it is necessary to note whether the figure represent emissions from only domestic transportation or includes air/ship departing from and/or arriving to the US.

Section 3.2 lists the IRA provisions for transportation, such as incentives for biofuel and clean fuel tax credit. However, the Clean Hydrogen Production Tax Credit (45V) is not listed under the transportation sector, but under the industry sector. What is the reason for not having hydrogen PTC under transportation, given that it could be used as a transportation fuel? The IRA incentives for biofuels and sustainable aviation fuels are listed both under the transportation and industry sections.

The paragraphs below the list provide some details on each provision. However, the descriptions on clean fuel PTC (13704) provide little information. It would be helpful to give more details; for example, what types of fuels are included and how “clean” is defined.

It would also be helpful to provide the definition or examples of sustainable aviation fuel.

The paragraph right above section 3.4 on page 59 talks about pipeline emissions. However, this paragraph is relatively vague and missing some background information, such as how this category

is defined. I found the descriptions from this EPA document

<https://www.epa.gov/system/files/documents/2023-06/420f23016.pdf> too more helpful. For example, this document explains “Pipelines: systems that transport liquids, gases, or slurries through either above or below ground pipes. In the Inventory, the pipelines category includes emissions from the combustion of natural gas used to power pumps and other distribution equipment, while leaks and other emission sources from pipelines are assigned to the natural gas systems category.”

The numbers and results in Transportation section differ from the numbers in the Executive Summary and Conclusion sections, and do not match the values in the spreadsheet. Please make sure the numbers, not just the ones listed here, are consistent throughout the report and with spreadsheet.

Historical CO₂ emissions in 2005 and 2021:

- Page 53 says “Transportation CO₂ emissions rose from 1,484 Mt CO₂/yr in 1990 to 1,874 Mt CO₂/yr in 2005. Transportation emissions then declined to 1,765 Mt CO₂/yr in 2021”.
- Page 79 of the Conclusion says “CO₂ emissions from both the combustion of fossil fuels (direct), combined with the CO₂ emissions from the generated electricity used (indirect) in the transportation sector, declined from 1,863 Mt CO₂/yr in 2005.

The spreadsheet (Fig1.2 and Fig3.3) has 1,863.3 Mt CO₂/yr in 2005 and 1757.4 Mt CO₂/yr in 2021.

Another publication by EPA that is also based on national inventory has 1765.4 Mt CO₂ for transportation in 2021. <https://www.epa.gov/system/files/documents/2023-06/420f23016.pdf>

Similar to my comment above, I think the discrepancy comes from either the number is based on the total emissions from the inventory or the sum of direct and indirect emissions.

Projections of IRA and No IRA emissions

- Page 59 on transportation CO₂ emissions says “Across the various models, the No IRA scenario had emissions declining from between 26.2 and 38.4 percent in 2035 relative to 2005, with a median decline of 31 percent. Investments and policies set forth in the IRA results in further reduced emissions, with a range of 28.3 to 40.2 percent in 2035 relative to 2005, and a median decline of 34.5 percent.”
- Page 79 of the Conclusion says “CO₂ emissions from both the combustion of fossil fuels (direct), combined with the CO₂ emissions from the generated electricity used (indirect) in the transportation sector, declined from 1,863 Mt CO₂/yr in 2005 to a median of 1,441 Mt CO₂/yr in 2035 in the No IRA scenario, a reduction of 23% (match with the spreadsheet). The IRA scenario shows a larger reduction of 27% to a median of 1,366 Mt CO₂/yr in 2035 (match with the spreadsheet).”
- Page 10-11 of the Executive Summary says “the IRA also drives emission reductions in the transportation (2030: 11-25%, 2035: 15-35% reductions from 2005)”

IRA vs No IRA

- Page 11 of the Executive Summary says, “Median emission reductions in transportation are only 25 Mt CO₂/yr in 2030 yet rise to 90 Mt CO₂/yr”.

Calculations based on numbers in the Conclusion section and the spreadsheet (they two match each other), it would be 55 Mt CO₂/yr in 2030, and 75 Mt CO₂/yr in 2035.

It would be helpful to provide figures or tables showing the share of fuels (e.g., diesel, gasoline, electricity, hydrogen, biofuel, ...) in transportation in 2021, and future projections under IRA and No IRA scenarios. This would be useful to understand how IRA is changing the fuel consumption in transportation, where the emission reductions come from, and where additional supports might be needed.

3. Does the executive summary provide sufficient context to understand the synthesized results?

Yes. The executive summary is simple and concise yet summarized the modeling approach and key results.

4. Does the introductory chapter clearly explain the purpose of the report and provide appropriate context for the sector chapter results?

Yes. The purpose of the report is clear and the context for the sectors is enough.

5. Does the introductory chapter adequately explain the overall analytic framework of the project?

The descriptions of the models being used are not consistent across different sections of the report and can be confusing. Particularly, I think 1.2.1 and 1.2.2 sections could be better organized and be more consistent with the other sections of the paper. For example, page 8 of the Executive Summary says, “The combined data includes results from nine multi-sector models, four power sector models, and one building sector model.” Then in section 1.2.1 and 1.2.2, the models are categorized into 4 EPA-supported and 10 external models. However, it is a bit hard to understand which are considered as the multi-sector models, and which are power sector models, especially under the external studies list. It was until table 1.1 on page 24 that things are getting clearer, particularly by having the * marker to indicate the power sector models. Also, texts under section 1.2.3 on page 23 and table 1.1. have 3 EPA-supported or internal models, which based on a closer look excludes the building sector model. Then, in 1.3.2, there are 6 multi-sector model used for economy-wide CO2 emissions estimate, rather than 9 multi-sector models in executive summary. I think there are three features of each model: (1) multi-sector, or power sector, or building sector; (2) EPA-supported or external; (3) CO2 emissions estimate as economy-wide or sector specific (and which specific sector). I think it is necessary to have clearer presentation of the models in section 1.2 and clarify these features of each model (maybe with a table) and have consistent descriptions throughout the whole report. Otherwise, it is very hard to digest the number of models and how each is used for what.

The report uses the language of EPA-supported models at multiple places. What does it really mean? Does EPA provide financial or technical support to those models? Or it’s just that EPA used these models to run the analyses for this study? Related, the third bullet at the beginning of page 20 has NREL’s ReEDS as one of EPA-supported models, which then appears as an external study on page 21. This again shows better to describe and introduce the models in a clearer, more organized and consistent way to avoid confusions.

6. Are the inputs and scenarios clearly explained and documented in the introduction? If not, please provide recommendations for improvement.

The report claims that there are existing federal and state policies taken into consideration in the models. However, it is not clear what kinds of policies are considered – are these sectoral specific policies, or all kinds of policies for the purpose of decarbonizing, or not, in the entire economy? It would be helpful to provide some details.

Top of page 22 says “Note that the IRA scenario for NEMS-OP, ReEDS, and USREP-ReEDS includes IRA plus the Bipartisan Infrastructure Law and the No IRA scenario excludes both IRA and BIL.” Does this mean other models do not consider BIL for the IRA scenario? If not, it would cause inconsistent modeling scope and results might not be comparable. I think it is necessary to provide some reasonings of why this inconsistency is ok and discuss the impacts of including and excluding BIL.

IRA implementation section on page 22 uses the word “internal modeling”. Are these the models that are phrased as EPA-supported models in above sections? It would be better to use consistent wordings throughout the report. The same section explains the optimistic and pessimistic scenarios as favorable or less favorable to emission reductions. However, is it not clear what that means and what underlying assumptions are being changed to reflect the scenarios of IRA implementation. Particularly, how this factor is quantified as a model input is unclear. It would be helpful to provide more explanations and some numeric examples.

Technology Cost section on page 22, it says using advanced or conservative ATB costs, but does not specify if the moderate costs are used for a central case. Also, in ATB, there are different resource classes for the same technology; for example, there are 10 resource classes of utility-scale PV, and the cost results could vary a lot across these different classes. It needs clarification on such assumptions. It would also be helpful to clarify the technology cost is for renewables only, not including power generated by fossil fuels. The last sentence of this paragraph says “USREP-ReEDS uses same electricity assumptions as ReEDS and also lowers the costs of transportation, energy efficiency, and CCS”. The word “transportation” here is not clear. Does it mean the transportation of electricity or fuels, or the transportation sector?

Technology Constraints section on page 22 says “Finally, it doubles the cost of CO₂ pipeline, injection, and storage infrastructure”. Why doubling specifically? Maybe the cited study provides a reasoning, but it would be helpful to provide a brief explanation of this specific number here for readers not reading the cited study.

Energy prices and economic growth scenario considers the high and low energy prices for sensitivity. However, it is not clear what kinds of energy prices are adjusted. Is this for retail energy prices that consumers pay for? What types of energy is included, electricity? Natural gas? Oil product? I don’t think this would also include the cost of renewables, which should be represented by the technology cost, but it’s not clear. Further clarifications are needed.

There is no description on how these different models are calibrated to have the same emissions estimate in 2021 that matches with the 2021 emissions from the national inventory.

The Bistline study provides separate results for power sector emissions and does not attribute that as indirect emissions for building, industry, and transportation. This report does not explain how that attribution was conducted to shown as the results in the report. This attribution is crucial and would affect the sectoral results a lot. It is necessary to provide explanations on the attribution methodology. For instance, if the emission is attributed based on the electricity demand share by each sector, a table or figure of the projected share could be provided.

7. Is the cited literature accurately represented?

The second bullet under multi-sector models in external studies on page 21 says “**Global Change Analysis Model (GCAM-CGS) from Center for Global Sustainability (CGS): [GCAM-USA-CGS](#)** is based on GCAM 5.3”. I think this might cause wrong interpretation. GCAM-USA is embedded within the GCAM model. Both are developed by JGCRI of PNNL, but it reads to me that CGS developed the GCAM-USA model. On page 20, GCAM-PNNL is already listed under the section of models supported by EPA. Similarly, I am guessing the IPM-EPA model and the IPM-NRDC model is essentially the same model, since the hyperlink provided when describing IPM-NRDC directs to a document by EPA. It is not clear to me what are the differences between them so that they would be considered as two different models. I would suggest making it clear to readers who the model developer is for each model and the reason for treating some of them (e.g., GCAM vs GCAM-USA, or IPM vs IPM-NRDC) as different models even though their cores are probably the

same. This site <https://jgcri.github.io/gcam-doc/gcam-usa.html>  provides documentation on GCAM-USA and the differences it has from GCAM. Here I am just providing two examples. It might be necessary to go through the whole lists.

I also found it surprising that the results of the similar models, e.g., GCAM vs GCAM-USA, or IPM-EPA vs IPM-NRDC are very much different, based on the figures in Appendix F. Particularly, the trend of electricity CO2 emissions from IPM-EPA is very different from IPM-NRDC. I would wonder what the reasons for these differences would be, and whether the results are accurately presented.

Some model results of this report are from the Bistline study. By checking the spreadsheets of the Bistline study (<https://zenodo.org/record/7879732> ) and the spreadsheet of this report, I found that results from certain models match with each other while results from certain models do not. For example, the economy-wide CO2 emissions with and without IRA in 2025, 2030, and 2035 of MARKAL-NETL in the spreadsheet of this report are exactly the same as in the spreadsheet of Bistline. However, the economy-wide CO2 emissions with and without IRA in 2025, 2030, and 2035 of EPS-EI in the two spreadsheets are different. It is not clear why some are the same and some are different, and what adjustments were made for the different results of the same model. In addition and related to the calibration comment in the box above, the starting points, i.e., the emissions in 2021, from Bistline, are different from the starting points in this study. For example, the 2021 economy-wide CO2 emissions from Bistline is 5000 Mt, compared to 5032 Mt in this report. It looks like this difference probably is not calibrated, given that future projections from certain models (e.g., MARKAL-NETL) are the same between the two reports. This might cause wrong interpretation of the model results.

8. Are there any additional relevant data sources that are not included but could be incorporated into this analysis?

This ICCT study evaluates the impact of IRA on EV and zero-emission vehicle uptake in light-duty and heavy-duty sectors in the US: <https://theicct.org/wp-content/uploads/2023/01/ira-impact-evs-us-jan23-2.pdf> . ICCT's projected EV sales share is in the same range as the projections in IRA emissions analysis. This ICCT study could also provide some data and discussion on the heavy-duty sector, which is currently lacking in the IRA emissions report.

9. The analysis presented in this report is multi-faceted, using results from several sophisticated multi-sector and single-sector energy-economy models. Is the use of a multi-model approach, incorporating multi-sector and power sector models, appropriate to estimate the potential effects of the energy- and climate-related provisions of the IRA? If not, please suggest other approaches.

Yes. These integrated models can capture the interconnections across different sectors and considers the policy and economics of the broad society.

10. Does the report provide an assessment of reductions in greenhouse gas emissions that result from changes in domestic electricity generation and use due to the Inflation Reduction Act of 2022 that are anticipated to occur on an annual basis through fiscal year 2031?

No for two reasons.

(1) It only assessed CO2 emissions, but not other GHG emissions.

(2) I don't think the modeling approach and results reflect the emission reductions that are only caused by changes in electricity generation. This is because the models include IRA provisions for

other sectors, not just power generation. All these other IRA provisions, for example the transportation clean fuel tax credits or the building energy efficiency tax credit, would lead to GHG reductions too. I think the scope of this report is more appropriate for the reduction in CO₂ emissions that result from the IRA, but not result from changes in domestic electricity generation. As a matter of fact, the framing of the Conclusion section is on the impact of IRA and has no description on electricity-caused reductions. To answer this question, it might work by focusing on the indirect emissions for the end-use building, industry, and transportation sectors, since this indirect emission is from the use of electricity and could reflect the impacts from changes in electricity generation. But on the other hand, the indirect emission could be resulted from other factors, not just the changes in domestic electricity generation. For example, higher or lower electricity consumption by sector due to certain IRA provisions.

11. Is the draft report missing important findings or messages based on your review?

For IRA impact on transportation, it is true that IRA enables emissions reductions through 2035 and the absolute reduction of IRA vs No IRA in 2035 is larger, as the report indicated. This conclusion delivers the message that IRA is effective in transportation decarbonization and the impact in 2035 is greater than in 2030. However, using the data from the spreadsheet, the percentage change of emissions reduction from IRA compared to No IRA is only 2.6% in 2030 and 1.4% in 2050 (based on the median values). This shows that IRA has minimal impact on transportation decarbonization and the impact in 2035 is even smaller. I think this result somewhat contradicts the key message from the report and I would suggest showing this percentage difference in the report as well for full disclosure. In addition, it would add a lot value to the report by providing further discussions why transportation sector has significantly lower emissions reduction (IRA compared to no IRA) compared to building and industrial sectors.

Figure 1.3 shows the impact of IRA on the consumption of fossil fuels, and the results worth some discussion but is currently lacking in the report. For example, the trend of natural gas between IRA and No IRA scenarios are very different – what might be the reasons for that. For petroleum, IRA has minimal impact on its consumption in 2030, but the gap widened significantly in 2035, whereas the gaps in 2030 and 2035 are similar for coal – what could cause this difference.

The emissions trends among models generally agree with each other. However, whenever there is very different trend in one model from the rest, it might worth discussing the underlying reasons. For example, in Figure ES.1 (and Figure 2.3), there is one model projected higher emissions in power sector under IRA than under No IRA in the next few years, which is very surprising, and readers would wonder why.

12. Do you have any recommendations for any key research that could be discussed but is not mentioned? Do you have recommendations for future updates to the report that EPA should consider?

If the models allow, it would be helpful to provide more detailed emissions reduction results within each sector. In the case of transportation sector, it would be helpful to see the specific reductions in e.g., light-duty, medium-duty, aviation. This helps the readers to understand the impact of IRA better and identify the sectors that might need additional policy support to reach deeper emissions reduction.

I would recommend evaluating other GHGs in addition to CO₂ in future studies, if not this one, not only because this is what the provision 60107 asked for. Given that other GHGs are more potent, and their emissions could be significant in the energy sector, such as methane. Particularly, the spreadsheet from Bistline suggests that the total non-CO₂ emissions could be almost half of the total

CO₂ emissions, which is significant. The inclusion and evaluation of other GHGs could enable a full picture understanding of the climate impacts from IRA. On this note, the report uses “GHG” and “CO₂” interchangeably in many places. For example, the beginning of the third paragraph in Executive Summary says, “The report examines the projected reductions in GHG emissions due to a subset of IRA provisions”, whereas it should be CO₂. Please do go through the whole report and check.

The future grid mix information is the key but currently is not clear presented in the report. It would be helpful to provide a figure or table on the projected grid mix by each model and discuss the results.

It would be helpful to provide some discussions on cross sectoral competition for electricity. As electrification is scaling up in all end-use sectors, it would put a lot of pressure on electricity generation and grid balancing, especially renewables. While the models can project increasing electricity capacity to meet the demand, the reality might be a different case. Especially the scale up of renewables might meet a lot of challenges due to grid balancing and permitting. It is not clear whether these barriers are reflected in the models and if not, it would need some discussions on how modeling results might not reflect the real world. And what might be the solutions if the electricity, especially renewable power, not able to meet the end-sector demands and whether certain sectors need to be prioritized.

4.5 Reviewer 5

1. Are the writing level and graphics appropriate for an educated but general audience including stakeholders and decision-makers?

The writing and graphics seem appropriate for educated but general audiences who may not know a lot about the Inflation Reduction Act (the overviews of IRA provisions are helpful for level setting). One area to consider adding a box or text early on is a high-level introduction to the models used in this report, emphasizing points such as the use of models for insight and not numbers (i.e., models aren't predictive), results are conditional on scenario assumptions, model ensembles are not statistical distributions (i.e., implying that uncertainty might be broader than is indicated in ranges), etc.

2. Do the text, figures, and tables in the sector specific chapters clearly communicate the modeling results? If not, please provide recommendations for improvement. Note that Appendix G contains additional figures and alternative figure styles.

Overall, the text, figures, and tables across the report's chapters do an excellent job of conveying modeling results. There are impressive and clear visualizations throughout. The line charts and panels in Figure ES.2 are especially well done!

The tables and figures in the appendix are useful for understanding differences across models.

For the Executive Summary and other chapters of the report, consider reporting a measure of central tendency for these statistics in addition to the range, given how the extremes may be driven by unrepresentative model results in some instances.

There are several specific areas to consider revising:

- P. 12, Figure ES.2: Add sentence on how power sector emissions are allocated across sectors.
- P. 13, Table ES.1: This table could use a sentence motivating the use of a median instead of a mean. Also, having the median between the min and max seems more intuitive to me.

3. Does the executive summary provide sufficient context to understand the synthesized results?

The Executive Summary provides a good overview of the study's motivations and findings. The authors use appropriate figures and tables to summarize the paper's top-line insights.

A few points to consider revising in the ES:

- P. 8 ("incentives estimated at nearly \$400 billion"): At a minimum, the text should mention that this fiscal cost estimate is over a 10-year budget window and that this is based on the initial estimate of fiscal impacts from CBO/JCT. It should also mention that subsequent analyses (e.g., Credit Suisse, Goldman, Brookings) indicate that impacts may be much larger by 2032 and even larger afterward.
- P. 8 ("...show how the... in a growing economy"): Consider revising this sentence for clarity. It took me a few reads to understand what was meant.
- P. 9 ("will depend on decisions that are not yet final"): This text is vague. Does it refer to Treasury guidance, decisions by firms related to building specific assets or use of bonus credits, or something else?
- P. 9: There are a couple additional caveats to add to the first full paragraph on this page. 1. Many models do not explicitly capture recent inflationary drivers (e.g., materials and labor cost increases, rising interest rates) that may offset some of IRA cost reductions; 2. Models

may not include barriers and bottlenecks to quicker adoption, including scaling up supply chains, infrastructure build-out, deploying first-of-a-kind emerging technologies, siting and permitting, etc.

- P. 10 (“between 35-43%”): It seems like the range does not include the lowest model from the Science study (33%), and the highest is higher than the study (40%). Why? I see this is reported in CO2 terms rather than all GHGs. How does this alter the range?

4. Does the introductory chapter clearly explain the purpose of the report and provide appropriate context for the sector chapter results?

The introductory chapter does a good job of providing context for the rest of the report.

A few specific areas for improvement:

- P.14 (“\$391 billion from 2022 through 2031”): Per my Executive Summary comment, this text should be modified to acknowledge uncertainty in the estimates.
- P. 15: Section 1.1 text could mention up front that more details on specific provisions are found in sector chapters. I see that footnote 15 mentions this, but it should be moved to the main text so that this is clear to readers.
- P. 17: Where is 45Q? Consider mentioning it with the Industry list.
- P. 19, footnote 23: Update with publication information for the Bistline, et al. Science article, since it is no longer forthcoming.
- P. 26: This is a good discussion of modeling caveats for readers to keep in mind!
- P. 26 (“CO2 emissions in 2005”): Not accounting for negative emissions from land, right? This could be indicated in a footnote.
- P. 31: Brown (2001) needs a footnote with citation.
- P. 32: In the risk aversion discussion, potential mention financing.

5. Does the introductory chapter adequately explain the overall analytic framework of the project?

The introduction gives a good overview of the analytic framework for the project. Per my comments elsewhere, this introductory chapter could be strengthened by provided more caveats about the models used in the report and how to interpret results of scenario ensembles.

6. Are the inputs and scenarios clearly explained and documented in the introduction? If not, please provide recommendations for improvement.

Input assumptions and scenario descriptions are generally presented well in the introduction. The additional detail in the appendices is useful for readers who are looking for more information. Two figures that are missing but seem like important enough to merit specific figures are capital cost assumptions of key electric sector technologies and fuel prices over time.

7. Is the cited literature accurately represented?

The cited literature largely seems to be accurately represented. There are several recommendations for refining some of these references in the text, which I provide in other comments.

8. Are there any additional relevant data sources that are not included but could be incorporated into this analysis?

Several additional IRA analyses (beyond those represented in the Bistline, et al. Science paper) are not compared or discussed in the report such as the Goldman Sachs report and Credit Suisse report.

In addition, sector-specific deep dive reports and papers should at least be discussed qualitatively. An example is 45V credits for hydrogen and the literature around these credits (e.g., Ricks, et al., 2023, “Minimizing emissions from grid-based hydrogen production in the United States”).

9. **The analysis presented in this report is multi-faceted, using results from several sophisticated multi-sector and single-sector energy-economy models. Is the use of a multi-model approach, incorporating multi-sector and power sector models, appropriate to estimate the potential effects of the energy- and climate-related provisions of the IRA? If not, please suggest other approaches.**

Overall, the multi-model approach used in the report seems appropriate given the research questions. This approach is a good way to disentangle structural uncertainty and parametric uncertainty. These comparisons can illustrate which findings are robust and which are more uncertain.

It would be ideal to complement this discussion with more harmonized scenarios and single-model sensitivities to investigate how parametric uncertainties could influence these findings. But given how these comparisons are resource-intensive and may not show an appreciable difference, the current methods seem appropriate.

10. **Does the report provide an assessment of reductions in greenhouse gas emissions that result from changes in domestic electricity generation and use due to the Inflation Reduction Act of 2022 that are anticipated to occur on an annual basis through fiscal year 2031?**

The report does a good job in assessing CO₂ emissions reductions associated with electricity generation and use resulting from IRA. The comparisons extend beyond 2031, which seems important given how expectations for the policy, market, and technology state-of-the-world after 2031 can influence earlier emissions and energy system outcomes.

11. **Is the draft report missing important findings or messages based on your review?**

It would be helpful to provide regional detail to illustrate differences in response to IRA incentives.

12. **Do you have any recommendations for any key research that could be discussed but is not mentioned? Do you have recommendations for future updates to the report that EPA should consider?**

- Regional deep dives
- More information on impacts of individual provisions and uncertainties about implementation (e.g., 45V)

13. **I have several additional comments that do not directly fall under the previous questions:**

- P. 36 (box on “Electric Demand”): Consider mentioning that not only impacts on annual demand that matter but also load shapes and peak load.
- P. 40: Per my earlier comments, it would be useful to have comparisons with the mean/median as well in addition to the ranges. The median is shown on figures, so it would be useful to have these values reflected in the text as well.
- P. 45, Figure 2.6: It would be clearer to have the median in between the min and max.
- P. 52, Figure 3.1: The “Other Sectors” bar is gray in the earlier figure.
- P. 60 (“In the reference scenario”): Use “No IRA scenario” instead for consistency?

- P. 60 (“at range increases from 31.7 to 52.4 percent in 2030”): Why does the text switch from two significant digits to three in this sentence?
- P. 63 (“reduces GHG emissions within the transportation sector”): Use CO₂ instead?
- P. 63 (“modeling results show that the effects are not as large as they are in the Buildings and Industrial sectors”): Comparative sectoral differences reflect the inclusion of electric sector emissions in values, and the transport share of electricity is relatively low, so it doesn’t benefit as much when power sector emissions decline by 2035. This text should also mention how emissions lag new sales shares.
- P. 63 (“6.4 percent”): Percent or percentage points?
- P. 65 (“Significantly more efficient electric heat pump water heaters could”): Potentially mention the possibility of dual-fuel systems, which may help to ameliorate electricity peaks from space heating electrification.
- P. 69, Figure 4.2: Should clarify in caption that total means direct and indirect from electricity. It seems like most of reductions come from decarbonization of electricity since building have high electrification share. The authors should mention and consider a figure showing the impact of direct reductions only to show the relative contributions.
- P. 72 (“industrial processes - the predominant emissions”): Should this be an em dash like the others?
- P. 76 (“IRA range from -22% to -56%”): Earlier values didn’t have negative sign.
- P. 77, Figure 5.2: What accounts for the 2022 increase in CO₂ with IRA?
- P. 77: Consider mentioning how many models do not explicitly include 45X incentives for manufacturing and potentially impacts on electricity demand from bringing manufacturing to US.
- P. 77 (“(less than 4 percentage points)”): As share of final energy? That seems significant to me. Relative to No IRA? In what year?
- All footnote URLs should have hyperlinks (several do not in the current draft, including footnote 109).

4.6 Reviewer 6

1. Are the writing level and graphics appropriate for an educated but general audience including stakeholders and decision-makers?

For the most part, yes. However, a more detailed primer on the types of models utilized in the analysis, and in particular their known limitations, would make it more accessible for a general audience. In addition, the inclusion of so many of the “external” models in the majority of figures in the Introduction often obscures the results and makes them harder to interpret for a general audience. For example, in the Conclusions, it is stated that “The results of the analyses of the IRA Moderate scenarios are robust across models.” This is certainly not clear from, for example, Fig. 1.2.

2. Do the text, figures, and tables in the sector specific chapters clearly communicate the modeling results? If not, please provide recommendations for improvement. Note that Appendix G contains additional figures and alternative figure styles.

Section 4 is perhaps the clearest section because it only includes the results from a single model. Reducing the number of Text boxes (and/or making them more concise) in the sector specific sections would make the report more accessible. For example, the text boxes “Environmental Justice” and “Managing SF6 in an Electrifying Economy” seem out of place in Section 2 and could be significantly reduced in length with minimal impact to the messaging. However, I do believe that the text boxes can be very valuable, if used properly. The Text Box on Hydrogen feels like the more appropriate level of detail and length for these critical topics.

The distinction between different models using left and right of a guideline (such as Figure 1.4) “Combined Technology + Implementation” is too subtle and often prompts more questions than it answers, such as why there are three scenarios for USREP-ReEDS versus two for OP-NEMS in this particular figure.

There are some unnecessary figures, for example Figures 3.1, 4.1, and 5.1 don’t really convey any new information that hasn’t already been provide with simple percentages.

3. Does the executive summary provide sufficient context to understand the synthesized results?

Yes, though the messaging around the multi-sector emission reductions is hindered by using the median, particularly for the transportation and industry sectors, where there is quite a bit of overlap between the IRA and NO IRA cases (See Fig. ES.2). It would also be more helpful to base the Executive Summary primarily around the “internal” models, with only a brief comparison to how these compare to “external” models.

4. Does the introductory chapter clearly explain the purpose of the report and provide appropriate context for the sector chapter results?

Yes, the introductory chapter provides appropriate context, though I would recommend making the textboxes more concise and lay audiences will likely not understand the modeling limitations that cause results to be shown in 2030 and 2035, as opposed to 2031. I would also recommend a textbox similar to the “Overcoming Deployment Challenges” one explaining the limitations of the modeling paradigms used in the study.

5. Does the introductory chapter adequately explain the overall analytic framework of the project?

This is an area where I believe readers not familiar with the energy modeling community will struggle with the report. The inclusion of so many “external” model results in many of the figures (e.g., Fig. 2.6) will likely distract from the main messaging, especially because some of these models produce counter-intuitive or conflicting results. This is likely to confuse the overall message.

I would also recommend a textbox similar to the “Overcoming Deployment Challenges” one explaining the limitations of the modeling paradigms used in the study. This subsection could then reference Appendix B for more details.

6. Are the inputs and scenarios clearly explained and documented in the introduction? If not, please provide recommendations for improvement.

The specific IRA versus non-IRA cases are clear. However, the use of so many “external” models makes it very difficult to keep clear which provisions of the IRA are actually being considered in each of the results that follow. I would recommend focusing on the results of the “internal” models in most sections and have a separate section for a comparison with the “external” models near the end to put the findings in the context of the literature. The current framing obscures the actual contributions of the current work and hinders an understanding of the results of the “internal” models.

7. Is the cited literature accurately represented?

I did not notice any particular instances of cited literature being inaccurately represented, though the report does seem to under-cite the relevant literature in general.

8. Are there any additional relevant data sources that are not included but could be incorporated into this analysis?

On the contrary, I believe that the report would be better served by not performing as many comparisons to other data sources. It makes the authors seem reluctant make any conclusions based on the “internal” models.

9. The analysis presented in this report is multi-faceted, using results from several sophisticated multi-sector and single-sector energy-economy models. Is the use of a multi-model approach, incorporating multi-sector and power sector models, appropriate to estimate the potential effects of the energy- and climate-related provisions of the IRA? If not, please suggest other approaches.

Yes, the multi-model approach is appropriate in this context. However, the messaging around which models are supported by the EPA for this report, versus which are only from external studies should be clarified before page 20 of the report. While it is great to include the external models, it does confuse the messaging significantly as currently presented. My recommendation would be to include only the internal models in the main body of the report (see for example Table 1.1), while including the external models in an appendix or another “comparison” section, for the sake of clarity and providing context.

10. Does the report provide an assessment of reductions in greenhouse gas emissions that result from changes in domestic electricity generation and use due to the Inflation Reduction Act of 2022 that are anticipated to occur on an annual basis through fiscal year 2031?

Yes, though the choice of comparison year as 2005 means that all of the percentage reductions are a bit misleading, particularly in the Executive Summary. I understand the reason for using 2005, but comparisons to 2021 would be more informative for the main topic of the work (IRA reductions), particularly in the case of min values (see Table ES.1)

11. Is the draft report missing important findings or messages based on your review?

One downside of the messaging approach of concentrating on the median values in a multi-model comparison is that very interesting individual scenarios are underexplained. For example, there are a number of model runs that indicate steady or increasing emissions in the NO IRA cases after 2025 (see Fig. ES.1). This is not the focus of the analysis but influences the percentage reductions from the IRA and could certainly use more context on what these particular runs have in common. However, there are some figures where this is handled well in the figure caption, such as in Figure 1.3 regarding the MARKA-NETL increase in coal consumption.

In the Textbox “Promising Technological Innovation”, I think that it is important to note that not only is long-duration energy storage developing rapidly, but also that it is extremely poorly represented by the type of models used in this analysis because of their non-sequential representations.

In the textbox “Promising Technological Innovation” there should be some mention of the limitations of representing distributed generation in the types of models used for this study.

12. Do you have any recommendations for any key research that could be discussed but is not mentioned? Do you have recommendations for future updates to the report that EPA should consider?

While there is some information in the textbox “Overcoming Deployment Challenges”, it would be useful to have a more mechanistic explanation of why the models consistently do not choose some of the “emerging technologies” that have specific IRA components, such as CCS and nuclear. This in particular, is where sensitivities could be included that would provide much more value. For example, “if SMR/CCS capital costs decrease to \$xx/kW, they are deployed at a yy% faster rate.”

U.S. Environmental Protection Agency
PEER REVIEW SUMMARY REPORT

5. Example Conflict of Interest Form

Below is the sample version of the conflict of interest form that reviewers were asked to sign.

U.S. Environmental Protection Agency
Conflict of Interest Inquiry

You have been requested by EPA to serve as a Peer Reviewer for Emissions Impacts of the Inflation Reduction Act: Assessment of Projected GHG Emissions Reductions from Changes in Electricity Generation and Use and your involvement in certain activities could pose a conflict of interest or create the appearance of a loss of impartiality in your review. Although your involvement in these activities is not necessarily grounds for exclusion from the peer review, affiliations or activities that could potentially lead to conflicts of interest are included in the table.

Conflict of Interest Analysis		
Question	YES	NO
a. To the best of your knowledge and belief, is there any connection between the subject topic and any of your and/or your spouse's compensated or uncompensated employment, including government service, during the past 24 months?		
b. To the best of your knowledge and belief, is there any connection between the subject topic and any of your and/or your spouse's research support and project funding, including from any government source, during the past 24 months?		
c. To the best of your knowledge and belief, is there any connection between the subject topic and any consulting by you and/or your spouse, during the past 24 months?		
d. To the best of your knowledge and belief, is there any connection between the subject topic and any expert witness activity by you and/or your spouse, during the past 24 months?		
e. To the best of your knowledge and belief, have you, your spouse, or dependent child, held in the past 24 months, any financial holdings (excluding well-diversified mutual funds and holdings, with a value less than \$15,000) with any connection to the subject topic?		
f. Have you made any public statements or taken positions on or closely related to the subject topic under review?		
g. Have you had previous involvement with the development of the document (or review materials) you have been asked to review?		
h. To the best of your knowledge and belief, is there any other information that might reasonably raise a question about an actual or potential personal conflict of interest or bias?		
i. To the best of your knowledge and belief, is there any financial benefit that might be gained by you or your spouse as a result of the outcome of this review?		

Please complete the table and sign the certification below. If you have any questions, contact the Peer Review Lead, Kirsten Franzen, at kfranzen@rti.org, at your earliest convenience to discuss any potential conflict of interest issues.

**U.S. Environmental Protection Agency
PEER REVIEW SUMMARY REPORT**

CERTIFICATION

I hereby certify that I have read the above statements and, to the best of my knowledge and belief, no conflict of interest exists that may diminish my capacity to provide an impartial, technically sound, objective review of the subject matter or otherwise result in a biased opinion.

(Name please print)

(Signature)

(Date)

Information Relating to Conflict of Interest (COI)

Peer reviewers are expected to provide an impartial, technically sound, objective, independent, and unbiased technical review of the study entitled:

Emissions Impacts of the Inflation Reduction Act: Assessment of Projected GHG Emissions Reductions from Changes in Electricity Generation and Use

We request the information in this COI Inquiry from interested peer reviewer candidates for the purpose of ruling out COI and other concerns as we work to create an independent and balanced selection of peer reviewers. An interested peer reviewer candidate's involvement in certain activities could pose a COI or create the appearance of a loss of impartiality in the peer review. Although involvement in such activities is not necessarily grounds for exclusion from the peer review, peer reviewer candidates need to disclose affiliations, interests, activities, or relationships that could lead to perceived COIs.

Before you can be selected and agree to serve as a peer reviewer, you will need to disclose any Actual or Potential COI (as explained below) on this form. The financial and professional information obtained from the interested peer reviewer candidate as part of the evaluation to determine the existence of an Actual or Potential COI is considered private and non-disclosable to outside entities except as required by law and/or regulation.

The following definitions provide general descriptions of Actual or Potential COI:

- **Actual COI:** An Actual COI would be any financial interest held by an individual (or certain related persons) that could be affected by their participation in the peer review.
- **Potential COI:** A Potential COI could be any circumstance related to an individual (or certain related persons) that may cause "a reasonable person with knowledge of the relevant facts" to question the individual's impartiality in participating in the peer review (i.e., "an appearance of loss of impartiality").

To preserve the independence and ethics of the peer review process, individuals with Actual or Potential COIs may not be allowed to participate in the peer review. Please consider carefully whether you might have an Actual or Potential COI or if any other interests, activities, or relationships would cause your impartiality as a peer reviewer to be questioned.

If you have any questions, contact the RTI Peer Review Lead, Kirsten Franzen (kfranzen@rti.org) at your earliest convenience to discuss any perceived COI issues.

For more information about peer reviews, see the EPA Peer Review Handbook, 4th Edition, October 2015.