Overselling BIL and IRA

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This Article argues that the Bipartisan Infrastructure Law (BIL) and Inflation Reduction Act (IRA) were less likely to reduce U.S. greenhouse gas emissions than believed when enacted, and that a misconceived narrative of spending effectiveness undercut the perceived urgency of further legislative action on climate change in the United States. With the passage of BIL and IRA, the United States committed to a climate law strategy predominated by public spending instead of regulatory mandates. Prominent studies of the laws' impacts, including studies produced by the U.S. federal government, predicted that this spending would push U.S. annual greenhouse gas emissions down to as much as 45 percent below 2005 levels by 2030, which would have been extraordinary progress if true. But these predictions were based on modeling that has a very poor predictive track record and assumes away many of the real-world constraints that BIL and IRA's spending programs faced. This Article undertakes an in-depth examination of one such model, explores how modeling influenced discourse around BIL and IRA, demonstrates that this discourse failed to acknowledge known barriers to BIL and IRA's effectiveness, and posits that the resulting narrative of effectiveness impacted the outlook of further climate legislation in the United States. This Article proposes that greater care be taken in the communication of energy-economic modeling results, that BIL and IRA should be evaluated as elements of a larger climate policy portfolio encompassing both constraining and spending policies, and that BIL and IRA did not obviate the need to continue pushing for further national climate legislation in the United States.

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INTRODUCTION

In 2021 and 2022, Congress enacted the Bipartisan Infrastructure Law (BIL)[1] and Inflation Reduction Act (IRA),[2] which, together, directed hundreds of billions of dollars toward reducing the United States' enormous annual contributions to climate change.[3] President Biden called IRA "one of the most significant laws … that has ever been enacted."[4] Others were similarly

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1. Infrastructure Investment and Jobs Act of 2021, Pub. L. No. 117–58, 135 Stat. 429 (2021).

2. Inflation Reduction Act of 2022, Pub. L. No. 117–169, 136 Stat. 1818 (2022).

3. The United States is currently the second largest annual emitter of greenhouse gases, behind China. *See* Hannah Ritchie et al., *Greenhouse Gas Emissions*, OUR WORLD IN DATA, https://ourworldindata.org/greenhouse-gas-emissions (last updated Jan. 2024) (showing most recent national emissions data). However, the U.S. is the largest historic emitter of CO_2. *See* Hannah Ritchie, *Who Has Contributed Most to Global CO2 Emissions?*, OUR WORLD IN DATA (Oct. 1, 2019), https://ourworldindata.org/contributed-most-global-co2; *see generally* Matthew W. Jones et al., *National Contributions to Climate Change Due to Historical Emissions of Carbon Dioxide, Methane, and Nitrous Oxide since 1850*, 10 SCI. DATA 155 (2023).

4. Robert Schroeder, *Biden Calls IRA "One of the Most Significant Laws" Ever as He Promotes Climate Investment*s, MARKETWATCH (Aug. 16, 2023), https://www.marketwatch.com/story/biden-calls-ira-one-of-the-most-significant-laws-ever-as-he-promotes-climate-investments-97311455; *see also* Zack Budryk, *Biden Takes Victory Lap on Climate Bill in State of the Union*, THE HILL (Feb. 7, 2023), https://thehill.com/policy/energy-environment/3848488-biden-takes-victory-lap-on-climate-bill-in-state-

celebratory.[5] Consistent with this outlook, U.S. federal agencies began publishing studies concluding that the spending authorized by BIL and IRA would reduce the nation's greenhouse gas emissions by billions of tons per year by 2030.[6] The United States made similar claims in filings to the United Nations.[7] The prevailing public narrative of BIL and IRA in the years after its enactment was one of unprecedented success.[8]

Regrettably, there were deep flaws in the prevailing narrative. True, BIL and IRA represented historic, if uncertain, investments toward decarbonizing U.S. society.[9] True, the spending that the laws authorized resulted in real

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of-the-union; Peter Baker, *For Biden, Celebrating What a Law Did rather than What It Did Not Do*, N.Y. TIMES (Aug. 16, 2023), https://www.nytimes.com/2023/08/16/us/politics/biden-inflation-reduction-act.html.

5. *See, e.g.*, Silvio Marcacci et al., *The Inflation Reduction Act Is the Most Important Climate Action in U.S. History*, FORBES (Aug. 2, 2022), https://www.forbes.com/sites/energyinnovation/2022/08/02/the-inflation-reduction-act-is-the-most-important-climate-action-in-us-history; *A "New Day for Climate Action in the United States" as U.S. Congress Passes Historic Clean Energy and Climate Investments*, THE NATURE CONSERVANCY: NEWSROOM (Aug. 10, 2022), https://www.nature.org/en-us/newsroom/us-house-passes-landmark-climate-bill; Sam Meredith, *IEA Chief Lauds U.S. Inflation Reduction Act as Most Important Climate Agreement since Paris Accord*, CNBC (Jan. 17, 2023), https://www.cnbc.com/2023/01/17/iea-chief-says-ira-most-important-climate-agreement-since-paris-accord.html (noting International Energy Agency Executive Director Fatih Birol lauded IRA "as the most important climate agreement since the landmark Paris Agreement"); Al Gore, *What the Fossil Fuel Industry Doesn't Want You To Know*, TED COUNTDOWN SUMMIT (July 2023), https://www.ted.com/talks/al_gore_what_the_fossil_fuel_industry_doesn_t_want_you_to_know ("[T]hey have passed the best, biggest climate legislation in all of history … ").

6. *See, e.g.*, U.S. DEP'T OF ENERGY, OFF. OF POL'Y, INVESTING IN AMERICAN ENERGY: SIGNIFICANT IMPACTS OF THE INFLATION REDUCTION ACT AND BIPARTISAN INFRASTRUCTURE LAW ON THE U.S. ENERGY ECONOMY AND EMISSIONS REDUCTIONS 5–6 (Aug. 2023), https://www.energy.gov/sites/default/files/2023-08/DOE%20OP%20Economy%20Wide%20Report_0.pdf [hereinafter DOE REPORT] (showing up to a 41 percent decline in net greenhouse gas emissions from 2005 levels by 2030); EPA, ELECTRICITY SECTOR EMISSIONS IMPACTS OF THE INFLATION REDUCTION ACT: ASSESSMENT OF PROJECTED CO_2 EMISSION REDUCTIONS FROM CHANGES IN ELECTRICITY GENERATION AND USE 9 (2023), https://www.epa.gov/system/files/documents/2023-09/Electricity_Emissions_Impacts_Inflation_Reduction_Act_Report_EPA-FINAL.pdf [hereinafter EPA ASSESSMENT] ("The IRA spurs substantial emission reductions from the electric sector of 49 to 83% from 2005 levels in 2030."). For comparison, U.S. greenhouse gas emissions in 2021 were 15 percent below 2005 levels. *See Greenhouse Gas Inventory Data Explorer*, EPA, https://cfpub.epa.gov/ghgdata/inventoryexplorer/#allsectors/allsectors/allgas/econsect/all (last updated Aug. 18, 2023). The Biden administration's 2021 emissions reduction target was 50–52 percent below 2005 levels by 2030. *Fact Sheet: President Biden Sets 2030 Greenhouse Gas Pollution Reduction Target Aimed at Creating Good-Paying Union Jobs and Securing U.S. Leadership on Clean Energy Technologies*, WHITE HOUSE (Apr. 22, 2021), https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies.

7. Voluntary Supplement to the U.S. Fifth Biennial Report 2023 at 17, https://unfccc.int/documents/635393.

8. *See*, *e.g.*, Adam Aston et al., *On the Climate Bill's Second Birthday, Surging Successes—But a Split Reality*, ROCKY MOUNTAIN INST. (Aug. 16, 2024), https://rmi.org/on-the-climate-bills-second-birthday-surging-successes-but-a-split-reality (focusing on investment and jobs
, though vague on the impact of grid decarbonization).

9. Even assuming the laws are not amended or repealed in the future, the exact amount of the investment is, in fact, unknown, because most of the spending will occur in the form of open-ended tax credits rather than set appropriations. The most commonly repeated claim was that IRA would invest $369

progress toward decarbonization of the U.S. economy. But, equally true, the laws' impacts were blunted by a range of predictable barriers and constraints that BIL and IRA's drafters did nothing to address, and that studies of the laws' impacts mostly ignored. Claims to the contrary were supported almost exclusively by a type of energy system model that assumes away most of the barriers that BIL and IRA's spending programs faced. When the models' outputs are translated into real-world outcomes and real-world constraints are accounted for, the limits of what BIL and IRA could accomplish become clear.

Equally regrettably, the flawed narrative of BIL and IRA's effectiveness may have made it less likely that the United States could enact further, necessary climate legislation. Although this is difficult to prove with certainty, theory suggests that BIL and IRA's passage drained away support for alternative or

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billion toward climate change solutions between 2022 and 2031, but that number was not necessarily accurate. It was, rather, attributable to a summary of the law published by Senate Democrats in August 2022, estimating $369 billion for "energy security and climate change" provisions. *See Summary: The Inflation Reduction Act of* 2022, SENATE DEMOCRATS (Aug. 2022), https://www.democrats.senate.gov/imo/media/doc/inflation_reduction_act_one_page_summary.pdf. It evidently came from the initial Congressional Budget Office (CBO) budget impact analysis, although exactly which provisions were included to arrive at the $369 billion "energy security and climate change" tally is not immediately clear. *See Estimated Budgetary Effects of H.R. 5376, the Inflation Reduction Act of 2022*, CONG. BUDGET OFF.: COST ESTIMATE, https://www.cbo.gov/system-/files/2022-08/hr5376_IR_Act_8-3-22.pdf (last updated Aug. 5, 2022) [hereinafter CBO, *Aug. 2022 Estimated Effects of IRA*]. In any event, the CBO later updated its analysis based on the final version of the law, again without summarizing total climate spending. *Estimated Budgetary Effects of Public Law 117-169, the Inflation Reduction Act of 2022*, CONG. BUDGET OFF.: COST ESTIMATE (Sept. 7, 2022), https://www.cbo.gov/system/files/2022-09/PL117-169_9-7-22.pdf. It was also widely reported that the final version of the bill included $391 billion in climate spending, evidently based on a tally conducted by the Committee for a Responsible Federal Budget. *See CBO Scores IRA with $238 Billion of Deficit Reduction*, COMM. FOR RESPONSIBLE FED. BUDGET (Sept. 7, 2022), https://www.crfb.org/blogs/cbo-scores-ira-238-billion-deficit-reduction (tallying energy and climate spending). A clearer review was published by the Rocky Mountain Institute, setting the final tally at $362 billion based on authorizations and appropriations in the bills but this study's tax expenditure estimates were not explained. Lachlan Carey & Jun Ukita Shepard, *Congress's Climate Triple Whammy: Innovation, Investment, and Industrial Policy*, ROCKY MOUNTAIN INST. (Aug. 22, 2022), https://rmi.org/climate-innovation-investment-and-industrial-policy. The issue of tax credits is of paramount importance, as outside analysts have provided much larger estimates, including a widely reported Goldman Sachs estimate that the total tax expenditure spending under the laws could top $1.2 trillion over ten years. *Editorial: The Real Cost of the Inflation Reduction Act Subsidies: $1.2 Trillion*, WALL ST. J. (Mar. 24, 2023), https://www.wsj.com/articles/inflation-reduction-act-subsidies-cost-goldman-sachs-report-5623cd29; *see also* Gore, *supra* note 5 (citing same figure). Credit Suisse estimated approximately $800 billion over the same time period. CREDIT SUISSE, TREEPRINT: US INFLATION REDUCTION ACT—A TIPPING POINT IN CLIMATE ACTION 14–16 (2022), https://www.credit-suisse.com/treeprintusinflationreductionact (explaining differences). Finally, in order to fully account for the climate and energy spending of BIL and IRA, it is necessary to incorporate the climate provisions of the Bipartisan Infrastructure Law, which is entirely dependent on what is counted. *See*, *e.g.*, *Senate Amendment 2137 to H.R. 3684, the Infrastructure Investment and Jobs Act, as Proposed on August 1, 2021*, CONG. BUDGET OFF.: COST ESTIMATE, https://www.cbo.gov/system/files/2021-08/hr3684_infrastructure.pdf (last updated Aug. 9, 2021); *Fact Sheet: Climate and Resilience in the Bipartisan Infrastructure Law*, U.S. DEP'T OF TRANSP., https://www.transportation.gov/bipartisan-infrastructure-law/fact-sheet-climate-and-resilience-bipartisan-infrastructure-law (last updated July 5, 2022) (tallying over $100 billion); Coral Davenport & Christopher Flavelle, *Infrastructure Bill Makes First Major U.S. Investment in Climate Resilience*, N.Y. TIMES (Nov. 6, 2021), https://www.nytimes.com/2021/11/06/climate/infrastructure-bill-climate.html (citing $47 billion). The truth is that the total spending amounts will only be ascertainable in retrospect.

additional climate policies during the remaining years of the Biden Administration, and the evidence available today, including particularly the substantial drop in legislative proposals for carbon taxes submitted in the 118th Congress as compared to prior Congresses, tends to support the conclusion that this may have happened.[10] In other words, there are strong reasons to be concerned that BIL and IRA not only were insufficient to achieve the nation's decarbonization goals but also stood in the way of other policies that would have actually done so. Therefore, overselling BIL and IRA was not merely a matter of harmless politicking: it risked locking in another generation of failure for U.S. climate law and policy.

To explain and explore these concerns, this Article proceeds in three parts that correspond to its major themes. Part I summarizes the history of the passage of BIL and IRA and provides context and background relevant to analyzing claims of these laws' climate impacts. The discussion shows that BIL and IRA are spending bills, that their climate impacts are typically analyzed by energy-economic modeling, and that such modeling is known to have a very poor predictive track record. Part II then examines an impact projection of BIL and IRA's provisions produced by the U.S. Department of Energy (DOE), generated using the type of model examined in Part I. The Article's analysis translates the model's numeric climate emissions reduction predictions into real-world technology adoption equivalents, and in so doing demonstrates how the DOE model failed to account for known constraints on BIL and IRA's impact. Finally, Part III discusses the implications of these findings on the prospect of further climate legislation during the remainder of President Biden's term. Theory suggests that if BIL and IRA were believed to be more effective than they really were, then the laws also posed barriers to more effective legislation, and available evidence suggests that this happened.

It is hoped that an accessible exploration of these issues will facilitate more critical engagement with energy-economic predictive models, improve how the results of such modeling are used in future discourse over climate law and policy in the United States, and influence the discussion over what needs to come next for U.S. climate legislation. But to arrive at that point, it is necessary to begin at the beginning, and to examine where BIL and IRA came from and what they did.

I. BACKGROUND

Before exploring how energy-economic modeling was used to oversell BIL and IRA's climate impacts (see Part II), it is helpful to understand how such modeling became so important to both the technical and political assessment of the laws' effectiveness.[11] This Part attempts to explain how BIL and IRA fit into

10. *See* Part III, *infra.*

11. "Effectiveness," for any policy, is its tendency to achieve a desired outcome. *See generally* Azad Singh Bali et al., *Anticipating and Designing for Policy Effectiveness*, 38 POL'Y & SOC'Y 1 (2019) (discussing the concept of effectiveness). The internationally agreed-upon goal for world climate policy is to hold global average surface temperature increases to below 1.5–2.0º Celsius over pre-industrial baselines by 2100. Paris Agreement to the United Nations Framework Convention on Climate Change, art. 2.1(a), Dec. 12, 2015, T.I.A.S. No. 16-1104 [hereinafter Paris Agreement]. Doing so requires reductions in global greenhouse gas emissions, which can be achieved in a variety of ways, all of which

the larger project of U.S. climate policy, why they were structured the way they were, and what they did. It then goes on to explain how modeling is used in general to assess the climate impacts of these kinds of laws, and the unique role that such modeling played, and is still playing, in the discourse around BIL and IRA specifically.

As described in further detail below, BIL and IRA directed billions of dollars in federal spending and tax benefits toward activities that tend to reduce U.S. greenhouse gas emissions. The effectiveness of such spending policies on greenhouse gas emissions reductions is uncertain, but can be predicted, at least in theory, by applying economic principles that translate price changes into energy market behaviors. Models capable of making such predictions already existed when BIL and IRA were passed, and were already frequently utilized to estimate greenhouse gas emissions reductions flowing from new legislation. Additionally, BIL and IRA's spending programs were mostly modifications and extensions of existing programs. Thus, as drafts of BIL and IRA were being debated, and immediately after they were enacted, existing models were able to be rapidly updated to make predictions about the laws' effects on U.S. greenhouse gas emissions. The top-line results of these rapid modeling efforts deeply influenced public discourse over what BIL and IRA could accomplish and, in the process, overshadowed essential caveats about the models' predictive limitations.

A. Climate Law from the Necessary to the Feasible

It is essential to examine what Congress actually intended to do with BIL and IRA because the laws represented such a significant shift in U.S. national climate policy. Prior to BIL and IRA, carbon taxation and sectoral emissions reduction mandates were typically held up as the most effective and important policies to pursue in order to give the country the best chance to achieve its emissions reduction targets.[12] Spending, on the other hand, was seen as an essential support strategy but incapable of achieving significant emissions

involve drastic reductions in the annual greenhouse gas emissions from the most heavily polluting nations by 2050. Joeri Rogelj et al., *Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development, in* GLOBAL WARMING OF 1.5°C: AN IPCC SPECIAL REPORT (Valérie Masson-Delmotte et al. eds., 2019). By "most effective" policies, this Article means those policies that are most likely to result in annual emissions reductions in highly polluting nations at the pace necessary to meet worldwide emissions reductions targets and thus warming targets. At the national level, these include policies that directly cause emissions reductions, while at the international level, they include governance frameworks that cause nations to adopt and implement such emissions reduction policies. Of course, real-world policies often attempt to achieve multiple goals, including for example avoiding unnecessary costs or improving distributive justice, but these are treated separately in policy analysis. *See generally* DAVID L. WEIMER & AIDAN VINING, POLICY ANALYSIS: CONCEPTS AND PRACTICE Ch. 15 (6th ed. 2017) (describing multifactor policy analysis approaches). Ultimately in this Article, however, "climate" policies are those that respond to the problem of climate change, and other goals tend to be treated as secondary.

12. *See, e.g.*, LEGAL PATHWAYS TO DEEP DECARBONIZATION 70–86, 487–88 (Gerrard & Dernbach eds., 2019) (highlighting carbon pricing as the first and most important strategy versus technology subsidies, which are discussed as a support strategy for grid decarbonization). The large number of carbon pricing and sectoral cap and trade bills proposed to Congress since 2015 are further evidence of this perspective. *See, e.g.*, *infra* note 29 and accompanying text.

reductions on its own.[13] After BIL and IRA, the mandate-oriented policy strategies previously thought to be necessary appear to have been abandoned as infeasible, in preference for more politically palatable, but less certainly effective, spending alternatives. But as the United States tried to spend its way out of climate change, it did not develop rigorous support for the proposition that this would actually work.

By way of disclosing relevant priors, it is also important to admit that this concern stems from deeper worries about the historical trajectory of international climate policy, and a concern that BIL and IRA repeated a pattern that has a troubling analogue at the international level. That is: A global climate governance system that produces necessary emissions reductions almost certainly requires some mechanism to compel nations to act even when they would prefer not to and when incentives lean toward continued emissions.[14] But two decades of efforts to develop such a mechanism ended in failure, as the international system proved incapable of inducing the world's most powerful nation states to bind themselves to such commitments.[15] Instead, nations adopted a voluntary system that is much more politically feasible, but is not producing the necessary results.[16] Moving toward a reliance on spending is, in other words, a domestic parallel to the abandonment of the Kyoto Protocol in favor of the Paris Agreement at the international level.

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13. LEGAL PATHWAYS TO DEEP DECARBONIZATION, *supra* note 12 at 85.

14. There is no way to prove this claim with certainty, as we can only ever run the experiment once. However, it was believed to be true in 1995, when the signatories to the United Nations Framework Convention on Climate Change (UNFCCC) adopted the Berlin Mandate, determining the UNFCCC commitments were inadequate to achieve the treaty's goals and agreeing to work toward a schedule of binding national commitments. *See Report of the Conference of the Parties on its First Session, Held at Berlin from 28 March to 7 April 1995*, U.N. Framework Convention on Climate Change Conference of the Parties, 1st Sess., Decision 1/CP.1, at 4, U.N. Doc. FCCC/CP/1995/7/Add.1 (1995); *see generally* Alison Abbott, *Meeting Agrees on Need for New Targets for Greenhouse Gas Emissions*, 374 NATURE 584 (1995). And it was believed to be true in 1997, when the UNFCCC parties adopted the Kyoto Protocol (discussed below). As further evidence, the very nations that would have had to reduce their emissions the most if such a mechanism existed were the nations that most opposed its creation, and, lacking such a mechanism, those nations have continued to contribute the most to climate change, and have not undertaken sufficient commitments under the voluntary system (the Paris Agreement, also discussed below) that was pursued after efforts to create a binding mechanism failed.

15. The problem of lack of commitment from powerful states is as old as international law itself. *See generally* Ryder McKeown, *The Power and Perils of International Law: A Review Essay on Lawfare, Constructivism and International Lawpower*, 5 INT'L POL'Y REV. 105 (2017) (reviewing longstanding realist concerns with the project of international law). The last decade has been particularly marked by an ebb of commitment, and development of counternarratives of the primacy of domestic sovereignty. *See generally* Ilya Marchuck, *Powerful States and International Law: Narratives and Power Struggles in International Courts*, 26 U.C. DAVIS J. INT'L L. & POL'Y 65 (2019).

16. *First Global Stocktake, Proposal by the President*, *Draft Decision -/CMA.5, Outcome of the First Global Stocktake*, Conference of the Parties Serving as the Meeting of the Parties to the Paris Agreement, 5th Sess., U.N. Doc. FCCC/PA/CMA/2023/L.17 (Dec. 13, 2023) ("Parties are not yet collectively on track towards achieving the purpose of the Paris Agreement and its long-term goals."); University of Exeter and Stanford Doerr School of Sustainability, *Global Carbon Emissions from Fossil Fuels Reached Record High in 2023*, STANFORD UNIV. (Dec. 5, 2023), https://sustainability.stanford.edu/news/global-carbon-emissions-fossil-fuels-reached-record-high-2023.

Under the Kyoto Protocol,[17] polluting nations were required to undertake binding emissions reductions commitments, and to implement national policies consistent with achieving those commitments.[18] However, the Kyoto Protocol did not require China to make significant reductions,[19] and the United States refused to participate without China's being bound by reciprocal commitments.[20] The refusal of the world's two most-polluting nations to be bound by the Kyoto Protocol's commitment system could never be overcome, and efforts to do so were effectively abandoned in 2009.[21]

The Kyoto system was wholly replaced by the Paris Agreement framework in 2015.[22] The Paris Agreement only requires participant nations to identify their emissions reduction ambitions and report on their progress toward reaching those

17. Kyoto Protocol to the United Nations Framework Convention on Climate Change, Dec. 10, 1997, 2303 U.N.T.S. 162 [hereinafter Kyoto Protocol]. The Kyoto Protocol went into effect in 2005. Climate Change Secretariat, Press Release: Kyoto Protocol to Enter into Force 16 February (Nov. 18, 2004), https://unfccc.int/files/press/news_room/press_releases_and_advisories/application/pdf/press0411 18_eng.pdf. Its first commitment period lasted from 2008 to 2012, and its second commitment period extended from 2013 to 2020. *See Report of the Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol on its Eighth Session, Held in Doha from 26 November to 8 December 2012*, Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol, Decision 1/CMP.8, at 2–13, U.N. Doc. FCCC/KP/CMP/2012/13/Add.1 (Feb. 28, 2013). The Doha Amendment was not actually ratified until 2020, as a formality allowing Kyoto to conclude. *See* Doha Amendment to Enter into Force, IISD: SDG KNOWLEDGE HUB (Oct. 8, 2020), https://sdg.iisd.org/news/doha-amendment-enters-into-force.

18. To this day, it is deeply contested whether the Kyoto system ever could have worked as intended. *See generally* Amanda M. Rosen, *The Wrong Solution at the Right Time: The Failure of the Kyoto Protocol on Climate Change*, 43 POL. & POL'Y 30 (2015) (reviewing contemporary critiques that Kyoto was not sufficiently ambitious to solve climate change, theorizing contribution of multiple design flaws to the system's ultimate failure, and noting alternatives not undertaken). Proponents of the system that replaced it, the Paris framework, tend today to point to the Kyoto regime as misguided. *See, e.g.*, Robert Falkner, *The Paris Agreement and the New Logic of International Climate Politics*, 92 INT'L AFF. 1107 (2015). However, binding commitments have a long record of success in international environmental law. Kal Raustiala & David G. Victor, *Conclusions*, *in* THE IMPLEMENTATION AND EFFECTIVENESS OF INTERNATIONAL ENVIRONMENTAL COMMITMENTS: THEORY AND PRACTICE 659, 688 (David G. Victor et al. eds., 1998) (concluding: "Legally binding commitments nonetheless retain an important role as one of many international policy instruments. Indeed, the benefits of nonbinding instruments have been most evident when applied in tandem with legally binding measures."). California and the EU have also demonstrated the effectiveness of binding domestic reductions commitments. *See infra* note 44 and accompanying text.

19. Kyoto Protocol, *supra* note 17, at Annex B (imposing no binding emissions reduction targets on China).

20. *See* S. Res. 98, 105th Cong. (1997) (Senate resolution indicating unwillingness to adopt Kyoto Protocol without reciprocal binding commitments from developing nations); President's Letter to Members of the Senate on the Kyoto Protocol on Climate Change, 1 PUB. PAPERS 235 (Mar. 13, 2001).

21. *See generally* Daniel Bodansky, *The Copenhagen Climate Change Conference: A Postmortem*, 104 AM. J. INT'L. L. 230 (2010); Mark Hertsgaard, *The Ugly Truth About Obama's "Copenhagen Accord",* VANITY FAIR (Dec. 21, 2009), https://www.vanityfair.com/news/2009/12/the-ugly-truth-about-obamas-copenhagen-accord ("In the end, Hopenhagen became Nopenhagen.").

22. Peter Christoff, *The Promissory Note: COP21 and the Paris Climate Agreement*, 25 ENV'T POL. 765, 781 (2016) ("[T]he Paris Agreement is a promissory note. Its value remains unclear. It will be a success only if it manages to ratchet up collective climate action in ways sufficient to meet its broad aims.").

voluntary goals.[23] It encourages industrialized nations to impose mandatory emissions reduction commitments upon themselves as a matter of their own domestic law, but nations are no longer asked to commit themselves to such initiatives by treaty. Nations that fail to achieve emissions reduction targets face only public shaming, rather than enforcement measures.[24] The Paris Agreement's primary selling point is that, unlike Kyoto, both the United States and China agreed to participate. In the shift from the Kyoto to Paris regimes, then, the world witnessed a global admission that independent, voluntary action and ongoing cooperative dialogue are the best that can be achieved under the current international order.[25] Lacking a common commitment to binding, reciprocal, economywide emissions reductions, we are required to make do with what is left: the power of public disclosure and hope in the goodwill of superpowers.[26] The Paris Agreement is certainly justified as the best of what was possible, and it remains extremely important to get as much value out of the Paris Agreement framework as is achievable, but that does not mean that we should not lament the loss of what might have been and judge our current situation against the ideals of the past.

Rather than lament our losses, however, the shift from the necessary to the feasible now seems to have become not only accepted as inevitable and necessary, but viewed as the preferable approach, even among those in the United States who support strong climate policy. This was never the intention, as even the Paris Agreement framework was understood to be effective only to the extent that nations undertook high-ambition domestic policies, and a national emissions reduction commitment (or carbon pricing regime) remains the most

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23. Paris Agreement, *supra* note 11, at art. 4; *see also* David Held & Charles Roger, *Three Models of Global Climate Governance: From Kyoto to Paris and Beyond*, 9 GLOB. POL'Y 527 (2018) (describing the Paris framework approach).

24. *Compare* Kyoto Protocol, *supra* note 17, at art. 18 (authorizing development of mechanisms to respond to non-compliance) *and Decision 27/CMP.1, Procedures and Mechanisms Relating to Compliance under the Kyoto Protocol*, Conference of the Parties Serving as the Meeting of the Parties to the Kyoto Protocol, at 92, U.N. Doc. FCCC/KP/CMP/2005/8/Add.3 (Dec. 2005) (detailing compliance mechanism) *with* Paris Agreement, *supra* note 11 (lacking any explicitly authorized or contemplated compliance mechanism).

25. *See*, *e.g.*, Daniel Bodansky, *The Paris Climate Change Agreement: A New Hope?*, 110 AM. J. INT'L. L. 288, 318 (2016) ("Given current political realities, the Agreement produced as much as could reasonably have been expected, and perhaps more."); Raymond Clémençon, *The Two Sides of the Paris Climate Agreement: Dismal Failure or Historic Breakthrough?*, 25 J. ENV'T & DEV. 3, 6 (2016) ("Ultimately, what the United States accomplished is to have the world accept the domestic constraints in the United States as a feature of international climate talks. … One has to accept that negotiating fair and equitable binding emissions reduction targets for each country was impossible.").

26. *See, e.g.*, GLOBAL CARBON PRICING: THE PATH TO CLIMATE COOPERATION xiii (Peter Crampton et al. eds., 2017) (arguing that the Paris framework "is only progress if the collective goal will be translated into a reciprocal, common climate commitment."); *see also id.* at 8 ("Only a common commitment can lead to a strong treaty."); Bodansky, *supra* note 25, at 289 ("The Paris conference gives new hope to the UN climate change regime. But much remains to be done, and much could still go wrong."); *see generally* Gabriel Weil, *Incentive Compatible Climate Change Mitigation: Moving Beyond the Pledge and Review Model*, 42 WM. & MARY ENV'T L. & POL'Y REV. 923 (2018) (arguing that the Paris pledge and its review system are "too weak" to achieve stated goals).

effective available climate policy for any high-polluting nation to adopt.[27] But whether justified by pragmatism or flowing from disenchantment following past defeats, interest in pursuing such high-ambition policies in the United States appears to have faded. Since the defeat of the Waxman-Markey bill in 2009,[28] and with no fundamental changes in the structure or operation of the U.S. Senate to give much hope of a different outcome now, the Democratic Party has declined to champion national carbon control legislation of any kind. Although dozens of proposals have been introduced in Congress, not a single one has escaped committee, even when the Democratic Party has held Congressional majorities.[29]

Instead, climate policy in the United States became dominated by discourse over the parameters of the Green New Dea, which was innovative in bridging the historic policy gap between environmental protection and social welfare, but proposed only weakly, and then abandoned, what were previously understood as high-ambition climate policies.[30] In its most official form, the original Green New Deal *did* promote deep decarbonization and universal clean power as goals,[31] but those policy ambitions were discarded as implementing legislation was crafted.[32] As pro-Green New Deal advocates criticized prior attempts at cap-and-trade and carbon pricing and called for "[e]nough of hoping markets work

27. Emissions reductions targets and carbon taxes are both theoretically and empirically demonstrated to be highly effective climate policies. For economic theory, *see* Robert N. Stavins, *The Relative Merits of Carbon Pricing Instruments: Taxes versus Trading,* 16 REV. ENV'T ECON. & POL'Y 62 (2022). For empirical evidence, *see* Yoomi Kim et al., *Environmental and Economic Effectiveness of the Kyoto Protocol*, 15 PLOS ONE e0236299 (2020) (finding strong association between these policies and subsequent emissions reductions); Oliver Heidrich et al., *National Climate Policies across Europe and their Impacts on Cities Strategies*, 168 J. ENV'T MGMT. 36 (2016) (reviewing European commitments and real reduction outcomes); *see also infra* note *44* (discussing California and European Union).

28. H.R. 2454, 111th Cong. (2009) (passed House 219-212, no vote in Senate); *see also* 155 Cong. Rec. H7471-H768616741 (June 26, 2009).

29. *See generally* BRENT YACOBUCCI ET AL., CONG. RSCH. SERV, COMPARISON OF SELECTED SENATE ENERGY AND CLIMATE CHANGE PROPOSALS (June 16, 2010); EPA, OFF. OF ATMOSPHERIC PROGRAMS, EPA ANALYSIS OF THE AMERICAN POWER ACT IN THE 111TH CONGRESS (June 14, 2010); JASON YE, CENTER FOR CLIMATE AND ENERGY SOLUTIONS (C2ES), COMPARISON OF CARBON PRICING PROPOSALS IN THE 113TH CONGRESS (Dec. 2014), https://www.c2es.org/wp-content/uploads/2014/12/113th-congress-carbon-pricing-proposals.pdf [hereinafter YE, 113TH CONGRESS CARBON PRICING]; JASON YE, C2ES, COMPARISON OF CARBON PRICING PROPOSALS IN THE 116TH CONGRESS (Sept. 2020), https://www.c2es.org/wp-content/uploads/2020/09/carbon-pricing-proposals-in-the-116th-congress.pdf [hereinafter YE, 116TH CONGRESS CARBON PRICING]; JASON YE, C2ES, CARBON PRICING PROPOSALS IN THE 117TH CONGRESS (Dec. 2022), https://www.c2es.org/wp-content/uploads/2021/12/carbon-pricing-proposals-in-the-117th-congress.pdf [hereinafter YE, 117TH CONGRESS CARBON PRICING]; *Carbon Pricing Bills in Congress,* CITIZENS CLIMATE LOBBY, https://community.citizensclimate.org/resources/item/19/220 (last visited Jan. 5, 2025).

30. H. Res. 109, 116th Cong. (2019) (calling for the United States "to achieve net-zero greenhouse gas emissions," by, among other things, "meeting 100 percent of the power demand in the United States through clean, renewable, and zero-emission energy sources").

31. *Id*.

32. The proposed and eventually eliminated program was called the Clean Electricity Performance Program (CEPP), which combined a mandatory nationwide clean energy standard and carbon tax by rewarding utilities for achieving 4 percent per year increases in clean energy on their grids and penalizing them financially if they did not. *See* Zoya Teirstein, *Meet the CEPP, the Biggest Federal Climate Policy You've Never Heard Of*, GRIST (Sept. 29, 2021), https://grist.org/politics/meet-the-cepp-the-biggest-federal-climate-policy-youve-never-heard-of.

magic,"[33] and as West Virginia Senator Joe Manchin insisted that the Biden Administration's centerpiece clean electricity mandate be removed from the bill,[34] the House's Build Back Better Act dropped the proposal's most rigorous provisions and did not replace them with effective alternatives.[35] The portions of Build Back Better that could muster sufficient Senate support then ended up as law in BIL and IRA,[36] but those provisions were largely spending provisions—all carrots and no sticks.[37] Policy proposals associated with steeper emissions reductions, like a nationwide renewable energy mandate, a nationwide carbon pricing program, or a nationwide cap-and-trade program, were abandoned in favor of public spending.

Unlike the cautious optimism following Paris, however, where it was widely understood that the new approach could only be effective if nations voluntarily undertook politically challenging, high-ambition domestic policies,

33. Erich Pica, *Role of Carbon Tax in the Green New Deal*, THE HILL (Feb. 22, 2019), https://thehill.com/opinion/energy-environment/431189-role-of-carbon-tax-in-green-new-deal; *see also* Frederick Hewett, *Putting a Price on Carbon: It Was Hot, Now It's Not*, WBUR (Aug. 3, 2020), https://www.wbur.org/cognoscenti/2020/08/03/carbon-pricing-tax-climate-change-policy-frederick-hewett; Zack Colman & Eric Wolff, *Why Greens Are Turning Away from a Carbon Tax*, POLITICO (Dec. 9, 2018), https://www.politico.com/story/2018/12/09/carbon-tax-climate-change-environmentalists-1052210.

34. *See* Coral Davenport, *Key to Biden's Climate Agenda Likely to Be Cut Because of Manchin Opposition*, N.Y. TIMES (Oct. 15, 2021), https://www.nytimes.com/2021/10/15/climate/biden-clean-energy-manchin.html.

35. *See* Scott Van Voorhis, *Unlocking the Transition: Biden, Congress Aim To Fill Gap from Clean Electricity Plan's Demise*, UTILITY DIVE (Nov. 4, 2021), https://www.utilitydive.com/news/unlocking-the-transition-biden-congress-aim-to-fill-gap-from-clean-electr/608395; Coral Davenport, *Biden Crafts a Climate Plan B: Tax Credits, Regulation and State Action*, N.Y. TIMES (Oct. 22, 2021), https://www.nytimes.com/2021/10/22/climate/biden-climate-plan.html; *What's in the $2.2 Trillion Social Policy and Climate Bill*, N.Y. TIMES (Nov. 21, 2021), https://www.nytimes.com/article/build-back-better-explained.html (discussing climate provisions entirely as spending provisions).

36. BIL contained infrastructure investment programs with the widest political support. *See* Tony Romm, *Senate Approves Bipartisan, $1 Trillion Infrastructure Bill, Bringing Major Biden Goal One Step Closer*, WASH. POST (Aug. 10, 2021), https://www.washingtonpost.com/us-policy/2021/08/10/senate-infrastructure-bill-vote-biden/. It passed the Senate 69-30, 167 CONG. REC. S6203 (Aug. 10, 2021), and the House 228-206, 167 CONG. REC. H6230 (Nov. 5, 2021), but only after being delayed for months by a debate between moderate and progressive Democrats over whether to condition the vote on a simultaneous budget reconciliation proposal vote. Sahil Kapur, *Centrist Democrats Now Hold the Cards as Infrastructure Bill Heads to Biden's Desk*, NBC NEWS (Nov. 8, 2021), https://www.nbcnews.com/politics/congress/centrist-democrats-now-hold-cards-infrastructure-bill-heads-biden-s-n1283485. IRA began as the much larger Build Back Better Act, introduced as H.R. 5376, 117th Cong. (2021). This bill passed the House on a party line vote, 167 CONG. REC. 6667 (Nov. 19, 2021), but was reduced significantly in the Senate at the insistence of Senator Joe Manchin (D-WV), who held the deciding vote there. *See* Emily Cochrane et al., *Manchin, in Reversal, Agrees to Quick Action on Climate and Tax Plan*, N.Y. TIMES (July 27, 2022), https://www.nytimes.com/2022/07/27/us/politics/manchin-climate-tax-bill.html. IRA passed the Senate 51-50 along party lines. 168 CONG. REC. S4201 (Aug. 6, 2022). The House acceded to the Senate's changes, again along party lines, 168 CONG. REC. H7704 (Aug. 12, 2022).

37. Maxine Joselow, *Why the Inflation Reduction Act Passed the Senate But Cap-and-Trade Didn't*, WASH. POST (Aug. 10, 2022), https://www.washingtonpost.com/politics/2022/08/10/why-inflation-reduction-act-passed-senate-cap-and-trade-didnt/ (quoting Barbara Boxer: IRA "is all incentives."). The one exception is the methane tax, discussed below.

the passage of BIL and IRA was presented in far more celebratory terms.[38] Clearly, like at Paris, what was passed is all that was politically feasible, but that is not the point. The point, as explored below, is that these spending provisions alone were then claimed to be able to achieve substantial greenhouse gas emissions reductions *without* the need for any of the more politically unpopular provisions.[39] But there was little evidence to support such optimism.

In order to actually hold global average surface temperature increases to between 1.5º and 2º C above preindustrial baselines,[40] worldwide annual greenhouse gas emissions must rapidly decrease to net zero, followed by a decades-long period of worldwide net negative emissions.[41] To actually achieve net zero emissions by 2050, societies must immediately and rapidly decarbonize their electric power, transportation, building, and land use sectors.[42] Achieving net negative emissions in later decades requires the world to develop new carbon removal technologies and practices, while simultaneously abstaining from depending overmuch on those technologies to offset current emissions.[43] To date, the jurisdictions that have made real progress along these decarbonization pathways have been those that have imposed mandatory emissions reductions on themselves.[44] The academic studies that have examined the question indicate that regulatory controls have been the most effective mechanism for real emissions reductions.[45] Indeed, the only other demonstrated way to rapidly reduce national annual greenhouse gas emissions has been to suffer an economic calamity, as for

38. *See, e.g.*, Marcacci, *supra* note 5.

39. *See infra* Part II.

40. Paris Agreement, *supra* note 11, at art 2.1(a).

41. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE 2023: SYNTHESIS REPORT. CONTRIBUTION OF WORKING GROUPS I, II AND III TO THE SIXTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 19–20 (H. Lee et al. eds., 2023), https://www.ipcc.ch/report/ar6/syr/downloads/report/IPCC_AR6_SYR_FullVolume.pdf.

42. *Id.* at 27, Figure SPM.7.

43. *See* M. Pathak et al., *Technical Summary*, *in* CLIMATE CHANGE 2022: MITIGATION OF CLIMATE CHANGE. CONTRIBUTION OF WORKING GROUP III TO THE SIXTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE 82 (P.R. Shukla et al. eds., 2022), https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_FullReport.pdf.

44. This includes California, which has enacted and enforced an effective economywide cap and trade system, CALIFORNIA AIR RESOURCES BOARD, CALIFORNIA GREENHOUSE GAS EMISSIONS FOR 2000 TO 2020: TRENDS OF EMISSIONS AND OTHER INDICATORS 3 (Oct. 26, 2022), https://ww2.arb.ca.gov/sites/default/files/classic/cc/inventory/2000-2020_ghg_inventory_trends.pdf, and the European Union, which did the same thing, *Greenhouse Gas Emission Statistics - Emission Inventories*, EUROSTAT (Apr. 2024), https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Greenhouse_gas_emission_statistics_-_emission_inventories.

45. *E.g.*, Geoff Martin & Eri Saikawa, *Effectiveness of State Climate and Energy Policies in Reducing Power-Sector CO2 Emissions*, 7 NATURE CLIMATE CHANGE 912, 912 (2017) ("[U.S. state] policies with mandatory compliance are reducing power-plant emissions, while voluntary policies are not."); Jessica Green, *Does Carbon Pricing Reduce Emissions? A Review of Ex-Post Analyses*, 15 ENV'T RSCH. LETTERS 043004 (2021) (concluding that carbon pricing does not reduce emissions as much as regulations); DANNY CULLENWARD & DAVID G. VICTOR, MAKING CLIMATE POLICY WORK 10 (1st ed., 2020) ("[M]ost of the real work of emission control is done through regulatory instruments.").

example occurred in former Eastern Bloc nations in the 1990s,[46] or as occurred worldwide during the COVID-19 pandemic.[47] While it is certainly the case that voluntary measures have *some* impact, and that financial incentives have *some* impact, there has previously been little reason to examine, let alone believe, the proposition that financial incentive policies alone will operate to bring down greenhouse gas emissions at the pace necessary to solve climate change. And yet claims were made to this effect when BIL and IRA were enacted: that the spending provisions in these laws would achieve these necessary results. It bears examining exactly what, if anything, had changed to justify this optimism.

B. BIL and IRA as Climate Spending Bills

Notwithstanding the above concerns, BIL and IRA were the cornerstone of the Biden Administration's national climate strategy, and to begin to assess claims about their impact, it is necessary to understand exactly what they did and how they were expected to work.

In relevant part, BIL and IRA were climate spending bills. Except for the methane charge explained below, their emissions-reducing provisions all operated via federal spending. The laws used both direct spending, meaning the appropriation of federal funds to be spent by federal agencies, and tax expenditures, meaning federal spending in the form of forgone tax revenues.[48] The general idea was that this spending would subsidize and thereby incentivize low-carbon behaviors that would reduce the United States' annual greenhouse gas emissions.

All of these provisions are examined in further detail in Part II, but as an initial summary, BIL and IRA's most important climate spending provisions fell into the following general categories:[49]

(1) Low-carbon electricity production incentives. The laws provided tax benefits and direct financial support for generating electricity from low-carbon energy resources like wind, solar, and nuclear. The Sections 25D, 45, 45Y, 48, 48E, and 45U electricity production and investment tax credits, as

46. *See* Hannah Ritchie & Max Roser, *Ukraine: CO2 Country Profile*, OUR WORLD IN DATA (2020), https://ourworldindata.org/co2/country/ukraine?country=UKR~BLR~CZE~HUN~POL~SVK~ROU~BGR (internal citation omitted).

47. *See* Marzieh Ronaghi & Eric Scorsone, *The Impact of COVID-19 Outbreak on CO_2 Emissions in the Ten Countries with the Highest Carbon Dioxide Emissions*, 2023 J. ENVT'L & PUB. HEALTH 1–2 (2023); *Emission Reductions from Pandemic Had Unexpected Effects on Atmosphere*, NASA: JET PROPULSION LABORATORY (Nov. 9, 2021), https://www.jpl.nasa.gov/news/emission-reductions-from-pandemic-had-unexpected-effects-on-atmosphere.

48. OFF. OF MGMT. & BUDGET, EXEC. OFF. OF THE PRESIDENT, *Overview of the Budget Process*, *in* OMB CIRCULAR A-11: PREPARATION, SUBMISSION AND EXECUTION OF THE BUDGET (2024), https://www.whitehouse.gov/wp-content/uploads/2018/06/a11.pdf; *Tax Expenditures*, U.S. DEP'T OF TREASURY, https://home.treasury.gov/policy-issues/tax-policy/tax-expenditures (last visited Jan. 7, 2024).

49. Complete listings of BIL and IRA's emissions reduction provisions are widely available. *See, e.g.*, *Inflation Reduction Act (IRA) Summary: Energy and Climate Provisions*, BIPARTISAN POL'Y CTR. (Aug. 4, 2022), https://bipartisanpolicy.org/blog/inflation-reduction-act-summary-energy-climate-provisions. The laws, especially BIL, also include substantial funding for climate resilience and adaptation activities, but those are not the subject of this Article.

well as a number of grant and loan programs that could be used for building electricity generating resources, all worked in this way.[50] The programs function by reducing the cost of constructing clean electricity generating facilities, which allows them to charge less for the electricity they generate, thereby increasing their overall competitiveness in energy markets.[51]

(2) Clean vehicle purchase incentives. The laws provided tax benefits for consumer and commercial purchases of both new and used zero-emissions vehicles (ZEVs), as well as the purchase and construction of related fueling infrastructure. The Sections 25E and 30D tax credits each subsidized clean vehicle purchase and ownership directly by increasing these vehicles' cost-competitiveness in the market,[52] while the Section 30C fueling infrastructure subsidy increased the availability of support technology that otherwise poses a common barrier to ZEV adoption.[53]

(3) Low-carbon fuel production incentives. The laws provided tax benefits for producing low-carbon fuels, again operating to reduce the market price and thus to increase cost-competitiveness of these fuels, promoting their development and use. The Sections 40, 40A, 40B, 45V, and 45Z tax credits (promoting, among other things, hydrogen, biodiesel, and low-carbon aviation fuels),[54] as well as appropriations to grants programs for ongoing fuel technology development, all functioned in this way.

(4) Building energy efficiency upgrade incentives. The laws provided tax credits and rebates for consumer purchases of high efficiency building technologies like heat pumps and insulation. Again, these tax provisions functioned as public subsidies altering market pricing and therefore consumer behavior, although in this case mostly for the purpose of promoting natural gas and electricity demand reduction. These subsidies are

50. All section references are to Title 26 of the United States Code as modified by IRA, unless otherwise indicated. The modern versions of Sections 45 and 48 were enacted by the Energy Policy Act of 1992, Pub. L. No. 102-486 §§ 1914, 1916, 106 Stat. 2776 (1992), as amended. IRA modified and extended these programs before they are phased out and replaced by new Sections 45Y and 48E. IRA §§ 13101–02, 13701–02. The Section 25D residential credit was added by the Energy Policy Act of 2005, Pub. L. No. 109-58 § 1335, 119 Stat. 594 (2005). IRA extended this program to 2035. IRA § 13302. IRA's new Section 45U is a special credit for nuclear power generation only. *Id.* § 13105.

51. Meredith Fowlie, *Are Clean Electricity Tax Credits a Bad Deal?,* U.C. BERKELEY HAAS ENERGY INSTITUTE BLOG (April 2025), https://energyathaas.wordpress.com/2025/03/31/are-clean-electricity-tax-credits-a-bad-deal/ (providing economic framework for understanding electricity tax credits).

52. Section 30D was added by the Energy Improvement and Extension Act of 2008, Pub. L. 110-343, div B, § 205, 122 Stat. 3765 (2008), and has been amended many times since, with subsequent extensions and modifications under IRA. IRA § 13401. The Section 25E tax credit is a new incentive for used car purchases. *Id.* § 13402.

53. 26 U.S.C. § 30C, originally added by the Energy Policy Act of 2005 § 1342. IRA substantially expanded the funding available for ZEV charging infrastructure. *Id.* § 13404.

54. The Sections 40 and 40A tax credits date to 1980 and 2004, respectively, and again IRA extended and modified them. IRA §§ 13201–02. The other programs are new. *Id.* §§ 13203–04, 13704.

found in Section 25C[55] and in appropriations in both BIL and IRA to fund home energy efficiency rebate, grant, and assistance programs.[56]

(5) Cleantech manufacturing incentives. The laws also subsidized domestic manufacturing of the low-carbon technologies that would receive the other subsidies listed above. The Sections 45X and 48C credits,[57] appropriations to retool auto manufacturing plants, and existing advanced manufacturing grant programs, all operated in this way.[58] Although their direct impact on U.S. greenhouse gas emissions was not immediately clear, these rules were designed to promote U.S. domestic supply chains in these industries. In doing so, the laws possibly engendered domestic acceptance of and investment in these industries and put U.S. companies on more competitive footing with foreign firms.[59] In any event, several of the tax credits mentioned above were contingent on domestic manufacturing and so the manufacturing credits materially impacted the ability of consumers to take advantage of the laws' other incentives.[60]

(6) Carbon capture, use, and sequestration incentives. The laws provided a significant financial incentive for the development of effective carbon capture and storage technologies. Many of these were post-combustion or post-process carbon capture technologies, but there was also support for the development of direct air capture technologies. These effectively subsidized pollution control costs at facilities that emit greenhouse gas pollutants and

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55. Section 25C dates to the Energy Policy Act of 2005 § 1333. IRA extended and modified it. IRA § 13301.

56. BIL § 40552 (appropriating $550 million for the Energy Efficiency and Conservation Block Grant Program); IRA § 50121 (appropriating $4.3 billion for the Home Energy Performance-Based, Whole-House Rebates Program); IRA § 50122 (appropriating $4.5 billion to the High-Efficiency Electric Home Rebate Program).

57. Section 48C was added by the American Recovery and Reinvestment Act of 2009, Pub. L. No. 111-5 § 1302, 123 Stat. 115 (2009). IRA extended and modified it. IRA § 13501. Section 45X is new. *Id.* § 13502.

58. IRA § 50142 (appropriating $3 billion for the existing Advanced Technology Vehicle Manufacturing grant program codified at 42 U.S.C. § 17013); IRA § 50143 (appropriating $2 billion for the Domestic Manufacturing Conversion Grants program).

59. Peter Slowik et al., ANALYZING THE IMPACT OF THE INFLATION REDUCTION ACT ON ELECTRIC VEHICLE UPTAKE IN THE UNITED STATES (2023) (studying increases in domestic electric vehicle uptake due to both consumer and manufacturing tax credits), https://theicct.org/wp-content/uploads/2023/01/ira-impact-evs-us-jan23-2.pdf; Liwen Wang et al., Investment Opportunities in Challenged Sectors Enabled by the Inflation Reduction Act 2 (2023) (studying "commercially challenged sectors viewed as having a greater chance of near-term investments over the next decade and beyond due to their increased competitiveness enabled by the IRA"), https://www.sipa.columbia.edu/sites/default/files/2024-01/For%20Circulation_Citi_Guidera.pdf.

60. *See* Section 30D(e)(1) & (2) (allowing portions of credits only for vehicles with batteries with critical minerals extracted or processed in the United States or a free trade partner, or recycled in North America and manufactured or assembled in North America); Sections 48(a)(12) & 45(b)(9) (allowing added credit for facilities using steel manufactured in the United States). *See also* Scooter Doll, *Here's Every EV that Currently Qualifies for the US Federal Tax Credit* (May 2025), https://electrek.co/which-ev-qualify-us-federal-tax-credit-ev-2025/ (identifying vehicles sold in the U.S.). In other words, the availability of consumer tax credits is conditioned on the purchase of technologies manufactured or using materials manufactured in the United States or preferred trading partners, and the new manufacturing tax credits promote construction of facilities that strengthen domestic supply chains, making these credits available.

the R&D costs of future negative emissions technologies. The program is found at Section 45Q and in various appropriations.[61]

(7) Methane charge. The one exception to BIL and IRA's spending story was a new regulatory provision imposing a "charge" (a fee or tax) on certain excess fugitive methane emissions from oil and gas operations.[62] The new methane charge functioned as a classic Pigouvian tax, incentivizing pollution abatement, although in this case only on a certain specified percentage of a given operation's emissions.[63] Although not a spending provision, the methane charge was similar in that it would influence the price of energy commodities.[64] It was different, however, because fugitive methane can be captured and sold, so the costs undertaken to avoid the charge would be possible to recoup over the long term, meaning that the charge's impact on commodity pricing was much less certain.

Although BIL and IRA's economic interventions were extensive, it is important to keep in mind that many of the above provisions were actually modifications or extensions of previously existing programs, some of which have been in place for decades. BIL and IRA did provide more secure funding and, in many cases, increased the amount of funding available for these programs. The laws also innovated in their tailoring of program spending to promote U.S. domestic industries and to achieve greater distributive justice. But these new elements did not change the existing spending programs' overall thrust: to subsidize and thereby promote the adoption and diffusion of lower-carbon technologies for the purpose of reducing the nation's greenhouse gas emissions.

The impact of these types of laws has been the subject of energy-economic modeling for forty years, and therefore the capacities and limits of such modeling are well understood. Those insights are essential for understanding impact projections of BIL and IRA.

C. *Predicting the Future with Energy-Economic Modeling*

When Congress enacted BIL and IRA, even those who supported the laws criticized both what they did not accomplish[65] and the counterproductive concessions that were necessary to get them passed.[66] There was also some

61. Section 45Q was added by the Energy Improvement and Extension Act of 2008, div B, § 115. IRA expanded the program. IRA § 13104. See also BIL §§ 40302–06 (appropriating over $8 billion for carbon capture, use, and sequestration research, development, and demonstration programs).

62. IRA § 60113 (codified at 42 U.S.C. § 7436 (Clean Air Act § 136)).

63. *See* Brian Galle, *The Tragedy of the Carrots: Economics & Politics in the Choice of Price Instruments*, 64 STAN. L. REV. 797, 806–09 (2012).

64. Brian C. Prest, *Methane Fees' Effects on Natural Gas Prices and Methane Leakage*, Resources for the Future Issue Brief 21-12 (2021), https://media.rff.org/documents/IB_21-12.pdf (finding small impact on retail prices of various methane fee amounts).

65. *See, e.g.*, Matteo Wong, *The Climate Movement Wanted More Than the IRA. Now What?*, THE ATL. (Sept. 28, 2022), https://www.theatlantic.com/science/archive/2022/09/inflation-reduction-act-climate-investments-criticism/671584.

66. *See, e.g.*, Nina Lakhani, *Landmark US Climate Bill Will Do More Harm than Good, Groups Say*, THE GUARDIAN (Aug. 9, 2022), https://www.theguardian.com/us-news/2022/aug/09/us-climate-bill-fossil-fuel-harm-environment-biden.

discussion of the enormous effort that would be required to administer the spending programs that the laws created.[67] But what was not widely questioned, which should have been, was the rising use of energy-economic modeling to influence the laws' passages. Since most of BIL and IRA's spending provisions were not completely new, there was already a system in place to assess their future impacts on the energy system and climate change. The laws' new provisions were examined via familiar methods. The problem with these methods is that they are very poor at prediction.

The methods in question are broadly classified as "energy-economic" (or "energy-economy") models.[68] As the name suggests, such models attempt to represent how changes in the economy result in changes in energy systems, such as how electricity price changes impact energy demand, or how technology cost changes influence the range of resources used to supply electricity.[69] Energy-economic modeling is widely used as a tool by energy policy analysts to provide information to energy system decisionmakers about the possible impacts of alternative policy options.[70] As public tax and spending policies have long been used to intervene in U.S. energy systems, there is a long history of attempting to use economic principles to understand the impact of these policies going forward in time.

The gold-standard energy-economic model in use in the United States today is the U.S. Energy Information Administration's (EIA) National Energy Modeling System (NEMS), which models the entire U.S. energy system.[71] NEMS was built and is maintained by EIA researchers,[72] and its primary function has been to support the production of the EIA's Annual Energy Outlook (AEO) reports, which make projections about what the U.S. energy system will look like in the future.[73] In EIA's words, "NEMS is used by EIA to project the

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67. *See, e.g.*, Jennifer Pahlka, *The IRA Is Our Best Shot at Tackling Climate Change—But Only If We Don't Squander It*, TIME (June 27, 2023), https://time.com/6290582/inflation-reduction-act-climate-change-implementation/.

68. *See, e.g.*, *US-REGEN Documentation*, EPRI (2020), https://us-regen-docs.epri.com/v2020/1-overview/1-summary.html (using both terms to describe one such model).

69. That is not to say that these models all work the same way. *See generally* MODELING ENERGY-ECONOMY INTERACTIONS: FIVE APPROACHES (Charles J. Hitch ed., 1977) (describing academic theory and practice in the field of energy-economic modeling).

70. *See generally* J.A. Laitner et al., *Room for Improvement: Increasing the Value of Energy Modeling for Policy Analysis*, 11 UTILITIES POL'Y 87 (2003).

71. Jordan T. Wilkerson et al., *End Use Technology Choice in the National Energy Modeling System (NEMS): An Analysis of the Residential and Commercial Building Sectors*, 40 ENERGY ECON. 773, 773 (2013) (NEMS "is arguably the most influential energy model in the United States. … NEMS is considered such a standard tool that other models are calibrated to its forecasts, in both government and academic practice. As a result, NEMS has a significant influence over expert opinions of plausible energy futures.").

72. Steven A. Gabriel et al., *The National Energy Modeling System: A Large-Scale Energy-Economic Equilibrium Model*, 49 OPERATIONS RSCH. 14, 14–15 (2001) (describing the development of NEMS).

73. U.S. ENERGY INFORMATION ADMINISTRATION (EIA), THE NATIONAL ENERGY MODELING SYSTEM: AN OVERVIEW 2018 (Apr. 2019), https://www.eia.gov/outlooks/aeo/nems/overview/pdf/0581(2018).pdf [hereinafter NEMS OVERVIEW]; *see also Download the National Energy Modeling System*, EIA: ANNUAL ENERGY OUTLOOK 2023 (Mar.

impact that energy, economic, environmental, and security factors can have on the U.S. energy system as a result of alternative energy policies and different assumptions."[74] NEMS can model numerous economic factors relevant to the U.S. energy system and then can attempt to predict the impact of changed economic assumptions on the model's baseline projections.[75] EIA's AEO reports develop energy system projections out to the year 2050.[76]

To accomplish this, NEMS combines fifteen separate sub-models (called "modules"), thirteen of which model various parts of the U.S. energy system, ten of which capture international and macroeconomic factors, and one of which integrates all of the others together and derives conclusions.[77] Each of the modules seeks to provide "projections of energy production, demand, imports, and prices through 2050."[78] The modules do this by identifying economic equilibria—the exchange prices at which supply and demand for all elements of the modules, and eventually the total model, are evenly matched. As described by EIA:

> The modules in NEMS represent the demand, supply, and conversion segments of the energy market as well as modules to provide economic and international oil market feedbacks. In effect, these modules represent energy supply and demand curves. That is, the supply and conversion modules determine prices and sources of supply, given the quantity of fuel demanded. The demand and conversion models determine the fuel demands, given the prices of those fuels. The solution algorithm attempts to determine a vector of fuel prices and quantities so that supply and demand curves in all fuel markets equilibrate. That is, a solution occurs when energy demands and prices, along with the macroeconomic variables, reach stable, convergent values.[79]

In other words, and to greatly simplify a very complex mathematical model, NEMS predicts the future by predicting prices. It arrives at a solution where demand is met by supply as cheaply as possible. Since prices vary by technology, price prediction also results in a prediction of the least costly suite of energy technologies that will meet projected demand. Since different technologies have different associated greenhouse gas emissions profiles, the prediction of the optimal technology suite also allows a prediction of greenhouse gas emissions. It is then possible to examine how prices, technologies, and greenhouse gas emissions change when economic assumptions change. Other energy-economic models differ in the parts of the energy system they model and the processes they

16, 2023), https://www.eia.gov/outlooks/aeo/info_nems_archive.php; EIA, INTEGRATING MODULE OF THE NATIONAL ENERGY MODELING SYSTEM: MODEL DOCUMENTATION 2022 (2022), https://www.eia.gov/outlooks/aeo/nems/documentation/integrating/pdf/integrating-2022.pdf [hereinafter INTEGRATING MODULE OVERVIEW].

74. NEMS OVERVIEW, *supra* note 72, at 8.

75. *Id*.

76. *Id.*

77. *Id.* at 15–16.

78. *Id*. at 1.

79. INTEGRATING MODULE OVERVIEW, *supra* note 72, at 29.

use to arrive at their conclusions,[80] but the basic relationship between prices, energy system elements, and greenhouse gases generally pertains.

EIA builds its AEO reports by modeling a range of NEMS scenarios, also called "cases," which are mixes of assumptions about the way the world will look.[81] The AEO "reference case," or "baseline scenario," is the NEMS equivalent of its authors' "best guess" about the future. According to EIA, "[i]t's best to think of the Reference case as the experimental control: a baseline against which we can judge the other cases."[82] Those other cases are called "side cases," representing "plausible variations in key input assumptions that tend to drive the largest changes in projected outputs from the Reference case,"[83] and "incorporate plausible alternatives to assumptions in the Reference case."[84] In other words, the AEO provides information about how the national energy system might respond to changes in key variables like oil prices and economic growth rates. Emphasizing the importance of the case development process, the 2023 AEO discusses the assumptions underlying its reference case and twelve side cases in a series of reports totaling over 300 pages of explanation.[85] While other models may vary in their details, a similar process of scenario analysis is at the heart of most such predictive endeavors.

Importantly, the AEO side cases do not typically model alternative laws or proposed legislation.[86] Rather, the reference case and side cases all take existing laws as their baseline and vary only in their economic assumptions.[87] NEMS is

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80. *See*, *e.g.*, National Renewable Energy Laboratory, Regional Energy Deployment System (REeDS), https://www.nrel.gov/analysis/reeds (modeling U.S. energy system capacity bottlenecks and forecasting expansion pathways based on economic factors); E3, RESOLVE, https://www.ethree.com/tools/resolve/ (optimizing for expansion of low-carbon resources at lowest cost in regional grids).

81. EIA, ANNUAL ENERGY OUTLOOK: AEO2023 1 (2023), https://www.eia.gov/outlooks/aeo/assumptions/pdf/AEO2023_Narrative.pdf [hereinafter AEO 2023].

82. *Id*.

83. *Id*. The twelve side cases (variations on the reference case) and each of the key uncertainties they address are described, *id*. at 33–34, including: high and low oil price assumptions, high and low oil and gas supply assumptions, high and low zero-carbon technology cost assumptions, high and low economic growth assumptions, and four combinations of economic growth and zero-carbon technology cost assumptions. It is important to note that the predictions of these side cases are just as prone to inaccuracy as the predictions of the reference case—oil prices could be high as assumed in the high oil price side case, and the energy system might, *or might not*, look like the system predicted by the side case. The most useful information is the direction and magnitude of the changes in the model's results when a key variable changes.

84. *Id*. at 30.

85. *See Assumptions of the Annual Energy Outlook 2023*, EIA: ANNUAL ENERGY OUTLOOK 2023 (Mar. 16, 2023), https://www.eia.gov/outlooks/aeo/assumptions/.

86. AEO 2023, *supra* note 81, at 4 ("All AEO2023 cases assume current laws and regulations.").

87. *See* EIA, THE BIPARTISAN INFRASTRUCTURE AND JOBS ACT [SIC] IN THE ANNUAL ENERGY OUTLOOK 2022 (2022), https://www.eia.gov/outlooks/aeo/pdf/AEO2022_BIJ_Law.pdf (explaining how BIL was incorporated into AEO 2022); EIA, SUMMARY OF LEGISLATION AND REGULATIONS INCLUDED IN THE ANNUAL ENERGY OUTLOOK 2022 (Mar. 2022), https://www.eia.gov/outlooks/aeo/assumptions/pdf/summary.pdf (discussing how BIL was incorporated); EIA, SUMMARY OF LEGISLATION AND REGULATIONS INCLUDED IN THE ANNUAL ENERGY OUTLOOK 2023 (Mar. 2023), https://www.eia.gov/outlooks/aeo/assumptions/pdf/Legs_Regs.pdf (discussing how IRA was incorporated); *see also* ASHLEY J. LAWSON & KELSI BRACMORT, CONG. RSCH. SERV., IF11691, THE

also typically not used by EIA to evaluate the specific impacts of any of the laws that it incorporates.[88] This is one of the most notable differences between NEMS as typically used by EIA and other energy-economic modeling efforts, which are often developed precisely to examine the impact of specific policy proposals.[89] That said, it is possible to alter NEMS to make such predictions, and EIA makes its NEMS model available to third parties for this purpose. Additionally, on rare occasions, typically in response to requests from other parts of the federal government, EIA will also use the model to analyze specific policies.[90] But before getting into further detail about that, it is necessary to examine the well-understood limitations of energy-economic models.

Experts have warned for years about overreliance on the top-line results of models like NEMS to guide policy decisions. A 2003 book-length examination of the use of energy-economic models for climate change policy explored a number of theoretical and technical concerns that are, frankly, the purview of economists to argue over.[91] But the study's most accessible critique was also its most devastating: "these models have almost no predictive power."[92] It demonstrated this by comparing past modeling outputs to real-world data that was collected in the years since the models were developed. The predictive and real-world data did not align, which has serious implications for what these modeling results can and should be used to say. According to that study:

> It would be going too far to claim that long-run energy/economic models have no value just because they have little or no power to predict the course of energy prices and demand. Long-term modeling exercises can be valuable for providing a consistent framework in which to work out the consequences of various scenarios. This kind of analysis is not the same thing as prediction, and the point that should be emphasized is that its primary use should be to explore alternative *assumptions*. At the same time, the poor predictive performance of models of this type indicates that considerable caution should

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ANNUAL ENERGY OUTLOOK (AEO): A BRIEF OVERVIEW (Dec. 1, 2020) ("EIA defends this practice as being consistent with its mandate to be policy neutral, and has stated in the past, 'the [AEO] projections provide policy-neutral baselines that can be used to analyze policy initiatives.' … EIA occasionally assesses potential policy outcomes, usually upon congressional request.").

88. NEMS begins with legislative impact predictions as part of its starting assumptions. For example, AEO 2023 modeled the impact of IRA's expanded ZEV tax credit by incorporating budgetary impact projections developed by the Congressional Budget Office. *See* EIA, TRANSPORTATION DEMAND MODULE ASSUMPTIONS 26 (Mar. 2023), https://www.eia.gov/outlooks/aeo/assumptions/pdf/TDM_Assumptions.pdf ("[W]e used the official U.S. government forecasted expenditures on the IRA clean vehicle credit to estimate impacts on battery-electric vehicle and PHEV adoption" (citing CBO, *Aug. 2022 Estimated Effects of IRA supra* note 9)).

89. *See, e.g.*, JOSIAH JOHNSTON ET AL., SWITCH-WECC: DATA, ASSUMPTIONS, AND MODEL FORMULATION 19–20 (2013) (describing policy scenarios that the model was developed to evaluate); *US-REGEN Documentation*, *supra* note 67.

90. See discussion of the no-IRA side case, *infra*.

91. *See generally* STEPHEN DECANIO, ECONOMIC MODELS OF CLIMATE CHANGE: A CRITIQUE (2003) (chapters on modeling representation of consumer demand, industrial supply, the treatment of time, and modeling performance). For insight into the author's perspective, the initial title of the book was: "Overreaching Hubris: The Failure of Economic Models of Climate Policy." *See* Laitner et al., *supra* note 69, at 93 (citing in-press manuscript with this title).

92. DECANIO, *supra* note 90, at 15.

> be used in interpreting the results of model runs. . . . If not only the magnitude, but even the sign of the effect of a proposed policy depends on contestable model assumptions, then the results of the analysis need to be taken with a very large grain of salt. Energy modeling in economics has a long enough history that the match between forecasts and actual outcomes can be compared. The result of such comparisons is not encouraging . . . .[93]

Three important concepts emerge from this critique. First, the best use of energy-economic models is not to predict, but to test the impact of varying economic assumptions on modeled energy system outcomes. Second, when these models have been used for prediction, comparison of those predictions to real-world outcomes demonstrates they have had very little success. Third, the consequence of the first two issues is that energy-economic modeling predictions should not be invested with the aura of certainty.

There is substantial evidence that the same limitations persist today. Recent reviews of NEMS results "have shown that observed values can differ from the projection by several hundred percent."[94] EIA itself acknowledges this, as the AEO now regularly discusses how accurate past AEO predictions have been and incorporates these past errors into uncertainty ranges in its predictive narratives and diagrams.[95] These uncertainty ranges are derived from the EIA's regularly updated *Annual Energy Outlook Retrospective Review*,[96] which has found, for example, that the AEO's past predictions of future greenhouse gas emissions and renewable energy construction levels have been off by wide margins.[97] As the EIA Administrator recently noted: "[i]deally, we would model [the many ongoing changes to the U.S. energy system and laws] to produce precise numerical forecasts that demonstrate how energy prices, technology deployment, and emissions will shift over time. Unfortunately, such precise forecasts are not possible."[98] Instead, EIA's "objective must be to identify robust insights rather than precise numbers—think ranges and trends, not predictions and point estimates."[99]

Again, NEMS is the gold standard. No other model of the U.S. energy system has received the same level of funding and developmental support, and none have a better demonstrated predictive track record than NEMS. For other models, there is less evidence of problems because other models have not been in use for as long or subject to the same scrutiny as has the EIA's work. Many of

93. *Id.* at 151–52 (emphasis in original).

94. Lynn H. Kaack et al., *Empirical Prediction Intervals Improve Energy Forecasting*, 114 PNAS 8752, 8752 (2017).

95. AEO 2023, *supra* note 81, at 31.

96. *Annual Energy Outlook Retrospective Review*, EIA: ANALYSIS & PROJECTIONS (Sept. 14, 2022), https://www.eia.gov/outlooks/aeo/retrospective/.

97. Between 2000 and 2020, the forecasts largely underestimated the rate of greenhouse gas reduction, while simultaneously consistently underestimating the amount of wind and solar energy being built. *Id.* at Table 1 (summary), Table 28 (carbon), Table 17 (solar net generation), Table 18 (wind net generation). However, since 2020, the results have been the opposite, with U.S. energy system greenhouse gas emissions somewhat underestimated, and wind and solar installs overestimated. *Id*.

98. AEO 2023, *supra* note 81, at 1.

99. *Id*.

these models are new enough, and untested enough, that no information about their predictive accuracy exists.[100]

Energy-economic modeling is a technical discipline, and the people developing these models engage in a robust academic dialogue about how to improve their work.[101] They understand the limitations of their efforts and often attempt to ensure that their models' predictive results are not misconstrued. But their caveats and disclaimers are too easily ignored. For lawyers and policy advocates reading this, perhaps the message should be: Professional modelers do not use models the way you want them to, and modeling outputs should not be interpreted as proof of their own accuracy. "In line with a [forty] year old plea from the energy modelling community, models deliver insights instead of answers."[102]

D. The Rise of Rapid Climate Law Impact Projections during BIL and IRA's Debate

Prior to BIL and IRA, energy-economic modeling projections were not typically the stuff of high-profile opinion pieces and widespread public discourse. But the enactments of BIL and IRA were accompanied by an unprecedented, and largely uncommented-upon, new weapon in the persuasive arsenal: the rapid climate impact projection model. These new models attempted to predict the likely climate impact of a given piece of legislation even before it was passed and, thus, to use this modeling to inform the climate policy debate directly. This effort was quite successful, as the models were cited extensively by politicians, policy advocates, the press, and academics during the debate over BIL and IRA. But as their prominence grew, these models were used not so much as informational tools but as advocacy tools, and it is this shift in role that is the primary concern here.

The REPEAT Project, housed at Princeton, has been the most prominent producer of rapid climate legislative impact projections.[103] The project, which has received extensive media attention, was built on a model that was designed for another purpose[104] and was then retooled to provide rapid assessments of the

100. *See generally* The Annual Energy Outlook: A Brief Overview, *supra* note 86, at 2 (noting few other analyses exist that are comparable to the AEO, in part due to the extensive resources required to produce a multi-decadal projection of the U.S. energy system).

101. *See generally* Brian O'Neill & Mausami Desai, *Accuracy of Past Projections of US Energy Consumption*, 33 ENERGY POL'Y 979 (2005); Jamee Winebrake & Denys Sakva, *An Evaluation of Errors in US Energy Forecasts: 1982–2003*, 34 ENERGY POL'Y 3475 (2006); Stefan Pfenninger et al., *Energy Systems Modeling for Twenty-First Century Energy Challenges*, 33 RENEWABLE & SUSTAINABLE ENERGY REVS. 74, 77–78 (2014); Xin Wen et al., *Accuracy Indicators for Evaluating Retrospective Performance of Energy System Models*, 325 APPLIED ENERGY 119906 (2022).

102. Neil Strachan, *UK Energy Policy Ambition and UK Energy Modelling—Fit for Purpose?*, 39 ENERGY POL'Y 1037, 1039 (2011).

103. *See* REPEAT: RAPID ENERGY AND POLICY EVALUATION AND ANALYSIS TOOLKIT, https://repeatproject.org (last visited Jan. 9, 2025).

104. The original model was developed for decarbonization pathways analysis and its primary novel contribution was to provide downscaled geospatial detail about what the energy transition will look like "on the ground." *See* ERIC LARSON ET AL., Net-Zero America: Potential Pathways, Infrastructure, and Impacts, FINAL REPORT SUMMARY 6–8 (Oct. 29, 2021), https://netzeroamerica.princeton.edu/img/

Biden Administration's climate policy proposals and, eventually, legislative proposals.[105] The REPEAT Project's reports generally were optimistic about BIL and IRA's climate impacts, but several of them also included a cautionary note on the interpretation of the analytical results:

> Optimization modeling used in this work assumes rational economic behavior from all actors. The modeling also has limited 'frictions' on deployment of infrastructure (e.g., power generation or transmission capacity), scale-up of industry supply chains (e.g., wind and solar), or consumer adoption of alternative products (e.g., EVs, heat pumps). . . . [T]hese results indicate what decisions make good economic sense for consumers and businesses to make. This is likely a necessary condition, but whether or not actors make such decisions in the real world depends on many factors we are unable to model. . . . Readers should interpret modeled results accordingly.[106]

The importance of these caveats to the interpretation of the REPEAT Project's modeling results cannot be overstated. The REPEAT Project authors clearly stated that their models predict how BIL and IRA will work in a world where all decision-making is economically rational and where virtually no transaction costs or other impediments to technology transition exist. The reports did not say in what direction these caveats would influence the model's results, but all of the limitations mentioned would tend to reduce the laws' effectiveness. That is, REPEAT's legislative impact analyses provide predictions about an energy system that does not actually exist because they do not include real-world constraints like consumer behavioral barriers to EV adoptions[107] or lengthy delays in energy facility siting and construction.[108] Nor is the potential magnitude of these omissions examined, although a separate REPEAT report concluded that transmission constraints alone could reduce BIL and IRA's climate benefits by as much as 80 percent.[109] The true headline of the REPEAT Project is that BIL and IRA will be effective only if the constraints to their effectiveness are also overcome.

Unfortunately, none of the media coverage citing the REPEAT Project's modeling predictions mentioned the report's specific caveats.[110] Paul Krugman

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Princeton%20NZA%20FINAL%20REPORT%20SUMMARY%20(29Oct2021).pdf. The REPEAT Project reports do not assess the model's predictive accuracy when used to evaluate legislation.

105. *See Reports*, REPEAT: RAPID ENERGY AND POLICY EVALUATION AND ANALYSIS TOOLKIT, https://repeatproject.org/reports (last visited Jan. 9, 2025).

106. JESSE D. JENKINS ET AL., PRELIMINARY REPORT: THE CLIMATE AND ENERGY IMPACTS OF THE INFLATION REDUCTION ACT OF 2022 5 (2022), https://repeatproject.org/docs/REPEAT_IRA_Prelminary_Report_2022-09-21.pdf. The language in other reports is not identical but is substantially similar.

107. *See, e.g.*, Pedro Gerber Machado et al., *Electric Vehicles Adoption: A Systematic Review (2016-2020)*, 12 WIRES ENERGY AND ENV'T 1, 9 (2023).

108. *E.g.*, Lawrence Susskind et al., *Sources of Opposition to Renewable Energy Projects in the United States*, 165 ENERGY POL'Y 1, 5–8 (2022).

109. JENKINS ET AL., *supra* note 93, at 5.

110. *E.g.*, Nadja Popovich and Brad Plumer, *How the New Climate Bill Would Reduce Emissions*, N.Y. TIMES, https://www.nytimes.com/interactive/2022/08/02/climate/manchin-deal-emissions-cuts.html (last updated Aug. 12, 2022) (mentioning there are "major uncertainties around the bill's precise effects"

did not delve into these nuances when, citing the REPEAT Project's conclusions, he wondered whether BIL and IRA had "saved civilization."[111] Similarly, to the best of this author's knowledge, no one who cited the REPEAT project's numbers highlighted the problems with the predictive ability of the modeling.[112] This is particularly problematic where all of the unmodeled factors mentioned by the model authors were likely to slow the deployment of technologies that are the foundation of the models' predictions—i.e., are likely to result in real-world results substantially worse than those of the purely economic prediction.

All of this was also true of the other commonly discussed rapid impact report, produced by a consulting firm called the Rhodium Group, which, prior to issuing rapid impact reporting related to BIL and IRA had released an annual projection of future U.S. greenhouse gas emissions under current policies based on NEMS, the same model used by EIA to create its AEOs.[113] Rhodium updated its existing model to incorporate information about the new policies from IRA, publishing a preliminary assessment before Congress passed the law, and a final assessment the next month.[114] The Rhodium Group reports contained none of the modeling caveats or uncertainty discussions included in the REPEAT reports, or in the EIA's reports using NEMS, although Rhodium did briefly disclose that their results reflect "uncertainty around economic growth, clean technology costs, and fossil fuel prices."[115] Again, these fundamental uncertainties were not mentioned in reporting or commentary on the Rhodium Group reports.

Regardless of the caveats included in the fine print, REPEAT and Rhodium consistently projected that the passage of BIL and IRA would reduce emissions substantially as compared to a world without the laws, and these projections proved extremely influential. Although this was the first time that non-experts and the media began relying on the results of these types of models to understand and make claims about climate legislation while it was under active debate, they did so without sufficient attention to the material caveats that altered the meaning of the reports' results. The resulting discourse failed to communicate the shortcomings of the models used to create the projections, and, given the models' systematic failure to incorporate constraints, therefore tended to systematically

without further explanation); Dave Levitan, *EPA Finds Biden's Inflation Reduction Act Will Take a Huge Bite Out of Emissions*, THE MESSENGER (Sept. 12, 2023).

111. Paul Krugman, *Did Democrats Just Save Civilization?*, N.Y. TIMES (Aug. 8, 2022), https://www.nytimes.com/2022/08/08/opinion/climate-inflation-bill.html.

112. *See generally The REPEAT Project in the Media*, REPEAT, https://repeatproject.org/media (last visited Jan. 13, 2025) (internal citations omitted) (lacking a substantive discussion of material caveats).

113. *E.g.,* BEN KING ET AL., TAKING STOCK 2022: US GREENHOUSE GAS EMISSIONS OUTLOOK IN AN UNCERTAIN WORLD 4–5 (2022), https://rhg.com/research/taking-stock-2022/; HANNAH PITT ET AL., TAKING STOCK 2021: US EMISSIONS OUTLOOK UNDER CURRENT POLICY 4–5 (2021), https://rhg.com/research/taking-stock-2021/. These are conducted on a version of the NEMS model maintained by the Rhodium group for this purpose.

114. Ben King et al., *A Congressional Climate Breakthrough*, RHODIUM GRP. (July 28, 2022), https://rhg.com/research/inflation-reduction-act; JOHN LARSEN ET AL., A Turning Point for US Climate Progress: Assessing the Climate and Clean Energy Provisions in the Inflation Reduction Act 1 (2022), https://rhg.com/research/climate-clean-energy-inflation-reduction-act (both using the RHG-NEMS model).

115. *Id.*; LARSON ET AL., *supra* note 109, at 3.

overstate the likely impact of BIL and IRA's spending provisions on U.S. greenhouse gas emissions.

E. The Post-Enactment Proliferation of BIL and IRA Predictive Models and Reports

Although the models discussed above were the most prominently reported, dozens of other energy-economic models were deployed around the same time to predict the impact of BIL and IRA on the U.S. energy system and its climate emissions profile. The precise number of models is impossible to ascertain—there are dozens of them in use in academic labs, government agencies, consulting firms, and advocacy organizations, many of which can easily be adapted to provide their own output of worlds with and without any given legislation, but few of which have been described in detail or demonstrated to have a strong predictive track record.[116] The proliferation of these models, however, has resulted in efforts to collect their results together and assess whether they are consistent, and this has led to further discourse about the meaning of these analyses on the credibility of the underlying models.[117]

The first effort at gathering together BIL and IRA predictive models was published in 2023 in *Science*, which is a highly credible and extremely well-respected peer-reviewed scientific journal.[118] The article presented the results of what is called "a model intercomparison project," meaning an examination of how multiple models handle the same set of conditions.[119] Written by the authors of the models that were compared, the study presented the various models' outputs while running as close as possible the same scenarios.[120] The results were widely variable, and the report included the usual interpretive caveats.[121] The predictive accuracy of the models was neither assessed nor discussed. Peer-reviewed publication is often noted as a proxy for scientific credibility and even truth,[122] but publication of the details of these models, and discussion and comparison of their outputs, is not the same as validating the accuracy of the

116. *E.g.*, Ekaterina Rhodes et al., *How Do Energy-Economy Models Compare? A Survey of Model Developers and Users in Canada*, 13 SUSTAINABILITY 1, 1–2 (2021) (seventeen models in Canada).

117. *See generally* Matteo Giacomo Prina et al., *Comparison Methods of Energy System Frameworks, Models and Scenario Results*, 167 RENEWABLE & SUSTAINABLE ENERGY REVS. 1 (2022) ("Increasing computing capabilities have resulted in a huge growth of the number of energy system models during the last 20 years.").

118. *See generally* John Bistline et al., Emissions and Energy Impacts of the Inflation Reduction Act, 380 SCIENCE 1324 (2023).

119. *Id.; see, e.g.*, *Model Intercomparison Projects*, COUPLED MODEL INTERCOMPARISON PROJECT, https://wcrp-cmip.org/mips/ (last visited Jan. 13, 2025) (describing concept and linking to dozens of climate-related MIPs).

120. Bistline et al., *supra* note 105, at 11–59.

121. *Id*. at 1327 ("Models attempt to capture many economic factors that could influence technology adoption, but several implementation challenges are difficult to model, including the scale-up of supply chains and materials, siting and permitting, infrastructure expansion, network effects, non-cost barriers to consumer uptake of incentives, and the economic incidence of subsidies.").

122. *E.g.*, Dan Farber, *Predictions of IRA's Success Solidify*, LEGAL PLANET (Sept. 21, 2023), https://legal-planet.org/2023/09/21/predictions-of-iras-success-solidify.

models' predictions, especially, in this case, as the predictive accuracy was not evaluated. Nor does peer review of such a study constitute expert determination of the models' accuracy. However, there is a risk that, without reading the *Science* piece closely, these models might be mistaken to be "peer reviewed" for their accuracy and credibility, rather than simply included in a multi-model analysis that itself was peer reviewed.

In the same vein, in September 2023, EPA published a study that collected together and discussed the results of even more models.[123] EPA prominently noted that the report had been "peer reviewed" by a number of outside reviewers,[124] although expert feedback on a government report is not the same thing as blind peer review in a scientific journal.[125] EPA's study was also a model intercomparison report.[126] Again, the reviewed models demonstrated a broad range of results, and again, the study did not demonstrate that the models had a track record of predictive accuracy. Unlike many other such projects, however, EPA did discuss relevant modeling limits in detail, although this was buried deep within the report.[127] EPA also included a three-page discussion of an "illustrative, not exhaustive" list of "deployment challenges," all of which would tend to slow down the technology transition that the BIL and IRA models attempted to predict.[128] Unfortunately, EPA's report said very little about how these barriers would be addressed. Nor did EPA's press releases or outside reporting on EPA's study explain these caveats or their relevance to the interpretation of EPA's findings.[129] Again, then, there is a risk that this report will be taken as more of a validation of these models than it actually represents.

The overall impression left by these studies was that a wide range of models reached similar, optimistic conclusions about BIL and IRA's impacts, and that

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123. *See generally* EPA ASSESSMENT, *supra* note 6; IRA § 60107 (requiring EPA to submit a report 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").

124. *See* EPA ASSESSMENT, *supra* note 6, at 3.

125. The EPA report was subject to external expert review pursuant to long-standing EPA policies. *See* EPA ASSESSMENT APPENDIX H, https://www.epa.gov/system/files/documents/2023-09/Electricity_Emissions_Impacts_Inflation_Reduction_Act_Report_Appendix.pdf, *and see* EPA, Peer Review Handbook 4th Ed. (2015), https://www.epa.gov/sites/default/files/2020-08/documents/epa_peer_review_handbook_4th_edition.pdf. For a general introduction to the issues faced in government agency scientific peer review, *see* GAO, Peer Review: EPA's Implementation Remains Uneven (1996), https://www.gao.gov/assets/rced-96-236.pdf; National Research Council, Strengthening Science at the U.S. Environmental Protection Agency: Research-Management and Peer-Review Practices (2000), https://nap.nationalacademies.org/catalog/9882/strengthening-science-at-the-us-environmental-protection-agency-research-management. Rather than a highly rigorous, confidential vetting of publication methods and conclusions that can result in rejection of the piece, agency peer review involves asking reviewers to answer specific questions and then incorporating their answers "as appropriate" into the final product. EPA Peer Review Handbook at 10.

126. EPA ASSESSMENT, *supra* note 6, at 8–9 (presenting "projected reductions in CO_2 emissions due to the IRA provisions" in "ten multi-sector models and four electric sector models").

127. *See id*. at 33–34.

128. *Id*. at 35–37.

129. *Electric Sector Emissions Impacts of the Inflation Reduction Act*, EPA, https://www.epa.gov/inflation-reduction-act/electric-sector-emissions-impacts-inflation-reduction-act (last visited Jan. 13, 2025) (listing "key findings" emphasizing the laws' impact).

these predictions, being similar, also tend to corroborate each other. But that is not, in fact, what these reports were showing. Rather, they showed that different models produced a range of predictions, and, although many of them tended to show positive impacts, this is to some unknown degree due to their being designed in the same way and in part due to their inability to model real-world factors that would tend to show otherwise. Running similar models with similar assumptions logically produces somewhat similar outcomes, and the most accurate interpretation of these outcomes is that it was not clear what BIL and IRA would do because the real-world outcome would depend on many more factors than the available models could assess.

In sum, energy-economic predictive modeling came to dominate the discourse around BIL and IRA's impacts. Yet, of the many modeling projects used as evidence of BIL and IRA's likely future impacts, few if any have ever been evaluated to determine whether they are providing accurate predictions. Rather, their top-line results were presented and widely reported as fact, with material caveats buried in the fine print and ignored. The problems with these models are well understood, but the desire to rapidly communicate certainty and assurance and to use modeling results to promote and justify legislative decisions saw these necessary cautions scattered to the winds.

II. BREAKING DOWN A BIL AND IRA IMPACT PROJECTION

The predictive limitations discussed in Part I are fundamental to all energy-economic modeling used today to analyze climate legislative impacts. The burden is on those using these models to demonstrate that they can make accurate predictions. Still, to demonstrate the models' limitations in practice, this Part examines a single predictive modeling effort in detail. This helps us assess what the model was actually doing when it translated its abstract numeric predictions into relatively concrete real-world equivalents by comparing those predictions to the available evidence. This analysis shows that, underneath a veneer of quantitative invulnerability, the model made some questionable claims about the future.

The model under examination was described in a Department of Energy report titled *Investing in American Energy: Significant Impacts of the Inflation Reduction Act and Bipartisan Infrastructure Law on the U.S. Energy Economy and Emissions Reductions* (the DOE Report).[130] It was selected for examination here in part because it was produced by a federal agency and, in part, because it was built on a customized version of the NEMS model discussed in the prior Part.[131] It is neither the best- nor worst-documented effort to model BIL and IRA, nor the most nor least optimistic about BIL and IRA's impacts. It is, rather, an

130. DOE REPORT, *supra* note 6; U.S. DEP'T OF ENERGY, OFF. OF POLICY, TECHNICAL APPENDIX, INVESTING IN AMERICAN ENERGY: SIGNIFICANT IMPACTS OF THE INFLATION REDUCTION ACT AND BIPARTISAN INFRASTRUCTURE LAW ON THE U.S. ENERGY ECONOMY AND EMISSIONS REDUCTIONS [hereinafter Technical Appendix] (Aug. 2023), https://www.energy.gov/sites/default/files/2023-08/2023%20Economy%20Wide%20Technical%20Implementation.pdf.

131. NEMS itself is not examined in detail primarily because, as discussed below, EIA's conservative assumptions in its 2023 AEO resulted in much lower impact projections than the DOE report, and thus do not demonstrate the "overselling" problem of concern here.

interesting example of the problems discussed above. It appears, furthermore, that DOE's effort was driven by a dissatisfaction with the treatment of BIL and IRA by EIA in the 2023 AEO, and the study was intended to demonstrate that BIL and IRA's impacts would be greater than what EIA had projected. But consistent with the warnings given above, the DOE's model tended to overstate what BIL and IRA could achieve.

A. DOE's OP-NEMS Model

The model used to generate the DOE Report examined in this Part was based on NEMS, but it was not the standard version. Rather, it was a custom version called "OP-NEMS" built by the DOE Office of Policy specifically to examine BIL and IRA's impacts.[132] DOE explained that the OP-NEMS model incorporated three additional modeling elements into the basic NEMS model, each representing aspects of BIL and IRA not modeled in NEMS itself: 1) a NEMS-compatible module representing the costs of carbon transport, utilization, and storage; 2) adjustments to incorporate additional building energy efficiency policies; and 3) other modifications related to clean hydrogen and biofuels production.[133] While the first of these additional elements is described in other literature,[134] there is currently no public information about the other two model extensions that were used in OP-NEMS. It appears, however, that DOE considered these additions necessary to capture the effects of BIL and IRA provisions that were not otherwise factored into the EIA's most recent AEO.[135]

The OP-NEMS model is also different from the usual implementation of NEMS in how it deals with law. As discussed in the prior Part, NEMS is not usually used to examine the impact of specific laws because it does not generally compare scenarios with and without the legislation in question. Rather, every year, all NEMS cases used to create the AEO are updated to incorporate all the laws that currently exist under the assumption that they will not change.[136] This means that the only way to examine the impact of any given piece of existing legislation using NEMS-as-designed is to compare the reference cases (the best-guess baseline projections) from previous years' AEOs. If the 1993 and 1994 greenhouse gas projections for the year 2000 were lower than those in 1992, that *could* be evidence that the Energy Policy Act of 1992 was having some effect.

132. Recall that the Rhodium Group model, RHG-NEMS, is similarly based on NEMS.

133. *Office of Policy - National Energy Modeling System (OP-NEMS)*, U.S. DEP'T OF ENERGY, https://www.energy.gov/policy/office-policy-national-energy-modeling-system-op-nems (last visited Jan. 13, 2025).

134. The original parameters of CTUS-NEMS were described, generally, in CHARLES ZELEK ET AL., BENEFITS OF THE NETL CLEAN COAL AND CARBON MANAGEMENT PROGRAM (2016), https://www.netl.doe.gov/projects/files/BenefitsoftheNETLCleanCoalandCarbonManagementProgram_041516.pdf; *see also* Hillard G. Huntington et al., *Key Findings from the Core North American Scenarios in the EMF34 Intermodel Comparison*, 144 ENERGY POL'Y 1, 4 (2020) (discussing the origin of CTUS-NEMS); *NETL Develops Flexible Carbon Capture, Utilization and Storage Analysis Tools and Resources*, NAT'L ENERGY TECH. LAB'Y (Dec. 19, 2019), https://netl.doe.gov/node/9384.

135. The author requested a copy of the model and was informed it is not publicly available.

136. AEO 2023, *supra* note 81, at 1 ("The Reference case represents our best guess under nominal conditions, which presumes no new policy or laws over the modeled time horizon.").

And, as EIA explains, greenhouse gas projections *have* trended downward in the AEO reports year after year as various laws have been incorporated into the model.[137] But this process does not isolate the impacts of any single law.

However, EIA will sometimes make NEMS cases that examine the impact of individual laws or policies. Since BIL and IRA had already been enacted, EIA's 2023 AEO reference case included BIL and IRA. But EIA also created a special "no-IRA" side case for its AEO that attempted to isolate the impacts of IRA's provisions by creating a side case that did not include them.[138] The result of this analysis was that without IRA, U.S. greenhouse gas emissions would fall 26 percent below 2005 levels by 2030, while with IRA, emissions would fall between 27 and 34 percent below 2005 emissions levels by 2030.[139] In other words, AEO 2023 predicted quite small reductions due to IRA's provisions. DOE built OP-NEMS on the EIA's no-IRA side case.[140] Thus, OP-NEMS was based on a no-IRA version of NEMS that was then updated with more recent economic data—but without the adjustments EIA made to factor in BIL and IRA's impacts. DOE's analysis was then built around three scenarios: 1) a baseline scenario representing a world without BIL and IRA (or where BIL and IRA have no effect), 2) a "moderate" scenario embodying middle-of-the-road assumptions about how successful BIL and IRA will be (per DOE), and 3) an "advanced" scenario embodying more favorable assumptions about BIL and IRA's efficacy.[141] The moderate and advanced scenarios each incorporated assumptions about forty-four provisions in BIL and IRA, including numerous provisions not modeled by EIA.[142] Unlike EIA's no-IRA analysis, DOE did not include a low-uptake scenario. It studied the good- and best-case outcomes, but not a worst-case scenario.

In sum, DOE's analysis was built on an experimentally extended version of an experimentally modified version of a NEMS side case. It is not inherently problematic to base policy efficacy claims on an experimental mix of modeling extensions of NEMS as used in this fashion. But there is no information available about the predictive power of any of these changes and no reason to assume that

137. *Id.* at 31.

138. The 2023 version of NEMS is available as a 549 MB download at *Annual Energy Outlook 2023*, U.S. ENERGY INFO. ADMIN. (Mar. 16, 2023), https://www.eia.gov/outlooks/aeo/info_nems_archive.php. The modeling files include scedes.noIRA, and other files tagged _noIRA, which constitute the no-IRA side case. These were not, however, discussed in its AEO 2023 report. Rather, they were reported in U.S. ENERGY INFO. ADMIN., AEO2023 Issues in Focus: Inflation Reduction Act Cases in the AEO 2023 (2023), https://www.eia.gov/outlooks/aeo/IIF_IRA/pdf/IRA_IIF.pdf [hereinafter AEO IRA ANALYSIS]; *Today in Energy: EIA Explores Effects of Inflation Reduction Act on the Annual Energy Outlook*, U.S. ENERGY INFO. ADMIN. (Apr. 6, 2023), https://www.eia.gov/todayinenergy/detail.php?id=56080). Note that AEO reference case did not examine most of the building efficiency provisions enacted in BIL, and thus the "no-IRA" side case is also a "no-BIL" case. See discussion below.

139. AEO IRA ANALYSIS, *supra* note 124, at 6.

140. TECHNICAL APPENDIX, *supra* note 116, at 1 (stating that the analysis was "based on a Pre-IRA/BIL baseline scenario (No BIL/IRA). The No BIL/IRA scenario is built in OP-NEMS to be analogous to the EIA Annual Energy Outlook 2022 (AEO2022), the most updated publicly available version of the AEO available at the time of modeling").

141. *Id*. at 1–2.

142. *Id.* at 2–4.

they are any more capable of accurate prediction than is NEMS itself. Still, DOE's new modeling assumptions dramatically increased how impactful the model said BIL and IRA would be, and those top-line results were highlighted to emphasize the laws' impacts.

B. OP-NEMS Top-Line Results

The DOE Report's top-line conclusion was that BIL and IRA were projected to reduce U.S. annual greenhouse gas emissions from about 4.8 gigatons CO_2 equivalent ($GTCO_2e$) in 2030 (27 percent below 2005 levels) in a world without the laws, to between about 3.9 and 4.3 $GTCO_2e$ in 2030 (35–42 percent below 2005 levels) in a world with the laws.[143] See Table 1. That is, DOE projected that BIL and IRA would reduce U.S. annual emissions by about 0.5 to 0.9 billion tons per year in 2030, an additional 8–15 percent below 2005 levels as compared to the world without the laws.

Table 1. DOE Projection of BIL and IRA's Impacts on U.S. GHG Emissions in 2030

U.S. 2030 Emissions	No BIL and IRA	"Mod" Projection	"Adv" Projection
Absolute	4.8 $GTCO_2e$	4.3 $GTCO_2e$	3.9 $GTCO_2e$
Percent below 2005	-27 percent	-35 percent	-42 percent

It should be noted that the DOE Report and accompanying press information never directly said that BIL and IRA *would* achieve these results. Rather, DOE stated that "President Biden's Investing in America agenda *is positioned to* . . . [r]educe U.S. net greenhouse gas emissions,"[144] that the laws "*enable* the U.S. to make significant headway toward climate targets," and that "DOE's analysis *shows*" the reductions discussed above.[145] Yet, in the DOE Report itself this more cautious language quickly gave way to more direct claims of causation: "Collectively, IRA and BIL provisions *lead to* accelerated deployment of clean electricity, *resulting in* a rapid reduction in electricity emissions, greater electrification in the transportation sector," etc.[146] Throughout the report, the implication was that these are the most accurate and dependable

143. DOE REPORT, *supra* note 6, at 5. Equivalencies from stated percentages to absolute terms are calculated using the data in the EPA Greenhouse Gas Inventory Data Explorer, *supra* note 6.

144. U.S. Dep't of Energy, *Investing in American Energy: Significant Impacts of the Inflation Reduction Act and Bipartisan Infrastructure Law on the U.S. Energy Economy and Emissions Reductions*, U.S. DEP'T OF ENERGY OFF. OF POL'Y (Aug. 16, 2023), https://www.energy.gov/policy/articles/investing-american-energy-significant-impacts-inflation-reduction-act-and (emphasis added).

145. DOE REPORT, *supra* note 6, at 5 (emphasis added).

146. *Id*. (emphasis added); *see also id.* at 7 ("The share of electricity generated from clean sources increases from 42% in 2022 to 72%–81% in 2030.") (internal citation omitted); *id.* at 8 ("Energy-related transportation CO_2 emissions decline 19%–24% below 2005 levels in 2030 as the fleet of cars and trucks transitions to zero emission vehicles.").

predictions of BIL and IRA's impacts possible and that the laws would achieve the results projected.

DOE's visual presentation of its top-line impact projection is reproduced in Figure 1a, and there were several shortcomings with this presentation that also deserve preliminary comment.[147] First, DOE's figure visually emphasized the magnitude of the laws' impact by setting its y-axis at 3.8 gigatons rather than 0.0. This is not a minor point: although dogmatic adherence to a "start the y-axis at 0" rule is not always necessary, upward adjustment of the baseline is recognized as a potentially misleading data visualization technique. If comparisons with zero are central to the problem, the best rule is to select a "logical and meaningful" baseline and to start at zero.[148] Since international climate policy is built around achieving net *zero* greenhouse gas emissions by 2050 and the purpose of emissions reduction impact projections is to assess progress toward net zero, it would make better visual sense to display the graphical baseline at zero gigatons in this case. Therefore, Figure 1b shows the same information, except with the y-axis extended to start at zero.

Second, the DOE Report did not present the information in the context of comparisons to other projections of the laws' impacts, nor to prevailing national or international goals. For example, early impact projections from the REPEAT Project and Rhodium Group said that these laws would achieve emissions reductions of 31–44 percent below 2005 levels by 2030.[149] DOE's analysis produced a range of 35–42 percent, largely consistent with initial optimistic projections, although with somewhat higher low-side and lower high-side projections than initially hoped. This is useful information and has been added to Figure 1b. Furthermore, at this time, the Biden Administration had set the U.S. national climate goal for emissions at 50–52 percent below 2005 levels by 2030, equivalent to annual national emissions of 3.3 gigatons in 2030,[150] a deeper reduction than even DOE's most optimistic impact projection. Another reframing, therefore, could be that the DOE Report concluded that BIL and IRA alone would miss the Administration's own targets substantially—achieving only about half of what the Administration deemed necessary to keep on track. Again, this is useful information and is included in Figure 1b.

Third, the information was similarly not presented in the context of the AEO 2023 projections that the report is implicitly responding to. EIA's projections did not incorporate all of the provisions that DOE did, but the magnitude of the

147. NB: the DOE is by no means the only agency to present its findings in this fashion, and these comments apply equally to any visual presentation of this kind of information.

148. *E.g.*, ALBERTO CAIRO, THE TRUTHFUL ART: DATA, CHARTS, AND MAPS FOR COMMUNICATION (2016) ("We can derive a simple and flexible rule from this discussion: rather than trying to invariably include a [zero]-baseline in all your charts, use logical and meaningful baselines instead.") (emphasis omitted); *see also How to Determine Whether or Not the Y-Axis of a Graph Should Start at Zero?*, STACKEXCHANGE, https://stats.stackexchange.com/questions/184525/how-to-determine-whether-or-not-the-y-axis-of-a-graph-should-start-at-zero (last visited Jan. 13, 2025) (discussing this issue, including: "Show zero on the y axis if comparisons with zero are central to the problem, or even of some interest").

149. King et al., *supra* note 113 (Rhodium: "we estimate the IRA will reduce emissions by 31-44% below 2005 levels by 2030."); JENKINS ET AL., *supra* note 94, at 7 (projected reduction of 42% below 2005 levels).

150. *See* WHITE HOUSE, *supra* note 6.

difference is remarkable and important to highlight. EIA projected that IRA would reduce U.S. greenhouse gas emissions 27–34 percent below 2005 levels.[151] It is useful to note that whatever changes DOE made to the NEMS model, those changes more than doubled EIA's impact projections and would highlight the importance of understanding how these models are different. One possible interpretation is that EIA's failure to incorporate certain provisions resulted in under-projection; another is that DOE's alterations resulted in over-projection. Either way, these questions are easily indicated by including EIA's predictions on the same graph. Once again, this information is included in Figure 1b.

Fourth, ending the visual projection in 2030 had at least two important consequences: it avoided discussing both the 2050 goal and whether the laws' projected impacts would be permanent. It would have been helpful to know whether the laws' salutary projected effects were predicted to continue at the same rate toward 2050 or to level out after 2030. This makes an enormous difference by 2050, where a forward projection of DOE's best-case scenario gets the country almost all the way to its ultimate goal. In contrast, a slowing of the worst-case projection could mean that all we get out of the law is the initial effect. In 2050, we would still have far to go. Likely, the answer is somewhere in between the two extremes, in the range of uncertainty indicated on Figure 1b, but this question was not even addressed by DOE. Since NEMS (and therefore OP-NEMS) produces projections out to 2050, it would have been worthwhile to include the complete projections.

Fifth and finally, it is worth noting that the DOE figure did not indicate that the DOE's model only produced mid- and high-impact ranges, and no low-impact result, while the other analyses assessed low- to high-impact results. Since other analyses indicate that there is very little difference between "no BIL/IRA" and "low-BIL/IRA" scenarios, DOE might have been better served representing its no-BIL/IRA as the bottom of the modeling range in the same color as the other projections. Again, this is reflected in Figure 1b.

With the top-line results more completely contextualized, it is easier to determine whether they are also accurate.

151. AEO IRA ANALYSIS, *supra* note 124, at 6.

Figure 1a: DOE OP Projection Original

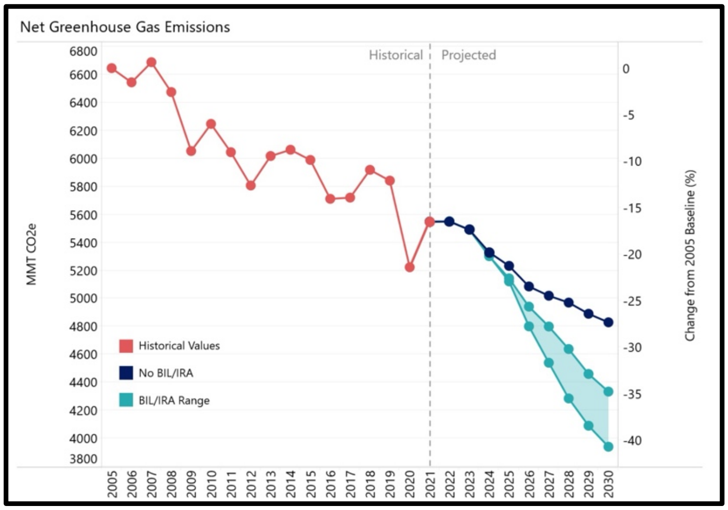
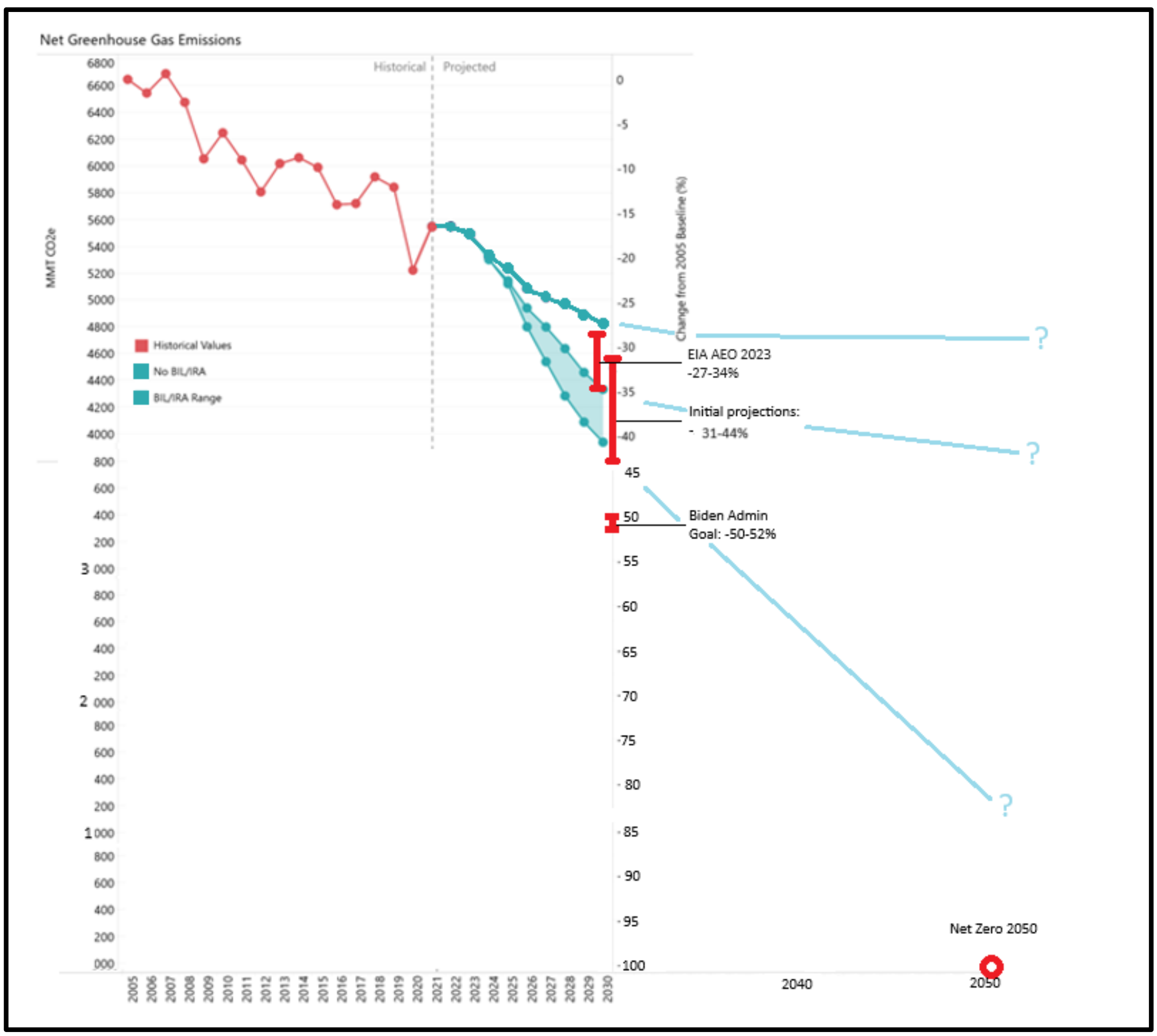


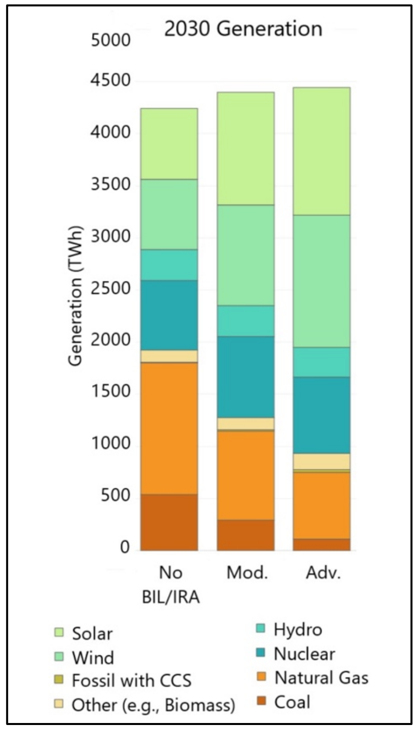
Figure 1b: Figure 1a with 0-Baseline, Projection and Goal Comparisons, and Projection Extensions



C. OP-NEMS Projected Impacts

DOE based its emissions reduction projections on the OP-NEMS's projections of the impacts of BIL and IRA's multiple spending provisions on a variety of energy system elements.[152] The first and most important of these was the amount of increase in clean electricity production, especially wind and solar, that it predicted BIL and IRA's tax credits and spending programs would create. The second was how much new tax credits would drive up the total market share of electric vehicles. Provisions promoting clean fuels, domestic manufacturing, home energy efficiency, and industry carbon capture and storage accounted for the remainder of the projected reductions.

Fig. 2: DOE Report Projection of 2030 Electricity Production by Source



The following Subparts examine the DOE model's projections of these provisions by determining what they meant in real-world terms—and whether those real-world projections were realistic. Consistent with the warnings discussed above, the model often assumed away major known impediments, and those omissions resulted in far higher-impact projections than made sense when considering the context that actually matters: the real world.

1. Low-Carbon Electricity Production

The DOE Report predicted that BIL and IRA would drastically change the nation's electric generating fleet, with coal-fired power plants largely disappearing and natural gas also diminishing, replaced with massive buildouts of wind and especially solar, as a direct result of BIL and IRA's enactment.[153] Per the model, this change was solely attributable to the low-carbon electricity spending programs enacted in IRA.[154]

152. *See generally* TECHNICAL APPENDIX, *supra* note 117.
153. *See* DOE REPORT, *supra* note 6, at 7.
154. *See id.*

The first of these programs are the tax credits.[155] Prior to IRA's enactment, the Section 45 production tax credit (PTC) had not been available for large solar installations for many years and had ended for large wind installations in 2021,[156] while the Section 48 investment tax credit (ITC) had been eliminated for onshore wind and subject to uncertainty for other resources for many years.[157] IRA re-extended both of these credits, and made them fully available for large-scale wind and solar energy facilities past 2030. Although restructured, the law maintained the standard PTC amount at its existing level ($26/MWh),[158] and the standard ITC value at its existing level (30 percent of facility construction cost).[159] IRA also created two new opportunities to increase PTC and ITC amounts by using domestically sourced materials and building facilities in "energy communities."[160] Thus, the maximum PTC a qualifying facility can receive is about $32/MWh,[161] while the maximum ITC is 50 percent of facility

155. IRA §§ 13101, 13701–02, 13702, 13105. Production tax credits (PTC) reduce a qualifying energy facility owner's tax liability per unit of energy produced at the facility during a qualifying period. Investment tax credits (ITC) reduce a qualifying energy property owner's tax liability by a percentage of the construction cost of the facility. Although the Section 45 PTC and Section 48 ITC will be replaced by the Section 45Y Clean Energy Production and 45E Clean Electricity Investment credits in 2025, the differences are not relevant for the projections discussed here. Facilities that receive these credits are also eligible for accelerated depreciation. *Id.* § 13703.

156. *Inflation Reduction Act Extends and Modifies Tax Credits for Wind Projects*, MCGUIRE WOODS (Aug. 24, 2022), https://www.mcguirewoods.com/client-resources/alerts/2022/8/inflation-reduction-act-tax-credits-for-wind-projects/; Adam Schurle & Tori Roessler, *The Inflation Reduction Act: Key Provisions Regarding the ITC and PTC*, FOLEY & LARDNER LLP (Aug. 12, 2022), https://www.foley.com/insights/publications/2022/08/inflation-reduction-act-key-provisions-itc-ptc/.

157. The ITC credit amounts as of 2021 were complex and varied by resource type, with solar at 26 percent, offshore wind at 30 percent, small wind at 26 percent, and onshore utility-scale wind excluded. *See* CONG. RSCH, SERV., THE ENERGY CREDIT OR ENERGY INVESTMENT TAX CREDIT (ITC) 1 (Apr. 23, 2021) (describing evolution of credits and status as of 2021).

158. NB: technically, the law set the baseline PTC at about ≈$5.20/MWh, with a 5x multiplier for meeting the new conditions. However, conceptually, this is the same as maintaining the existing credit amount and adding additional conditions, which is how it is described here. Regarding the credit amount, statutory PTC credit amounts are stated in terms of c/kWh in 1992 dollars, adjusted for inflation. 26 U.S.C. § 45(e). Therefore, the real PTC amount differs substantially from statutory credit amounts. In 2022, the *statutory* PTC was 1.5 c/kWh ($15/MWh), but the inflation-adjusted PTC was 2.6 c/kWh ($26.00/MWh). *See*, *e.g.*, Isaac L. Maron, *Updated: IRS Releases 2022 Section 45 Production Tax Credit Amounts*, MAYER BROWN (May 6, 2022), https://www.mayerbrown.com/en/insights/publications/2022/05/irs-releases-2022-section-45-production-tax-credit-amounts (reporting adjustment of 2022 inflation factor to 1.7593). IRA maintained the 1.5 c/kWh base amount (subject to the conditions discussed below), and did not change the Section 45 inflation adjustment calculation.

159. Again, the statute sets the baseline ITC lower, at 6 percent and with a 5x multiplier as a bonus for meeting the new requirements, and, again, this is the same as extending the original ITC amount and adding conditions. 26 U.S.C. §§ 48(a)(2)(a), (a)(9)(a)(i) (six percent energy percentage baseline and 5x conditioned multiplier).

160. 26 U.S.C. §§ 45(b)(9), 48(a)(12) (domestic content bonuses: 10 percent increase in PTC amount, and 10 percent increase in total ITC); 26 U.S.C. § 45(b)(11), 48(a)(14) (energy community bonuses: identical increases for construction on a brownfield site or in an economically depressed coal community, or near a retired coal mine or coal-fired power plant).

161. That is, $15/MWh (meeting PWA requirements) * 1.20 (both bonus credits) * 1.7593 (current IRS inflation factor).

construction cost.[162] However, receipt of the full credit amounts was conditioned on meeting new "prevailing wage and apprenticeship" (PWA) requirements: Workers employed in the construction of a qualifying facility must receive prevailing wages and trainees must undertake a minimum percentage of that construction labor. These provisions were intended to increase and expand the workforce necessary for renewable energy construction.[163] IRA also included a new tax credit for nuclear power plants, adding a variable PTC for nuclear power generation, conditioned on prevailing wage requirements for maintenance labor.[164]

In the OP-NEMS no-BIL/IRA scenario, these credits were treated as expired, so no facilities qualified for them through 2030. In both the moderate and advanced IRA scenarios, OP-NEMS assumed that the credits were available and, furthermore, that all of the facilities otherwise qualifying for the credit would be able to meet the new PWA requirements.[165] The moderate scenario also assumed that all the facilities would qualify for at least one of the bonus credits (working out to a \$29/MWh PTC and 40 percent ITC available for all new wind and solar), while the advanced scenario assumed that about half would also qualify for a second bonus credit (a \$30/MWh PTC and 45 percent ITC for all wind and solar).[166] As data about the impact of the PWA requirements or bonus credit qualification would not be available for at least several years, both of these assumptions were extremely generous.

IRA also appropriated \$1 billion for the USDA to provide loan guarantees for rural renewable energy development[167] and appropriated \$1.72 billion for the Rural Energy for America Program, which in part supports the development of

162. Calculated as 6 percent credit and 5x multiplier totaling 30 percent, plus 20 percent increase for energy community and domestic content bonuses. *See* David Burton and Hilary Lefko, *Q&A on the Inflation Reduction Act*, NORTON ROSE FULBRIGHT (Aug. 19, 2022), https://www.projectfinance.law/tax-equity-news/2022/august/qa-on-the-inflation-reduction-act (discussing new ITC mechanisms); INTERNAL REVENUE SERV., DOMESTIC CONTENT BONUS CREDIT GUIDANCE UNDER SECTIONS 45, 45Y, 48, AND 48E, NOTICE 2023-28 3–4 (2023), https://www.irs.gov/pub/irs-drop/n-23-38.pdf (clarifying that PTC "is increased by 10 percent (not 10 percentage points) if the Domestic Content Requirement is satisfied," while ITC is increased "by 10 percentage points"); INTERNAL REVENUE SERV., ENERGY COMMUNITY BONUS CREDIT AMOUNTS UNDER THE INFLATION REDUCTION ACT OF 2022, NOTICE 2023-29 3 (2023), https://www.irs.gov/pub/irs-drop/n-23-29.pdf (explaining that energy community bonus is calculated the same way).

163. 26 U.S.C. §§ 45(b)(8), 48(a)(11). If the facility fails to meet the PWA requirements, the PTC credit amount is ≈\$5/MWh, and the ITC credit amount is 6 percent.

164. 26 U.S.C. § 45U. In the case of nuclear, however, the credit value is significantly reduced depending on the price of electricity. Although the basic credit is \$15/MWh (with prevailing wage conditions met), that credit is reduced incrementally as the facility's power sales price exceeds \$25/MWh. *See* Paul A. Gordon et al., *Inflation Reduction Act of 2022 Boosts Nuclear Power with Tax Credits and Funding*, MORGAN LEWIS (Aug. 16, 2022), https://www.morganlewis.com/pubs/2022/08/inflation-reduction-act-of-2022-boosts-nuclear-power-with-tax-credits-and-funding (discussing operation of the reduction amount).

165. TECHNICAL APPENDIX, *supra* note 117 at 4 (assuming that the "wage and apprenticeship requirements can be met").

166. *Id*. (bonus credits of 10 percent and 15 percent in the moderate and advanced scenarios, respectively).

167. IRA § 22001 (amending 7 U.S.C. § 8103(h) and appropriating funds for loan program at 7 U.S.C. § 940g).

renewable energy technologies in farm operations.[168] IRA also allocated $10 billion to USDA to provide loans to rural electric cooperatives to undertake activities that "achieve the greatest reduction in [greenhouse gas] emissions associated with rural electric systems through the purchase of renewable energy, renewable energy systems, zero-emission systems, and carbon capture and storage systems, to deploy such systems, or to make energy efficiency improvements to electric generation and transmission systems."[169] In OP-NEMS the first two programs "were combined to fund new wind and solar PV power plants," and the third to "fund new wind, solar PV, and carbon capture power plants."[170] Again, these were very generous assumptions, as these programs are available for many other technologies, so were unlikely to be used entirely for carbon reduction projects as assumed in OP-NEMS.[171]

Although it is not possible to disaggregate the impact of each provision separately, DOE reported that its electricity sector projections were "driven in large part" by the tax credit provisions.[172] Specifically, OP-NEMS predicted that wind-generated electricity would increase to between 1000 and 1200 terawatt hours (TWh) in 2030 with BIL and IRA—compared to 750 TWh in 2030 without them and that total (utility- and small-scale) solar electricity generation would increase to between about 1000 and 1500 TWh in 2030 with BIL and IRA, compared to 700 TWh without them (see Figure 2).[173] Combined with steady hydroelectric power output and small increases in nuclear power output, the national share of low-carbon electricity in 2030 was projected to increase to between 72 percent (moderate scenario) and 81 percent (advanced scenario) with BIL and IRA, compared to about 58 percent without them.[174] In the moderate and advanced scenarios, lower-cost renewables displace drastically decreasing coal and natural gas use. To put these numbers into clearer context, in 2022 wind

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168. IRA § 22002(a); and *see Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Guaranteed Loans & Grants*, U.S. DEP'T OF AGRIC. RURAL DEV., https://www.rd.usda.gov/programs-services/energy-programs/rural-energy-america-program-renewable-energy-systems-energy-efficiency-improvement-guaranteed-loans (last visited Jan. 14, 2025).

169. IRA § 22004.

170. TECHNICAL APPENDIX, *supra* note 116, at 5.

171. See 7 U.S.C. §§ 8101 (spending allowed for any renewable energy source), 940g (spending allowed for wind, solar, biomass, geothermal, etc.). Breakdowns of past program spending by type are not available: individual awards for the Rural Energy for America Program, for example, are tracked at *Rural Energy for America Program, Rural Business-Cooperative Service, Agriculture*, USASPENDING.GOV, https://www.usaspending.gov/federal_account/012-1908 (last visited Jan. 14, 2025), but projects are not described.

172. DOE Report, *supra* note 6, at 7.

173. These figures are estimates based on a visual examination of Figure 2, which is the only numerical data on generating totals provided in the DOE Report. DOE REPORT, *supra* note 6, at 7. This is why the word "about" is used for all references to these numbers, and any numbers derived from them. Solar includes both utility- and small-scale solar. DOE Report, *supra* note 6, at 7 (noting that solar includes solar thermal and photovoltaic technologies, plus distributed solar generation, and citing to an EIA report that includes utility- and small-scale solar).

174. The 72 percent and 81 percent statistics are in the DOE Report at 7. *Id*. The 58 percent figure is an estimate based on Figure 2. *Id.*

farms produced about 435 TWh of electricity and solar farms (utility- and small-scale combined) produced about 204 TWh.[175]

It is useful to translate all of these figures into capacity measurements, which are more commonly used when describing the pace of energy facility construction (see Tables 2 and 3, below). In 2022, there were about 110 gigawatts (GW) solar and 141 GW wind installed capacity in the United States.[176] The DOE Report was saying that without BIL and IRA, there would be about 245 GW of wind and about 320 GW of solar installed capacity in the United States in 2030, while with BIL and IRA there will be between about 360 and 390 GW of wind, and between about 460 and 680 GW of solar.[177] Since this growth was supposed to occur between 2023 and 2030 (an eight-year span), DOE was projecting that without BIL and IRA, 13 GW of wind and 26 GW of solar would be built in the United States per year on average, while with BIL and IRA, 27–31 GW of wind and 44–71 GW of solar will be built per year on average. For comparison, in 2020–2022, there were about 13 GW of wind capacity[178] and about 21 GW of solar capacity built in the U.S. per year[179]—record highs in both cases.

Thus, what DOE was saying was that it expected the pace of renewables installation to continue to increase regardless of the new programs, but that the BIL and IRA programs would cause the amount of wind and especially solar construction in the U.S. to explode to unprecedented heights.

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175. *See Electricity Data Browser*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/electricity/data/browser/ (last visited Jan. 14, 2025) (chart for Net generation, United States, All Sector, Annual, 2022) (146 TWh utility-scale and 58.5 TWh other solar).

176. *Today in Energy: Renewable Generation Surpassed Coal and Nuclear in the U.S. Electric Power Sector in 2022*, U.S. ENERGY INFO. ADMIN. (Mar. 27, 2023), https://www.eia.gov/todayinenergy/detail.php?id=55960 ("Utility-scale solar capacity in the U.S. electric power sector increased … to 71 GW in 2022 …. Wind capacity grew … to 141 GW in 2022."); *Today in Energy: Record U.S. Small-Scale Solar Capacity was Added in 2022*, U.S. ENERGY INFO. ADMIN. (Sept. 11, 2023) ("U.S. small-scale solar capacity grew … to 39.5 GW in 2022.") [hereinafter EIA, *Today in Energy 2022*].

177. Conversions from energy to capacity require application of a "capacity factor," which accounts for times when generating facilities are not operating at full capacity. *See generally* Nataneal Bolson et al., *Capacity Factors for Electrical Power Generation from Renewable and Nonrenewable Sources*, 199 PNAS 1 (2022). In the United States, the average capacity factor for solar is 25 percent, and the average capacity factor for wind is 35 percent. *Today in Energy: Southwestern States Have Better Solar Resources and Higher Solar PV Capacity Factors*, U.S. ENERGY INFO. ADMIN. (June 12, 2019), https://www.eia.gov/todayinenergy/detail.php?id=39832 ("On average, utility-scale solar … power plants in the United States operated at about 25% of their electricity generating capacity"); *Today in Energy: Wind Was Second-Largest Source of U.S. Electricity Generation on March 29*, U.S. ENERGY INFO. ADMIN. (Apr. 14, 2022), https://www.eia.gov/todayinenergy/detail.php?id=52038 ("The average capacity factor of U.S. wind generators [was] 35% in 2021…"). Thus, it takes roughly 0.5 GW of solar capacity to produce 1 TWh of electricity in one year (1 TWh/y = 1,000 GWh/y = 0.456 GW * 8760 h/y * 0.25 capacity factor), and about 0.33 GW of wind capacity to produce the same amount (1 TWh/y = 1,000 GWh/y = 0.326 GW * 8760 h/y * 0.35 capacity factor).

178. *Annual New Installations of Solar Energy Capacity in the United States from 2005 to 2022*, STATISTA, https://www.statista.com/statistics/264048/annual-installed-solar-photovoltaics-capacity-in-the-united-states/ (last visited Jan. 14, 2025).

179. *Wind Market Reports: 2022 Edition*, U.S. DEP'T OF ENERGY, https://www.energy.gov/eere/wind/wind-market-reports-2022-edition (last visited Jan. 14, 2025) (showing 2020 and 2021); EIA, *Today in Energy 2022*, *supra* note 162.

Table 2. DOE Projections of No-BIL/IRA Future

	2022 Actual	DOE 2030 No BIL/IRA	Δ 2022-2030	Δ Annual
Wind Capacity	141 GW	245 GW	+104 GW	+13 GW/y
Solar Capacity	110 GW	320 GW	+210 GW	+26 GW/y

Should these projections have been believed? They appear to have been optimistic, to say the least. Among other things, they assumed away challenges in qualifying for bonus credits and meeting PWA requirements. They did not even attempt to account for inflationary or supply chain cost pressures on facility construction, siting and permitting challenges or delays, or factors such as technological lock-in that slow the pace of technology transition even in the face of price changes. The impacts of such constraints could have been examined—they were included in a separate analysis (using a different model) by the National Renewable Energy Laboratory (NREL), which noted that "[b]arriers to deployment, such as siting and permitting challenges, supply-chain constraints, and social acceptance of electricity infrastructure development, could significantly reduce the rate of clean electricity deployment" predicted in the study, reducing total climate benefits by up to 24 percent through 2030.[180] This was also consistent with more circumspect conclusions provided in other reports on this topic issued by DOE itself.[181]

The outlook does not improve when considering other events and projections. With respect to wind power (projected by OP-NEMS to increase by 27–31 GW per year), the OP-NEMS projections were difficult to square with news from the wind industry from around the same time. For example, the Biden Administration's Gulf of Mexico auction had underperformed and numerous offshore projects had been cancelled and delayed around the world.[182] With

180. DANIEL C. STEINBERG ET AL., EVALUATING IMPACTS OF THE INFLATION REDUCTION ACT AND BIPARTISAN INFRASTRUCTURE LAW ON THE U.S. POWER SYSTEM VI 11 (2023), https://www.nrel.gov/docs/fy23osti/85242.pdf.

181. U.S. DEP'T OF ENERGY OFF. OF ENERGY EFFICIENCY & RENEWABLE ENERGY, LAND-BASED WIND MARKET REPORT: 2023 EDITION 66–67 (2023), https://www.energy.gov/sites/default/files/2023-08/land-based-wind-market-report-2023-edition.pdf; U.S. DEP'T OF ENERGY OFF. OF ENERGY EFFICIENCY & RENEWABLE ENERGY, OFFSHORE WIND MARKET REPORT: 2023 EDITION 88–90 (2023), https://www.energy.gov/sites/default/files/2023-09/doe-offshore-wind-market-report-2023-edition.pdf; U.S. DEP'T OF ENERGY OFF. OF ENERGY EFFICIENCY & RENEWABLE ENERGY, DISTRIBUTED WIND ENERGY MARKET REPORT: 2023 EDITION 39–40 (2023), https://www.energy.gov/sites/default/files/2023-08/distributed-wind-market-report-2023-edition_0.pdf.

182. Jennifer A. Dlouhy, *US Sells Just One Offshore Wind Lease in Gulf of Mexico Auction*, BLOOMBERG L. (Aug. 29, 2023), https://news.bloomberglaw.com/environment-and-energy/hope-for-offshore-wind-boom-in-gulf-of-mexico-dims-amid-low-bids; Will Wade & Jennifer A. Dlouhy, *Spiraling Offshore Wind Costs Show Limits of Biden Inflation Act,* BLOOMBERG L. (Sept. 7, 2023), https://news.bloomberglaw.com/environment-and-energy/spiraling-offshore-wind-costs-show-limits-of-

respect to solar (projected by OP-NEMS to increase by 44–71 GW per year), the AEO 2023 reference case—which incorporated the same tax credits—predicted only approximately 30 GW per year solar installation between 2025 and 2030.[183] Even the 2023 Solar Market Insights Report, a typically over-optimistic solar industry publication, only imagined the solar industry achieving 45 GW capacity additions per year by 2028, still well below the DOE's modeled prediction.[184]

OP-NEMS, therefore, appears to have provided unrealistically optimistic projections for wind and solar capacity additions through 2030. These, in turn, appear to have driven the DOE Report's optimistic climate impact projections. The only way to know for sure will be to wait to compare what actually happens with various predictions. But what limited data now exists also appears to support this conclusion: in 2023, the pace of solar installation increased only to 32 GW, and new wind construction actually fell, to only 6 GW.[185] Preliminary figures from the first half of 2024 are consistent with 2023.[186] These additions are well below the predicted averages in the OP-NEMS moderate and advanced scenarios and data increasingly indicates that these averages could never be reached by BIL and IRA spending alone.

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biden-inflation-act; Nina Chestney, *Wind Power Industry Drifts Off Course*, REUTERS (Sept. 28, 2023), https://www.reuters.com/sustainability/climate-energy/wind-power-industry-drifts-off-course-2023-09-28/.

183. *Annual Energy Outlook 2023, Table 16: Renewable Energy Generating Capacity and Generation*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/outlooks/aeo/data/browser/#/?id=16-AEO2023&region=0-0&cases=ref2023&start=2025&end=2030&f=A&linechart=ref2023-d020623a.4-16-AEO2023&map=&sourcekey=0 (last visited Jan. 14, 2025).

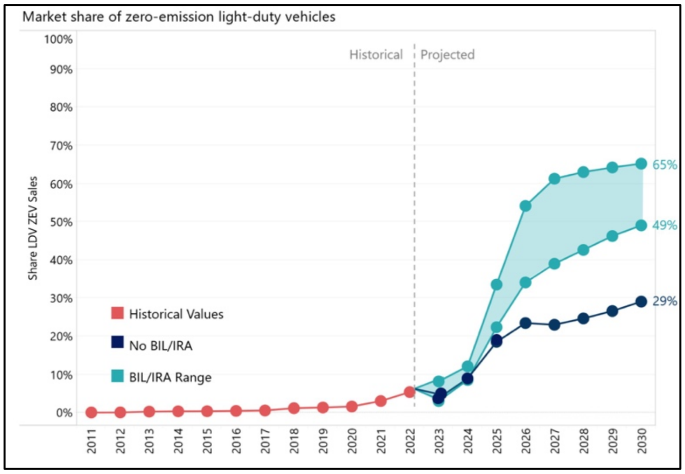
184. *Solar Market Insight Report 2023 Q3*, SOLAR ENERGY INDUS. ASSOC. (Sept. 7, 2023), https://seia.org/research-resources/solar-market-insight-report-2023-q3/.

185. DAVID FELDMAN ET AL., SPRING 2024 SOLAR INDUSTRY UPDATE 18 (2024), https://www.nrel.gov/docs/fy24osti/90042.pdf (indicating 32 GW solar capacity addition in 2023); *Wind generation declined in 2023 for the first time since the 1990s*, U.S. ENERGY INFO. ADMIN. (Apr. 30, 2024), https://www.eia.gov/todayinenergy/detail.php?id=61943# (showing 6 GW wind capacity additions in 2023).

186. Preliminary data from FERC, through May 2024, show 13 GW of wind and solar capacity addition from January to May 2024. FED. ENERGY REGUL. COMM'N OFF. OF ENERGY PROJECTS, ENERGY INFRASTRUCTURE UPDATE FOR MAY 2024 6–7 (2024), https://cms.ferc.gov/media/energy-infrastructure-update-may-2024.

2. Zero-Emissions Vehicles Sales

Figure 3: DOE Projection of BIL/IRA Impact on ZEV Sales Share



The DOE Report also predicted that BIL and IRA would cause a drastic increase in zero-emissions vehicle (ZEV) sales in the United States, primarily attributable to IRA's tax credits.[187]

Prior to IRA's enactment, there was already a consumer tax credit for electric vehicles, which was not set to expire prior to the enactment of IRA.[188] However, the pre-IRA tax credit excluded vehicles from major manufacturers that had already reached statutory sales thresholds. IRA modified the Section 30D tax credit by eliminating the sales limits but also imposed several new requirements on vehicle eligibility: Final assembly must occur in North America, vehicles must meet MSRP limits, taxpayers must meet income limits, and the vehicles must meet new critical mineral and battery component sourcing and manufacturing requirements.[189] In addition, IRA created two new clean vehicle tax credits, a used light-duty ZEV tax credit, and a new commercial ZEV tax credit that applies to light, medium, and heavy-duty vehicles.[190]

The DOE Report did not explain where its ZEV reference case projection came from. It appears consistent with AEO 2022 (i.e., the Section 30D tax credit regime prior to IRA), which predicted ZEV market share growth prior to IRA and BIL enactment. DOE explained that both its moderate and advanced scenarios were developed under assumptions used in a separate study, which

187. *See* DOE REPORT, *supra* note 6, at 8.

188. 26 U.S.C. § 30D (2021); *see* MOLLY F. SHERLOCK, CONG. RSCH. SERV., IF11017, THE PLUG-IN ELECTRIC VEHICLE TAX CREDIT (May 14, 2019).

189. 26 U.S.C. § 30D (2023); *see* MOLLY F. SHERLOCK, CONG. RSCH. SERV., IN11996, Clean Vehicle Tax Credits in the Inflation Reduction Act of 2022 (Aug. 24, 2022).

190. IRA § 13402 (adding 26 U.S.C. § 25E); IRA § 13403 (adding 26 U.S.C. § 45W); CRS SHERLOCK, *supra* note 175 (describing details).

assumed that 100 percent of national EV sales will comply with domestic battery assembly and final vehicle assembly requirements through 2030, that 87 percent of EV sales will meet MSRP eligibility requirements in 2030, that 77 percent of EV sales will meet adjusted gross income eligibility requirements in 2030, and that between 72–89 percent of EV sales will meet the critical mineral requirements in 2030.[191] The exact basis of these assumptions is unclear, but again they seem very optimistic. Contrary to these assumptions, even as late as mid-2024, only certain car models had been certified as meeting the domestic battery assembly and final vehicle assembly requirements.[192] There will be no information about how many ZEVs sold will qualify under the new requirements for at least another year.

DOE's assumptions about the Section 45W commercial clean vehicle credit are also difficult to decipher. As the credit was new, it would not have been included in the baseline scenario. In the moderate scenario, it is possible it again borrows assumptions from the same separate report.[193] In the advanced scenario, however, DOE stated that it assumed that "EV sales shares are based on national adoption of [the] Advanced Clean Truck (ACT) rule, representing target adoption."[194] Of all the assumptions in the DOE Report, this is the most unusual, for two reasons. First, it is completely unrealistic because there is no indication whatsoever that all states will adopt the ACT rule. Second, this Report specifically models a non-BIL and non-IRA policy as part of an analysis purporting to examine the impact of BIL and IRA. Unfortunately, there is no way to tell what portion of DOE's total ZEV projection is traceable to this assumption. Finally, DOE rounds out its projections with three BIL and IRA direct funding provisions related to heavy-duty vehicles.[195]

The result of these modeled assumptions is a light-duty ZEV market share in 2030 of 29 percent without BIL and IRA, and a 49–65 percent market-share with the laws (see Figure 3).[196] Given roughly 15 million light-duty vehicles sold per year in the United States,[197] this translates to about 4.5 million ZEVs sold in 2030 without BIL and IRA and between 7.5 and 9.75 million ZEVs sold in 2030 with BIL and IRA—literally millions more ZEVs on U.S. roads than would otherwise be the case. The OP-NEMS model's predictions about BIL and IRA's

191. TECHNICAL APPENDIX, *supra* note 116, at 5, adopting assumptions in PETER SLOWIK ET AL., ANALYZING THE IMPACT OF THE INFLATION REDUCTION ACT ON ELECTRIC VEHICLE UPTAKE IN THE UNITED STATES 6 (2023), https://theicct.org/wp-content/uploads/2023/01/ira-impact-evs-us-jan23-2.pdf.

192. Keith Barry, *Electric Cars and Plug-In Hybrids That Qualify for Federal Tax Credits*, CONSUMER REPS., https://www.consumerreports.org/cars/hybrids-evs/electric-cars-plug-in-hybrids-that-qualify-for-tax-credits-a7820795671 (last updated July 18, 2024).

193. *See* TECHNICAL APPENDIX, *supra* note 117, at 5; *see also* SLOWIK ET AL., *supra* note 178, at 9-11 (describing 45W treatment, including use of Advanced Clean Truck rule in states that had adopted as of 2022).

194. *Id*. at 6.

195. *Id.* (describing incorporation of IRA §§ 60101, 60102 and BIL § 11402 (port and heavy-duty vehicle funding programs projected "based on exogenous DOE modeling" in moderate scenario, based on full electrification in advanced scenario)).

196. DOE REPORT, *supra* note 6, at 8.

197. *Light Vehicle Sales in the United States 1976–2022*, STATISTA, https://www.statista.com/statistics/199983/us-vehicle-sales-since-1951/ (last visited Jan. 14, 2025).

impacts on medium- and heavy-duty vehicles sales is not disclosed. Although, again, the "advanced" case assumes nationwide adoption of the Advanced Clean Trucks rule.[198]

Again, these projections do not appear realistic when compared with other market analyses produced at the time. In 2020, Deloitte was predicting that EV market share would reach about 25 percent by 2030.[199] Although expectations have increased, the predicted numbers in 2022 were not close to the percent projection range in OP-NEMS. For example, Lang Consulting was predicting that EVs could reach 35 percent market share by 2030.[200] Morningstar was projecting a 40 percent market share by 2030, although in that case the report noted this was "far more optimistic" than the general consensus.[201] Cox Automotive summed up the contemporary consensus view as one of a market beset by headwinds:

> When it comes to EV sales, the market is likely heading into its Trough of Disillusionment . . . . Building EVs is one thing, and many in the industry are proving excellent at that skill. Selling EVs is something different altogether. Yes, EV sales records will continue to be set, and EV growth will continue to outpace overall industry growth, but the days of 75 percent year-over-year growth are in the rearview mirror. The hard-growth days are ahead.[202]

In the same vein, a wealth of social science continues to demonstrate that a wide range of social factors, from range anxiety to political preference, continue to negatively impact consumer EV uptake rates regardless of cost competitiveness over the lifetime of the vehicle.[203] Again, it appears that OP-NEMS was providing unrealistically optimistic projections for low-carbon technology uptake, which in turn was driving optimistic climate impact projections.

It should be noted that there were more optimistic projections for ZEV uptake in 2030. In 2022, for example, Bloomberg New Energy Finance predicted

198. ACT status is available at *States are Embracing Electric Trucks*, ELEC. TRUCKS NOW, https://www.electrictrucksnow.com/states (last visited Jan. 14, 2025). As of mid-2024, ten states had adopted it. *Id.*

199. Michael Woodward et al., *Electric Vehicles: Setting a Course for 2030*, DELOITTE INSIGHTS (July 28, 2020), https://www2.deloitte.com/us/en/insights/focus/future-of-mobility/electric-vehicle-trends-2030.html.

200. Adam Malik, *The Rocky Path Forward for EV Sales*, AUTO SERV. WORLD (Sept. 29, 2023), https://www.autoserviceworld.com/the-rocky-path-forward-for-ev-sales/.

201. Seth Goldstein, *We Forecast Global Electric Vehicle Sales to Quadruple by 2030*, MORNINGSTAR (Sept. 12, 2023), https://www.morningstar.com/stocks/we-forecast-40-global-ev-adoption-rate-by-2030-up-10-2022.

202. *Data Point: Electric Vehicle Sales in Q2 Strike Another Record, but Growth Ahead Will Be Hard Fought*, COX AUTOMOTIVE (July 23, 2023), https://www.coxautoinc.com/market-insights/q2-2023-ev-sales/; *see also* Aparna Narayanan, *U.S. Auto Sales Jump For GM And Ford. But EV Momentum Sluggish*, INV.'S BUS. DAILY (July 6, 2023), https://www.investors.com/news/u-s-auto-sales-q2-2023-gm-ford-toyota-ev-sales-tesla-rivian/.

203. Machado et al., *supra* note 94, at 14; *see generally* LUCAS DAVIS ET AL., POLITICAL IDEOLOGY AND U.S. ELECTRIC VEHICLE ADOPTION (2023), https://haas.berkeley.edu/wp-content/uploads/WP342.pdf.

that over 50 percent of automobiles sold in the U.S. would be electric by 2030, although its model is not available to examine.[204] However, EIA's no-IRA analysis—again, using NEMS in 2023—projected EVs to capture only 17 percent market share by 2030, one of the most significant differences between NEMS and OP-NEMS' results.[205] This wide range of results, combined with the negative evidence from other disciplines, is yet another reason not to take any one projection too seriously. ZEV uptake is subject to enormous uncertainties and could be either higher or lower than current market or modeling projections. But these uncertainties can and should be communicated—rather than subsumed in a single number that is presented as the most likely truth. As the real numbers come in, these concerns once again appear to be substantiated: In 2022 ZEV market share turned out to be about 5.8 percent, totaling about 800,000 of the 13.75 million light-duty vehicles sold in the United States that year.[206] In 2023, EV market share increased over 50 percent, to 1.2 million vehicles sold, which is spectacular growth, but still only 7.5 percent of total sales, and indications today are that this market share growth rate is set to slow, not grow.[207]

3. Residential Energy Demand

The DOE Report relied on its clean electricity and clean transportation projections to predict that total U.S. residential energy demand would be 2–3 percent lower in 2030 with BIL and IRA than without the laws.[208] Although it did not specify exactly what this meant in absolute terms, for comparison, AEO 2023 predicted U.S. residential energy demand in 2030 to be 22.36 quads.[209] A 2–3 percent reduction would be about a 0.44 to 0.67 quad difference, equivalent to 129 to 196 TWh or about the total amount of energy produced by solar power in the United States in 2022. According to DOE, these demand reductions would be achieved by promoting the uptake of high-efficiency home energy

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204. BLOOMBERG NEF, US CLIMATE LAW SHIFTS EV RACE TO WARP SPEED (2022) (on file with author), reported in Ira Boudway, *More Than Half of US Car Sales Will Be Electric by 2030: Report*, BLOOMBERG L. NEWS (Sept. 20, 2022), https://www.bloomberg.com/news/articles/2022-09-20/more-than-half-of-us-car-sales-will-be-electric-by-2030. This analysis was built on the Economic Transition Scenario in the in the Bloomberg NEF Economic Transition Scenario, plus an additional 5 percent cost reduction due to IRA tax incentives. *Id*. at 10; *see* David Hostert et al., *New Energy Outlook* 2022, BLOOMBERGNEF, https://about.bnef.com/new-energy-outlook (last visited Jan. 14, 2025).

205. AEO IRA ANALYSIS, *supra* note 124, at 11–12.

206. Andrei Nedelea, *US Car Market Shrunk In 2022 But EV Sales Went Up By Two Thirds*, INSIDEEVS (Jan. 18, 2023), https://insideevs.com/news/631980/us-ev-market-share-increased-2022.

207. Stephanie Brinley, *US EV Sales Grew Nearly 52% in 2023. So Why Are Automakers Slowing EV Investments?*, S&P GLOB. MOBILITY (Mar. 6, 2024), https://www.spglobal.com/mobility/en/research-analysis/us-ev-sales-grew-nearly-52-in-2023.html#.

208. DOE Report, *supra* note 6, at 7.

209. *Annual Energy Outlook 2023, Table 2: Energy Consumption by Sector and Source*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/outlooks/aeo/data/browser/#/?id=2-AEO2023&region=1-0&cases=ref2023&start=2021&end=2050&f=A&linechart=ref2023-d020623a.3-2-AEO2023.1-0~ref2023-d020623a.4-2-AEO2023.1-0~ref2023-d020623a.5-2-AEO2023.1-0~ref2023-d020623a.6-2-AEO2023.1-0~ref2023-d020623a.7-2-AEO2023.1-0~ref2023-d020623a.8-2-AEO2023.1-0~ref2023-d020623a.9-2-AEO2023.1-0~ref2023-d020623a.10-2-AEO2023.1-0~ref2023-d020623a.11-2-AEO2023.1-0&map=ref2023-d020623a.4-2-AEO2023.1-0&sourcekey=0 (last visited Jan. 15, 2025).

technologies, particularly water heating and space heating and cooling, plus major improvements in building energy efficiency through upgrades in insulation.[210]

BIL and IRA impact residential energy demand, once again, through a combination of tax credits and direct spending programs. IRA extended and expanded the existing Sections 25C and 45L tax credits for energy efficiency upgrades in existing and new buildings[211] and the Section 25D tax credits for behind-the-meter renewable energy generation, which are modeled in NEMS as demand reduction.[212] Spending programs in IRA sections 50121, 50122, 50131, and 60502, and BIL sections 40502, 40551, and 40109, all combined to increase the modeled "shell indices," meaning the insulation efficiencies, of the total U.S. building stock.[213] Unfortunately, the DOE Report did not provide enough information to determine what it was doing with these provisions. Rather, it only discussed the impact of these modeled provisions on residential space heating and water heating technology stocks.[214]

In that brief discussion, the DOE Report projected that Americans would replace natural gas and resistance electric heating units with heat pumps at a rate of about 80,000 to 100,000 per year starting in 2023 and replace electric water heaters with solar and heat pump water heaters at a rate of about 1.0 to 1.4 million per year starting in 2023. EIA's analysis, by comparison, projected the addition of only 2.6 million electric water heaters *total* between 2022 and 2030, combined with an additional 5.5 million natural gas water heaters.[215] This makes it impossible to compare the results. Clearly, differences in NEMS and OP-NEMS drive different outcomes. But since DOE provided very little information about its novel modeling extensions, it is not possible to assess its predictions about buildings. However, it should be noted that the average error rate for NEMS 5-year residential energy demand projections exceeds 3 percent.[216] That is, the DOE Report's residential energy demand projections were built on an experimental model, inconsistent with EIA projections, and within past error rates for NEMS, all of which weigh against putting too much trust in these numbers.

Furthermore, emerging evidence is demonstrating that, as in the case of renewable energy resources and ZEVs, equipment cost is not the only barrier to appliance replacement or household energy efficiency upgrades. Therefore, subsidies alone may not be sufficient. Among other things, installations often

210. DOE Report, *supra* note 6, at 7.
211. IRA §§ 13301, 13304.
212. IRA § 13302.
213. TECHNICAL APPENDIX, *supra* note 116, at 7–8 (discussing modeling of building provisions).
214. DOE Report, *supra* note 6, at 9.
215. *Annual Energy Outlook 2023, Table 21: Residential Sector Equipment Stock and Efficiency, and Distributed Generation*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/outlooks/aeo/data/browser/#/?id=30-AEO2023&cases=ref2023&sourcekey=0 (last visited Jan. 15, 2025).
216. U.S. ENERGY INFO. ADMIN., ANNUAL ENERGY OUTLOOK 2022 RETROSPECTIVE: EVALUATION OF PREVIOUS REFERENCE CASE PROJECTIONS 59–60 (2022), https://www.eia.gov/outlooks/aeo/retrospective/pdf/retrospective.pdf.

include hidden costs that are not modeled, like wiring upgrades, and complex juggling of contractor schedules at a time when there is a national shortage of qualified electricians.[217] Typical human preferences for familiar things, retailer familiarity and willingness to support new technologies, contractor familiarity with installation particulars of new building technologies, and numerous other barriers other than equipment cost are likely to significantly blunt the impact of subsidies unless additional legal steps are taken to knock down those barriers.[218] None of this is reflected in energy system modeling based solely on equipment price. So, once again, DOE's analysis appears to have been overly optimistic.

4. Industry Carbon Capture and Sequestration

Following electricity, transportation, and buildings, the DOE Report discussed its predictions of industrial emissions reductions. It predicted that the expanded Section 45Q tax credits for carbon capture and storage (CCS) would drive industrial and manufacturing sectors—including ethanol, ammonia, and refining—to adopt carbon capture and sequestration technologies that would reduce emissions from these sectors by 33–42 percent by 2030.[219] Again, this prediction was based entirely on price with no real-world frictions, and we can assess if this claim was realistic by considering what it would actually mean for this reduction to be accomplished.

Unfortunately, the DOE Report's conclusion was not as straightforward as it appeared because it only examined direct emissions, while facilities in the industries it discusses produce CO_2 both directly as part of their operation and indirectly by consuming energy. For example, in ammonia production, the process of creating hydrogen from natural gas produces CO_2 directly, but the plants also involve very high energy reactions that may require electricity or other combustion, releasing CO_2 indirectly.[220] Ethanol production, which in the United States generally involves fermentation of corn starch, also releases CO_2 at multiple points in its production chain, and requires energy.[221] Petroleum refining, similarly, releases CO_2 directly at multiple points in the many chemical processes found in a typical refinery, and requires substantial energy inputs.[222]

217. Andrew G. Campbell, *Filling in Home Electrification Gaps*, ENERGY INST. AT HAAS (Oct. 23, 2023), https://energyathaas.wordpress.com/2023/10/23/filling-in-home-electrification-gaps/.

218. Melissa Powers, *Electrifying Everything Through the Inflation Reduction Act?* (early draft on file with author).

219. DOE Report, *supra* note 6, at 10.

220. Leigh Krietsch Boerne, *Industrial Ammonia Production Emits More CO2 than Any Other Chemical-Making Reaction. Chemists Want to Change That*, CHEM. & ENG'G. NEWS (June 15, 2019), https://cen.acs.org/environment/green-chemistry/Industrial-ammonia-production-emits-CO2/97/i24 (energy-associated and direct process emissions from ammonia production are responsible for about 1 percent of the world's annual energy emissions).

221. STATE CO2-EOR DEPLOYMENT WORK GRP., Capturing and Utilizing CO2 from Ethanol: Adding Economic Value and Jobs to Rural Economies and Communities While Reducing Emissions 6–8 (2017), https://www.kgs.ku.edu/PRS/ICKan/2018/March/WhitePaper_EthanolCO2Capture_Dec2017_Final2.pdf.

222. Nixon Sunny et al., A Pathway Towards Net-Zero Emissions in Oil Refineries, 4 FRONTIERS IN CHEM. ENG'G 1, 1–3 (2022).

All of these industries have been exploring carbon capture and storage as a potential solution to their industrial carbon emissions problems.[223] But carbon capture would presumably only capture the emissions coming from the processes at the facilities themselves, not at the power plants generating the electricity the plants are using.

Assuming for the sake of analysis that DOE meant that carbon capture would reduce these facilities' direct CO_2 emissions (CO_2 from steam reforming natural gas to create hydrogen used in ammonia production, CO_2 produced during fermentation to create ethanol, and CO_2 released at various points in petroleum refineries) by 33–42 percent; and assuming that if carbon capture is employed at a facility, it will capture all of the facility's direct CO_2 emissions, then it appears that DOE was saying that one-third to two-fifths of all the ammonia plants, ethanol plants, and oil refineries in the country would install CCS technology in the next seven to eight years. There were 183 ethanol plants, thirty-two ammonia plants, and 129 oil refineries in the country at the time.[224] Currently, five ethanol plants, six ammonia (fertilizer) plants, and zero oil refineries are capturing their CO_2 emissions.[225]

It is not clear exactly which additional facilities DOE thought would avail themselves of CCS. But this is a sector where location is particularly important, as carbon capture only reduces a facility's emissions if there is associated infrastructure to transport the captured carbon to an appropriate use or sequestration site.[226] Very little of that infrastructure currently exists and cost is not the only—or even primary—barrier to its construction.[227] Permitting and safety concerns continue to plague carbon pipelines in the few places where they are currently being proposed, and the idea that tax credits alone could spur this kind of technological transformation seems fantastical without significant changes to permitting regimes. Surely, some additional demonstration projects will come online, and these will get a great deal of attention, but this is not the same as achieving substantial reductions in these industries' emissions via CCS.

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223. *E.g.*, Leah Douglas, *U.S. Ethanol Industry Banks on Carbon Capture to Solve Emissions Problem*, REUTERS (Mar. 11, 2022), https://www.reuters.com/business/sustainable-business/us-ethanol-industry-banks-carbon-capture-solve-emissions-problem-2022-03-11/; Justine Calma, *Louisiana Kicks Off One of the US's Biggest Carbon Capture Projects Yet*, THE VERGE (Oct. 14, 2022), https://www.theverge.com/2022/10/14/23404296/louisiana-carbon-capture-project-ammonia-fertilizer-cf-industries-exxon-mobil (ammonia production facility); *Climate Solutions: Carbon Capture and Storage*, EXXONMOBIL, https://corporate.exxonmobil.com/what-we-do/delivering-industrial-solutions/carbon-capture-and-storage#Denbury (last visited Jan. 15, 2025).

224. *Numbers Taken from U.S. Ethanol Plants, Capacity, and Production*, U.S. DEP'T OF ENERGY, https://afdc.energy.gov/data/10342 (last visited Jan. 15, 2025); *Natural Gas Weekly Update*, U.S. ENERGY INFO. ADMIN., https://www.eia.gov/naturalgas/weekly/archivenew_ngwu/2021/04_01 (Apr. 1, 2021) (discussing ammonia plants); *Number and Capacity of Petroleum Refineries*, U.S. ENERGY INFO. ADMIN, https://www.eia.gov/dnav/pet/pet_pnp_cap1_dcu_nus_a.htm (last visited Jan. 15, 2025).

225. *Facilities Database*, GLOB. CCS INST., https://co2re.co/FacilityData (last visited Jan. 15, 2025) (USA, Commercial CCS Facilities, Operational).

226. *See, e.g.*, *What Is Carbon Capture and Storage?*, NAT'L GRID, https://www.nationalgrid.com/stories/energy-explained/what-is-ccs-how-does-it-work (last visited Jan. 15, 2025).

227. *See generally* PAUL W. PARFOMAK, CONG. RSCH. SERV., IN12269, SITING CHALLENGES FOR CARBON DIOXIDE (CO2) PIPELINES (Nov. 30, 2023).

Some of these industries may achieve reductions through other means—for example, green hydrogen for ammonia production—but again, these technologies are still largely experimental and there are no current projections of deep market penetration by 2030. Whatever happens, it is not yet clear what role Section 45Q tax credits will play. The DOE Report's claims again appear overly optimistic.

5. Other Industrial Decarbonization

The OP-NEMS model also attempted to capture several other industrial decarbonization provisions. The Advanced Industrial Facilities Deployment Program appropriated $5.812 billion to the DOE's Office of Clean Energy Demonstrations for a competitive grant program for industrial decarbonization projects.[228] According to DOE, "[t]his funding is assumed to go toward additives in cement, carbon capture and sequestration and electrification options in cement, steel, glass, paper, and aluminum facilities."[229] The Low Carbon Transportation Materials Program appropriated $2 billion to the Federal Highway Administration to subsidize the purchase of low-carbon materials for road construction, which OP-NEMS models as a price modification to low-carbon cement in the advanced scenario.[230] There was no information provided about the predicted impact of these programs.

However, DOE also stated that the cleantech manufacturing credit in Section 48C "is assumed to combine with IRA Section 50161 in supporting industrial decarbonization at energy intensive facilities," in both scenarios.[231] The problem with this is that there are a limited amount of funds and industrial decarbonization is not the only thing that Section 48C pays for. Rather, Section 48C provides funds for construction and modification of cleantech facilities, construction or modification of critical minerals processing facilities, *and* greenhouse gas reduction initiatives at industrial facilities.[232] There is no basis for assuming that 100 percent of these funds will go to greenhouse gas reduction projects. Market summaries describing the operation of this tax credit certainly do not make this assumption.[233] Even DOE itself has emphasized that these tax credits will spur investment in manufacturing and critical minerals industries, rather than decarbonization.[234]

228. IRA § 50161.

229. TECHNICAL APPENDIX, *supra* note 116, at 8.

230. IRA § 60506.

231. TECHNICAL APPENDIX, *supra* note 116, at 8.

232. 26 U.S.C. § 48C(c)(1)(A).

233. *E.g.* Irina Antonache et al., *How IRC Sections 45X and 48C Incentivize Green Product Manufacturing*, MOSS ADAMS (May 24, 2023), https://www.mossadams.com/articles/2023/05/inflation-reduction-act-irc-section-45x-48c (discussing broad range of projects eligible for Section 48C credits without particular emphasis on carbon capture).

234. *New 48C Tax Credit Will Spur Historic Investments in Manufacturing and Critical Materials*, U.S. DEP'T OF ENERGY OFF. OF MAFG. AND ENERGY SUPPLY CHAINS (May 31, 2023), https://www.energy.gov/mesc/articles/new-48c-tax-credit-will-spur-historic-investments-manufacturing-and-critical.

Remarkably, OP-NEMS did not even attempt to model the impacts of the Section 45X manufacturing tax credit. This will be used to build the facilities that will be necessary for renewable energy and ZEVs to qualify for the domestic manufacturing requirements of their respective tax credit programs, discussed above. Again, then, DOE's model made a series of generous assumptions about the efficacy of the tax credits, while ignoring elements of the prediction problem that would constrain BIL and IRA's positive effects.

6. Fuel Carbon Intensity

In its last analysis relevant to greenhouse gas emissions reductions, DOE incorporated IRA's tax credit provisions for reducing fuel intensity. IRA amended the tax credits available for alternative fuels in Sections 40 (ethanol) and 40A (biodiesel and renewable diesel), added two new alternative fuel tax credits in Sections 40B (aviation fuel) and 45V (clean hydrogen), and added section 45Z, which will replace the Sections 40, 40A, and 40B credits and extend them through 2027.[235] All of these provisions pay fuel producers a flat rate per unit of fuel produced.

According to EIA, the NEMS reference case modeled the ethanol, diesel, aviation fuel, and clean fuel credits at statutory levels.[236] According to DOE, OP-NEMS did not include the 40B sustainable aviation fuel credit but modeled the others,[237] and although the credit prices were not disclosed, it is likely they are the same as NEMS.[238] There is no indication in AEO 2023 or the DOE Report that these credits have a significant impact on U.S. greenhouse gas emissions in 2030, a discouraging if not particularly surprising result. EIA projections of biodiesel and ethanol production have been stable for years, and there is little reason to imagine that the IRA credit extensions will change this outlook.[239]

For clean hydrogen (which EIA did not model), DOE stated that "OP-NEMS also represents applications of clean hydrogen production and uses with exogenous inputs developed by the DOE Office of Energy Efficiency and Renewable Energy."[240] What this means is that DOE forced its model to assume total demand for clean hydrogen at 2 MMT H_2 in the moderate case, and 10 MMT H_2 in the advanced case. In reality, this demand is going to depend on the price and availability of clean hydrogen. Assuming the demand is not the same thing as analyzing the impact of the clean hydrogen credits on hydrogen prices and therefore demand for hydrogen. Currently, almost all hydrogen production

235. IRA §§ 13202, 13203, 13204, 13704.

236. U.S. ENERGY INFO. ADMIN, ASSUMPTIONS TO THE ANNUAL ENERGY OUTLOOK 2023: LIQUID FUELS MARKET MODULE 26 (2023), https://www.eia.gov/outlooks/aeo/assumptions/pdf/LFMM_Assumptions.pdf.

237. TECHNICAL APPENDIX, *supra* note 116, at 3.

238. *Id*.

239. *See Today in Energy: EIA Projects U.S. Biofuel Production to Slowly Increase Through 2050*, U.S. ENERGY INFO. ADMIN. (Mar. 9, 2020), https://www.eia.gov/todayinenergy/detail.php?id=43096 (showing a very small increase through 2030); *Annual Energy Outlook 2023, supra* note 81, at Table 1 (showing biodiesel and ethanol production stable through 2030).

240. TECHNICAL APPENDIX, *supra* note 116, at 1.

in the United States is from fossil sources.[241] In any event, DOE did not indicate that the hydrogen credits make a substantial difference in its claims about the climate impact of BIL and IRA.

7. An Informative Counterexample: The Methane Charge

To this point, the analysis has suggested—uniformly—that the DOE Report overstated the climate impact of BIL and IRA's spending provisions. However, this suggestion is complicated by a major omission from DOE's analysis, which may tend to have the opposite effect: OP-NEMS did not model the IRA methane charge. This omission is informative, as it calls into question the entire project of using energy system modeling to make claims about U.S. national greenhouse gas emissions because the methane charge is likely to be a significant and impactful provision and yet went totally unmodeled in the DOE analysis.

As noted previously, IRA included one non-spending climate provision: a "waste emissions charge" applicable to fugitive methane emissions from oil and gas development operations.[242] This is, in fact, the first nationwide charge, fee, or tax imposed on greenhouse gases in the United States. The price appears steep—$900 per ton of methane in 2024, increasing to $1500 per ton in 2026 and thereafter. Yet this is equivalent to $50–60 per ton of CO_2 equivalent, given that methane is a much more powerful greenhouse gas.[243] The full impact of the charge is also offset by statutory thresholds equal to:

> (1) for production facilities, methane emissions over the lesser of 0.2 percent of the output of a natural gas production facility, or ten metric tons of methane per million barrels of oil produced;
>
> (2) for transmission facilities, methane emissions over 0.11 percent of the facility's throughput; and
>
> (3) for other facilities, methane emissions over 0.05 percent of the facility's throughput.[244]

241. *Today in Energy: U.S. Refiners and Chemical Manufacturers Lead Hydrogen Production and Consumption*, U.S. ENERGY INFO. ADMIN. (Apr. 8, 2024), https://www.eia.gov/todayinenergy/detail.php?id=61763# ("About two-thirds was sourced from the steam methane reformer (SMR) process, which mainly uses natural gas as a feedstock. The remaining one-third of hydrogen production came as a byproduct of other chemical processes. A small but growing amount of hydrogen is also produced from electrolysis of water—a process that separates water molecules into hydrogen and oxygen.").

242. IRA § 60113 (codified 42 U.S.C. § 7436 (Clean Air Act § 136)). *See also* JONATHAN R. RAMSEUR, CONG. RSCH. SERV., R47206, INFLATION REDUCTION ACT METHANE EMISSIONS CHARGE: IN BRIEF 1 (Aug. 29, 2022); *Estimates of Methane Emissions by Segment in the United States*, EPA, https://www.epa.gov/natural-gas-star-program/estimates-methane-emissions-segment-united-states (last visited Jan. 15, 2025).

243. This is equivalent to $50–60 per ton of CO_2 equivalent, using a global warming potential (GWP) of 25–30 for methane. On global warming potentials, *see Understanding Global Warming Potentials*, EPA, https://www.epa.gov/ghgemissions/understanding-global-warming-potentials (last visited Jan. 15, 2025).

244. 42 U.S.C. §§ 7436(f)(1)(A), (f)(3), (f)(2).

The law also included sweeteners in the form of federal grants to support elimination of fugitive emissions,[245] exempts wells from the fee in the year they are permanently closed,[246] and does not apply if the facility is currently in compliance with methane emission regulations adopted under Clean Air Act section 111.[247]

Taken together, these provisions can be expected to substantially reduce fugitive methane emissions from the U.S. energy system. Indeed, according to the Congressional Research Service, early modeling showed that the methane charge would account "for a considerable percentage of the estimated [greenhouse gas] reductions that could be achieved by [BIL and IRA]," although of course these models are as highly dependent on their assumptions as are any others discussed here.[248] Since then, however, few energy system models have accounted for the methane charge in any way.[249] The AEO 2023 did not model it,[250] and the DOE Report also does not discuss it.[251] To be fair, this is certainly a defensible choice—energy-economic models are not necessarily complete inventories of energy-system greenhouse gases, they likely do not properly account for fugitive emissions in the first place,[252] and there is little clear information on the actual future scope of the regulation or what its impact will be on oil or natural gas prices.[253] But it is still surprising to find the groundbreaking and potentially impactful methane charge excluded in a predictive model that so assiduously accounted for so many other things.

Investigation of the NEMS model helps shed light on why the methane charge is not discussed in the DOE Report. In short, NEMS is currently only capable of determining combustion emissions and does not model fugitive methane. The details are found in the NEMS documentation for the Emissions Policy Submodule, which functions as part of the NEMS Integrating Module.[254] The Emissions Policy Submodule determines national sums of emissions based on amounts of fuel consumed using a "carbon dioxide emission factor" for each fuel.[255] The emission factor is a "carbon dioxide coefficient" (the amount of CO_2 released in combustion) and a "combustion fraction" (the amount of the fuel

245. *Id*. §§ 7436(a)–(b).

246. *Id*. § 7436(f)(7).

247. *See EPA VOC and Methane Standards for Oil and Gas Facilities*, HARV. L. SCH. ENV'T & ENERGY L. PROGRAM, https://eelp.law.harvard.edu/tracker/epa-voc-and-methane-standards-for-oil-and-gas-facilities-2 (last updated Oct. 7, 2024).

248. RAMSEUR, *supra* note 229, at 1 n.3 (internal citations omitted).

249. *See. e.g.*, EPA ASSESSMENT, *supra* note 6, at 29 (showing methane emissions reduction program included in only 3 of 14 models examined).

250. AEO 2023, *supra* note 81, at 45.

251. TECHNICAL APPENDIX, *supra* note 116, at 2–4 (IRA § 60113 not listed).

252. Leehi Yona, *Emissions Omissions: The Greenhouse Gas Accounting Gap*, 49 HARV. ENV'T L. REV. (forthcoming 2025) (manuscript at 31–38) (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4436504).

253. *See, e.g.*, AEO 2023, *supra* note 81, at 45 (citing implementation uncertainty and difficulty modeling as reasons for exclusion of the methane charge from the 2023 NEMS model).

254. INTEGRATING MODULE OVERVIEW, *supra* note 72, at 51–61.

255. *Id*. at 55 (describing SUM_EMISSIONS routine and Emissions Factor parameter).

combusted when used).[256] For natural gas used as fuel, "combustion fractions are assumed to be 1.00"—meaning *all* of the natural gas is burned cleanly.[257] Upstream fugitive emissions in the natural gas system, therefore, are simply not calculated. From this emissions data, NEMS is capable of modeling four emissions policies: a carbon tax, permit auction, a market for tradeable permits, and a permit market with offsets.[258] But each of these policies is focused on accounting for combustion emissions, not upstream emissions, and therefore, none of the calculations for these policies are useful for determining the impact of pricing on fugitive emissions either.

In order to fully examine the impact of the IRA's methane charge in NEMS, it would be necessary to, among other things, accurately model baseline fugitive emissions from the oil and gas system, determine the quantity of those emissions that are subject to the charge, model the cost abatement of those fugitive emissions, compare the cost of abatement to the cost of the charge, determine the impact of that cost on abatement behavior, and determine the impact of those abatement activities on the price of natural gas and oil. The IRA approach adds an additional complexity because the charge only becomes applicable in the absence of regulations under CAA section 111, which would require similar determinations under the alternative regulatory regime. All of this would require the development of a completely new module for NEMS. Unlike carbon capture, where a ready-made model extension was available, OP-NEMS could not be extended to provide estimates of fugitive emissions—with or without a fee—and so the provision was ignored.

Thus, while it is true that DOE's treatment of the methane charge did not fit with the larger pattern of overstatement of BIL and IRA's impacts that is the primary concern of this Article, this does not so much disprove that trend as reveal another limitation of using NEMS to model energy system greenhouse gas emissions in the first place. Ultimately, the treatment of the methane charge is a reminder of how assumption-driven these modeling efforts are and the care that must be taken when comparing "similar" results from different models. If a model that does account for the methane charge arrives at the same prediction as one that does not, what does that mean? Do they corroborate each other? Or undercut each other? Ultimately, they do neither. Again: "In line with a [forty] year old plea from the energy modelling community, models deliver insights instead of answers."[259] And it is always necessary to try to understand what a model is doing in order to interpret its results.

8. Overall Results

To summarize, OP-NEMS predicted that BIL and IRA would drive renewable electricity capacity additions to 70–100 GW per year by 2030; would drive ZEV sales to 50–65 percent of market share by 2030; would reduce residential energy demand by about 150 TWh per year by 2030; would drive the

256. *Id*. at 46.
257. *Id*. at 46–47.
258. *Id*. at 48–50.
259. Strachan, *supra* note 101.

capture and sequestration of 33–42 percent of the carbon emissions from U.S. ammonia, ethanol, and refinery plants; and would direct billions of dollars toward other industrial decarbonization projects. As demonstrated above, these projections appear unrealistic when compared to projections and predictions that accounted for real-world constraints.

Thus, it is more accurate to describe the DOE Report's projection of BIL and IRA's impacts as a best-case scenario. *If all goes perfectly*, BIL and IRA's spending provisions could drive a 10–20 percent additional annual emissions reduction over baseline in 2030. But it was extremely unlikely that all would go well. The enormous frictions of the energy transition should have been predicted to place significant constraints on the actual success of BIL and IRA's spending programs.

III. WHAT COMES NEXT FOR U.S. CLIMATE LEGISLATION?

Parts I and II demonstrated the manner in which optimistic projections of BIL and IRA's climate impacts systematically oversold BIL and IRA's impacts. It is fair to ask: So what? After all, politics is politics, and it is understandable for politicians to promote their wins, especially in an election year. It is not unusual for advocates and analysts to use data to promote narratives. This might be understood, in many ways, as business as usual.

The answer to the question is found in another question: To what extent might the narrative of BIL and IRA's success impact the likelihood of further climate legislation? This includes both legislation that streamlines and improves the effectiveness of BIL and IRA's provisions, as well as totally distinct legislation that contains alternatives or additions to BIL and IRA's spending-only approach. As discussed below, theory predicts that BIL and IRA displaced other climate policies to the extent that BIL and IRA were perceived to be highly successful climate solutions, and preliminary evidence from the 118th Congress is consistent with that theory. Remedying this would require a shift back toward a more realistic and measured public understanding of what BIL and IRA were able to accomplish, which in turn would require more clearly communicating the limitations on modeling evidence that have been discussed so far.

A. The Impact of BIL and IRA on Future Climate Legislation

In an article devoted to demonstrating the inadequacies of prediction, it would be hypocritical to confidently project that BIL and IRA had some particular political impact. Politics are unpredictable, and too many factors influence political and legislative decisions to allow anyone to say for sure what impact one piece of legislation might have had on a decision to enact further legislation in the future. Nonetheless, the theory of political agenda-setting does provide a basis for the proposition that BIL and IRA's enactments made further climate legislation less likely, and that this is particularly the case when the laws enacted were believed to be highly effective.

In 1984, University of Michigan political science professor John W. Kingdon published *Agendas, Alternatives, and Public Policies*, now considered a classic in the public policy literature.[260] The book was concerned with examining governmental "predecision processes," meaning the processes by which particular matters become added to public decision-making agendas.[261] Kingdon himself described this as a descent into "the labyrinth of policy formation" and provided an extremely influential framework for navigating the territory: the "multiple streams" model.[262] Kingdon conceptualized "three process streams flowing through the [policy formation] system—streams of problems, policies, and politics," each essential to bringing ideas to prominence before decisionmakers.[263] The "problem stream" meant the process of defining situations as problems, whether through ongoing analysis of known problem indicators or as the result of some crisis or other focusing event.[264] The "policy stream" meant the process of defining potential solutions to identified problems, a practice particularly engaged in by specialized communities of experts and interested parties.[265] The "political stream" encompassed the networks of power in government, influenced by ideology, elections, and the public mood.[266] According to Kingdon, legislation only becomes possible when the three streams combine, and combination only ever occurs for a brief and always limited period of time—the policy window.[267] During that brief window, "[a] problem is recognized, a solution is developed and available in the policy community, a political change makes it the right time for policy change, and potential constraints are not severe."[268] Legislation may be the result, at least until the policy window closes.[269]

Kingdon was also concerned with what makes ideas unsuccessful and incapable of progress in the predecision process. He noted that problems and policies not only come to dominate the agenda landscape, but also often "fade from view," for a variety of reasons.[270] In his words:

> Why do they fade? First, government may address the problem, or fail to address it. In both cases, attention turns to something else, either because something has been done or because people are frustrated by failure and refuse to invest more of their time in a losing cause. Second, conditions that highlighted a problem may change—indicators drop instead of rise, or crises go away. Third, people may become accustomed to a condition or relabel a

260. *See* Scott Greer, *John W. Kingdon,* Agendas, Alternatives, and Public Policies*, in* OXFORD HANDBOOK OF CLASSICS IN PUBLIC POLICY AND ADMINISTRATION 417 (Martin Lodge et al. eds. 2016).

261. JOHN W. KINGDON, AGENDAS, ALTERNATIVES, AND PUBLIC POLICIES 1–2, PEARSON NEW INTERNATIONAL EDITION 1 (2d ed., 2014).

262. *Id*. at 18, 19. Kingdon himself did not use the term "multiple streams," but it is known as such in public policy literature. *See e.g.*, Paul Cairney and Michael D. Jones, *Kingdon's Multiple Streams Approach: What Is the Empirical Impact of this Universal Theory?* 44 POL'Y STU. J. 37 (2015).

263. *Id*. at 19.

264. *Id*. at 90–115.

265. *Id*. at 116–44.

266. *Id*. at 145–64.

267. *Id.* at 165–66.

268. *Id*. at 165.

269. *Id*. at 168–70.

270. *Id*. at 104.

> problem. Fourth, other items emerge and push the highly placed items aside. Finally, there may simply be inevitable cycles in attention; high growth rates level off, and fads come and go.[271]

The Kingdon model, though by no means perfect, provides a useful framework for expressing concerns about what BIL and IRA have done, and what effect they could have on the future of U.S. climate policy.[272]

Considered from the perspective of the problem stream, BIL and IRA may have reduced the salience of climate change as a problem still requiring legislative solutions. Since BIL and IRA have been passed, and since according to President Biden, IRA is among the most important laws ever passed, and since according to U.S. federal agencies, BIL and IRA are likely to do a great deal to respond to the problem of climate change, then the salience of federal legislative inaction on climate change as a problem may appear to have been reduced. A subtler potential impact is that BIL and IRA have now shifted what a "climate law" is even understood to be, which is particularly relevant to those who consider climate law itself to be a problem. Prior to their passage, the Energy Policy Act of 1992 and the Energy Policy Act of 2005 (which enacted many of the provisions that BIL and IRA modified) were not strongly influenced by climate politics, and they were neither advocated for nor opposed as climate legislation.[273] To those for whom climate change legislation itself is an ideological problem, it is now more likely than not that even modest financial interventions like BIL and IRA will be conceptualized as problematic climate policies.[274] By reconceptualizing omnibus energy policy bills as climate laws, BIL and IRA may have ceded policy territory and made more stringent regulatory controls appear more radical than before.

Imagining the policy stream, BIL and IRA may have reduced the advocacy energy and supportive expertise devoted to non-spending climate policies. The above analysis suggests that the success of spending legislation has already begun incentivizing the development of expertise on the assessment of climate

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271. *Id*. at 198; *see also id*. at 103–05.

272. Indeed, political scientists have already begun studying the enactment of the Inflation Reduction Act using Kingdon's methods. *See* Morgan McGlynn & Aaron C. Sparks, *Climate Change Policy Development: A Multiple Streams Analysis of the Inflation Reduction Act of 2022*, 22 THE FORUM 177 (2024) (analyzing the influence of advocacy groups on Democratic lawmaking); Guri Bang, *The U.S. Inflation Reduction Act: Climate Policy as Economic Crisis Response*, ENV'T POL. 1 (2024) (discussing Kingdon's theory of shocks promoting legislative action). They have not, however, commented on its potential effects on future legislation.

273. *E.g.*, *Report of the Committee on Legislation and Regulatory Reform*, 13 ENERGY L. J. 409, 440 (1992) (discussing H.R. 776, which would become the Energy Policy Act of 1992, as "comprehensive energy legislation"); *Legislation Committee*, 27 ENERGY L.J. 349 (2006) (discussing the Energy Policy Act of 2005 as "omnibus energy legislation"). That is not to say that these laws did not have some climate-relevant and even climate-specific provisions. *E.g.*, *see* Energy Policy Act of 1992 Title XVI (mandating certain climate reporting actions). Rather, the discourse around the enactment and subsequent implementation of these laws was not strongly influenced by climate change politics.

274. Evidence is already emerging that existing political polarization around climate change is influencing support for the Inflation Reduction Act. *See* Melissa K. Merry and Rodger A. Payne, *Climate Fatalism, Partisan Cues, and Support for the Inflation Reduction Act*, 57 POL'Y SCI. 379 (2024) (finding reduced support for IRA among U.S. Republicans and Independents when exposed to Democratic Party rhetoric on the law).

spending policies, rather than climate regulatory policies. At the same time, as BIL and IRA allocated billions of dollars to spending that, in the end, flows to the benefit of particular people and organizations. The laws may simultaneously be developing special interest complexes exclusively devoted to the implementation of spending policies, taking away potential advocacy attention from more effective but less immediately beneficial climate policies. It is even possible to imagine a world where climate mandates are opposed by special interest groups that support spending policies to the extent that alternatives reduce the amount of funding made available for spending priorities.

Finally, considered as a matter of the politics stream, BIL and IRA may have reduced the likelihood that any of those involved in getting the laws passed will ever again work toward responding to climate change. The political capital that was spent on BIL and IRA was largely spent on climate change. Legislators may have expended what energies they had for the climate change problem on these solutions and have had little left for further initiatives. As other crises came to dominate the legislative agenda, climate change could fall away because, after all, something had been done.

These potential impacts, together, might have operated to keep the policy window closed during the remainder of President Biden's term. If BIL and IRA reduced the salience of climate change as a problem, entrenched spending policies to the detriment of mandates, and spent up whatever political capital existed for climate action at the time, then it may have become impossible to address climate change at the national level again in the same legislative session. All of this, taken together, highlights the problematic logic that inaccurate projections enable in the policymaking milieu. Overselling BIL and IRA tends to reinforce the idea that these laws have done what is necessary to solve climate change, to shift interest away from mandates toward inquiries into spending impact and benefit, and to take the pressure off politicians who are happy to have done something about climate change.

Of course, this discussion is largely speculative and theoretical. There is, however, some evidence that these concerns are at least partially valid. One possible way to assess the early impact of BIL and IRA on other climate legislation is to examine whether the numerous carbon tax bills introduced prior to BIL and IRA, particularly in the 117th Congress (2021–2022), have been reintroduced in the 118th Congress (2023–2024).[275] Not including the methane charge in BIL and IRA, there were eight carbon tax proposals introduced during the 117th Congress, most of which had also been introduced in the 116th Congress, and some of which had been introduced as early as the 113th Congress.[276] Although most of them had only a few sponsors, one had ninety-

275. YE, 117TH CONGRESS CARBON PRICING, *supra* note 29 (listing legislation introduced in the 117th Congress).

276. *Compare* YE, 113TH CONGRESS CARBON PRICING, *supra* note 29, *with* YE, 116TH CONGRESS CARBON PRICING AND YE, 117TH CONGRESS CARBON PRICING, *supra* note 27, *and* CITIZENS' CLIMATE LOBBY, *supra* note 27 ("This factsheet summarizes and compares nine federal carbon pricing proposals introduced in the 117th Congress (2021–2022), highlighting similarities and differences. Six of these proposals would establish a carbon tax (or 'carbon fee'), one would establish a cap- and-dividend (i.e., cap-and-trade) program, and would establish a charge on methane emissions.").

five sponsors in the House, and another had ten sponsors in the Senate. But so far in the 118th Congress, only two of these bills have been reintroduced, garnering far fewer sponsors than previously, and the other proposals have been abandoned.[277] As Kingdon would predict, there has been a drastic reduction in the number of climate legislative proposals and in the number of sponsors for the proposals that have been submitted since BIL and IRA were enacted.

For the time being, the climate policy window appears closed. Only time will tell whether it will reopen. In the meantime, modeling projects that overstate BIL and IRA's likely impacts are unlikely to facilitate conversations about what is needed next.

B. What Is Needed Next

In a famous turn of phrase, statistician George Box said that "all models are wrong, but some are useful."[278] What this means is that models are necessarily imperfect simulations of more complex reality that can, nonetheless, provide useful information, especially when their limitations are kept in mind. For example, street maps are models, and street maps are very useful for navigating in a car—at least, as long as they are accurate. But the corollary to Box's aphorism should also be kept in mind: If some models are useful, then some are not. Perhaps a better guiding quote could be: "While a model can never be 'truth,' a model might be ranked from very useful, to useful, to somewhat useful, to, finally, essentially useless."[279] And no model is useful if its predictions are inaccurately characterized.

The energy-economic models discussed in this Article are not useless. They demonstrate the potential of BIL and IRA in a perfect world. They provide generalized insights into the impact of different economic futures on the U.S. energy system. They sketch out the manifold relationships between prices and outcomes in the energy system. And they provide some insight into the operation of federal spending programs on greenhouse gas emissions. But this Article has demonstrated that their design and communication leave much to be desired.

To remedy this, modelers themselves should continue not only to include, but to highlight and explain, their own models' limits and uncertainties. The meaning of caveats should be made clear to those who might later use the modeling results to make a point. Likewise, those interested in using modeling

277. America's Clean Future Fund Act, H.R. 2451, 117th Cong. (2021) (eleven sponsors), not yet reintroduced in 118th Cong.; Energy Innovation and Carbon Dividend Act of 2021, H.R. 2307, 117th Cong. (2021) (ninety-five sponsors), reintroduced as Energy Innovation and Carbon Dividend Act of 2023, H.R. 5744, 118th Cong. (2023) (twenty-two sponsors); MARKET CHOICE Act, H.R. 3039, 117th Cong. (2021) (two sponsors), reintroduced as MARKET CHOICE Act, H.R. 6665, 118th Cong. (2023) (same two sponsors); America Wins Act, H.R. 3311, 117th Cong. (2021) (three sponsors), not yet reintroduced in 118th Cong.; Save Our Future Act, S. 2085, 117th Cong. (2021) (ten sponsors), not yet reintroduced 118th Cong.; Carbon Reduction and Tax Credit Act, H.R. 8572, 117th Cong. (2022) (one sponsor), not yet reintroduced 118th Cong.; Healthy Climate and Family Security Act of 2022, H.R. 9645, 117th Cong. (2022) (one sponsor), not yet reintroduced 118th Cong.

278. LITTLE OXFORD DICTIONARY OF QUOTATIONS 389 (Susan Ratcliffe ed., 5th ed. 2012).

279. *See, e.g.*, KENNETH P. BURNHAM & DAVID R. ANDERSON, MODEL SELECTION AND MULTIMODEL INFERENCE: A PRACTICAL INFORMATION-THEORETIC APPROACH 20 (2d ed. 2002).

results for policy and legislative advocacy should seek out models that explain this information forthrightly and should especially prefer open-source models that can be easily and independently reviewed. Ideally, it is advisable to try to use models that have a track record of predictive accuracy—if any such can be found. Furthermore, if tempted to communicate the results of modeling, it should be standard practice to explain the models' predictions in real-world terms, not simply as numeric results bereft of all context. Ideally, the communication would also include a disclosure of the relevant range of uncertainty and the factors that the model is not accounting for that could change the result. This would at least make it easier for everyone to understand what the models are, and are not, saying.

With respect to the modeling of BIL and IRA, the analysis also suggests that climate spending laws should not be modeled on their own as their spending provisions do not operate on their own. In the language of climate policy analysis, BIL and IRA are best understood as portfolios of policy instruments that operate interdependently to achieve a goal, in this case greenhouse gas emissions reductions.[280] But they should be imagined as part of an even larger portfolio of policy instruments designed to reduce U.S. greenhouse gas emissions by promoting technology transition. The spending provisions in the laws that promote renewable energy development interact with a wide range of real-world constraints and barriers that slow its pace. It makes no sense to ignore these barriers in a model that is, underneath the hood, just predicting the amount of renewable electricity generating capacity likely to be constructed in the future. Similarly, the system that caters to consumer preference for fossil-powered vehicles is a policy system, and it makes little sense to ignore that system in a model that is, underneath the hood, predicting the future market share of electric vehicles. Permitting restrictions on CO_2 pipelines and injection wells are policies. Operating permits for leaky natural gas systems are policies. Energy efficiency standards for existing buildings are policies. It makes no sense to completely ignore these policies just because BIL and IRA contained no mechanisms for addressing them. Indeed, the failure of BIL and IRA to include remedial measures for these known issues was itself a policy choice and should be modeled as such. Energy-economic models that fail to account for these constraints in any way are simply not providing accurate or useful policy-relevant information.

None of this is conceptually difficult to do. Analysts regularly distinguish between policies that are designed to directly reduce carbon emissions and "technology policies." Policies designed to reduce emissions include carbon taxes, fossil fuel subsidy removal, emissions trading schemes, regulatory limits, information measures, and voluntary actions.[281] "Technology policies," are

280. Recent discussion of climate policy effectiveness has been heavily influenced by the IPCC assessment of climate policy instruments and their effectiveness. *See generally* Eswaran Somanathan et al., National and Sub-national Policies and Institutions, *in* CLIMATE CHANGE 2014: MITIGATION OF CLIMATE CHANGE. WORKING GROUP III CONTRIBUTION TO THE FIFTH ASSESSMENT REPORT OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (Ottmar Edenhofer et al. eds., 2014), https://www.ipcc.ch/site/assets/uploads/2018/02/ipcc_wg3_ar5_chapter15.pdf.

281. *Id*. at 1157–74.

those which function to drive the adoption of climate-friendly alternative technologies,[282] and are best understood as "complementary to . . . policies aimed directly at reducing current [greenhouse gas] emissions."[283] BIL and IRA include both technology-push and demand-pull policies, meaning policies that promote the introduction of technologies into the marketplace and technologies that promote consumer selection of those technologies once introduced.[284] It might be argued that the large number of policy instruments contained in BIL and IRA demonstrate high ambition.[285] The laws might also be argued to contain a high "density" of policy instruments, meaning a large total number of provisions addressing a multitude of policy problems and offering a multitude of solutions.[286] Arguments about the impact of these rules might be said to be arguments over the "stringency" or "intensity" of their many provisions.[287] Yet, BIL and IRA might also be understood to operate at only one policy level and in one policy register, limiting their effectiveness.[288]

BIL and IRA might best be understood as policy portfolio monocultures which demonstrate similar weaknesses. All of the laws' climate provisions are vulnerable to the same things. A healthier policy ecosystem would include a wider variety of approaches arranged as a mutually reinforcing mix of incentives and mandates. Where market forces temporarily stymie the demand-pull of tax incentives, renewable portfolio standards and ZEV mandates could stand in to maintain policy progress. Where voluntary programs fail to achieve results, backstop mandates might loom, not only as alternatives but as incentives to make the voluntary programs work. Analyzing BIL and IRA outside of this larger policy possibility is an unrealistic approach.

The United States already has a significant credibility gap on the topic of climate change. It also faces a well understood ambition gap as even the best-case scenarios of BIL and IRA's impacts did not put the nation on track to achieve its target emissions of 50–52 percent below 2005 levels by 2030. This Article has demonstrated that the U.S. also faces a serious climate projection gap:

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282. *Id.* at 1174–79.

283. *Id.* at 1178.

284. *Id.* at 1174, citing Kelly Sims Gallagher et al., *The Energy Technology Innovation System*, 37 ANN. REV. OF ENV'T AND RES. 137, 150 (2012).

285. *See, e.g.*, Leonardo Nascimento & Niklas Hohne, *Expanding Climate Policy Adoption Improves National Mitigation Efforts*, 2 NPJ CLIMATE ACTION 1, 5–6 (2023) (more policy instruments correlated with more emissions reductions); *see generally* Giliberto Capano & Michael Howlett, *The Knowns and Unknowns of Policy Instrument Analysis: Policy Tools and the Current Research Agenda on Policy Mixes*, 10 SAGE OPEN 1 (2020) (including a literature review of the study of policy instrument analysis, including challenges of examining sets of policy instruments, integrating behavioral questions, measurement challenges, and implementation issues).

286. Simon Schaub et al., *Climate Policy Ambition: Exploring A Policy Density Perspective*, 10 POL. & GOV. 226, 232 (2022) (assessing existing policy databases for usefulness in policy density analysis).

287. *E.g.*, Andre Schaffrin et al., *Toward a Comparative Measure of Climate Policy Output*, 43 POL'Y STUDS. J. 257, 261 (2015) (proposing an index for determining national climate policy intensity).

288. *See* Michael Howlett & Pablo del Rio, *The Parameters of Policy Portfolios: Verticality and Horizontality in Design Spaces and Their Consequences for Policy Mix Formulation*, 33 ENV'T AND PLAN. C: GOV'T & POL'Y 1233, 1236 (2015) (proposing taxonomy of policy mixes depending on whether they are single- or multi-level, -policy, and -goal, and examining interactions between dimensions).

the difference in its laws' projected and real-world impacts, even assuming that current and future presidential administrations or Congress do not further undermine decarbonization initiatives that are already facing serious incidental headwinds. What is needed next are laws that close the projection gap and allow BIL and IRA to achieve their full potential by reducing the frictions and impediments standing in the way of success. To make that clear, what is needed next is modeling that clearly communicates this gap.

Of course, the reason BIL and especially IRA were spending-only bills, and the reason why it will be so difficult to pass the laws that are needed, is that it only takes fifty votes in the U.S. Senate to pass a budget reconciliation bill, while sixty votes are required to pass any other law, placing veto power in the hands of Senators from states containing approximately 21 percent of the U.S. population.[289] The antidemocratic structure of U.S. national government will continue to stymie climate policy reform for as long as the present system remains in place, to the benefit of polluters and the detriment of the rest of the world. And so, perhaps, what is needed next is also a return to the understanding of the past: that we cannot spend our way out of climate change. As remarkable as it was that BIL and IRA ever became law, they alone cannot result in the reductions in annual emissions that the United States needs to achieve, and building discourse around models that obscure that fact denies the public, and the world, an accurate assessment of the United States' likely future contributions to climate change. The climate law community should redouble its efforts to push the United States toward stronger, more effective measures.

CONCLUSION

BIL and IRA were climate spending bills. They directed billions of dollars toward subsidies for low-emissions behaviors and technologies and, to the extent those subsidies influence behavior, will operate to reduce greenhouse gas emissions. In an economically rational world, BIL and IRA's pricing interventions would have had enormous impacts on renewable energy construction, ZEV purchase, home energy technology choice, carbon capture technology expansion, industrial decarbonization project adoption, and fuel carbon intensity reduction. But the world is not economically rational, and prices

289. In the 119th Congress, twenty-eight states were represented by a total of fifty-three Republican Senators. *See List of Current Members of U.S. Congress*, BALLOTPEDIA, https://ballotpedia.org/List_of_current_members_of_the_U.S._Congress (last visited Aug. 27, 2025). From smallest to largest populations in millions, these were Wyoming (0.59), Alaska (0.74), North Dakota (0.80), South Dakota (0.92), Montana (1.14), Maine (1.41), West Virginia (1.77), Idaho (2.00), Nebraska (2.01), Mississippi (2.94), Kansas (2.97), Arkansas (3.09), Iowa (3.24), Utah (3.50), Oklahoma (4.10), Kentucky (4.59), Louisiana (4.60), Alabama (5.16), South Carolina (5.49), Wisconsin (5.96), Missouri (6.25), Indiana (6.92), Tennessee (7.23), North Carolina (11.05), Ohio (11.88), Pennsylvania (13.08), Florida (23.37), and Texas (31.29), with a total population about 168 million people. *See* List of U.S. States by Population, ENCYCLOPEDIA BRITANNICA (2024), https://www.britannica.com/topic/largest-U-S-state-by-population. The U.S. population is currently about 335 million. *Id*. Therefore, dropping Texas and Pennsylvania, 50 Republican Senators from states with a population of about 123 million (37 percent) can veto legislation requiring a majority vote to pass. Dropping Texas, Florida, Pennsylvania, Ohio, North Carolina, Tennessee, and Wisconsin, forty-one Republican Senators from states with a population of about 70 million (21 percent) can effectively veto legislation requiring cloture to overcome a Senate filibuster.

alone do not predict the future. Rather, numerous non-price factors posed additional barriers to the behaviors that BIL and IRA hoped to promote, and BIL and IRA did little to address these constraints.

Models that ignored known barriers tended to oversell what BIL and IRA would accomplish, which not only denied the public of a true assessment of the United States' likely future greenhouse gas emissions but also simultaneously made it much more difficult to pass further necessary climate legislation. To address this, it is necessary to reconceptualize BIL and IRA as useful but incomplete climate policy portfolios that could not, alone, achieve significant greenhouse gas reductions. This perception of further need is necessary to generate public and political support for the additional, more difficult, legislative initiatives that are still needed to reduce U.S. greenhouse gas emissions. Without these further efforts, the United States remains unlikely to achieve the Biden Administration's climate targets, and if those targets are not met, the world will continue to warm, and humanity will continue to career along the path toward climate catastrophe. Laws addressing the remaining barriers to the energy transition, and laws imposing a price on carbon pollution, are needed as much today as they were before BIL and IRA were enacted.

We welcome responses to this Article. If you are interested in submitting a response for our online journal, *Ecology Law Currents*, please contact cse.elq@law.berkeley.edu. Responses to articles may be viewed at our website, http://www.ecologylawquarterly.org.