Annual Cost per Household of Achieving Net-Zero 2050 in the U.S.[1]

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Executive Summary

There is an extensive literature regarding estimation if the “social cost of carbon.” In principle, this is an estimation of the environmental damage associated with carbon emissions to the atmosphere, not an estimate of the benefits of abating these emissions. There are substantially fewer estimates of the cost of abatement, and apparently no estimates of the cost of abatement at the household level, where all costs are ultimately manifest. In January 2021, President Biden announced that it would be Administration policy to achieve Net Zero 2050 — the reduction to zero of carbon emissions net of those which cannot be abated at any known price. This announcement directed all federal agencies to take action and did not include any estimates of the cost of achieving this policy objective. The rhetoric surrounding the policy announcement displays little or no interest in what it would cost.

This paper provides a plausible lower-bound estimate of the cost of achieving Net Zero 2050 in the U.S. It is a lower bound for at least four reasons. First, it takes as given the view that “advanced economies [must] reach net zero before developing economies do,”[2] which means achievement of the goal must occur in the U.S. well before 2050, and thus more expensively.

Second, it assumes Net Zero 2050 is achieved in the U.S. via a uniform carbon tax on energy-related CO2 emissions. Such a tax does not exist and appears unlikely to be enacted by Congress. Nonetheless, a uniform carbon tax would be the least-cost means of achieving Net Zero 2050, and much less expensive than continuing to pursue it through regulations promulgated under the authority of various marginally-related federal statutes.

Third, applying a carbon tax to all energy-related CO2 emissions would not result in all emissions being abated, even in the long-run. For any carbon tax rate, there will always be emissions that cost more to abate per unit than the carbon tax rate. Thus, substantial CO2 emissions would remain, and achieving Net Zero 2050 would require extraordinary investments in carbon capture and sequestration.

Fourth, not all CO2 emitted is energy-related, and CO2 is not the only greenhouse gas that must be controlled for Net Zero 2050 to be conceptually rational. According to U.S. Environmental Protection Agency (2022, ES-2), CO2 comprised 80% of U.S. greenhouse gas emissions in 2019 (in CO2 equivalents).

Cost is reported at the household-level, in both dollars and percentage of median household income, disaggregated by State. Two scenarios are examined: (A) annual household-level cost defined as tax revenues collected from each State’s energy-related CO2 emissions divided by the number of households in the State; and (B) annual household-level cost as tax revenues collected nationally divided by the number of households in the nation. These scenarios do not account for the myriad complexities that accompany real-world tax design for the purpose of rewarding favored geographies and interest groups, which necessarily would result in punishing others. All such adjustments

[2] International Energy Agency (2022b, 4) (“Foreword,” Dr. Fatih Birol, IEA Executive Director).

have the effect of increasing, probably substantially, the SCC or carbon tax needed to achieve any policy goal.

Four alternative carbon tax rates are considered, ranging from $100/metric ton to $700/metric ton. The paper is agnostic concerning which of these values is correct. It is noted, however, that Net Zero 2050 advocates portray climate change as an “existential” “crisis” deserving an “emergency” response. Therefore, tax rates at the upper end of this range are not unreasonable, whereas tax rates at the lower end have been criticized as likely to be ineffective.

Looking across States under Scenario A, the household-level burden, assuming Net Zero 2050 can be achieved at $100/metric ton, ranges from $974 per year (District of Columbia) to $25,338 per year (Wyoming), with a State median of $4,165 per year. Expressed as percent of median household income, this range is 1.1% to 39%, At $700/metric ton, the range is $6,817 per year to $177,368 per year, with a State median of $29,157 per year.

Under Scenario B, the highly disproportionate household-level costs on households residing in carbon-based energy-exporting States is substantially reduced, with households in carbon-based energy importing States picking up the slack. All U.S. households are assumed to pay $4,231 per year at $100/metric ton and the range is $29,619 per year at $700/metric ton. Because household income differs substantially by State, this uniform carbon tax would have disproportionate interstate impacts. At $100/metric ton, the range is 4.7% of median household income (District of Columbia) to 9.1% of median household income (Mississippi). At $700/metric ton, the range is 7.4% to 64% of median household income.

I. Introduction

Climate change in general and Net Zero 2050 in particular now occupy center stage in domestic and international environmental policy fora. Moreover, a Google Scholar search yields 146,000 apparently unique scientific references published in 2022 alone. A small fraction of these publications is concerned with the cost of mitigation, and fewer still provide useful insight concerning the costs households can expect to bear. This paper provides default cost estimates for U.S. households. It relies on respected third-party estimates of the transformative economic changes that are expected to be required, with shadow prices for carbon under alternative implementation scenarios. Finally, it takes as given the economic principle that all costs which cannot be exported are ultimately borne by households, even if the distribution of costs among households varies or is today unknown.

The remainder of this Section briefly describes Net Zero 2050 and the alternative means available to the U.S. (or other national governments) to achieve it. Most of these means, such as myriad examples of command-and-control regulation, would not be transparent because their opportunity costs are poorly understood by experts and the public alike. Several nontraditional forms of indirect regulation also have been proposed or implemented, such as financial regulations, and environmental, social, and governance

(ESG) policies the effects of which would be mediated through financial markets. Estimating the costs of these nontraditional regulatory approaches is especially difficult.

The most transparent (and economically cost-effective) means of achieving Net Zero 2050 is through a direct tax on the emission of carbon dioxide and other greenhouse gases. Because a carbon tax is uniquely transparent and would be more cost-effective than any other policy approach, it provides a credible lower-bound cost estimate. When divided by the number of households in any jurisdiction, the resulting quotient is the (minimum) cost per household. Though there are many ways to implement a carbon tax in the U.S., two simple alternatives are considered: (1) a carbon tax based on energy-related CO2 emissions by State, and (2) a tax based on national energy-related CO2 emissions. Under Tax 1, households in each State would share equally the aggregate tax on in-State CO2 emissions; under Tax 2, households in the U.S, would share equally the aggregate tax on nationwide CO2 emissions. Both are oversimplifications. For example, the actual burden of a carbon tax, even if levied directly on households, would not be borne equally across households. Also, Tax 1 would be transferred to households in other States to the extent that factors of production (e.g., stock ownership) and distribution (e.g., suppliers and customers) are located elsewhere. Similarly, the burden of Tax 2 would be redistributed unequally across States. Intensive modeling is required to tease out these second-order effects, and it is more important at this stage to provide broad indicators.

Finally, there is an infinite number of carbon tax designs from which legislators could choose, not just the two considered here. Any actual carbon tax is virtually certain to have complex design features intended to shift burdens away from protected interests.

A. Net Zero 2050

Global energy-related CO2 emissions are forecast to rise from 39,259 million metric tons in 2022 to 42,839 million metric tons in 2050. The U.S. share is projected to decrease from 13.3% (2022) to 11.2% (2050).[3] Net-Zero 2050 is a plan to reduce these emissions to zero, taking account of the fact that some emissions cannot be prevented at any known cost. Net Zero 2050 would require that the quantity of emissions that cannot be eliminated be stored instead of released, this resulting in *net* zero emissions.

This is a highly ambitious goal agreed upon in 2016 in the Paris Agreement.[4] In 2021, President Joseph R. Biden Jr. committed to reduce net greenhouse gas (GHG) emissions by 50-52% below 2005 levels by 2030 (United Nations Framework Convention on Climate Change 2021). In this "base" year, GHG emissions are estimated to have been 6,645 million metric tons (U.S. Environmental Protection Agency 2022a). Thus, the

[3] U.S. Energy Information Administration (2022b).

[4] United Nations Framework Convention on Climate Change (2016). Art. 2, Sec. 1(a) sets forth the goal of limiting the increase of global temperature to 1.5°C above its pre-industrial level. Art. 4, Sec. 1 sets forth the implementation goal "to achieve a balance between anthropogenic emissions by sources and removals by sinks of greenhouse gases in the second half of this century." The year 2050 is the beginning of that range (2099 also qualifies as within the range) and, while not explicitly mentioned, is usually expressed as the stated goal.

Administration's commitment is to eliminate 3,232 million metric tons by 2030 and all 6,645 million metric tons by 2050.[5]

The magnitude of this policy goal is hard to overstate. Its advocates characterize it as

B. Alternative ways to achieve Net Zero 2050

There are two primary ways to achieve this goal: (1) leverage market forces by establishing either a cap-and-trade system or a carbon tax, or (2) expand reliance on traditional command-and-control regulations such as those promulgated by U.S. EPA under the Clean Air Act, regulations issued under other statutory authorities,[6] and nongovernmental entities attempting to advance Net Zero 2050 through coordinated private sector action.[7] Many of these actions face legal challenges, including disputes about whether federal agencies have requisite statutory authority and whether coordinated action by asset managers is compliant with antitrust law. I

The costs of these actions are much less transparent than Clean Air Act regulation, in large part because their authors generally conduct no benefit-cost analysis. For purposes of this paper, all that matters is that they are (or would be) considerably less cost-effective than a simple carbon tax. For that reason, the carbon tax provides a credible lower bound for the cost of Net Zero 2050.

1. Market-based regulation

Under a cap-and-trade scheme, Congress would establish a fixed number of emission permits and let markets set the price. Generally, more than *de minimis* quantities CO2 could not be emitted without a permit. They would reduce their own emissions to the extent they could at a cost below the market-clearing permit price and earn permits to the extent they reduced more emissions than permits allowed. They would buy permits to cover emissions that cost more to reduce than the permit price. Permits would be bought and sold in government run or sponsored markets.

[5] Because the U.S. Senate has not ratified an applicable treaty, and the U.S. Congress has not enacted any legislation establishing Net Zero 2050 as U.S. policy, the Administration's commitments are its own. They are not legally binding and may be rescinded at any time.

[6] See, e.g., certain appliance standards (U.S. Department of Energy 2021a, 2021b), data collection potentially leading to a ban on residential gas ranges (Consumer Product Safety Commission 2023), and proposed CO2 disclosure mandates on publicly traded firms (Securities and Exchange Commission 2022).

[7] See, e.g., the Net Zero Asset Managers initiative (2022a, 2022c, 2022b) and (Glasgow Financial Alliance for Net Zero 2023).

Under a carbon tax, Congress would legislatively levy a tax on each unit (e.g., metric ton) of CO2 emissions. Emitters would pay a tax equal to the product of the tax rate and the quantity of their emissions. No permits would be required, so the government would not establish or sponsor markets for permits to be bought and sold. Under broad conditions, a cap-and-trade scheme and a carbon tax are indistinguishable.[8]

It is commonly assumed that firms but not households are "emitters." This is false. Every household emits CO2 — primarily in the form of motor vehicle tailpipe emissions and as a byproduct of energy combustion for residential heating, cooling, refrigeration, cooking, and lighting; and secondarily with respect to its other consumption choices that include carbon-based energy as an input. If Congress were to enact a carbon tax, it could tax each metric ton of CO2 emitted regardless of source, or it could tax each metric ton of potential CO2 emissions, thereby focusing the apparent burden on firms. (As discussed in Section II.B below, imposing a carbon tax on firms alone would not shield households from bearing the tax because costs initially borne by firms wind up being borne by households.)

2. Traditional command-and-control regulation

U.S. EPA has been responsible for regulating air pollutants since its establishment in 1970. It has been regulating CO2 and other greenhouse gases since 2009.[9] A key input to the Agency's climate change regulations is its determination of the "social cost of carbon" (SCC). Under traditional regulation, a credible estimate of the SCC is needed to estimate the climate benefits of regulations, and estimates of benefits and costs are required pursuant to a longstanding presidential directive.[10] If properly calculated, the optimal SCC and the optimal carbon tax are equal.[11]

In 2010, an Obama Administration interagency working group (Obama IWG) established SCC values ranging from $21-$65/metric ton (emitted in 2010) to $45-$136/metric ton (emitted in 2050)[12] The estimated SCC increases over time to reflect the belief that the marginal damage to the climate caused by CO2 emissions is rising over time.

The Obama IWG revised the SCC in 2016 to $31-$86/metric ton (emitted in 2010) to $69-$212/metric ton (emitted in 2050).[13] A Biden Administration interagency working group (Biden IWG) updated for inflation the 2016 SCC to a range of $14-$152/metric ton (emitted in 2020) to $32-$260/metric ton (emitted in 2050).[14] The Biden IWG was directed to substantively revise the SCC by January 2022, but as of this writing it has not done so. Draft guidance to agencies has been published for public comment but has not been

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[8] Nichols (1984).

[9] U.S. Environmental Protection Agency (2009).

[10] Clinton (1993).

[11] Stern and Stiglitz (2021, at 1).

[12] Interagency Working Group on Social Cost of Carbon (2010).

[13] Interagency Working Group on Social Cost of Carbon (2016).

[14] Interagency Working Group on Social Cost of Greenhouse Gases (2021).

finalized,[15] and U.S. EPA has proposed or promulgated regulations that rely on SCC values greater than those in the Biden IWG 2021 guidance.[16]

Federal agencies use the SCC for estimating the benefits of regulations that reduce CO2 emissions. Regulations costing less than the SCC are presumed to have net benefits.[17] Congress also might delegate this legislative act to the Executive branch. Whether that would pass constitutional muster is beyond the scope of this analysis.

3. Nontraditional regulation by government agencies

The Securities and Exchange Commission has recently proposed a regulation to impose certain climate-related disclosures by publicly traded firms, most notable estimates of CO2 emissions by firms from suppliers and customers ("Scope 3").[18] Obtaining the former requires them to obtain from other firms, including firms that are not publicly traded. Obtained such information from customers the latter may be impossible, at least if the SEC expects the data obtained to be reliable.

Section 5(b) of Executive Order 14,030 directed the Federal Acquisition Regulatory Council to impose similar reporting burdens on federal contractors. In response, the major federal acquisition agencies issued a proposed common regulation affecting as estimated 4,413 entities that received $7.5 million or more in federal contract dollars.[19] To date, no final agency action has been taken.

These regulations are best understood as a form of traditional but highly indirect and untargeted command-and-control regulation. Benefits and costs are unknown. Pursuant to Executive Order 12,866, the proposed Federal acquisition regulation is required to, but does not, include a Regulatory Impact Analysis with credible benefit and cost estimates. SEC is exempt from Executive Order 12,866, and its proposed rule includes no credible benefit or cost estimates.

The Paperwork Reduction Act (PRA)[20] applies to both regulations and can, under certain circumstances, be a useful source of cost information. The proposed FAR regulation includes burden estimates (4,812 entities with average paperwork burden of 254 burden hours to prepare and disclose Scope 1 and 2 emission estimates; 793 entities with average paperwork burden of 4,117 burden hours).[21] SEC estimated average paperwork burden of more than $10 billion in annual paperwork burden.[22]

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[15] Council on Environmental Quality (2023),

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[17] Aldy et al. (2022).

[18] Securities and Exchange Commission (2022).

[19] Department of Defense, General Services Administration, and National Aeronautics and Space Administration (2022, at 68313).

[20] Paperwork Reduction Act of 1995 (Pub. L 104-13) (1995), and its implementing regulations (Office of Management and Budget 1995).

[21] Department of Defense, General Services Administration, and National Aeronautics and Space Administration (2022, at 68326-68327).

[22] Securities and Exchange Commission (2022, at 21461 [PRA Table 4]).

The Office of Management and Budget (OMB) has the statutory authority to disapprove agency Information Collection Requests (ICRs) that, in OMB's view, do not comply with the PRA. This authority is rarely exercised, however. During the period 1994-2022, OMB disapproved 0.05% of the 123,927 Information Collection Requests it reviewed.[23] From this statistic alone it is beyond question that OMB liberally exercises its administrative discretion to permit agencies to publish noncredible paperwork burden estimates and allow agencies to not respond in good faith to public comments alleging that agency burden estimates are unrealistically low. For this reason, paperwork burden estimates are not reliable even if they are authoritative.

4. Nontraditional regulation by nongovernmental entities

The United Nations has established a Principles for Responsible Investment (PRI) program intended to conform international investment with Net Zero 2050.[24] PRI is affiliated with the Glasgow Financial Alliance for Net Zero (GFANZ), a UN program launched in 2021 "in partnership with the UNFCCC Race to Zero campaign."[25] GFANZ includes eight sector-specific "alliances" to "drive progress at the grassroots level to raise the ambition on net-zero commitments, increase engagement, and support their members' acceleration of their alignment journeys."[26] One such alliance, the Net Zero Asset Managers Alliance (NZAM), reports that as of June 30, 2023, its "[m]ore than 315 asset managers" have "USD 59 trillion in assets under management."[27] Most major asset managers that service U.S. households, whether directly through brokerage and retirement accounts or indirectly through government and private sector pension funds, are NZAM signatories. Being a signatory purportedly commits an asset management firm to:

- "Work in partnership with asset owner clients on decarbonisation goals, consistent with an ambition to reach net zero emissions by 2050 or sooner across all assets under management ('AUM');
- "Set an interim target for the proportion of assets to be managed in line with the attainment of net zero emissions by 2050 or sooner; and
- "Review our interim target at least every five years, with a view to ratcheting up the proportion of AUM covered until 100% of assets are included"[28]

NZAM signatories' actions include, among other things, voting by proxy the shares owned by investors and beneficiaries, and conducting thousands of "engagements" in which they pressure company executives and boards to support Net Zero 2050 or risk various hostile actions.[29] Absent legislative authority (or regulatory authority, if the SEC regulation mentioned in subsection I.B.3 above is finalized and survives legal challenge),

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[23] Calculations by the author based on data reported at reginfo.gov. During the period 1981-1993, OMB disapproved only 1.9% of the ICRs it reviewed.

[24] United Nations Environment Program Principles for Responsible Investment (2022).

[25] Glasgow Financial Alliance for Net Zero (2023a).

[26] Glasgow Financial Alliance for Net Zero (2023b).

[27] Net Zero Asset Managers Initiative (2022c).

[28] Net Zero Asset Managers Initiative (2022b).

[29] *See*, e.g., BlackRock (2021).

these actions could subordinate beneficiary interests to other objectives (such as Net Zero 2050) and thus may be breaching their fiduciary duties to investors under federal and State law.[30] Collaborations like NZAM also may violate U.S. antitrust law if they are concerted action in restraint of trade.[31]

Net Zero 2050 is a significant component of ESG, and as GFANZ implies, it dominates social and governance factors as well as other environmental considerations. This is further apparent when considering asset managers' own characterizations of ESG investing. For example, the largest asset manager in the world — BlackRock — touts Net Zero 2050 as the dominant aspect of its ESG investing and engagement activities.[32]

The household-level burdens of Zero 2050 resulting from these indirect regulatory means have not been estimated. Moreover, the lack of transparency in asset managers' engagement strategies makes estimation exceedingly difficult, if not impossible. Nonetheless, it is reasonable and appropriate to assume that the cost of Net Zero 2050 would be considerably greater if achieved through such nontraditional means rather than via a direct carbon tax. Whereas a carbon tax has key economic efficiency attributes, coercive nontraditional approaches, whether conducted by governments or private parties such as NZAM members, do not.

ESG investing and Net Zero 2050 appear to have enjoyed substantial public support. In a 2023 U.S. poll, 30% of respondents said it was "very important" for the U.S. to achieve Net Zero "as quickly as possible."[33] But the poll did not include tangible information about cost in its survey design, and respondents were concerned that consumer cost must be kept low "low."[34]

Public support may be contingent on cost being hidden from view. A 2021 poll estimated that support in the U.K. ranged from 47% to 68%, depending on the activity. This

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[30] Cameron, Iaccarino, and Richards (2022). Normally, fiduciaries must manage assets for the sole interest of the beneficiary, and any evidence of mixed motives is irrebuttable evidence that this fiduciary duty has been breached. *See* Schanzenbach & Sitkoff (2020, 401). However, States may direct fiduciaries of its pension funds to serve mixed motives. Kentucky, for example, requires pension trustees to "give priority to the investment of funds in obligations calculated to improve the industrial development and enhance the economic welfare of the Commonwealth" (see Cameron *et al* 2022 at 5, footnote 19). Here, Kentucky's relevant interest is the protection of carbon-based energy production, and the statutory instruction to "give priority to" it can be read to subordinate pension beneficiaries' financial interests to this state objective. The merits of Kentucky's policy aside, there is no doubt that it conflicts with Net Zero 2050 and managers of state pension assets cannot give preference to Net Zero 2050 without violating their fiduciary duty to Kentucky state pension beneficiaries. Indeed, the violation is more transparent than if Kentucky law prescribed a sole beneficiary interest motive.

[31] Brnovich et al. (2022) (State attorneys general alleging potential antitrust violations). *See also* Miazad (2022) (concerns expressed by a Net Zero 2050 advocate about asset managers' vulnerability to antitrust enforcement).

[32] BlackRock (2021, 8) (describing how climate risk dominates its ESG "engagement priorities") and (2022, 4) (emphasizing the UN's net-zero heavy Principles for Responsible Investment).

[33] Kennedy et al. (2023, 35-36). 11% of Republicans and 49% of Democrats supported this goal.

[34] Id, 35-36. "60% say keeping consumer costs low is a very important consideration to them in climate proposals," including 51% of Democrats and 68% of Republicans. The survey design encouraged the myth that consumers could avoid paying costs if they were imposed on industry.

declined substantially, however, when respondents were "presented with the possible lifestyle and financial cost implications [qualitatively characterized] for them personally."[35] Public support appears to depend on the assumption that costs would be minor or others would pay. It is plausible, therefore, if not likely, that public support would significantly decline if the public understood the cost in practical, quantitative terms, such as household-level burden.

C. How market-based and traditional regulation differ

Market-based approaches offer three important potential advantages over traditional regulation. First, they can achieve any policy goal at much less expense than command-and-control regulation. The reasons are simple. No government agency can possibly know everything it needs to minimize cost. At best, an agency can know only part of what market actors know, and they can only learn this by demanding that market actors belatedly reveal the information. This is something market actors are loath to do because much of their knowledge consists of trade secrets.

In contrast, existing law (primarily the Clean Air Act) does not require (or in many cases, even allow) U.S. EPA to issue economically efficient regulations. The Agency is constrained to act within the four corners of constitutionally permissible congressionally delegated authority. The Clean Air Act was not written with either climate change or economic efficiency in mind. That means achieving Net Zero 2050 through command-and-control regulation using the Clean Air Act will have costs substantially greater than a carbon tax.

Second, a market-based approach would allow the climate-related elements of traditional command-and-control regime to be terminated. Indeed, the efficiency of a market-based approach cannot be achieved by layering it on top of the existing command-and-control regulatory regime. Thus, it is assumed that if Congress enacts a carbon tax, it explicitly rescinds any direct or indirect authority for U.S. EPA — or any other Federal or State agency — to issue climate regulations. If a carbon tax were enacted without these provisions, it could not achieve Net Zero 2050 cost-effectively. The tax would have to be set at a level above the SCC to achieve the same results as a carbon tax alone would accomplish on its own.

Third, a market-based approach would make the cost of achieving Net Zero 2050 highly transparent. Whereas the cost of traditional regulation is difficult to estimate and easy to obfuscate, the cost of a market-based system would be visible via the market-clearing permit price or the tax rate.

These advantages are highly unlikely ever to be realized, however, so the household-level cost estimates reported here are unrealistically low. These estimates depend on a carbon tax that Congress has had many opportunities to enact but has declined to do so. The most recent such opportunity was in the FY 2022 budget reconciliation bill, which includes hundreds of billions of dollars in climate change-related subsidies.[36] Subsidies are inherently inefficient because, among other things, they are

[35] IPSOS (2021).

[36] H.R. 5376 (Pub, L. 117-169, (*Inflation Reduction Act of 2022*).

poorly targeted and susceptible to debilitating leakage from rentseeking and corruption. Thus, the most likely scenario is the U.S. continues to rely on traditional command-and-control regulations despite their well-known and pervasive economic inefficiency. And that means household-level costs would be much higher than the estimates reported here.

D. Net Zero 2050 is driven by cost-effectiveness, not benefit-cost analysis

It is important to note that the SCC (or carbon tax rate) would not be determined based on traditional benefit-cost criteria, in which costs are subtracted from benefits to obtain the net improvement in human welfare. Standard benefit-cost analysis seeks the greatest excess of benefits over costs, which if applied here would require that both the global temperature goal and the date by which it is achieved are endogenous rather than fixed policy assumptions.

Net Zero 2050 is different because benefits are assumed to exceed costs no matter how high costs might be. In the words of Lord Nicholas Stern and Nobel prize awardee Joseph Stiglitz, "now that a target has been adopted by the Biden administration, the appropriate notion of the carbon price is one that would guide decisions to achieve the target"[37] — in other words, it is strictly a cost-effectiveness policy exercise. The policy, and perhaps to a lesser extent the date it is achieved, are *not* open to debate. Indeed, Stern and Stiglitz (2021) further assert that there is a global consensus supporting their view:

> [T]he international community arrived at the consensus that temperature changes should be limited to 1.5°C to 2°C because they believed higher temperature increases posed unacceptable risks that could be avoided at an acceptable cost.[38]
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> …
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> The international community has balanced the risks of increased climate change with the reasonable costs of containing it, and has agreed on keeping temperature change to well below 2°C. Having made that commitment, the task at hand is how to efficiently implement it, which includes a derivation of the SCC that reflects the targets that have been set.[39]

For serious Net Zero 2050 advocates, the best possible outcome would be achieving this goal at the lowest possible cost. It follows that if any proffered SCC is too low to justify regulations deemed by the Biden administration necessary to achieve Net Zero 2050, the SCC must be increased to whatever value is required to ensure that benefits at least exceed costs. As for the methods used by the Biden IWG to estimate the SCC, Stern and Stiglitz (2021) characterize these methods as "flawed" and elsewhere say they "cannot be relied upon to produce reliable estimates of the SCC that are in line with international temperature targets or domestic emissions targets."[40]

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[37] Stern and Stiglitz (2021, at 2).

[38] Stern, Stiglitz, Karlsson, and Taylor (2022, at 6).

[39] Stern, Stiglitz, Karlsson, and Taylor (2022, at 2). They posit no role for Congress in setting climate policy.

[40] Stern, Stiglitz, Karlsson, and Taylor (2022, at 1).

II. Key Elements of the Analysis

A. Data

Annual U.S. aggregate and State carbon tax revenue is calculated by multiplying each of four alternative carbon tax rates by CO2 emissions in 2019.[41] Other State-level energy data also were obtained from the Department of Energy's State database.[42] Numbers of persons,[43] households,[44] average household size,[45] and median income[46] for the US and each State in 2020 were obtained from the U.S. Census Bureau.

Estimates of the social cost of carbon (SCC) come from Obama and Biden Administration interagency working groups,[47] the international consulting firm McKinsey & Company,[48] international insurance colossus Swiss Re Institute,[49] and the Network for Greening the Financial System (NGFS).[50]

B. Virtually all costs are borne by households

Taxes and regulatory burdens are not borne solely by the party on whom they are imposed. Rather, they are passed on to households in a complex web of relationships related to households' consumption and employment choices, taxes, and direct or indirect stock ownership.[51] The fraction of a carbon tax not borne by stockholders is passed on to customers (in the form of higher prices), suppliers (in the form of reduced payments for inputs), and employees (in the form of lower wages and reduced benefits). These are not different households, but rather different roles households play in the economy. In the aggregate, escaping the cost of Net Zero 2050 requires that cost be exported to other countries, other current U.S. households (via government-mandated transfer payments), or future U.S. households (via government expenditures financed by debt).

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[41] U.S. Energy Information Administration (2022d). CO2 emissions in 2020 and 2021 were not used because they were seriously diminished, in an unsustainable way, by government responses to COVID-19. Data for 2022 are not yet available, making 2019 the most representative recent year.

[42] U.S. Energy Information Administration (2022c).

[43] U.S. Census Bureau (2022a).

[44] U.S. Census Bureau (2022b).

[45] U.S. Census Bureau (2022b).

[46] U.S. Census Bureau (2022d).

[47] Interagency Working Group on Social Cost of Carbon (2010, 2016); Interagency Working Group on Social Cost of Greenhouse Gases (2021).

[48] McKinsey & Company (2022).

[49] Swiss Re Institute (2022).

[50] Network for Greening the Financial System (2021b, 2021a, 2022a). NGFS is "a group of Central Banks and Supervisors willing, on a voluntary basis, to share best practices and contribute to the development of environmental and climate risk management in the financial sector and to mobilize mainstream finance to support the transition to a sustainable economy" (Network for Greening the Financial System 2019).

[51] An estimated 58% of all U.S. households bear part of the cost of the corporate income tax via direct or indirect stock ownership. *See* Saad and Jones (2022).

Indeed, the most popular method of escaping current household costs is to shift them to future households. For FY 2022, the latest year for which complete data are available, the federal government budget deficit was $1.4 trillion[52] on a budget of $6.8 trillion,[53] thereby shifting more than one-fifth of current outlays to future generations.[54] From FY 2009 to FY 2022, total federal debt increased from $12.3 trillion to $31.4 trillion.[55] To be sure, shifting costs to future generations may be ethically justifiable insofar as future generations are expected to reap the benefits of costly actions taken today in hopes of reducing climate impacts tomorrow. Current deficit financing does not qualify, however, because it shifts the burden of current *consumption* to future generations.[56]

To say that virtually all costs of Net Zero 2050 will be borne by households does not mean that household-level burden will be the same for all households. Costs will vary in complex ways. Describing the cost distribution is critically important but beyond the scope of this initial analysis, the purpose of which is to characterize household-level impacts in rough terms.

Therefore, the most complete picture that can be obtained today of the lower-bound cost of achieving Net Zero 2050 is revealed by estimating average household burden regardless of its actual incidence. This captures all five roles that households play in the economy: shareholders, suppliers (including bondholders, who supply debt financing), customers, workers, and taxpayers. And the most transparent way to reveal the lower-bound average household burden is to report it as if it were directly levied on households as an annual carbon tax.

Households are likely to have already borne some of these costs indirectly through rising prices for energy, and goods and services for which energy is a significant input. While rising prices have been blamed on supply chain issues, energy is a key component of modern supply chains.

In the short run households can avoid bearing only the capital component of household cost, by disinvesting in firms with large direct or indirect carbon "footprints" that cannot be easily reduced. Only in the long run can households reduce their own carbon "footprints," and this will require radically changing their consumption choices, including where they live and work. These long-run changes will be costly and must be added to long-run residual carbon tax payments to derive total long-run household costs. To a

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[52] Federal Reserve Bank of St. Louis (2023c).

[53] Federal Reserve Bank of St. Louis (2023b).

[54] The cost of even more current consumption is expected to be shifted in FY 2023. During the first 10 months of the fiscal year, the federal deficit was $1.61 trillion. *See* U.S. Department of the Treasury (2023).

[55] Federal Reserve Bank of St. Louis (2023a).

[56] An obvious exception occurred in 2022 via the Inflation Reduction Act of 2022 (Pub. L. 117-16), which appropriated hundreds of billions in federal subsidies on technologies and activities intended to reduce future climate impacts. Because these expenditures were debt-financed, their opportunity costs will be borne mostly by future households.

significant, household opportunity cost will include accepting a mandated reduced quality of life—a cost difficult to quantify and monetize, but nevertheless, quite real.

Meanwhile, none of the major Net Zero 2050 modeling teams has addressed the question of how its extraordinary cost would be paid, or by whom. NGFS says "the role of governments is crucial in ensuring a just transition and cushioning the impact of decarbonization on the most vulnerable groups in society,"[57] but offers no insight concerning what it means for the transition to be "just," how governments would accomplish it if they wanted to, or why it is reasonable to expect that they would. McKinsey, which relies on NGFS's scenarios to derive its $275 trillion global cost estimate for the *transition* to Net Zero 2050 (i.e., excluding the cost of sustaining it thereafter), discusses a subset of obviously relevant questions about who pays but says its results "do not factor in these considerations."[58] The Swiss Re Institute synthesizes over a dozen external estimates (including McKinsey's) to obtain its estimated $290 trillion "investment gap,"[59] but instead of confronting the question of who would pay, claims that there would be "huge benefits" amounting to 90-140% of costs,[60] presumably making the question irrelevant. Finally, none of the modeling teams has given any public attention to the cost of rentseeking—resources consumed for the purpose of capturing benefits and shifting costs to others.

C. Household-level burden is the most informative estimate of the cost of Net Zero 2050

Because Net Zero 2050 is a cost-effectiveness policy exercise, the best way to approximate its household-level burden is to assume that the SCC used for regulation (or its equivalent, the carbon tax rate) is set as high as necessary to ensure that the goal is achieved. This has the advantage of making household-level burden highly transparent. Decision-makers in each household can envision paying this amount as if it were a lump-sum tax due every April 15.

This paper reports plausible estimates of the average direct and indirect household-level burdens of a carbon tax, using several alternative tax rates, irrespective of whether the tax is levied directly (via an explicit carbon tax) or indirectly (via regulation supported by the SCC). It is generally agreed that a uniform tax per unit of CO2 is the least costly means of achieving any desired reduction in emissions, including the 100% reduction demanded by Net Zero 2050. Market actors (including household decision-makers) have the best available information concerning the marginal cost of reducing these emissions. A carbon tax gives them a powerful incentive to efficiently use this information. They will try to eliminate any CO2 emissions that can be abated at a cost less than the tax rate. At the same time, it is important to note that all other means of achieving Net Zero 2050 would be more expensive than a carbon tax. Thus, the household-level burdens reported here are lower bounds, and quite possibly, very much lower than all other Net Zero 2050 implementation paths.

[57] Network for Greening the Financial System (2022b, at 3).

[58] McKinsey & Company (2022, at 6).

[59] Swiss Re Institute (2022, Table 3).

[60] Swiss Re Institute (2022, at 21).

D. Alternative values for the SCC (or carbon tax)

The Obama administration estimated multiple SCCs, with its preferred value dependent on the year in which CO2 emissions were abated. When updated to 2020 dollars, this range is $56/metric ton for 2025 emissions to $85/metric ton for 2050 emissions. A higher range was obtained using statistical methods to account for the unlikely probability that damages from CO2 could turn out to be greater than currently expected. That higher range SCC was $169/metric ton for 2025 emissions to $260/metric ton for 2050 emissions.[61]

A recent U.S. Environmental Protection Agency report estimated the SCC at $200/mt and $480/mt for 2025 emissions using a 2.5% and 1.5% discount rate, respectively.[62] Under guidelines proposed in April 2023 by the Office of Management and Budget (2023a), a 1% discount rate would be used for all regulations with a 30-year or greater time horizon, thus increasing the SCC for 2025 emissions well above $480/mt.

Alternative SCC estimates can be obtained from net zero analyses sponsored by NGFS.[63] Two scenarios are relevant here. The first is an "orderly" scenario that would achieve Net Zero 2050 "through stringent climate policies and innovation."[64] The second is a "disorderly" scenario called "divergent net zero" that would achieve Net Zero 2050 but "with higher costs due to divergent policies introduced across sectors."[65] The "orderly"

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[61] Interagency Working Group on Social Cost of Carbon (2016); Interagency Working Group on Social Cost of Greenhouse Gases (2021). Meanwhile, the price of a carbon emissions permit in the European Union increased from about EUR 20 per metric ton in 2021 to more than EUR 80 per metric ton in 2022. *See* European Commission (2022, Figure 2). In 2021, the Commission proposed to "tighten[] the cap on emissions and make[] its annual reduction steeper" (2022, 3). This would increase the market clearing price for emission permits, which the Commission recognizes as fiscally beneficial to Member States (2022, 13). They can use auction revenues, which are supposed to be dedicated to designated "green" activities, This includes indirect cost compensation, the effect of which is to reduce e4lectricity prices where rapidly rising prices is politically sensitive. All such subsidies increase the minimum emissions price needed to achieve Net Zero 2050.

[62] U.S. Environmental Protection Agency (2022b, ES.1).

[63] Network for Greening the Financial System (2021a). McKinsey & Company (2022) relies on the NGFS "orderly" transition scenario to derive its global cost estimate for Net Zero 2050 of $275 trillion ($9.2 trillion per year on average) through 2050. "Orderly" scenarios require a high level of national and international coordination through central planning, supplanting decision-making by democratic or republican means.

[64] Network for Greening the Financial System (2022c): "Net Zero 2050 is an ambitious scenario that limits global warming to 1.5 °C through stringent climate policies and innovation, reaching net zero CO_2 emissions around 2050. <u>Some jurisdictions such as the US, EU and Japan reach net zero for all greenhouse gases by this point</u>" (emphasis added).

"This scenario assumes that ambitious climate policies are introduced immediately. <u>CDR [carbon dioxide recovery]</u> is used to accelerate the decarbonisation but kept to the minimum possible and broadly in line with sustainable levels of bioenergy production. Net CO_2 emissions reach zero around 2050, giving at least a 50 % chance of limiting global warming to below 1.5 °C by the end of the century, with no or low overshoot (< 0.1 °C) of 1.5 °C in earlier years. Physical risks are relatively low but transition risks are high."

[65] Network for Greening the Financial System (2022c): "Divergent Net Zero reaches net-zero by 2050 but with higher costs due to divergent policies introduced across sectors and a quicker phase out of fossil fuels.

"This scenario differentiates itself from the Net Zero 2050 by assuming that climate policies are more stringent in the transportation and buildings sectors. This mimics a situation where the failure to coordinate scenario predicts shadow carbon prices (i.e., implicit SCCs) ranging from $180/metric ton (2025 emissions) to about $450/metric ton (2050 emissions). Shadow carbon prices are predicted to range from about $200/metric ton (2025 emissions) to about $700/metric ton (2050 emissions).[66] Neither scenario is unlikely to achieve the temperature change targets set in the Paris Agreement.

The analysis here uses four alternative values: first, a pair of values ($100/metric ton and $300/metric ton) derived from authoritative Administration and U.S. EPA reports; and second, a pair of carbon shadow prices obtained from NGFS ($450 and $750/metric ton). Each alternative SCC can be criticized. For example, highly influential nongovernment economists who favor Net Zero 2050 say the Administration's lower range SCCs (i.e., ~$100/metric ton) "are too low to be consistent with the aim of reaching net zero by 2050," which they regard as a consensus international agreement beyond legitimate debate.[67] The Administration's upper-bound range (~$300/mt) reflects higher than expected marginal damages from CO2, but like the lower-bound it does not capture the higher cost of command-and-control regulation, the purpose for which it was devised. The NGFS "orderly" scenario ($450/metric ton) is suspect because it includes highly restrictive conditions that do not reflect sociopolitical realities. Finally, the NGFS's "disorderly" scenario ($700/metric ton) is criticized as inefficient and undesirable,[68] but not for being unrealistic.

Analysts and Net Zero advocates may disagree concerning which estimate is most accurate, but there appears to be no dissent from the proposition that higher SCCs are more likely to achieve Net Zero 2050. Moreover, advocates also insist that the transition to Net Zero 2050 must be "immediate,"[69] "coordinated,"[70] "more sudden than expected,"[71] and that it will require "a fundamental transformation of the global economy."[72] For these reasons, the higher SCC alternatives appear more plausible than the low SCC alternatives.

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policy stringency across sectors results in a high burden on consumers, while decarbonisation of energy supply and industry is less stringent. Furthermore, the availability of CDR [carbon dioxide recovery] technologies is assumed to be lower than in Net Zero 2050. Emissions are in line with a climate goal giving at least a 50 % chance of limiting global warming to below 1.5 °C by the end of the century, with no or low overshoot (<0.1 °C) of 1.5 °C in earlier years. This leads to considerably higher transition risks than Net Zero 2050 but overall the lowest physical risks of the 6 NGFS scenarios."

This scenario is more consistent with democratic and republican decision-making, though it still assumes that there democtatic or republ,ican decision-makers have agreed on the policy goal. No such agreement currently exists in the U.S. Key emitting nations have publicly stated they do not agree, and developing country agreement requires massive external funding, the cost of which to U.S. households is assumed here to be zero.

66 Network for Greening the Financial System (2022a, slide 9).

67 Stern, Stiglitz, Karlsson, and Taylor (2022). They do not specify how high they believe the SCC must be to achieve Net Zero 2050.

68 Boissinot et al. (2022).

69 International Energy Agency (2021b, 14), Boissinot et al. (2022).

70 Boissinot et al. (2022).

71 Network for Greening the Financial System (2022b, at 3).

72 McKinsey & Company (2022, 1).

E. Discounting and the SCC

While the SCC is informed by economic estimates of the marginal damage from CO2 emissions, its value critically depends on several key assumptions, most notably the discount rate. The discount rate matters because the costs of mitigation are borne now, and any benefits are realized many decades hence.

Objectively defined, the discount rate captures how much it is worth to postpone current consumption. Consider a simple illustration. Assume that a particular CO2-reducing action would provide $1,000 in benefits in 2073 — 50 years from now. If the discount rate is set at 0%, the value of this benefit is the same today as it would be in 2073 — $1,000. But households never value current and future consumption the same. Discounting at 7%, the $1,000 benefit delivered in 2073 is worth $33.95 today. Put another way, a household that discounts future consumption at 7% would be willing to pay $33.95 today to receive (or enable the household's children or grandchildren to receive) a $1,000 payment in 2073.

The choice of discount rate for calculating the SCC matters because the lower the rate, the higher will be the estimated SCC. The Obama administration used a discount rate of 3%. When updated to 2020 dollars, the range of SCC estimates was $56/metric ton (for 2025 CO2 emissions) to $85/metric ton (for 2050 CO2 emissions). A higher range was obtained using, for example, the 95th percentile (i.e., the reasonable worst case) of the 3% discount rate, yielding a range of $169/metric ton (for 2025 CO2 emissions) to $260/metric ton (for 2050 emissions).[73]

Highly influential nongovernment economists who favor Net Zero 2050 as a policy goal argue for rates of 2%,[74] or even 0%.[75] They say that SCC values based on discount rates of 3% or higher "are too low to be consistent with the aim of reaching net zero by 2050."[76] Recently, the Office of Management and Budget formally proposed to use 1% for climate change-related regulations.[77] If finalized, this will significantly increase the maximum SCC that federal regulators will interpret as reasonable and appropriate.

F. Discounting and household preferences

None of these discount rates reflect household preferences; indeed, OMB's recent proposal to establish 1% as the discount rate for climate-related regulations explicitly denies that household preferences are even relevant. Nonetheless, household preferences surely matter for estimating the household-level burden of Net Zero 2050. Few households discount future consumption at rates as low as 3%; likely none discount at 0%.

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73 Interagency Working Group on Social Cost of Carbon (2016); Interagency Working Group on Social Cost of Greenhouse Gases (2021).

74 Greenstone and Stock (2021).

75 Stern, Stiglitz, Karlsson, and Taylor (2022).

76 Stern, Stiglitz, Karlsson, and Taylor (2022).

77 Office of Management and Budget (2023a, 2023b).

Implicit household discount rates have been estimated for various energy conservation investments, such as air conditioners[78] and weatherstripping,[79] in which the same household that bears up-front capital costs (e.g., a carbon tax) also captures future benefits in the form of reduced operating costs (e.g., lower future electricity prices). Quite reasonably, household decision-makers are uncertain about whether actions paid for today will actually return benefits in the future, and their implicit discount rates may reflect this uncertainty. Uncertainty would be much greater in the broad climate change context because future benefits are delayed many decades (instead of only months or years in the examples studied), and they are less certain actually to be realized. Nevertheless, implicit discount rates derived from these empirical studies are instructive because the average discount rate estimated—26%—is much higher than the discount rate used by government decision-makers on their behalf in applications where benefits are realized much earlier and uncertainty about the existence of benefits is much less. For low- and middle-income households, which often borrow at double-digit interest rates to pay for unexpected consumption (such as medical bills or sudden increases in the price of energy), implicit discount rates would be much greater.

Looking ahead, Section III calculates the lowest annual average household burden of a carbon tax design in which each State is responsible for covering all energy-related CO2 emitted within its borders. Section IV provides the comparative calculation in which every U.S. household is assigned the same financial burden. Both approaches are intentionally simple and, importantly, require no household-specific information except taxpayer identity, which with fairly minor errors easily could be obtained from IRS income tax filings. Many other approaches are, of course, feasible and potentially worthy of analysis. However, they could require a great deal of household-specific data that may be difficult or impossible to obtain. Also, as tax design gets more complicated, administrative costs and errors both rise, along with deadweight losses due to rentseeking, which can be expected to be truly unprecedented.

III. Scenario A: Annual Burden of Net Zero 2050 per Household Assuming its Share is Proportional to Its State's Energy-related CO2 Emissions

In this Section, it is assumed that each State's share of the national carbon tax burden is proportional to the State's energy-related CO2 emissions, and that each household's share is the same as every other household in that State. This is largely the path of the suite of current and expected future command-and-control regulations promulgated under the Clean Air Act, which target stationary sources and motor vehicle manufacturing. Federal and State regulation using other authorities are inherently less well-targeted, and thus even more expensive.

Here, the distinguishing feature is that Net Zero 2050 is assumed to be achieved at the lowest possible cost—i.e., through the lowest carbon tax that can achieve it instead of command-and-control regulation. If a carbon tax is not enacted, or to the extent that Net Zero 2050 is achieved either through a more complex carbon tax designs, command-and-

[78] Hausman (1979).

[79] Hartman and Doane (1986).

control regulations, or a mix of both, the actual household-level burden of achieving Net Zero 2050 will be much higher.

Twenty-eight States and the District of Columbia, representing 68% of the population, are net importers of carbon-based energy. They clearly would prefer the Scenario A allocation formula because their share of the national burden would be disproportionately low. Therefore, it would be unsurprising if their Members of Congress steadfastly supported a carbon tax designed this way. Further, 56 Senators serve these States. Thus, if the enactment of a carbon tax designed this way required only majority support in the Upper House, it could pass handily.

Unsurprisingly, the 22 States that export carbon-based energy to importing States would intensely dislike the Scenario A regime and would vigorously oppose it, and given a choice, would prefer Scenario B. Their Senate minority would be sufficient to prevent a cloture vote, thereby blocking passage of Scenario A under normal Senate rules. Of course, the Senate could abandon the filibuster (either in whole or "just for this" action) or enact this carbon tax as part of a budget reconciliation bill exempt from the filibuster.[80]

A. Annual Carbon Tax per Household, by State

Figure 1 displays the average annual cost of Net Zero 2050 in dollars per household for each State if it can be achieved for $100/metric ton CO2. Jurisdictions are arrayed alphabetically by state code on the horizontal axis, with gridlines separating each group of five. For 32 States and the District of Columbia, shown in green, the cost of Net Zero 2050 is less than $5,000 per household per year. For seven States, shown in blue, the cost of Net Zero 2050 is between $5,000 and $10,000 per household per year. The burden is between $10,000 and $15,000 per household per year for two States, shown in yellow, and exceeds $25,000 per household per year in one State: Wyoming. For the median jurisdiction, the average annual burden is $4,165 per household per year. The jurisdiction with the lowest annual average cost is the District of Columbia: $974 per household per year.

Cost is linear with the carbon tax rate assumed to be necessary to achieve Net Zero 2050. Thus, trebling unit cost to $300/metric ton results in a threefold increase in the annual average household-level burden. In all 50 States (but not the District of Columbia), this burden would exceed $5,000 per household per year. For nine States, shown in orange, burden would exceed $20,000 per household per year, and for three States it would exceed $30,000 per household per year. In five States, the annual average household burden per year would exceed $50,000 per household per year, with Wyoming ($76,000) being the worst case.

Figure 2 displays results if Net Zero 2050 costs $700/metric to CO2 to achieve. For all 50 States (but not the District of Columbia), Net Zero 2050 costs more than $10,000 per household per year. For only 10 States (and the District of Columbia) is the average household cost is between $10,000 and $20,000 per household per year, and for 25 States,

[80] A carbon tax designed this way could have been included in the 2022 budget reconciliation bill (Pub. L 117-169) but was not. If Congress were to enact a carbon tax of this design, carbon-based energy exporting States could shift burdens back onto carbon-based energy importing States. This is discussed in Section V.

shown in yellow, it is between $20,000 and $40,000 per household per year. The average household burden exceeds $40,000 per household per year for 13 States, and for two States it exceeds $100,000 per household per year: North Dakota ($124,682) and Wyoming ($177,368).

B. Annual Carbon Tax per Household as a Percent of Annual Household Income

To put these household-level burdens in perspective, they can be expressed as fractions of median household income, which varies by State. This is shown in Figure 3 for the case in which Net Zero 2050 is achieved at a cost of $100/metric ton CO2. In 12 States (and the District of Columbia), shown in green, the burden of Net Zero 2050 per household is less than 5% of median household income. But the average burden is between 5% and 10% of median household income in 22 States, and between 10% and 15% in 11 States, shown in yellow. In four States, shown in red, the average burden exceeds 20% of median household income: Louisiana (22%), West Virginia (24%), North Dakota (27%), and Wyoming (39%).

Figure 4 shows the average annual household burden if achieving Net Zero 2050 costs $700/metric ton CO2. This burden per household is less than (but approaches) 50% of median household income. (It's lowest in the District of Columbia: 7.5%). In 14 States, shown in yellow, the household-level burden of Net Zero 2050 is between 50% and 100% of median household income, and it exceeds 150% of median household income in four States, shown in red: Louisiana (153%), West Virginia (170%), North Dakota (191%), and Wyoming (272%).

Absolute measurers are instructive, but States may be acutely interested in how they fare relative to others. Figure 5 answers that question by displaying the fraction of median household income extracted by Net Zero 2050 as a multiple of the fraction extracted from households in the District of Columbia, the jurisdiction with the lowest household-level burden. (The multiple is the same irrespective of the SCC or carbon tax rate.)

For 32 States, the average household burden of achieving Net Zero 2050 is less than five times the average household burden in the District of Columbia. (The smallest multiple, 2.34, is found in Massachusetts.) For 13 States, the average household burden is between five and 10 times the burden in the District. And it exceeds 10 times the burden in the District in five States: Alaska (14x), Louisiana (11x), North Dakota (18x), West Virginia (12x), and Wyoming (26x).

IV. Scenario B: Annual Burden of Net Zero 2050 per Household Assuming its Share is the Same as all other Households Nationwide

An obvious alternative tax scheme is to impose the same tax on every U.S. household regardless of residence. As noted above, States that import carbon-based energy are likely to perceive this as unfair, as would States with milder climates independent of energy production.

A. Annual Carbon Tax per Household

For this alternative, the annual burden of Net Zero 2050 per household is defined as the product of total U.S. CO_2 emissions and the tax rate, divided by the number of U.S. households. Because the state of origin of CO_2 emissions would be immaterial, it would be the same for all U.S. households:

- $4,231 per year at $100/metric ton CO_2
- $12,694 per year at $300/metric ton CO_2
- $19,041 per year at $450/metric ton CO_2
- $29,619 per year at $700/metric ton CO_2

B. Annual Carbon Tax per Household as a Percent of Annual Household Income

Median household income varies across States, so the effective household-level burden would vary across States even if the carbon tax was constant. Figure 6 displays for Scenario B the fraction of median household income extracted by Net Zero 2050 if it can be achieved for $100/metric ton. For all States and the District of Columbia, Net Zero 2050 would extract more than 4% of annual median household income. For 14 States and the District of Columbia, shown in yellow, the income fraction extracted is between 4% and 6%. The income fraction extracted is between 6% and 8% for 29 States, shown in orange, and between 8% and 10% for seven States, shown in red: Alabama (8.1%), Arkansas (8.6%), Kentucky (8.1%), Louisiana (8.3%), Mississippi (9.1%), New Mexico (8.3%), and West Virginia (8.8%).

Figure 7 shows the burden of achieving Net Zero 2050 if it costs $700/metric ton to achieve. For all States and the District of Columbia, Net Zero 2050 would extract more than 30% of median household income. For 12 States, shown in yellow, Net Zero 2050 would extract 30-40% of median household income. For 19 States, shown in orange, Net Zero 2050 would extract 40-50% of median household income. And for 18 States, it would extract at least 50%.

The design in Scenario A resulted in some States having highly disproportionate annual household-level burdens resulting from interstate differences in median household income and CO_2 emissions. Differences in Scenario B reflect only interstate differences in median household income. Much, but not all, of the interstate disproportionality in burden found in Scenario A is attenuated in Scenario B. Twenty-two States would be better off under this scenario than under Scenario A, but 28 States and the District of Columbia would be worse off. Among States better off, average gains per household range from $52/household in Pennsylvania to $21,107 in Wyoming; the average gain is $5,237. Among States worse off, average loss per household ranges from $62/household in Ohio to $3,258/household in the District of Columbia; the average loss is $1,107.

C. Percent of Mean Household Income for Quintiles, and Top 5 of Household Income

Median income is a useful indicator but it does not reveal how the burden of Net Zero 2050 would vary by household income. One would intuitively expect low- and middle-income households to face disproportionately high costs. This intuition is correct. To see why, note that the Census Bureau divides the income distribution into quintiles ("fifths", 0-

20%, 20-40%, 40-60%, 60-80%, and 80-100%) and calculates the average (not median) income for each quintile. It also reports average income for the top 5% of households.[81]

Figure 8 shows the percentage of U.S. median household income extracted by Net Zero 2050 under each of the four alternative costs of achieving it. For the lowest quintile (0-20%), Net Zero 2050 would extract between 29% (at $100/mt) and 204% (at $700/mt) of median household income. These fractions are not quite as large for the second quintile (20-40%), ranging from 10% (at $100/mt) to 72% (at $700/mt) of median household income. For the third quintile (40-60%), which contains the median household income for the U.S. population, Net Zero 2050 extracts between 6% (at $100/mt) and 42% (at $700/mt) of median household income. None of these fractions seems politically acceptable. Even for the fifth quintile (80-100%), the fraction of income extracted ranges from 2-12%, and at least the upper-bound is likely to be politically unacceptable. Only for the Top 5% of the income distribution is the fraction extracted, which ranges from 1-7%, plausibly acceptable.

Some of these results are technically infeasible (households simply cannot pay more than their household income) or politically dubious (Congress surely would not levy taxes that extract an additional 25% of household income). But there is another factor that must be taken into account: Census income figures generally do not account for taxes (disproportionately paid by high-income households) and transfer payments (disproportionately received by low-income households.[82] Figure 9 accounts for this rebalancing, showing that the technically infeasible and political dubious Net Zero 2050 income extraction rates shown in Figure 8 are misleading. For quintile 1, the range of income extracted declines from 29-204% of median household income to 9-60%; and for quintile 2, the range declines from 10-72% to 8-55%.

Figure 9 leads to a pair of obvious questions. First, is it plausible to imagine Congress extracting these income fractions to achieve Net Zero 2050? Probably not, but it is plausible to imagine the household-level burden of command-and-control climate regulation rising over time to reach these levels, primarily because costs are hidden and fairly easily blamed on industry or a period of what seems to be sustained inflation.

As a thought experiment, consider the case in which households in quintile 5 are taxed to cover the Net Zero 2050 costs that otherwise would be assessed on quintile 1. Because the number of households in each quintile is the same, the burden per household in the top quintile would simply double, both in dollars and in percent of household income. For quintile 5, burden per household would increase from a range of $4,231-$29,619 to a range of $8,463-$59,239. And the fraction of their income extracted to pay for Net Zero 2050 also would double, from a range of 1.7-11.7% to a range of 3.4-23.4%. Such extractions from quintile 1 seem quite feasible, especially if accomplished in a manner that deflects responsibility.

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[81] Census's income definition generally ignores taxes and transfers.

[82] Gramm et al. (2022).

D. Other allocation formulae

Many other variables could be meaningful (or just useful) to individual States. For example, some States might argue that the carbon tax burden should account for States' relative poverty rates,[83] or they might want to leverage the Administration's stated concerns about racial equity.[84] For every State, there is a way to minimize its residents' household-level burden. Because this is a zero-sum game, whatever any group of States gains by shifting burdens to other States, those other States lose by having burdens shifted onto them.

In short, every carbon tax design will have such winners and losers. The same is true of course for command-and-control regulation, the only other alternative available. States can be expected to do everything within their power protect the interests of their residents, whether the battlefield is the design of a carbon tax or the design of a climate regulation.

V. Carbon-based energy exporting states could shift part of the burden to Carbon-based energy importing states

A. All States would rationally seek to shift burdens to other States

As noted above, there are many ways to allocate the burden of the SCC or carbon tax. This paper considers only two alternatives: (1) Scenario A: allocating household burden by differences in State-level CO2 emissions, or (2) Scenario B: allocating household burden equally across all U.S. households. If only these two tax designs were considered, their effects are so different that this alone is sufficient to divide the States into sharply divided camps. States that import carbon-based energy would prefer Scenario A, where costs are allocated based on State CO2 emissions. States that export carbon-based energy would prefer Scenario B, where costs are allocated based on population.

All States (except AK and HI) and the District of Columbia are either net electricity importers or exporters.[85] Under Scenario A, States that export electricity to other States would have to subsidize the consumption by importing States. Exporting States would say this design is unfair, but as noted at the beginning of this Section, importing States would have the votes unless the Senate filibuster is preserved. And it's likely that importing States also would have the votes to impose a carbon tax regime even more disadvantageous to exporting States than Scenario A.

B. States that produce carbon-based energy could easily shift burdens to States that import carbon-based energy

Assuming that importing States win the legislative battle and Scenario A is enacted, exporting States would still be able to shift some (and potentially a lot) of the burden of Net

[83] U.S. Census Bureau (2022c). Any reliance on poverty rates likely would trigger pushback based on the Census Bureau's incomplete calculation of income. See, e.g., Gramm and Early (2022).

[84] See, e.g., Biden Jr. (2021a) and Biden Jr. (2021b).

[85] U.S. Energy Information Administration (2022e).

Zero 2050 to electricity-importing States.[86] They could do this, for example, by imposing their own tax on in-State electricity generation and fully rebating the proceeds to State residents. This would hold their own residents harmless, at least on average, while forcing energy-importing States to pay the tax.[87]

Electricity-importing States could not as easily shift burdens to electricity-exporting States. They could not tax electricity generated out of state without unconstitutionally burdening interstate commerce. Even if they could impose such a tax, much of the tax would be borne by their own residents, the intended beneficiaries. (Electricity-importing States would have to be more creative to figure out how to shift burdens to electricity-exporting States, but there is no question that they would be highly motivated to do so.)

VI. Avoiding Dramatically Increased and Politically Unpopular Net Zero 2050 Burdens

A. The extraordinary magnitude of Net Zero 2050 burdens

Collecting carbon taxes on all energy-related U.S. CO2 emissions would generate revenue ranging from $515 billion (at $100/mt) to $3,611 billion (at $700/mt). If a carbon tax were levied on top of existing taxes, that would increase static federal revenues by 13-90%.[88] This would have devastatingly contractionary effects on the U.S. economy and impose incalculable harm on low- and middle-income households. (Using the SCC as the basis for command-and-control regulation would hide or disguise these contractionary effects, but it would not make them go away.)

Congress might try to prevent these outcomes by enacting a "revenue-neutral" carbon tax — that is, one that offsets carbon tax revenues dollar-for-dollar with reductions in other taxes. Revenue neutrality would keep the aggregate tax burden constant, thus avoiding catastrophic macroeconomic outcomes. However, it would not prevent catastrophic effects on low- and middle-income households without massive additional income redistribution, and it is far from clear that upper-income households would tolerate the dramatically increased effective tax rates they would have to bear.

B. A revenue-neutral carbon tax is theoretically superior but practically infeasible

For several reasons, a revenue-neutral carbon tax is highly unlikely to be enacted or sustained in practice. First, design tradeoffs apply to all taxes, whether they are explicit or implicit. States and households vary on myriad dimensions, and there is no universally acceptable method for allocating the burden of Net Zero 2050 or distributing compensating

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[86] For this reason, one would expect a carbon tax designed to favor importing States to include a federal preemption of such taxes. Whether such a provision could survive constitutional challenge is beyond the scope of this paper.

[87] The five States that exported the most electricity in 2020 were Pennsylvania (714 tBTUs), Alabama (420 tBTUs), Illinois (3,231 tBTUs), Wyoming (261 tBTUs), and Washington (258 tBTUs). The five States that imported the most electricity were California (757 tBTUs), Massachusetts (333 tBTUs), Ohio (289 tBTUs), Georgia (243 tBTUs), and Maryland (242 tBTUs). See U.S. Energy Information Administration (2022c).

[88] USASpending.gov (2022) reports total federal government revenue for 2021 was $4.05 trillion.

tax relief. Tax designs and command-and-control regulations are both determined by politics, not tenured economics professors. The federal income tax is already the most progressive among all developed economies, and low-income households generally pay little or no income taxes. Nonetheless, tax rebates would have to be structured so that low- and middle-income households received substantially greater refunds — that is, the already highly progressive U.S. federal income tax would have to become extraordinarily more so. This would be complicated and likely riven with unexpected consequences. Many low- and middle-income households would fall through the cracks, and many high-income households would succeed in legally evading the new tax.

Second, even if today's Congress could agree on a revenue-neutral carbon tax design, tomorrow's Congress could change it, or even repeal it; no Congress can statutorily bind a successor. It's likely that Congress would succumb to the temptation to breach any statutory requirement for revenue-neutrality. Congress could vote to collect more revenue from a carbon tax than is required, skimp on promised tax reductions and rebates, allocate rebates to favored interest groups, or spend it on district-specific purposes, or some combination thereof. Congress has ample experience under the Budget Impoundment and Control Act offsetting actual new spending with speculative or imaginary budget cuts such that purported spending reductions inevitably turn into spending increases. This experience likely would guide congressional deliberations, resulting in a tax regime substantially different from any promised revenue-neutral scheme. And it supports the inference that revenue neutrality could not be assured without a carefully crafted constitutional amendment.

Third, any system of taxing CO2 emissions within the Nation's boundaries must ensure that imports do not escape taxation. This is especially important for imports from nations such as China that would be exempt from both a carbon tax and conventional command-and-control regulation. Taxing carbon only within the Nation's borders would result in more goods and services production being offshored to these noncompliant jurisdictions, profoundly enriching them, punishing U.S. producers and consumers, and making voters angry.

Ensuring equitable tax treatment of imports requires "border adjustment taxes."[89] Unfortunately, these taxes are highly complex, data intensive, fraught with irreducible error and uncertainty, and subject to more than the usual special interest pleading and opaque foreign affairs considerations.

VII. How Households Would Respond to Increased Prices

Households generally respond to price increases by replacing their purchases of newly higher-priced goods and services with goods and services with unchanged or reduced prices. For example, it is commonplace to observe that when the price of one fruit (say, blackberries) rises in price, households reduce their consumption of blackberries and buy more of a substitute (say, strawberries). This does not fully eliminate the adverse

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[89] Nordhaus (2020).

effect of higher blackberry prices, but it substantially reduces it if blackberries and strawberries are close substitutes.

Carbon taxes and regulations based on the SCC both raise the price of carbon-based energy, and households respond slowly to energy price increases because there are no good substitutes. A carbon tax directly increases the cost of many things — heating, cooling, and lighting a home; traveling to work; shopping; attending school; and obtaining medical care, to consider just a few examples. In the short run, it is hard to buy a lot less energy when the price goes up. When faced with new energy costs consuming 10% or 25% of their income each year, households would have no choice but to severely reduce their consumption of other goods and services they value highly, such as groceries, clothing, medical care, education, and travel. And a carbon tax indirectly increases the cost of these other goods and services, as well. Their prices also would rise to include a significant portion of Net Zero 2050 taxes or regulatory costs. It cannot be escaped just by reducing energy consumption at the margin.

Indeed, there would be few ways to escape. The only reliable long-term path forward is to adopt a Spartan lifestyle: wear sweaters and coats to keep warm indoors in the winter; open windows or sleep on the porch to keep cool in the summer; move from a country or suburban house to a small urban apartment; sell the family car and walk or bicycle for transportation. These changes are not bugs but intended features of the radical economic transformation that may climate change advocates seek.[90]

VIII. Net Zero 2050 Would Be Much More Expensive than its Advocates Acknowledge

The household-level burden estimates reported here may seem large, but they aren't if one recognizes the scope and scale of Net Zero 2050 and the haste with which its advocates insist on achieving it. And there are many reasons why advocates likely have underestimated the true cost of Net Zero 2050.

Subsection A briefly discusses several assumptions embedded in Net Zero 2050 transition modeling that appear to materially understate likely costs. Subsection B discusses reasons why it's likely that the Administration's SCC also has been underestimated.

A. <u>Unrealistic assumptions in Net Zero 2050 transition scenarios</u>

1. Renewables will cost more than forecast

Net Zero 2050 transition scenarios include unrealistic cost forecasts. For example, the International Energy Agency (IEA) assumes:

- The capital cost of solar photovoltaic electricity generation will decline 63%, from $1,140/kilowatt (kW) in 2020 to 420/kW in 2050.[91]

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[90] See, e.g., Schwab and Malleret (2020) and McKinsey & Company (2022), which (at 58) expresses the same view in more temperate language that disguises the cost ("a universal transformation of energy and land-use systems").

[91] International Energy Agency (2021b, Table B.1).

- The capital cost of U.S. offshore wind electricity will decline 63%, from $4,040/kW in 2020 to $1,480/kW in 2050.[92]

Among other things, these unit cost declines are inconsistent with limitations in the supply of essential minerals. This includes both conventional minerals (e.g., aluminum, chromium, cobalt, copper, lithium, nickel, platinum, and zinc) and rare earth elements (REEs) (e.g., neodymium). The top three nations producing lithium, cobalt, and REEs control three-fourths of global supply, with China dominating. China also dominates world production of nickel.[93] IEA alludes to the obvious national security concerns but does not analyze them or include their management as a cost of Net Zero 2050.[94]

IEA characterizes the estimated sevenfold increase in demand not as the cost driver it is, but as "substantial new opportunities for mining companies."[95] These opportunities will not be in the U.S., where it is virtually impossible to secure the permits for a new mine. Thus, even if greater supplies are forthcoming, it remains likely that supply will be under the control of a small number of nations capable of exercising economic and political power.

2. Renewables will face no significant barriers or resistance to siting

Solar photovoltaics and onshore wind require extraordinary amounts of land. Recently, developers of these projects have encountered significant and rising opposition due to noise, health effects (especially sleep deprivation), reductions in property values, wildlife mortality, and despoliation of viewsheds.[96]

U.S. offshore wind projects have encountered siting opposition due to, among other things, an increase in the number of North Atlantic right whale strandings coincident with high frequency ocean surveying. Causal inferences are contested, with opponents asserting adverse effects from underwater sound and developers denying such effects. This conflict between wind energy development and other environmental goods and services is supposed to be mediated by Environmental Impacts Statements prepared pursuant to the National Environmental Policy Act (NEPA). However, agency EISs have been routinely challenged, resulting in increased costs, project delays, and cancelations.

3. Essential future technologies are assumed to be invented and be inexpensive

Net Zero 2050 transition scenarios include numerous assumptions about future technology. For example, an extensive system of batteries is needed to store the electricity produced by the greatly expanded supply of wind and solar photovoltaics, and to produce the hydrogen needed to supply fuel cells. IEA assumes that these technologies will be invented, and that they will be less expensive than current technology. IEA assumes:

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92 International Energy Agency (2021b, Table B.1).

93 International Energy Agency (2021c, 32).

94 International Energy Agency (2021b, 23).

95 International Energy Agency (2021b, 17).

96 Bryce (2021). Bryce (2023) counts 579 wind or solar rejections, with an upward trend since 2021.

- The capital cost of batteries will decline 50-58%, from $130-155/kWh in 2020 to $55-80/kWh in 2050.[97]
- The capital cost of low-temperature electrolyzers used to make hydrogen will decline 70-76%, from $835-$1,300/kWh in 2020 to $200-390/kWh in 2050.[98]

Because some CO2 would still be emitted in 2050, achieving Net Zero 2050 also requires that CO2 be captured and indefinitely stored, and that the cost of doing so will be lower than today. IEA assumes:

- The capital cost of natural gas carbon capture will decline 19%, from $1,155-$2,010/kWh in 2020 to $935-$1,625/kWh in 2050.[99]

Each of these forecasts appears highly optimistic and obviously is overly precise; uncertainties well exceed the ± $2.50/kWh estimates. If future technologies are invented, they may be more costly because they must push difficult engineering boundaries and be quickly scalable to the scope of the demand. A considerable amount of technological uncertainty is not reducible, especially in a crisis policy environment, and that means higher costs.

Technologies that appear promising when modeled may fail when implemented or scaled. These costs would be stranded. Private investors can be expected to be apprehensive about bearing the risk of stranded costs, so the government may have to directly fund the R&D or backstop private investments with loan guarantees for technologies that fail and ironclad intellectual property rights for those that succeed.

4. Stranded assets, both existing and transitional

Net Zero 2050 is understood to require the early retirement of existing assets, especially coal and natural gas electric power stations. This is, in fact, an explicit goal of EPA's latest proposed regulation of electric power plants.[100] Assets that are retired early prevent the normal recovery of capital costs. This, in turn, discourages future investment in similar assets, this raising the cost of capital. Advocates of Net Zero 2050 may not be disturbed by this, and may even welcome it because it incrementally increases the likelihood of achieving their preferred policy goal, but it constitutes an unaccounted cost of Net Zero 2050.

Also, because Net Zero 2050 would proceed in haste because of real or perceived urgency, it is virtually certain that innovations developed and adopted early will prove ineffective, inefficient, or more costly than innovations developed and adopted later. Thus, investments in earlier technology may also be stranded with no practical means of capital cost recovery. Market participants, well aware of these risks, likely would insist on government guarantees to shoulder stranded costs if they materialize. That would insulate investors but do so as the expense of future taxpayers. Indeed, to the extent that achieving Net Zero 2050 requires early deployment of new technology, financial benefits would

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[97] International Energy Agency (2021b, Table B.2).

[98] International Energy Agency (2021b, Table B.2).

[99] International Energy Agency (2021b, Table B.2).

[100] U.S. Environmental Protection Agency (2023).

remain private but financial risks would be socialized. This, in turn, means that some innovations that are deployed early may be reasonably suspected, if not known in advance, to be likely to fail.

5. The cost of overcoming potentially devastating grid reliability problems is excluded

As the fraction of asynchronous electric power produced by intermittent renewables rises, the electric grid becomes increasingly fragile. Grid reliability is a known and serious problem that has grown as this fraction has increased. Net Zero 2050 calls for renewables to comprise between 67%[101] and virtually 100%[102] of electricity supply, thus exacerbating existing grid reliability issues to an unknown dimension. Grid reliability would be made worse if funds usually spent on conventional electric power system maintenance are diverted to building out renewables capacity.[103] In practical terms, grid instability means frequent, large-scale blackouts.

Net Zero 2050 transition scenarios acknowledge these issues but do not include them as costs[104] despite the known scale of the technical problem.[105] Instead, it is assumed that grid reliability issues will be solved by unknown future technology, the cost of which is assumed to be low, or even negligible.

6. Unemployment costs are excluded

Net Zero 2050 transition scenarios forecast substantial unemployment, but they do not include these effects as costs. Rather, they assume virtually costless substitution of new jobs for old. Unemployment is characterized as an "opportunity" to invest in green technology.[106] This practice follows long-discredited reasoning that broken windows are a social good because they increase employment among glaziers.[107]

Much of the unemployment from the transition to Net Zero 2050 would be permanent. Among Western nations, this would put substantial burdens on social safety nets. Where workers can be retrained, effective programs are expensive. It is unclear whether Western political systems can withstand this disruption. In less-developed countries, where social safety nets are rudimentary or nonexistent, unemployment caused

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101 International Energy Agency (2022, Table A.1).

102 McKinsey & Company (2022).

103 It has been reported that Hawaiian Electric faced precisely this tradeoff with respect to investments in renewables versus system resilience. *See*, e.g., Blunt et al. (2023).

104 See, e.g., McKinsey & Company (2022, 116). ("[C]ontinued technological and market innovation would be needed to manage grid intermittency and ensure reliability").

105 International Energy Agency (2021b, 176) ("Maintaining electricity security also requires a range of measures to ensure flexibility, adequacy and reliability at all times. Enhanced electricity system flexibility is of particular importance as the share of variable renewables in the generation mix rises. As a consequence, electricity system flexibility quadruples globally in the [Net Zero 2050 scenario] in parallel with a more than two-and-a half-fold increase in electricity supply.")

106 See, e.g., International Energy Agency (2021b), Network for Greening the Financial System (2022a), and McKinsey & Company (2022).

107 Bastiat (1850).

by the Net Zero 2050 transition should be expected to result in existential social and political crises.

7. Opportunity costs are excluded

Net Zero 2050 transition cost estimates are based on expenditures,[108] not on what economists call "opportunity cost" — the value of goods and services that must be sacrificed.[109] In regulatory impact analysis, opportunity costs are notoriously difficult to comprehensively estimate. A key reason is regulatory costs usually are assumed to be borne by firms, contrary to Section II.B above, and household-level effects generally are not estimated at all. In addition, opportunity costs will be different across households for a host of reasons including divergent tastes and varying income.

Examples of opportunity costs abound. For example, all Net Zero 2050 scenarios envision very large increases in the number of wind generation units and fields of solar photovoltaic panels. The IEA predicts that worldwide solar electrical capacity will increase from 737 gigawatts (GW) in 2020 to 14,458 GW in 2050 — a compound average annual growth rate of 21%.[110] Each megawatt of rated capacity (MW, 1/1000 GW) requires about 15 acres of land. Therefore, if the IEA's prediction supply of solar photovoltaic is true, about 206 million acres (326,563 square miles) would be required, and even more to the extent that the marginal utility of land declines as more productive sites are exhausted. The opportunity cost of converting that land to solar photovoltaic farms is the value it produces in its current uses.

8. Cost estimates assume frictionless policymaking in democratic societies

Net Zero 2050 scenarios (like the NGFS "orderly" scenario) assume that the transition is led and implemented by a technocratic elite insulated from politics, policies, and procedures, and immune to the temptations of corruption. This is not realistic. Considering just domestic challenges, whether Net Zero 2050 is implemented by explicitly legislating a carbon tax or by continued command-and-control regulation, it will be subject to an array of compromises, all of which will increase cost. Indeed, the more difficult it is to achieve legislative consensus, the more significant and expensive these compromises will be. For now, the most likely U.S. scenario is the government muddles through using existing statutory authorities, none of which were designed for climate change. Independent of the compromises required in a democratic society, substantial (and perhaps unprecedented) opportunities for corruption, fraud, and rentseeking will drive up costs.[111] These domestic challenges are not unique to the U.S. Every nation will face them.

9. Current Net Zero 2050 transition cost estimates are based on efficient global central planning

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[108] See, e.g., International Energy Agency (2021b).

[109] See, e.g., Mishan (1976), Office of Management and Budget (2003), U.S. Environmental Protection Agency (2014), Boardman, Greenberg, Vining, and Wi1emer (2017), and Dudley et al. (2017).

[110] International Energy Agency (2021b, Table: Electricity: World).

[111] Rentseeking is the expenditure of resources to reallocate costs and benefits without producing anything of value. It is a deadweight loss.

Every Net Zero 2050 transition scenario requires implementation to be performed by selfless, gifted, and possibly omniscient global central planners endowed with unprecedented power.[112] This has never occurred in human history. Lesser exercises in central planning have not been successful. The costs of global central planning are extraordinarily difficult to estimate, but no less real and likely to be exceedingly large.

In addition to constraints inherent to democratic societies, achieving global Net Zero 2050 as envisioned by its advocates requires all nations to fully participate in enforceable global central planning.[113] Nations that have tried central planning on much small scales have failed, and nothing in the Paris Agreement commits any nation to submit to globally centralized control even if it agreed to meet Net Zero 2050 targets. Some nations are unlikely to ever agree to bear the costs that the Net Zero 2050 scenarios implicitly assign to them. Achieving Net Zero 2050 would require other nations to bear these costs, most notably the U.S — and that means U.S. households.

B. Unrealistic assumptions about the SCC

1. *Current SCC estimates depend on models that assume economic efficiency*

Economic efficiency is a convenient heuristic, but it is generally used as a baseline from which real-world costs can be estimated. To approximate the effect of certain economic inefficiencies, the SCC can be increased by an appropriate multiplier. Household-level burden estimates reported here can be modified accordingly. Incorporating these adjustments, however, would increase estimated household-level burden accordingly.

2. *Current SCC estimates assume trivial administrative costs*

The administrative costs of both command-and-control regulation and its market-based alternatives are counterfactually assumed to be trivial. As for the administrative costs of a global central planning regime, which any "orderly" Net Zero 2050 scenario assumes, these costs are unknown.

These costs can be approximated by increasing the SCC or carbon tax used in the analysis, with the difference attributable to administrative costs. Household-level burdens would be proportionately higher. Thus, whether administrative costs are small (e.g., 25%) or large (e.g., 200%), the analysis can be modified to explicitly incorporate these costs as if they were a surcharge to the analyzed SCC or carbon tax rate.

3. *Current SCC estimates assume global benefits that cannot materialize unless U.S. households pay the costs of reducing CO2 emissions by other key nations*

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[112] McKinsey & Company (2022, ix): "Government and business would need to act together with singular unity, resolve, and ingenuity, and extend their planning and investment horizons even as they take immediate actions to manage risks and capture opportunities." Western forms of representative decision-making are not mentioned, nor is any attention given to property rights.

[113] See, e.g., Network for Greening the Financial System (2021b, 2021a, 2022a), International Energy Agency (2021b, 2021a), and McKinsey & Company (2022).

Major CO2 emitters include India and China, which in 2019 were responsible for 9,877 mt and 2,310 mt CO2 emissions, respectively, or 29% and 7% of world emissions. The SCC is derived from models that assume these nations and others "do their part" by mitigating their national emissions.

For example, a key Net Zero 2050 scenario assumes that CO2 emissions from coal-fired power plants in China will decline 85% between 2020 and 2050.[114] This seems highly unlikely at best, and China has indicated that it expects to increase carbon-based energy production (mostly coal) through at least 2030. China's energy-related CO2 emissions have significantly increased — 750 million metric tons from 2019-2021 — enough to fully offset all reductions achieved in the rest of the world.[115]

The SCC is based on global benefits assuming that other nations reduce their emissions as expected by the models used to estimate the SCC. Both China[116] and India,[117] which together emit 37% of global CO2, have publicly stated that their nationally determined contributions toward the Paris Agreement are nonbinding. If these nations cannot reasonably be expected to achieve the reductions assumed by the models, achieving Net Zero 2050 would require U.S. households to cover the costs of non-U.S. emission reductions. This would raise the minimum SCC necessary to achieve Net Zero 2050 by an unknown but large amount. And even this adjustment likely would not be enough. While emission reductions would be much less expensive to achieve in other nations (especially China and India), ensuring that these reductions actually occur if U.S. households paid for them would be exceedingly difficult.

Even under the best-case assumptions in the various Net Zero 2050 scenarios, it is not clear that the highest of the tax rates analyzed here would be sufficient. Each of the assumptions in subsection A above should be reconsidered by Net Zero 2050 transition modelers and their effects on the SCC be estimated.

C. Other unrealistic circumstances

It is conventional practice to conduct demonstration projects to validate key theories and ensure that new technologies are feasible. Such projects are routine for transformative proposals that have modest scope and scale.

Net Zero 2050 is very different. Scope and scale are unprecedented. Key international entities that support Net Zero 2050 have acknowledged this, but none have called for first conducting demonstration projects.[118] In short, the Net Zero 2050 transition

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114 International Energy Agency (2021b, 44).

115 U.S. Energy Information Administration (2022a, 8). This period understates the trend because it includes output reductions due to governmental responses to COVID-19, and China's response was extraordinarily strict.

116 Shepherd et al (2023).

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118 See, e.g., Schwab and Malleret (2020), World Economic Forum (2021), Network for Greening the Financial System (2021b, 2021a, 2022a), International Energy Agency (2021b), and McKinsey & Company (2022).

is actually an experiment undertaken in an environmental of maximum technological uncertainty and unlimited social, political, economic, and financial risks.

Like the direct costs of Net Zero 2050, the costs of these risks will be borne by households. Because indirect costs have not been seriously discussed in the prevailing literature, much less estimated, how much they will increase household-level burden beyond the estimates in this analysis can only be guessed.

Should any element of the Net Zero 2050 transition prove to be technologically infeasible, this will not necessarily reduce household-level burden. Costs will be borne even if their technologies fail or projected benefits are not realized. That, in turn, will compel additional, unexpected regulations, systematically higher direct carbon taxes, or a belated recognition of failure.

IX. Conclusion

Net Zero 2050 has broad support among U.S. government and academic elites but the extent of public support is unknown. A key reason is elites supporting Net Zero 2050 have not communicated in practical terms how much it would cost U.S. households. The public does not understand this because, despite huge investments in climate change research and exploding media coverage of Net Zero 2050, its likely cost has received little attention. This may be a desirable feature of the policy debate for the elites. Drawing attention to cost diminishes public support for action, unless of course the public can be persuaded that costs will be paid by others. Costs can be described this way, but such public communications are highly misleading. No matter who initially bears the cost, sooner or later cost will find its way into the household economy.

This paper shows that under a range of plausible assumptions concerning the unit cost of achieving Net Zero 2050, the total cost is staggeringly large. Even in Scenario B, at the lowest unit cost examined ($100/metric ton), Net Zero 2050 can be expected to extract more than 4% of median household income everywhere, and more than 6% of median household income in 36 States. If Net Zero 2050 costs $700/metric ton to achieve, U.S, households would expect to forego at least 30% of their household income, and in some States more than 60%. In Scenario A, the household-level burden goes sky high in several States—more than 20% of household income in four States if Net Zero 2050 costs $100/metric ton to achieve, and more than 30% of household income everywhere if Net Zero 2050 costs $700/metric ton to achieve.

For the poor and working class, paying these costs is financially infeasible. If forced to pay it, they would endure abject poverty never before experienced in the U.S. They must be substantially (if not fully) subsidized, and that requires shifting the cost burden to high-income households. These households would see large increases in their effective tax rate, from the current 35% to more than 50%. And there are knock-on effects from these subsidies: those households subsidized would have little or no incentive to reduce their direct and indirect CO2 emissions, making the achievement of Net Zero 2050 even more elusive and its burdens more divisive.

Finally, the cost of Net Zero 2050 does not go away if the policy is not achieved and its presumptive benefits do not materialize. This could happen simply if other major CO2 emitters, most notably China and India, decline to participate. Costs are borne early; benefits, if any, are captured later, and in the case of climate change mitigation, many decades later. By the time benefits are due to be realized, costs will have been borne and cannot be recovered. To the extent that these costs significantly reduce the U.S. households' standard of living, that change will be permanent.

X. References

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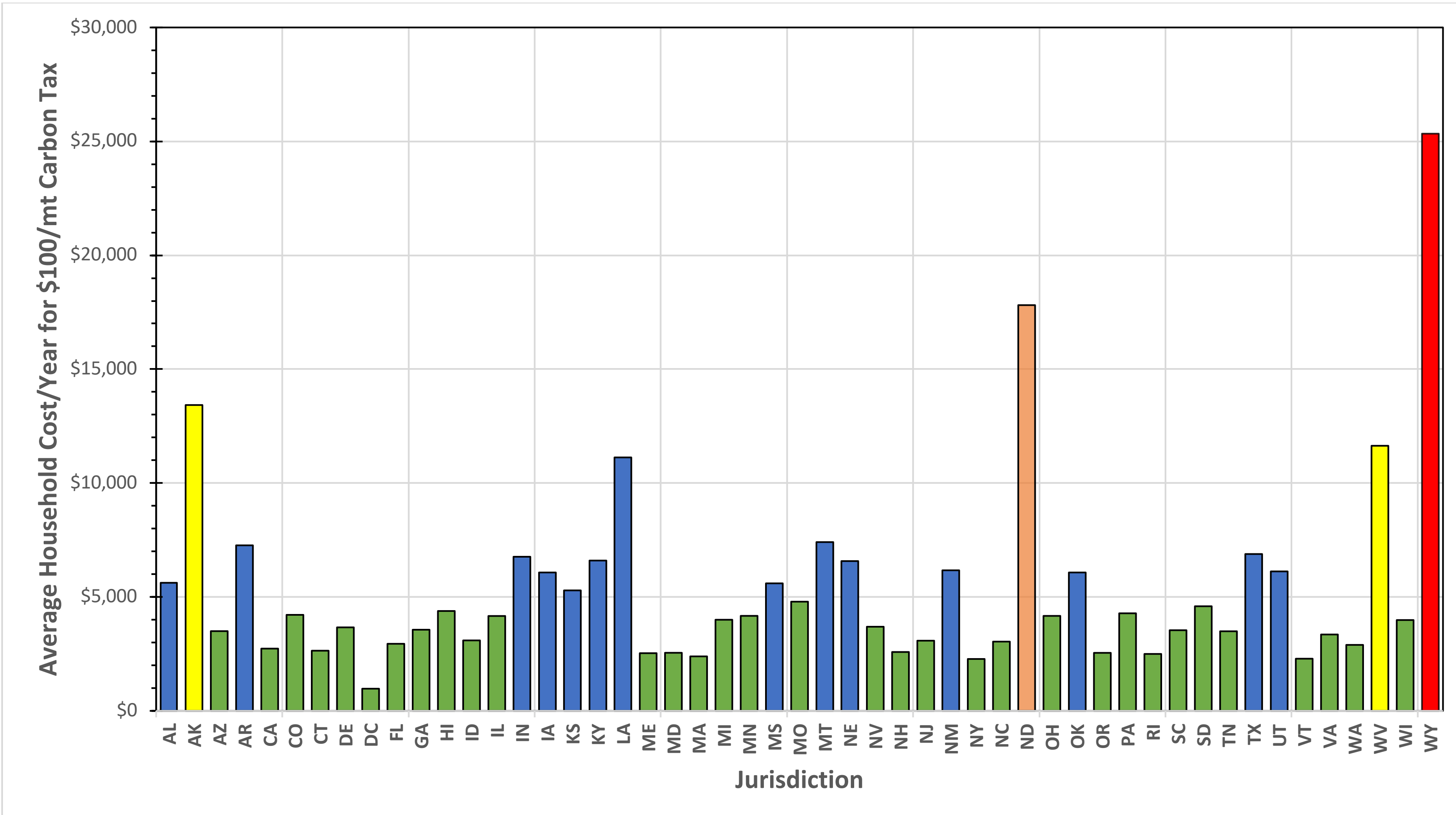

Figure 1: Average Annual Household Cost of Net Zero 2050 at $100/mt, Scenario A

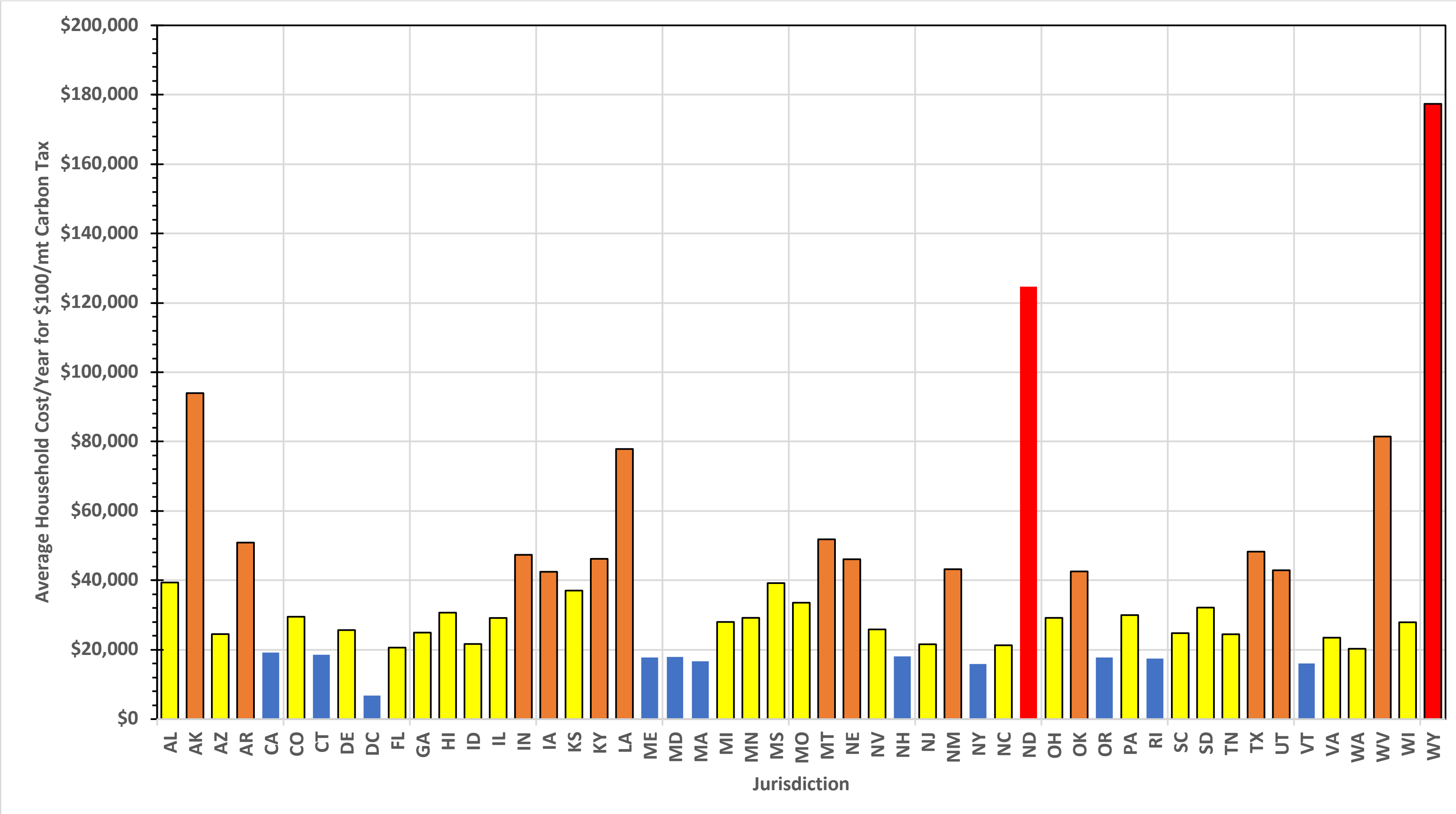

Figure 2: Average Annual Household Cost of Net Zero 2050 at $700/mt, Scenario A

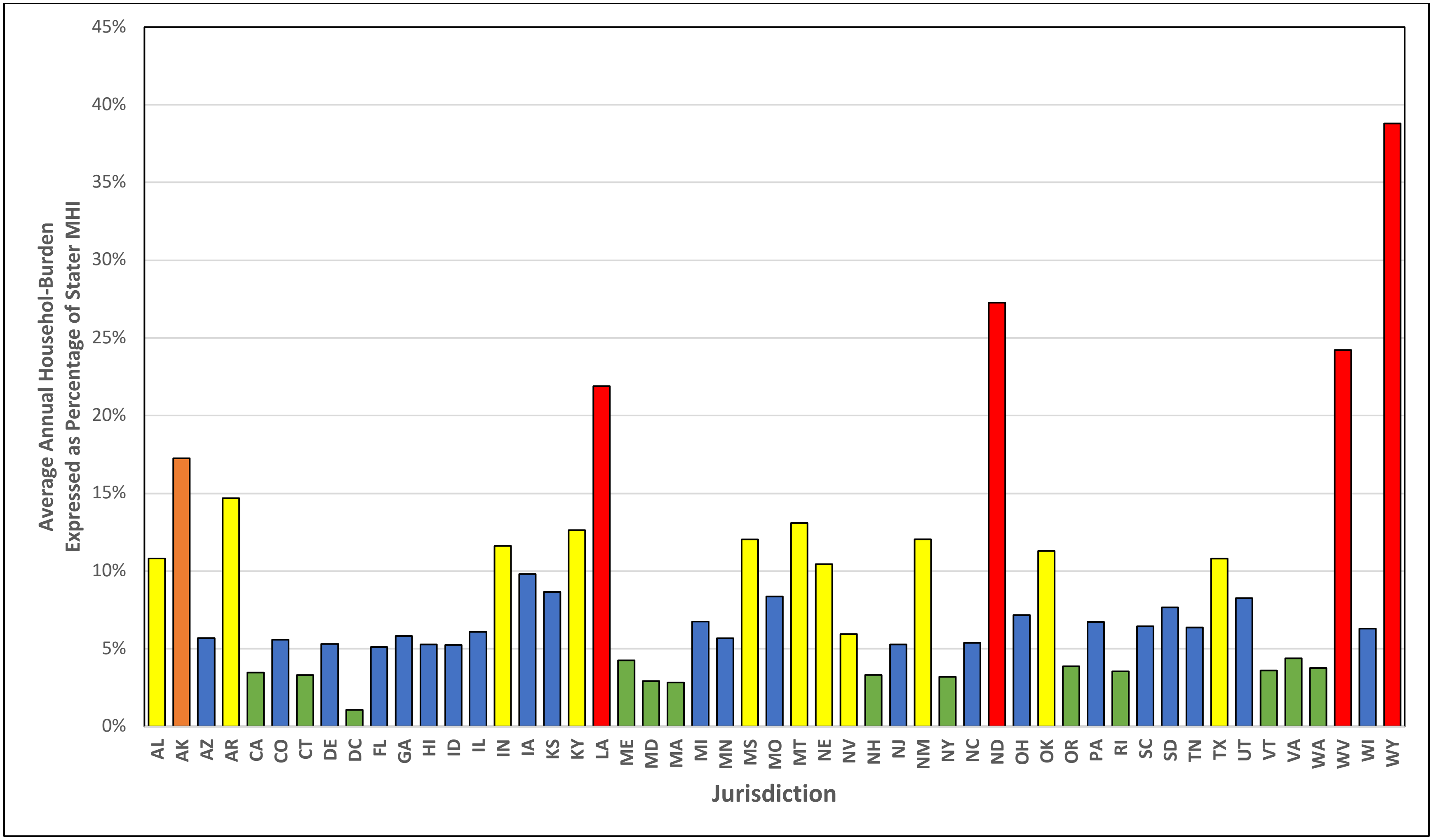

Figure 3: Average Annual Household Cost of Net Zero 2050 at $100/mt Expressed as Percent of Median Household Income, Scenario A

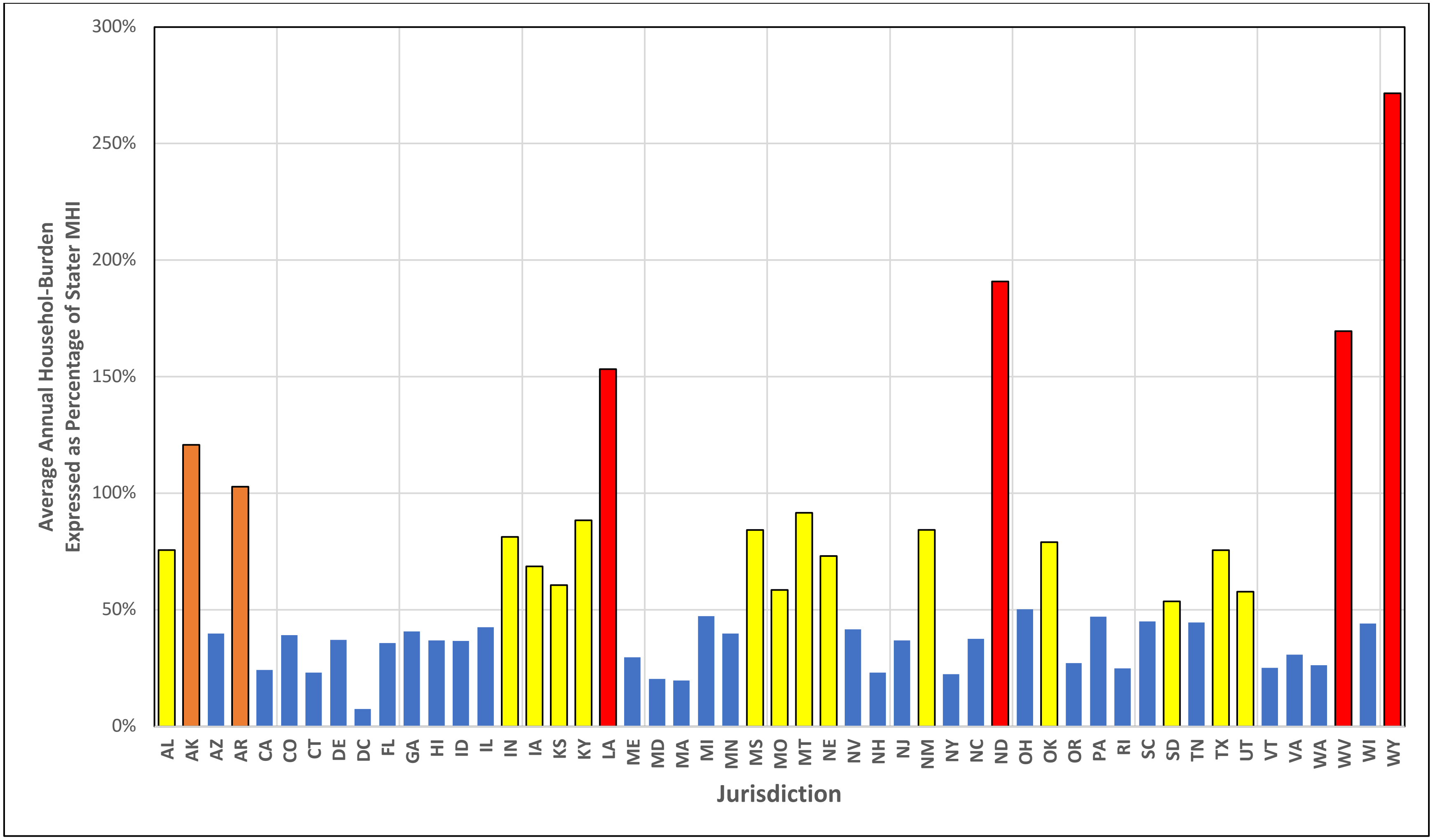

Figure 4: Average Annual Household Cost of Net Zero 2050 at $700/mt Expressed as Percent of Median Household Income, Scenario A

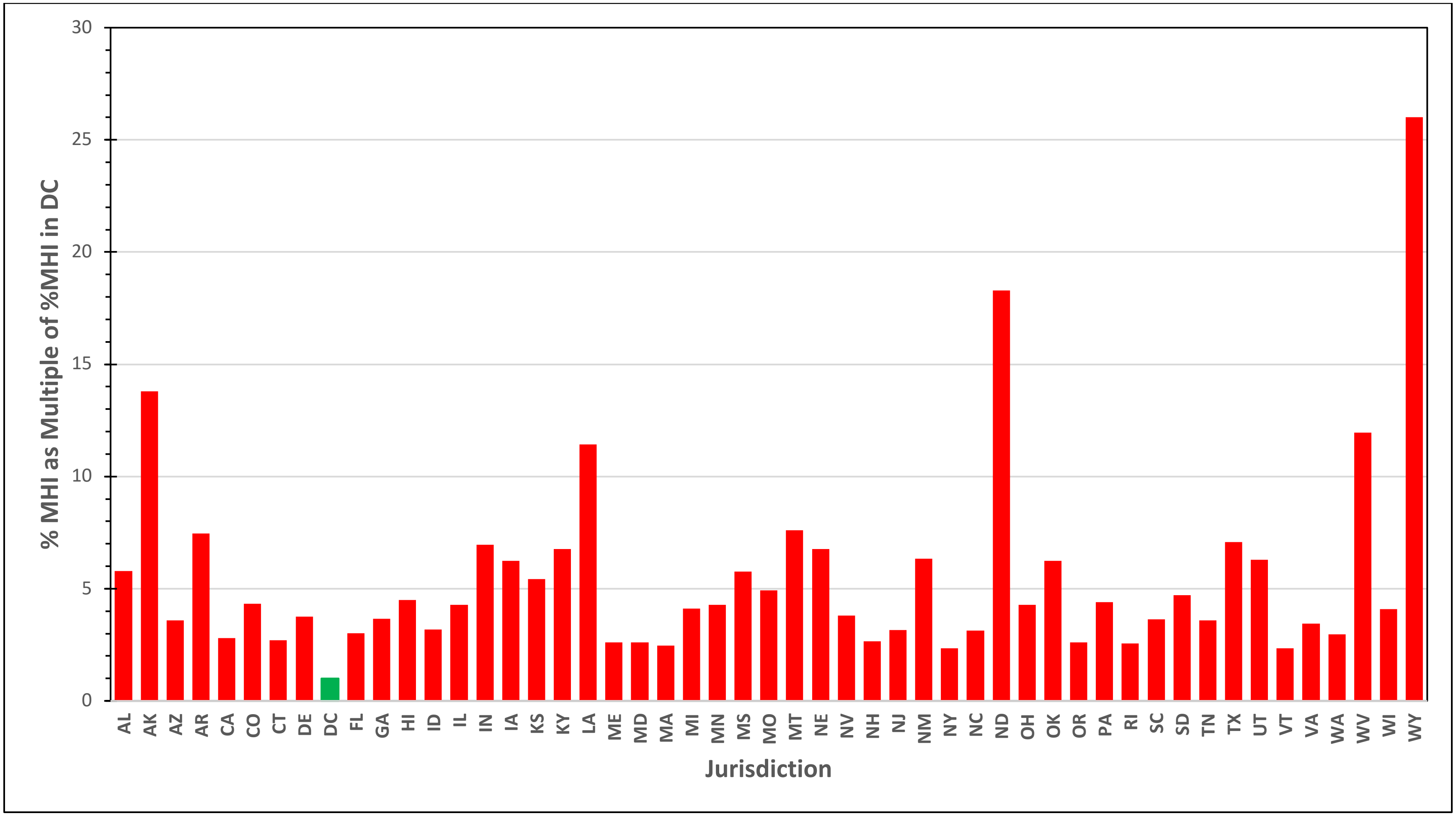

Figure 5: Burden of Net Zero 2050 Expressed as the Multiple Median Household Income Divided by Median Household Income for the District of Columbia, Scenario A

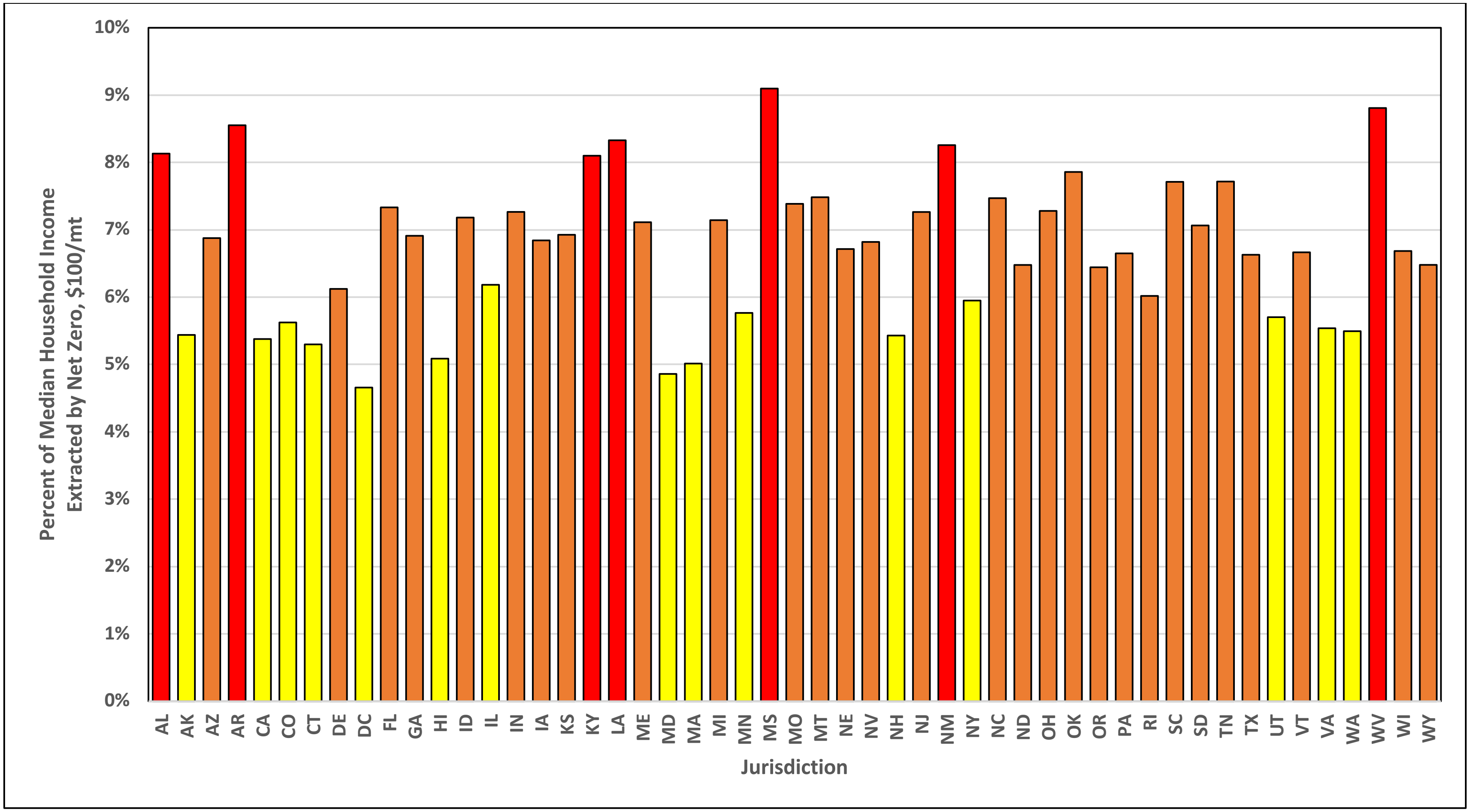

Figure 6: Average Annual Household Cost of Net Zero 2050 at $100/mt Expressed as Percent of Median Household Income, Scenario B

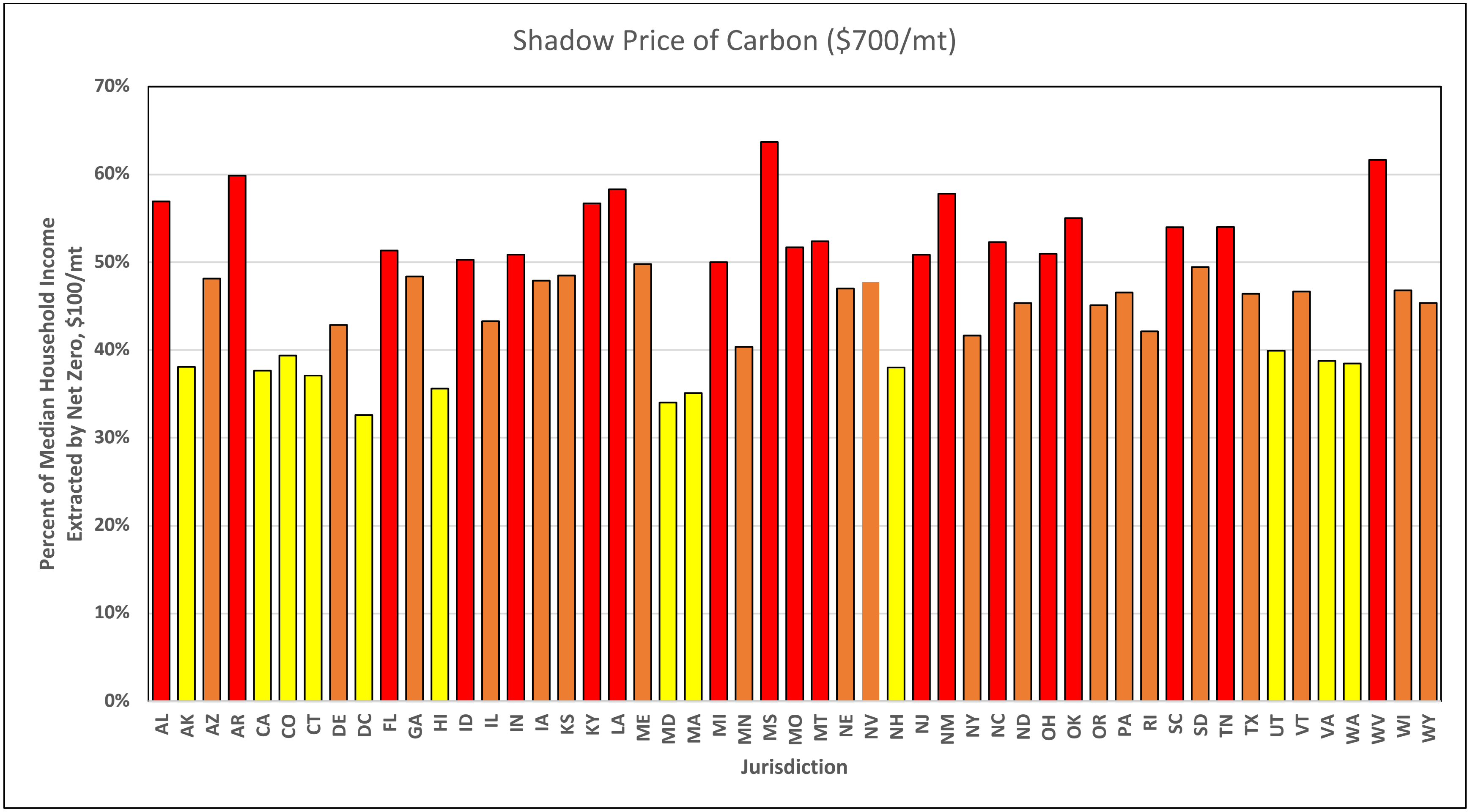

Figure 7: Average Annual Household Cost of Net Zero 2050 at $700/mt Expressed as Percent of Median Household Income, Scenario B

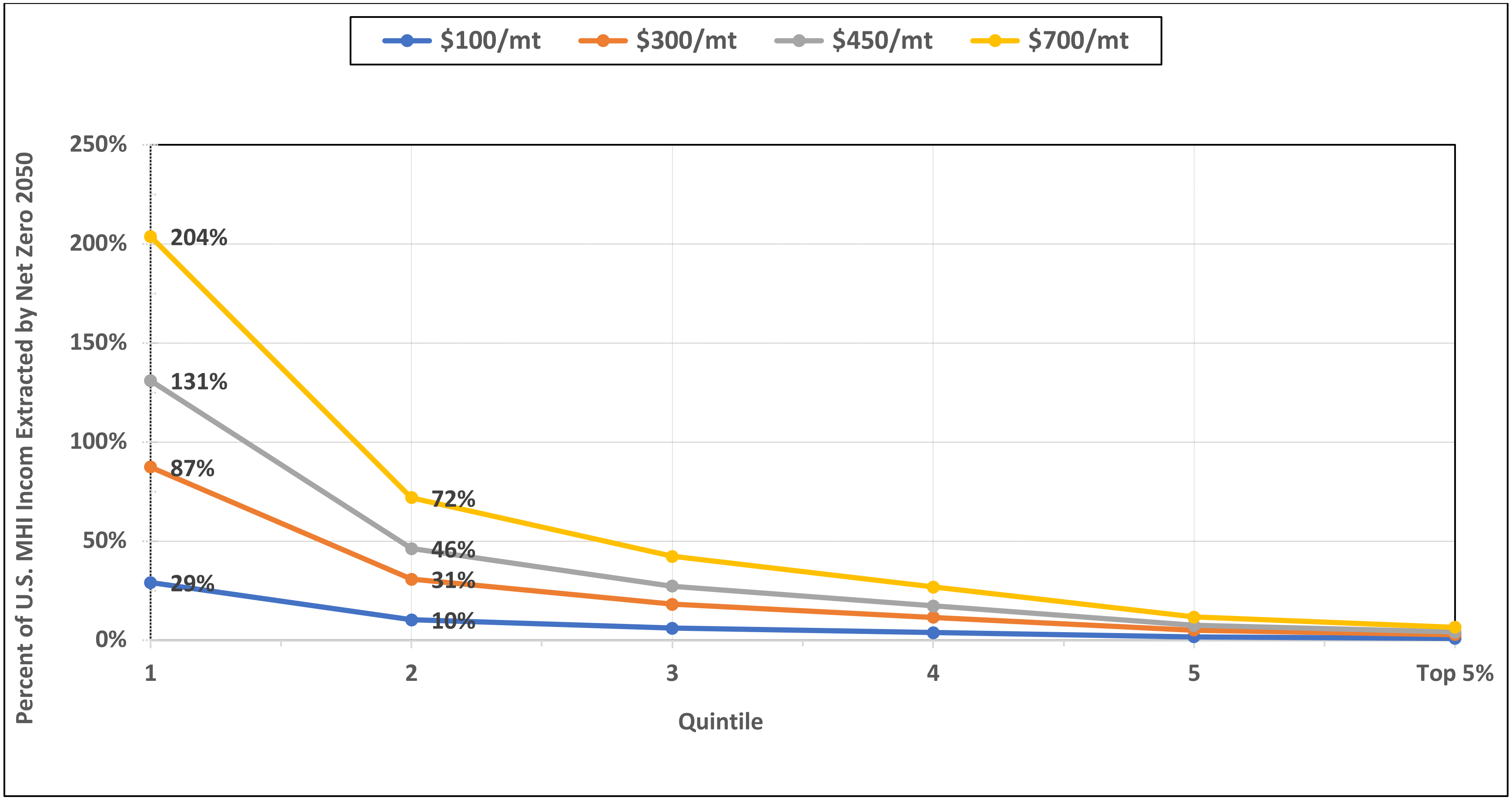

Figure 8: Average Percent of U.S. Median Household Census Income Extracted by Net Zero 2050, Scenario B

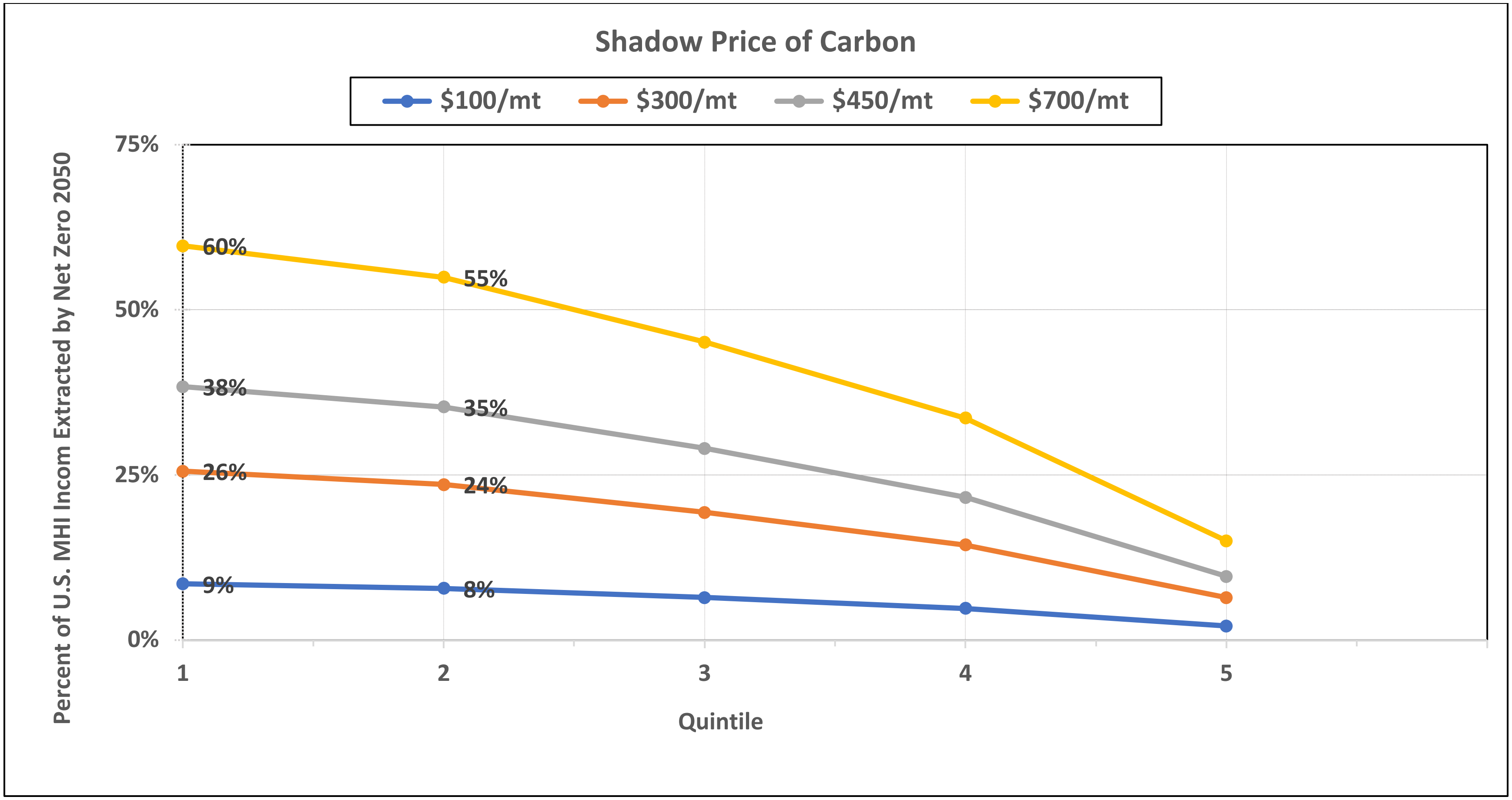

Figure 9: Average Percent of U.S. Median Household After-Tax and After-transfer Income Extracted by Net Zero 2050 Scenario B