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CONTENTS

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ECONOMIC AND ENVIRONMENTAL POTENTIAL OF CARBON OFFSETS MAY BE UNDERESTIMATED

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EXECUTIVE SUMMARY

The use of carbon offsets provides a considerable opportunity to produce an environmental benefit. Carbon offsets arise through the mostly private sector practice of investing in activities that temporarily or permanently diminish atmospheric concentrations of carbon dioxide (CO_2), thus producing a climate benefit compared to the alternative of not having carbon offsets. Importantly, achieving this benefit is constrained by the need to verify that carbon offsets produce an additional and verifiable benefit compared to whether or not the action had not occurred. Reliance on carbon offsets that would have existed regardless of policy or action do not provide a benefit, but policies that induce new action can produce significant new benefit.

Carbon offsets have a unique climate benefit opportunity due to their potential to satisfy the demand for environmental benefits that producers are faced with. Major emission sources such as airlines, transportation companies and industrial producers have few cost-effective ways of reducing their emissions yet have the available capital to invest in climate benefits elsewhere. In doing so, they are able to claim the benefits of such action as a means of catering to a consumer demand for environmental benefit. The advantage of this approach over a mandate, which would force an action upon industry, the carbon offset can be produced through various means and bought by various entities, creating a market of supply and demand which creates an incentive for finding the most efficient means of offsetting emissions, and thus is economically advantageous over a mandate. Furthermore, mandates may not require behavioral change for years if the requisite technology is not yet available, but the cumulative nature of greenhouse gas emissions naturally lends an advantage to policies that deliver an earlier benefit, allowing for carbon offsets to potentially deliver earlier benefits than mandates on industries that cannot yet be fulfilled.

Markets for carbon offsets also allow for the potential of comparative advantage to reduce the costs of environmentally beneficial actions. For example, the global nature of markets is such that the potential investments from a company in the United States would freely flow to and induce environmental action in other nations, especially ones where there may be numerous low-cost carbon offsetting opportunities. This results in a much more efficient investment in environmental action, which carbon offset markets can facilitate.

While there are already analyses that assess the potential market size of carbon offsets, or the benefit carbon offsets can have over efficient climate policies such as carbon pricing, this paper looks specifically at the potential for carbon offsets to address the emissions of sectors that have high abatement costs, such as industrial or aviation emissions. This paper finds that not only have prior analyses established that there is little doubt that the potential volume of carbon offsets in a global market exceeds the potential demand for offsets from U.S. sources, but also that the benefits of effi-

ciently allocating carbon offsets to high-abatement cost sectors yields greater economic benefit than alternative policies that would mandate emission abatement regardless of cost.

This paper presents an economic analysis of the potential benefits of carbon offsets, and in doing so finds that by 2030, in present value dollars supplanting U.S. industrial emissions and international aviation emissions with carbon offsets would have an economic benefit of $220 billion relative conventional abatement costs in those sectors. By 2050 the benefit would be $340 billion (present value). Compared to a prior analysis of the economic benefit of carbon offsets, this is 23 percent higher in 2030 and 147 percent higher in 2050.

While the analyses in this paper are not exhaustive, they are intended to illustrate that conventional discourse surrounding the potential of carbon offsets to deliver environmental and economic benefit may be underestimating their potential.

INTRODUCTION

With policymakers pursuing climate objectives through ambitious emission mitigation targets, such as President Joe Biden's new nationally determined contribution under the Paris Agreement (50-52 percent reduction by 2030), there are questions regarding the feasibility of reaching those targets—especially in difficult to abate sectors.[1] Consequently, carbon offsets have increasingly emerged as an opportunity to "offset" emissions that are otherwise uneconomical to abate, which allows for private sector investment to produce equal or better climate benefit via low-cost opportunities from offsets relative to the higher-cost abatement opportunities.

However, there is considerable skepticism around the feasibility of offsets to produce reasonable climate benefits that are substitutable with other emission mitigation measures. Carbon offsets may not always provide additional climate benefit or offer permanent storage of carbon. Nevertheless, this paper explores some of the existing literature on estimating the potential for carbon offset growth and its economic utility.

While the potential for carbon offsets seems uncertain, their potential is considerable. Efficient allocation of carbon offsets is more economically efficient than alternative, command-and-control emission mitigation measures. The cost of a carbon offset can be under $10, while emission abatement opportunities can exceed hundreds or even thousands of dollars per ton.[2] Furthermore, offsets also deliver a global incentive for private sector investment in emission mitigation. Despite the difficulties, carbon offsets offer a fruitful opportunity for improving greenhouse gas emission concentrations beyond solely relying on emission mitigation.

IMPORTANCE OF CARBON OFFSETS

There is a common understanding throughout climate policy proponents that addressing climate change is best solved by reaching "net-zero emissions" by an early enough date to avoid climatic warming beyond a specified temperature target (usually either 1.5 degrees Celsius or 2.0 degrees Celsius). This approach, unfortunately, frequently runs afoul of the economic benefits of achieving climate objectives. The estimated social cost of carbon (SCC) is roughly $50 per metric ton of emissions.[3] But while significant abatement opportunities can fall below the value of the SCC and result in net global benefits, many of the sectors that would need to decarbonize for a net-zero approach have abatement costs far in excess of the SCC. They also have significant economic value that makes them difficult to forgo, such as air travel and industrial production.

Yet, a net-zero emissions target by its very nature acknowledges the important role of carbon sinks. Forests are the largest global carbon sink, reducing annual carbon dioxide emissions by about 7.6 billion metric tons per year.[4] In the United States, carbon sinks reduce annual emissions by 789 million metric tons of CO_2 equivalent, or about 12 percent of emissions.[5] As policymakers have grappled with the challenges of what policies could incentivize decarbonization in sectors that have both high value and high abatement costs, they increasingly recognition that it may be more economically efficient to expand carbon sinks to offset those emitting activities. Indeed, doing so could produce environmental benefits even if outright emission mitigation is cost-prohibitive or unfeasible.

A simple example of this phenomenon at play is with airline emissions. Air travel accounts for 2.5 percent of global

1. Steve Baragona, "Biden's Climate Pledge: Not Easy, Not Impossible," *Voice of America*, April 22, 2021. https://www.voanews.com/science-health/bidens-climate-pledge-not-easy-not-impossible.

2. Philip Rossetti, "To Achieve Climate Goals, Embrace (Carbon) Markets," R Street Institute, April 27, 2021. https://www.rstreet.org/2021/04/27/to-achieve-climate-goals-embrace-carbon-markets.

3. "The Social Cost of Carbon," United States Environmental Protection Agency, Jan. 9, 2017. https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon_.html.

4. Nancy L. Harris et al., "Global maps of twenty-first century forest carbon fluxes," *Nature Climate Change* 11 (Jan. 21, 2021), pp. 234-240. https://www.nature.com/articles/s41558-020-00976-6.

5. "Inventory of U.S. Greenhouse Gas Emissions and Sinks," United States Environmental Protection Agency, April 2021. https://www.epa.gov/sites/default/files/2021-04/documents/us-ghg-inventory-2021-main-text.pdf.

emissions.[6] Low carbon sustainable aviation fuels (SAF) are extraordinarily high cost, with an abatement cost of approximately $260-4,800 per metric ton of avoided emissions.[7] A carbon offset, by contrast, can cost under $6 per ton.[8] Many airlines have pledged to reach net-zero emissions, but they are usually looking to carbon offsets rather than SAF to achieve that objective. Fuel costs account for 9.1 percent of airline operating costs (though this data is from 2020, and likely will rise when updated), meaning a heavy reliance on SAF—which costs several times more than conventional jet fuel—could significantly increase ticket prices.[9]

Beyond aviation, there are other sectors that have particularly high abatement costs, making them ill-suited to low-cost decarbonization strategies. For example, a recent analysis of reaching President Biden's pledged Paris Agreement target assumes supplanting industrial fuel requirements with low-carbon hydrogen, but the estimated abatement cost is $489 per ton—far above the estimated social cost of carbon.[10] From an economic perspective, when abatement costs are far more than estimated benefits, the abating activity could entail more harm than benefit.

Carbon offsets, by contrast, frequently come from either forestry or agricultural practices, and can cost between $3-5 currently, potentially rising to $20-50 in the future due to anticipated increases in demand.[11] Note that these offset costs also fall below the SCC, meaning that the practices are likely to be net beneficial in a global and economic sense.

In addition to cost advantage, carbon offsets are an important tool for decarbonization because they require no additional technology or breakthrough innovation. Most carbon offsets can be produced with existing technology, making their achievement possible much more rapidly than achieving decarbonization of sectors that rely on resources that cannot be produced at scale with existing technology. Some carbon offsets are attained by simple actions such as conserving or expanding forests, or adjusting agriculture practices to increase soil sequestration. Other carbon offsets can result in a permanent change or avoided emission, such as investing in alternative cook stoves in developing nations. The key feature of carbon offsets, though, is that there are opportunities for activities that reduce atmospheric concentrations of carbon dioxide now that are not captured as there is no market incentive for the action.

The temporality of emission abatement is often overlooked in climate policy, but is important because greenhouse gases are cumulative, and in the case of carbon dioxide is a long-lived pollutant. Similar to the finance sector where early investments compound, early emission reductions yield greater benefit than later reductions, even if those reductions have greater annual reductions. An analysis of carbon pricing's impact on emissions found that a $35 per ton carbon price would reduce cumulative U.S. emissions by 58 billion metric tons over a 30-year period, whereas regulation aimed at delivering the same annual emissions at the end of the same period would reduce emissions cumulatively by 37 billion metric tons.[12] Because the carbon price has an immediate effect in the market rather than a gradual the climate benefit is ultimately much higher. Similarly, carbon offsets can allow for earlier emission abatement, which yields more climate benefit than far flung decarbonization targets that aim beyond 2030, and sometimes even to 2050.

The disadvantage of carbon offsets is that there is finite upward potential. Estimates for the upper bounds of carbon sinks range between 3 and 13 billion metric tons.[13] With global emissions at 50 billion metric tons, it is not possible for carbon offsets entirely mitigate global emissions, but this is the case for all mitigation opportunities.[14] As a low-cost, immediately deployable emission mitigation opportunity, carbon offsets have significant potential. Furthermore, carbon offsets also offer a method for offsetting emissions that may not otherwise be feasible to abate in the near term. Abatement cost curves tell us that a significant portion of global emissions have abatement costs well in excess of the social cost of carbon, and it is these emissions that carbon offsets can best address.[15]

Importantly, carbon offsets are also frequently critiqued for having less environmental benefit than outright mitigation. A carbon offset reduces the atmospheric concentration of

6. Hannah Ritchie, "Climate change and flying: what share of global CO_2 emissions come from aviation?" Our World in Data, Oct. 22, 2020. https://ourworldindata.org/co2-emissions-from-aviation.

7. Nikita Pavlenko et al., "The cost of supporting alternative jet fuels in the European Union," The International Council on Clean Transportation, (March 2019), p. 14. https://theicct.org/sites/default/files/publications/Alternative_jet_fuels_cost_EU_20190320.pdf.

8. Ibid.

9. "A4A Passenger Airline Cost Index," Airlines for America, June 4, 2021. https://www.airlines.org/dataset/a4a-quarterly-passenger-airline-cost-index-u-s-passenger-airlines.

10. "Energy Policy Solutions Simulator," Energy Innovation Policy & Technology LLC, last accessed Oct. 12, 2021. https://us.energypolicy.solutions/scenarios/home.

11. Michael Holder, "Carbon offset prices set to increase tenfold by 2030," GreenBiz, June 14, 2021. https://www.greenbiz.com/article/carbon-offset-prices-set-increase-tenfold-2030.

12. Philip Rossetti et al., "Comparing Effectiveness of Climate Regulations and a Carbon Tax," American Action Forum, July 2, 2018. https://www.americanactionforum.org/research/comparing-effectiveness-climate-regulations-carbon-tax-123.

13. Christopher Blaufelder et al., "A blueprint for scaling voluntary carbon markets to meet the climate challenge," McKinsey & Company, Jan. 29, 2021, p. 4. https://www.mckinsey.com/business-functions/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge.

14. Hannah Ritchie and Max Roser, "Greenhouse gas emissions," Our World in Data, last accessed Sept. 30, 2021. https://ourworldindata.org/greenhouse-gas-emissions.

15. Kenneth Gillingham and James H. Stock, "The Cost of Reducing Greenhouse Gas Emissions," *Journal of Economic Perspectives* (Aug. 2, 2018), p. 9. https://scholar.harvard.edu/files/stock/files/gillingham_stock_cost_080218_posted.pdf.

carbon dioxide, delivering similar benefits to emission mitigation, which is temporary in nature. Trees can offset emissions in the years they are alive, but to make the benefits of their carbon sequestration longer lived they must not be allowed to decay. Carbon offsets are not a perfect substitute for emission abatement, but they provide opportunities for environmental benefits and reduced climate impacts that may not otherwise be attainable due to the high cost of some emission abatement opportunities.

DIFFICULTY OF VERIFICATION

Despite potential economic and environmental benefits of carbon offsets there is considerable opposition to their expansion from both conservative and progressive skeptics.[16] Concerns are primarily rooted in the verifiability of carbon offsets. Such concerns are not unfounded, as recent controversies have highlighted that firms selling carbon offsets may have strong incentives to overestimate the benefits of their conservation efforts to sell more offsets.[17]

Getting the full environmental and economic benefits from carbon offsets will require two issues to be addressed: additionality and permanence. Additionality refers to the "additional" benefit that a carbon offset provides. Selling a carbon offset from the carbon sink that an already-protected forest provides would offer no additional value, because whether the investment occurs or not the forest will be there. By contrast, selling a carbon offset from newly planted trees, which would not have been planted if not for the financial motive of the carbon offset market, does provide additional environmental benefit.

Some existing carbon offsets are being scrutinized to determine their additionality. For example, in China, carbon offsets are being sold by renewable power plants that have existed for years—plants that would not be dismantled if the carbon offset revenue was not present, and that would still produce power even if higher-emitting power plants were present.[18] Similarly, conservation groups have sold carbon offsets for purchased forests, claiming that without their intervention the forests would have been cut for logging, but this is a difficult counterfactual to verify.[19]

16. Jim Walsh, "Carbon Offset Scams Facing Broad Opposition," Common Dreams, April 19, 2021. https://www.commondreams.org/newswire/2021/04/19/carbon-offset-scams-facing-broad-opposition.

17. Ben Elgin, "These Trees Are Not What They Seem," *Bloomberg*, Dec. 9, 2020. https://www.bloomberg.com/features/2020-nature-conservancy-carbon-offsets-trees.

18. Fred Pearce, "Is the 'Legacy' Carbon Credit Market a Climate Plus or Just Hype?" *Yale Environment 360*, March 9, 2021. https://e360.yale.edu/features/is-the-legacy-carbon-credit-market-a-climate-plus-or-just-hype.

19. Elgin. https://www.bloomberg.com/features/2020-nature-conservancy-carbon-offsets-trees.

Despite controversies, it should be noted that projects that sequester carbon and that only occur because of a carbon offset market are possible and can deliver environmental benefits. If the presence of the market to monetize emission abating activity spurs additional activity, then there is additional environmental benefit. Better quality analysis and improved understanding of environmental economics today make it possible to identify true additionality, and this unlocks the potential of carbon offsets in ways that may not have been possible in the past.

The second major challenge is the permanence of carbon dioxide sequestration. A tree that is planted, but then cut down and combusted for biofuel does not provide a permanent sequestration of carbon dioxide. In such a scenario, all carbon dioxide sequestered by the tree is released through its combustion. The concern around the permanence of carbon offsets is valid, as paying for activities that result in no net change in atmospheric concentrations of carbon dioxide would yield no environmental benefit. Permanent sequestration is possible, and in the same example of combusting a tree, if that combustion occurs with carbon capture and sequestration the offset can be permanent, or if trees are sustainably harvested and used for construction it can at least result in temporal biogenic carbon storage.[20]

To a lesser extent, another key—but solvable—challenge is that of double counting of emissions. Without defined processes for who can claim an emission credit, there is the potential for two or more parties to claim the same emission abatement opportunity towards their stated climate contributions. For example, if Country A invests in reforestation in Country B, both Country A and Country B have legitimate claims to the offset carbon. Appropriate rules, though, should award the carbon offset to the investor, in this case Country A, to maximize incentives for investment in emission abatement. The Paris Agreement's new approach to international carbon trading prohibits the double counting of emissions.[21]

Some challenges for policymakers are the wide array of potential sequestering activities, and the difficulty in assuring the permanence and additional benefit of such activities in a manner that gives confidence to environmentalists, investors and policymakers. Indeed, the numerous different carbon markets and the challenge of discerning quality are often-cited barriers to the growth of carbon offset demand.[22]

20. Lars. G. F. Tellnes et al., "Cross-laminated timber constructions in a sustainable future – transition to fossil free and carbon capture technologies," IP Conference Series: Earth and Environmental Science, 2020. https://iopscience.iop.org/article/10.1088/1755-1315/588/4/042060/pdf.

21. Kelley Kizzier et al., "What You Need to Know About Article 6 of the Paris Agreement," World Resources Institute, Dec. 2, 2019. https://www.wri.org/insights/what-you-need-know-about-article-6-paris-agreement.

22. "Taskforce on Scaling Voluntary Carbon Markets Phase II Report," Institute of International Finance, July 8, 2021, p. 12. https://www.iif.com/Portals/1/Files/TSVCM_Phase_2_Report.pdf.

Because the verifiable emission benefit is central to the value of carbon offsets as a relative policy mechanism for emission mitigation, it may be worthwhile for policymakers to pursue more policy that creates or enhances the verifiability of carbon offset activities. This need not come in the form of centrally managed carbon markets but could instead lean on existing private verifiers—such as the Verra Verification Standard—to set the benchmark for what policymakers can accept as environmentally beneficial carbon markets, and to determine which markets should not be considered when policymakers estimate carbon offset benefits.[23]

An example of a proposed policy to enhance the verification of carbon offsets is the Growing Climate Solutions Act, which passed the Senate earlier in 2021 and would authorize the U.S. Department of Agriculture (USDA) to aid in the verification of greenhouse gas sequestration certification through a voluntary program. This program would ideally improve confidence in the additionality and permanence of sequestered carbon.[24] Third party, non-governmental entities would also be eligible to participate under the Growing Climate Solutions Act's programs.

Confidence in the environmental benefit of carbon offsets is also central to the economic value that the offsets provide. The economic value of a carbon offset is, as always, determined by supply and demand. The demand for the carbon offset is related to how consumers view the intrinsic value of the offset, which is influenced by their confidence in the delivered environmental benefit. A consumer that does not think carbon offsets provide any additional environmental benefit would see no intrinsic value from using an airline with offset emissions over an airline that does not, and so all industries that can benefit from carbon offsets should seek to improve confidence in their environmental benefit.

ECONOMIC OPPORTUNITIES FROM CARBON OFFSETS

While somewhat sporadic, the economic literature on carbon offsets is consistent in acknowledging the benefits of carbon offsets that are properly verified. Several studies, referenced in Table 1 below, give insight into the volume of potential carbon offset markets. Knowing the volume of carbon offset potential is the first step toward understanding the economic benefits.

TABLE I: ESTIMATED ADDITIONAL CARBON OFFSET POTENTIAL BY STUDY (GIGATONS OF CO_2)

	2030	2050
Current Commitments	0.2	2.0
TSCVM Survey (low)	1.0	3.0
TSCVM Survey (high)	1.0	4.0
NGFS Scenarios	1.5	7.0
NGFS Scenarios (immediate action)	2.0	13.0
IETA Report	4.3	N/A

Source: R Street analysis based on McKinsey & Company composition of estimates, and IETA and Carbon Pricing Leadership Coalition estimates.[25]

Table 1 shows that the range of potential carbon offset production is quite large, with the Network for Greening the Financial System (NGFS) estimating a ceiling of 13 gigatons by 2050, which is more than six-fold the estimated committed amounts. Meanwhile, a report prepared by scholars from the Pacific Northwest National Laboratory (PNNL) and the International Emissions Trading Association (IETA) estimated 4.3 gigatons of carbon offsets by 2030, which was more than double the next highest estimate of 2 by the NGFS.[26]

While we may not know with certainty what estimates for total carbon offsets are appropriate, even the median estimates are significant. The Taskforce on Scaling Voluntary Carbon Markets (TSVCM) estimates modestly that three to four gigatons of carbon dioxide could be sequestered annually by 2050, but even this amount is between 7 and 9 percent of global CO_2 emissions projected for 2050, roughly the climate benefit of the European Union getting to zero emissions. Carbon offsets have significant emission abatement potential, even when compared to major developed economies phasing out their emissions entirely.

Estimations of the economic benefit from carbon offsets are more complicated. There is limited literature to draw upon for such estimates, and they rely heavily on the assumptions that potential offset opportunities are properly verified and have permanence. There exist several studies estimating the potential size of the carbon offset market; a measurement of economic activity devoted to carbon offsets. These estimates range between $100 and $400 billion annually by 2030.[27] The IETA analysis estimated an economic benefit, which can be measured as the delta between the economic activity and the cost of emission mitigation without offsets, at $249 bil-

23. "Verified Carbon Standard," Verra, last accessed Sept. 30, 2021. https://verra.org/project/vcs-program.

24. "S. 1251, Growing Climate Solutions Act," 117th Congress, June 14, 2021. https://www.congress.gov/bill/117th-congress/senate-bill/1251.

25. Blaufelder et al., p. 4. https://www.mckinsey.com/business-functions/sustainability/our-insights/a-blueprint-for-scaling-voluntary-carbon-markets-to-meet-the-climate-challenge; Jae Edmonds et al., "The Economic Potential of Article 6 of the Paris Agreement and Implementation Challenges," IETA and Carbon Pricing Leadership Coalition, September 2019, p. 11. (Hereafter: IETA Report). https://www.ieta.org/resources/International_WG/Article6/CLPC_A6%20report_no%20crops.pdf.

26. Ibid., p. 6.

27. Ibid., p. 7.

lion annually by 2030, and $345 billion annually by 2050 (in real 2015 dollars).[28] The table below also shows the value of carbon markets if "discounted" to the present value of today, at a 3 percent rate (meaning the economic value of the investment in today's dollars).

TABLE 2: MARKET SIZE AND ESTIMATED ECONOMIC BENEFIT OF CARBON MARKETS (BILLIONS, USD)

	2030	2050
IETA Report (Market Size)	167	347
World Bank and Ecofys (Market Size)	100 - 400	N/A
IETA Report (Economic Benefit)	249	345
IETA Report (Economic Benefit, NPV)	180	138
Berenberg Report (Market Size)	N/A	200

Source: IETA and S&P Summary of the Berenberg Report. Net present value based on R Street estimate.[29]

The estimates of economic size and potential benefit in Table 2 may be deceiving. Estimating the size of a market, while a conventional metric of economic scope, fails to capture the full benefits from the avoided costs of alternative scenarios if some other abatement requirement is put in place. For example, if a carbon offset is used as a compliance mechanism for a regulation, the economic benefit can be crudely thought of as the surplus created from the difference in cost between the offset and the alternative mitigation mechanism. If an offset costs $20 per ton, but it avoids the need to invest $100 per ton in a different abatement opportunity, then the benefit can be considered as $80 per ton, even though the offset only contributes $20 to the market value.

The IETA analysis attempted to estimate benefits in such a manner, and its $249 billion of benefit in 2030 is illustrative of the delta between the costs of abatement with or without international carbon offset trading under Article 6 of the Paris Agreement. However, the IETA analysis assumes that the alternative option is the imposition of economy-wide carbon pricing, which is one of the most efficient abatement methods, and thus understates the potential benefits of carbon offsets if used to supplant abatement requirements that could have costs exceeding what would be incentivized by a carbon price.

The analysis below offers a ballpark estimate of the benefits of using carbon offsets in a more efficient allocation, where offsets are used to avoid new emission reduction requirements on high-abatement cost industries. As a ballpark estimate, the analysis below does not capture the full array of opportunities for offsetting high-abatement cost emissions, but simply picks candidates with the available data. The examples used are assuming that international carbon offsets could be used to replace emission abatement in U.S. industry via electrification, hydrogen, and CCS to meet President Biden's Paris Agreement target and that carbon offsets supplant the need for sustainable aviation fuels in international aviation.

TABLE 3: REQUIRED CARBON OFFSET VOLUME AND SAVED ABATEMENT COSTS

	Required Carbon Offsets		Emission Abatement Cost (billions, present day value)	
	2030	2050	2030	2050
U.S. Industrial Emission Abatement via electrification, hydrogen and CCS	0.4	1.7	197	353
International Aviation	0.8	1.2	144	126
Carbon Offset Expenditures			(121)	(139)
Total	1.2	2.9	220	340

Source: R Street analysis based on available data from Energy Innovation, International Civil Aviation Organization, International Council on Clean Transportation, and IETA analysis. Present day value for 2020 and 3 percent discount rate.[30]

The table above shows two key points: first, the total required carbon offsets for offsetting U.S. industrial emissions and international aviation is roughly in line with or below the estimated number of offsets that can be produced, which stands at 1.2 and 2.9 gigatons in 2030 and 2050 respectively. Second, the benefits (measured as the difference between the abatement costs for those sectors) are in present value (discounted at a rate of 3 percent) roughly $220 billion in 2030, and $340 billion in 2050. Compared to the IETA analysis, this is 23 percent higher in 2030, and 147 percent higher in 2050.

The caveat, of course, is that a perfectly efficient allocation of carbon offsets will probably never be achievable, and such estimates should not be taken as a projection of carbon offset value, but rather as a takeaway that by underestimating the high abatement costs of decarbonizing key industries we

28. Ibid., p. 8.

29. Ibid., pp. 7-8; Frank Watson, "Global carbon offsets market could be worth $200 billion by 2050: Berenberg," *S&P Global Platts*, May 13, 2020. https://www.spglobal.com/platts/en/market-insights/latest-news/natural-gas/051320-global-carbon-offsets-market-could-be-worth-200-bil-by-2050-berenberg.

30. See, e.g., "Energy Policy Simulator." https://us.energypolicy.solutions/scenarios/home; Gregg Fleming and Ivan de Lepinay, "Environmental Trends in Aviation to 2050," International Civil Aviation Organization, 2019. https://www.icao.int/environmental-protection/Documents/EnvironmentalReports/2019/ENVReport2019_pg17-23.pdf; Nikita Pavlenko et al., "The cost of supporting alternative jet fuels in the European Union," The International Council on Clean Transportation, (March 2019), p. 14. https://theicct.org/sites/default/files/publications/Alternative_jet_fuels_cost_EU_20190320.pdf; IETA Report, p. 11. https://www.ieta.org/resources/International_WG/Article6/CLPC_A6%20report_no%20crops.pdf.

may consequently be underestimating the utility and economic benefit of carbon offsets.

While this paper will leave it to subsequent, more robust analysis to explore the economic benefits from carbon offsets, it is fair to describe the potential economic and environmental benefit as significant—presuming that such emission abatement would otherwise occur via less efficient methods. Additionally, because the cost of emission offsetting activity typically falls below the social cost of carbon, there is also incremental environmental benefit from carbon offsets if no emission mitigation would have otherwise occurred. The physical potential for carbon offsets, either through negative emissions or avoidance, is large enough to offset major sources of emissions that may be cost-prohibitive to abate. Further, the potential for economic benefit from an efficient allocation of offsets could be described as economically significant, presuming that alternative less efficient means of emission curtailment would be utilized.

INTERNATIONAL OPPORTUNITIES

In addition to economic and environmental benefits from carbon offsets, there is also a foreign policy opportunity from carbon offset markets. As noted above, the quality of offsets is essential to actualizing their climate and economic benefits. This raises a legitimate concern about the authenticity of foreign offsets, especially ones produced from rival emitters. It is certainly possible that low-quality offsets procured internationally could diminish investor confidence in offset markets, but if offsets are used for compliance with domestic U.S. policy, an appropriate standard of authenticity would create a global incentive for meeting such a standard.

Although international emission mitigation schemes are difficult to achieve, owing to highly variable interests across nations, carbon offsets create an opportunity to send a price signal across borders that there is a market for emission offsetting activities. Article 6 of the Paris Agreement, which establishes international emission trading, is key to ensuring that low-cost abatement opportunities via carbon offsets have appropriate opportunities to be rewarded financially, even in nations that do not have policies encouraging emissions mitigation.

Importantly, well defined standards for additionality and permanence of sequestration can correct for informational deficiencies that are otherwise exacerbated by the incentives for individual actors to provide low-quality carbon offsets.[31] In addition to this being an economic opportunity, it is also an opportunity to undercut the potential for inauthentic foreign offsets from undercutting the value of climate action in the United States and elsewhere. Absent any definition or standard for determining offset quality, the United States could end up forgoing considerable economic and environmental benefit, while simultaneously creating an incentive for producing fraudulent offset credits abroad.

CONCLUSION

This paper refrains from making specific policy recommendations but finds a strong economic and environmental case for policy direction and objectives that improve the quality of offset markets. The literature affirms that there is significant potential for carbon offsets to grow, and that annual carbon offsets could even reach a point that they would substantially offset major emission sources from difficult to abate sectors. Further, there is economic value in carbon offsets on the order of hundreds of billions of dollars, due to private sector demand for the intrinsic value they provide. There is also economic potential from carbon offsets that are allocated in an efficient manner, in which they are used to minimize the need for emission mitigation from sectors with abatement costs that may exceed environmental benefits.

The challenge for policymakers will be in improving confidence for investors and consumers of offsets alike that the climate action has meaningful, additional environmental benefit. Some legislation, such as the Growing Climate Solutions Act, aims to improve verification standards, but a light touch may be needed to ensure that action from policymakers is complementary to private sector action in offsets, rather than stifling.

The benefits of a market that appropriately values carbon offsets, though, may go beyond U.S. borders. Demand for carbon offsets from developed nations has the potential to send a global, market price signal to incentivize emission mitigation. Because carbon offsets deliver a global price incentive for investing in environmental benefits wherever it is economically feasible to do so, the presence of carbon offset markets can result in the capture of global climate benefits everywhere—even in developing nations that would otherwise not be willing to bear the costs of climate action.

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31. David G. Victor, "The Politics and Economics of International Carbon Offsets," in *Modeling the Economics of Greenhouse Gas Mitigation: Summary of a Workshop*, (National Academic Press, May 17, 2010), p. 132. https://www.nap.edu/read/13023/chapter/21.