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LETTER

Disciplinary and institutional diversity of federally funded academic research on climate solutions in the United States

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Abstract

To meet the demands of technological change required for climate change mitigation, academic research must cover a broad range of climate solutions. Diverse participation in this research is important because research shows that a variety of backgrounds and problem-solving approaches are important to solving complex problems such as climate change. In our study, we examine the discplinary and institutional diversity of federal funding for academic research on climate solutions (ARCS) in the United States. We identify $1.42 billion in federal funding for ARCS in fiscal years 2019 and 2020. Our findings reveal that 85% of federal ARCS grants are awarded to Principal Investigators in engineering and the natural sciences. Additionally, institutions classified as having high research activity (R1s) receive over 60% of the ARCS funding per student. Tribal institutions, Historically Black Colleges and Universities, and Hispanic Serving Institutions collectively receive only $109.20 in ARCS funding per student, compared to $334.30 per student for other institution types. These disparities in federally funded ARCS grants are, in part, a consequence of the absence of policies that promote interdisciplinary collaboration and broader participation in academic research. We discuss the policy implications that have contributed to the identified inequities in ARCS funding and current policies that could enhance the distribution of ARCS in the future. We propose strategies for federally funded ARCS to support an equitable energy transition that addresses the needs of contemporary society and beyond.

1. Introduction

Innovative climate solutions are needed to meet the demand for climate mitigation and technological change. Universities have historically generated activity around three main purposes: teaching, research, and service. Yet often universities' capabilities are underutilized and do not represent the full educational mission of higher education; they neglect an important 'fourth purpose' of mobilizing the institution's knowledge resources to solve real-world challenges in real time (Lemann 2019). In this research brief, we focus primarily on one of these functions, research, by examining the institutional diversity of federal funding for academic research on climate solutions (ARCS) in the United States. Our focus is on the allocation of federal grants to academic institutions. Specifically, we ask: How can the academic research enterprise and federal funding programs ensure that ARCS investments contribute to equitable climate solutions? We examine the distribution of these funds across disciplines, institution types, and the government policies that determine the existing distribution of funds.

Based on our analysis, we identify $1.42 billion in federal funding ARCS in FY 2019 and 2020. Institutions with high research activity (R1) account for more than 86% of federal grants ARCS. Tribal Colleges and Universities (TCUs), Historically Black Colleges and Universities (HBCUs), and Hispanic-Serving Institutions (HSIs) collectively receive less than 9% of federal grants ARCS. To gain a better understanding of the distribution of ARCS, it is crucial to assess it in relation to the proportion of the

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academic population they serve. We calculate the dollar amount of ARCS per full-time enrollment based on Carnegie Classification and institution type. We observe significant differences in the dollar amount of ARCS per full-time enrollment across Carnegie Classifications and institution types. R1 institutions receive three to four times more ARCS funding per enrollment compared to R2 and non-R1/R2 institutions, respectively. HBCUs, HSIs, and Tribal Colleges collectively account for only 24% of the total dollar amount of ARCS grants per full-time enrollment.

The lack of disciplinary and institutional diversity in federally funded ARCS identified in this paper is explained by a lack of policies focused on this important issue. We anticipate that future federal funding of ARCS will improve as the Justice 40 Executive Order, and related policy, allocates resources to expand ARCS research enterprises by discipline and institution type. The America COMPETES Act of 2022 and the Inflation Reduction Act provides federal grants and offers tax incentives to higher education institutions to improve sustainability on campus and in surrounding communities.

To maximize the diversity of ideas used to develop climate solutions, researcher participation should be broadened in ARCS, both in terms of research disciplines and type of institutions. Communities of color have the greatest risk of being impacted by the climate crisis. For ARCS to reach its full potential, more research funding must be distributed to institutions that serve these communities and to disciplines that can address the social dynamics of climate change.

Our paper is organized as follows: section 2 describes the data and methodology, section 3 discusses our findings, section 4 describes the policies that have influenced the distribution of ARCS at the federal level, and section 5 is the conclusion.

2. Method

We collected quantitative and qualitative data to examine the current landscape of federally funded ARCS and potential pathways to greater impact. Our quantitative data consist of extramural research grants from federal agencies to higher education institutions for climate solutions topics, awarded in fiscal years 2019 and 2020. We define climate solutions topics as being related to three key concepts: clean energy, energy efficiency, and climate change. See figure 1 for a summary of our quantitative data collection process.

We searched for ARCS grants from six agencies who we knew to engage in extramural funding of climate-related research: Department of Energy (DOE), Environmental Protection Agency (EPA), National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA), National Science Foundation (NSF), and United States Department of Agriculture (USDA). For each agency, we identified a public web platform for searching past grants. We completed a keyword search using the phrases 'climate change', 'clean energy', and 'energy efficiency'[4].

- DOE PAMS[5]
- DOE J40[6]
- EPA[7]
- NSF & NASA[8]:
- USDA (NIFA)[9]
- NOAA[10]

EPA, NSF/NASA, and USDA platforms provided a single text box for keyword search. DOE PAMS required separate searches for the title and abstract fields. DOE J40 provided a full dataset download, in which each grant was coded with one of nine categories of J40 relevance. We selected those grants that were coded as either 'Climate Change' or 'Clean Energy and Energy Efficiency,' as well as those grants that were issued by the Advanced Research Projects Agency–Energy (ARPA-E) or the Office of Energy Efficiency and Renewable Energy (EERE).

We limited the dataset to fiscal years 2019 and 2020 by requiring awards to be issued on or after 1 October, 2018, but no later than 30 September, 2020. We limited our dataset to higher education organizations by requiring the awardee name to contain either 'college', 'university', or 'school.' We then manually reviewed the set of included institutions and removed awards to consortia or non-profit organizations supporting higher education institutions, including Thurgood Marshall College Fund and the University Corporation for Atmospheric Research.

This process generated a dataset of 1829 ARCS grants awarded in FY 2019 and FY 2020. Next, we merged our grant data with higher education

[4] DOE does not provide a unified grant search platform for the entire Department, so we combined two data sources: the Portfolio Award Management System (PAMS) from DOE's Office of Science, and the Beta Energy Justice Dashboard from DOE's Office of Economic Impact and Diversity. USDA similarly does not offer a search platform for all grants; instead, we used the public grant search platform for the National Institute for Food and Agriculture (NIFA). NASA and NSF share a combined grant search platform.

[5] DOEPAMS grant search was accessed via https://pamspublic.science.energy.gov/WebPAMSExternal/interface/awards/AwardSearchExternal.aspx.

[6] DOE J40 grant data were downloaded via www.energy.gov/diversity/energy-justice-dashboard-beta.

[7] EPA grant search was accessed via https://cfpub.epa.gov/ncer_abstracts/index.cfm/fuseaction/search.welcome.

[8] NSF and NASA grant search was accessed via www.nsf.gov/awardsearch/advancedSearch.jsp.

[9] There is no search platform for all USDA grantmaking. The NIFA grant search was accessed via: https://portal.nifa.usda.gov/lmd4/recent_awards?report_title=Recent%20Awards&from_site=NIFA&search_label=Awards%20Listing.

[10] NOAA grant search was accessed via https://grantsonline.rdc.noaa.gov/flows/publicSearch/begin.do. As of December 8, 2021, the public search function is no longer available for NOAA grants.

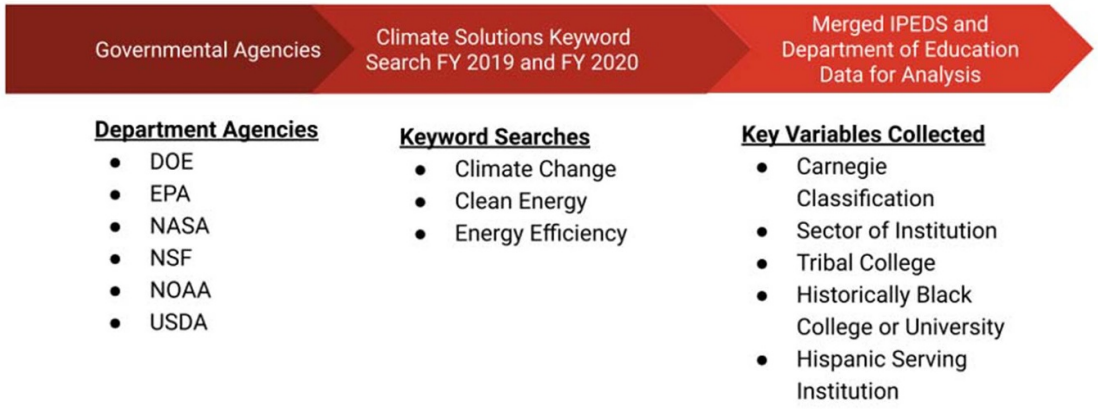

Figure 1. Flow chart of quantitative data collection process.

data from the Department of Education's Integrated Postsecondary Education Data System (IPEDS) to analyze institutional differences between universities and colleges receiving federal funding for ARCS. In cases where the grantee listed was a university system, we assigned those grants to the flagship campus. The key variables collected were:

- Basic Carnegie Classification—Categorizes all degree-granting higher education institutions into classifications including Doctoral University: Very High Research Activity (R1), Doctoral University: High Research Activity (R2), and many others[11].
- Sector of Institution—Categorizes higher education by public or private institution, and by 2 years or 4 years institution.
- Tribal College and Universities—Defined by the Higher Education Act of 1965, Tribal College and Universities are institutions that are operated by Native American tribes.
- Historically Black College or University (HBCU)—Institutions that were established prior to 1964 who primarily serve the African American community.

Separately, we obtained data on Hispanic Serving Institutions (HSIs) from the 2019 NCES Digest of Education Statistics (Carnegie). HSIs are institutions that have at least 25% enrollment of full-time equivalent undergraduate students who are Hispanic. We merged this dataset with other university characteristics obtained from IPEDS.

We also created a random sub-sample of 100 NSF ARCS grants to examine the discipline associated with the research. We manually recorded the academic departments associated with each grant based on the faculty webpage of the lead PI, and we then assigned each department name to the most closely related NSF directorate.

Next, we examined innovation policy in the context of ARCS. We analyzed the America COMPETES Act of 2022 and the NSF Strategic Plans of 2014–2018 and 2018–2022. We discuss how the policy environment may have affected the distribution of federal funds for ARCS.

We acknowledge several major limitations to this dataset. We are likely missing many grants related to our three key concepts ('clean energy', 'energy efficiency', 'climate change') that do not contain those keyword phrases in the title or abstract. The use of only three keyword phrases also omits other highly relevant concepts, such as climate resilience and adaptation. Because there is no simple method for identifying federal grants that relate to climate solutions, we do not claim that our dataset is a comprehensive view of all ARCS grants made by these six federal agencies, much less the whole of the federal government. Instead, we consider this dataset to be an important sample of recent ARCS grants, which we can use to reach a better general understanding of how federal funds are distributed for this purpose.

3. Results

The total grant amount awarded for ARCS over the six agencies in FY 2019 and 2020 was approximately $1.42 billion: DOE and NSF account for approximately 87% of this total. NOAA accounts for approximately 13%, while the USDA accounts for less than 1%. No ARCS grants were identified from NASA and EPA at this time. Comparing DOE

[11] https://carnegieclassifications.iu.edu/classification_descriptions/basic.php.

Table 1. Research sample of ARCS grants from DOE and NSF in FY 2019 and 2020.

	Department of Energy	National Science Foundation
Grants awarded in sample	757	1036
Total funding amount in sample	$693 228 456.30	$536 614 803.00
Average funding amount for grants in sample	$915 757.54	$517 967.96
Example grants	Title: Composite PEMs from Electrospun Crosslinkable Poly (Phenylene Sulfonic Acid)s Objective: To use electrospinning to create a novel membrane material for proton-exchange membrane (PEM) fuel cells[a] Institution: Vanderbilt University Award Amount: $536 014	Title: Marine Sky Brightening: Prospects and Consequences Objective: Explore marine sky brightening as a method of solar geoengineering wherein sea salt particles are injected into the marine boundary layer[b] Institution: Indiana University Award Amount: $299 994

[a] www.hydrogen.energy.gov/pdfs/review19/fc310_wycisk_2019_p.pdf.
[b] www.nsf.gov/awardsearch/showAward?AWD_ID=1931641.

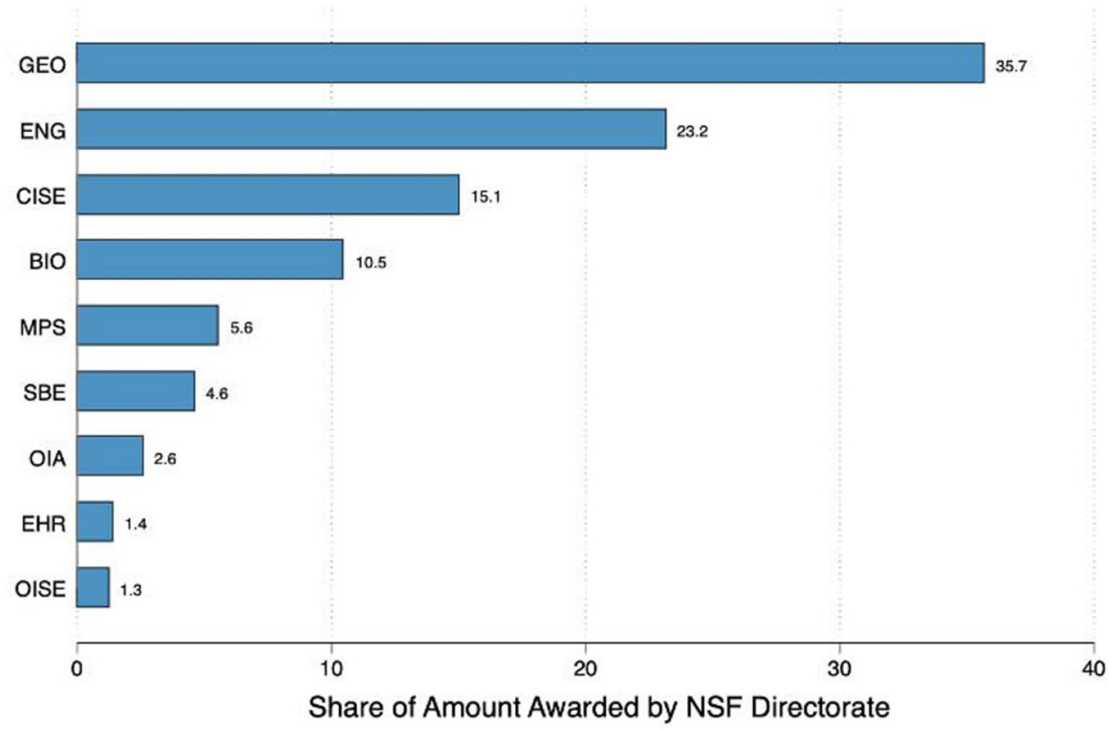

Figure 2. Share of NSF ARCS grant funding in FY 2019 and 2020 by directorate, including the seven primary directorates—biological sciences (BIO), Computer And Information Science And Engineering (CISE), Engineering (ENG), Geosciences (GEO), Mathematical and Physical Sciences (MPS), Social, Behavioral, and Economic Sciences (SBE), and Education and Human Resources (EHR)—and two cross-cutting directorates—Office of Integrative Activities (OIA) and Office of International Science and Engineering (OISE).

and NSF, DOE had a larger total funding amount and a higher average funding amount per grant, due to a small set of multi-million-dollar grants (table 1).

Two example ARCS grants, one from DOE and one from NSF, are shown in table 1. These grants represent research into two narrow segments of a diverse array of climate solutions: hydrogen-based fuel cells and solar geoengineering.

The climate crisis is a multi-faceted problem that impacts society, requiring participation across a wide variety of academic disciplines. Solving climate problems means having a sophisticated understanding of the physical and biological processes of a changing climate, the social and behavioral dynamics of human societies, and the technologies that can either emit greenhouse gasses or reduce emissions. And yet, in the current landscape of ARCS grantmaking, we find

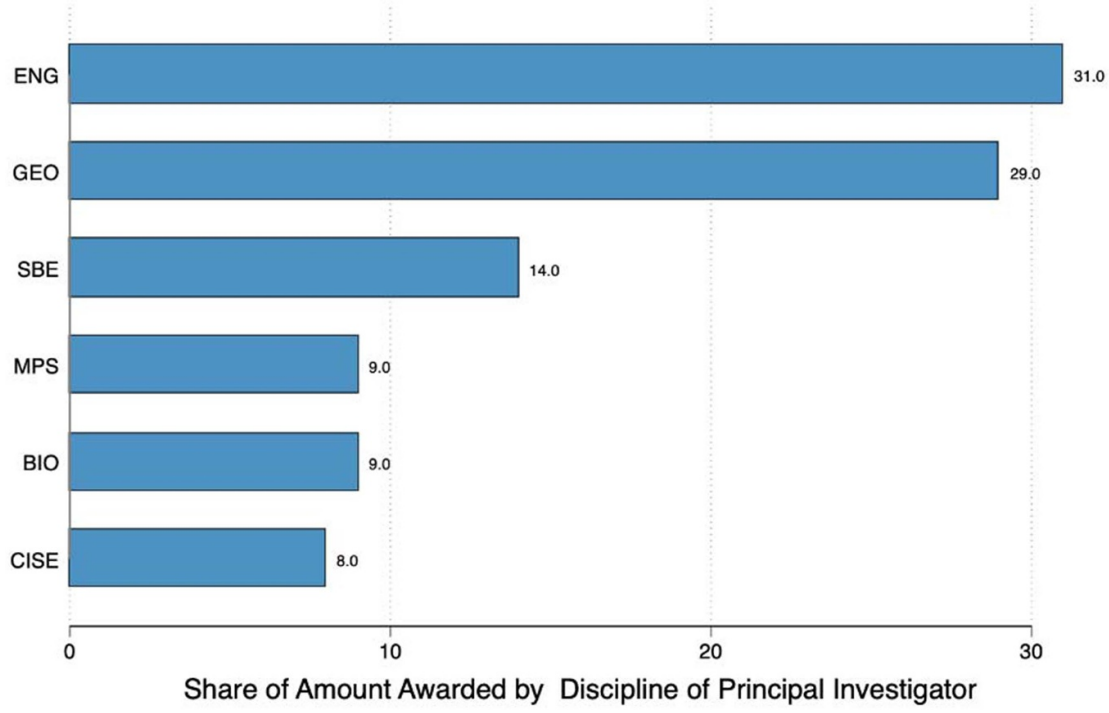

Figure 3. Share of amount awarded for random sub-sample of 100 NSF ARCS grants by Principal Investigator discipline.

that research funds are not well-distributed across all disciplines.

We examined the share of federally funded ARCS grants, as shown in figure 2, by academic discipline within NSF specifically, taking advantage of the fact that NSF organizes its grants under directorates of science and engineering that correspond roughly to research disciplines. The majority of NSF ARCS funding in our dataset was awarded to the physical and natural science directorates: the largest group of grants was in the Geosciences (GEO) directorate (35.7%), with a substantial amount in Computer and Information Science and Engineering (CISE), Engineering (ENG), and Biological Sciences (BIO) directorates. Only 4.6% of the funding in this dataset went to the Social, Behavioral, and Economics Sciences (SBE) directorate.

Similarly, in a random subsample of 100 NSF ARCS grants, we found that ENG and GEO are the most common specialty of lead PIs, with 31% and 29% of funding respectively. However, in this sample there is a higher proportion of lead PIs in SBE-related departments (14%) than the corresponding share of funding from the SBE Directorate (4.6%). This result, as depicted in figure 3, could indicate social science participation in the physical and natural sciences ARCS funding at NSF. And yet, the fact remains that geoscience topics appear to be the dominant focus for NSF in terms of climate solutions.

Perhaps the imbalance across disciplines and lack of focus on social sciences should come as no surprise, given prior research showing that natural and technical sciences receive far more funding than the social sciences for research on issues related to climate change. In one study, only 0.12% of climate research funding worldwide 1990–2018 was spent on social science of climate change mitigation (Overland *et al* 2020).

In our analysis of ARCS grants for FY 19 and 20, we find that funding was distributed across much of the US (figure 4). At least one ARCS grant was issued to institutions in each of the 50 states, plus the District of Columbia, Guam, and US Virgin Islands. The regions with the greatest portion of the ARCS funding total were the Far West (24%) and Mid-Atlantic (19%), followed by Southeast (14%), New England (11%), and the Great Lakes (11%).

Although there was a wide geographic spread of federal ARCS funding, we find that funding was in fact highly concentrated within certain types of institutions. In figure 5, we show that R1 institutions received $372.60 per full-time enrolled student, while R2 institutions received $130.70, and non-R1/R2 institutions received $94.00. These findings underscore the imbalance in the distribution of ARCS. A similar disparity can be seen in the broader landscape of academic research, in which R1 institutions receive 90% of federal science and engineering research and development (R&D) funding overall (APS 2021).

Some degree of concentration of research funds within research universities may seem appropriate but consider how this affects students' access to

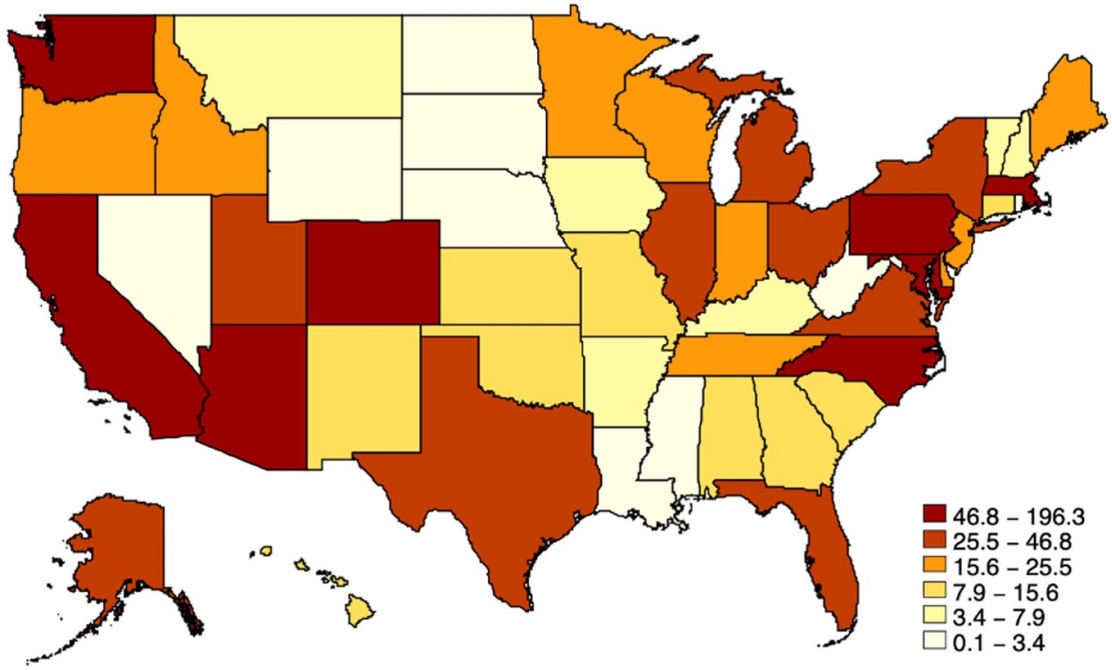

Figure 4. Map of ARCS grant funding distribution in FY 2019 and 2020.
Note: The total amount awarded by state in FY 2019 and FY 2020 is in millions of dollars.

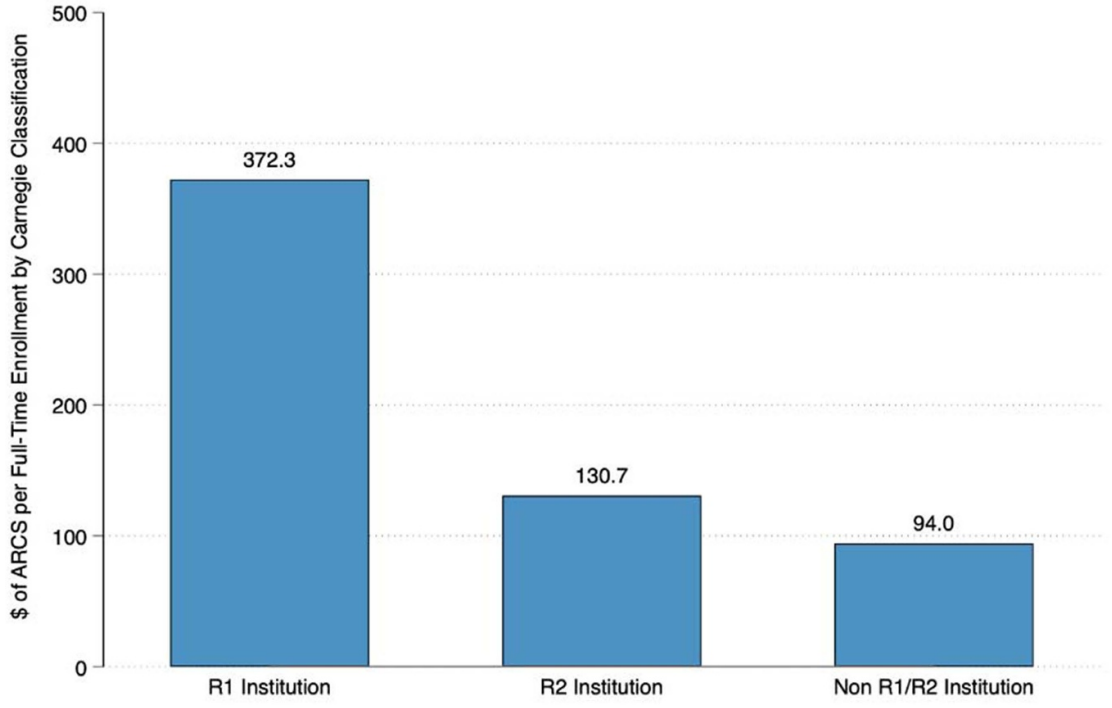

Figure 5. Dollar amount of ARCS per full time enrollment by Carnegie Classification.

opportunities. Among the institutions in our dataset, R2 schools only received 10% of ARCS grants but account for 20% of full-time enrolled students. The racial inequity is dramatic; only 34% of students of color in higher education are enrolled at R1 institutions (US House of Representative 117th Congress 2021). As a result, most students of color are excluded from climate solutions research opportunities relative to their R1 counterparts.

ARCS funding also appears to be concentrated outside of MSIs. For non-MSIs in our sample, ARCS grants amount to $334.30 per full-time enrolled student, while HBCUs, HSIs, and Tribal Colleges combined receive only $109.20 per full-time enrolled

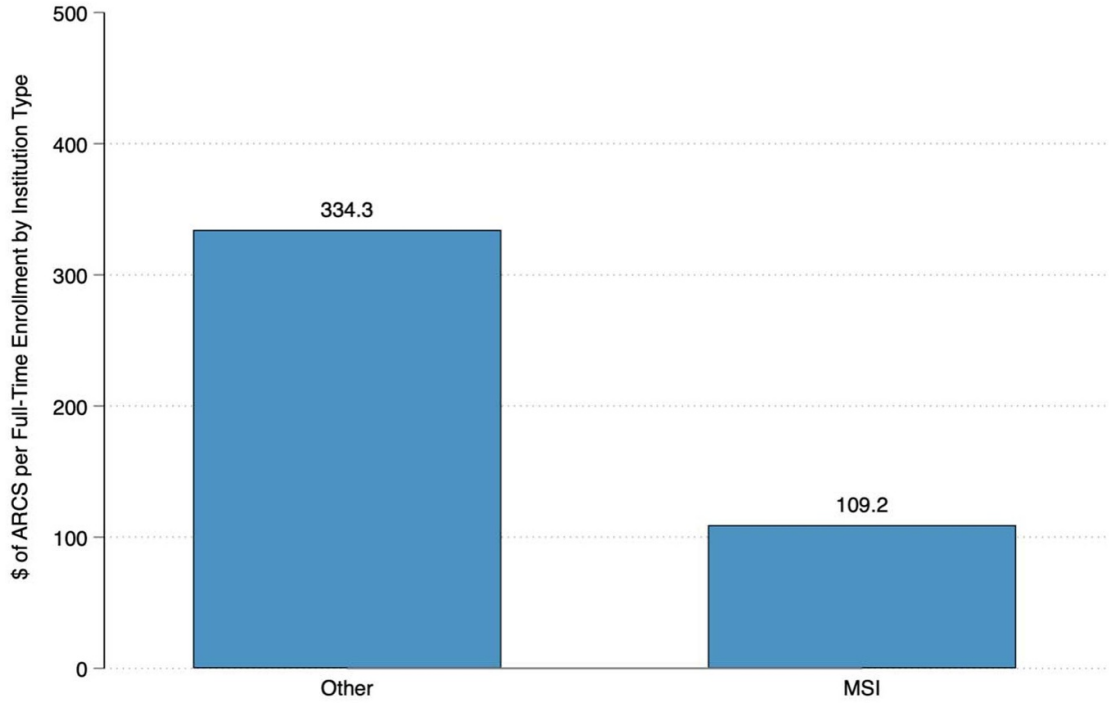

Figure 6. Dollar amount of ARCS per full time enrollment by institution type.
Note: The MSI category includes HBCUs, HSIs, and Tribal College institutions. The MSI findings are predominantly influenced by HSIs, which have the largest enrollment among the MSI categories. The 'Other' category is primarily composed of non-MSIs but could potentially include some MSIs outside of the HBCU, HSI, and Tribal College/University classifications. Other types of MSIs encompass Alaska Native-serving institutions, Native Hawaiian-serving institutions, Predominantly Black Institutions, Asian American and Native American Pacific Islander-serving institutions, as well as Native American-serving nontribal institutions.

student, as shown in figure 6. Non-MSIs receive nearly three times the amount of ARCS funding per student compared to MSIs in our sample.

It is important to note that several categories of MSIs are not represented in IPEDS data. However, the consistently low funding amounts for HBCUs, HSIs, and Tribal institutions indicate that MSIs are not given a high priority for ARCS funding. These findings underscore the unequal distribution of ARCS grants by institution type.

4. Discussion

Policy is vital for steering appropriations for federal agencies to encourage greater diversity of resources focused on ARCS. The distribution of grants in this report highlights the disparities amongst the disciplinary and institutional diversity of federally funded ARCS. This section discusses how federal agency policy and strategy may have contributed to disparities and how current and future policy can address the lack of diversity in ARCS.

4.1. NSF

The NSF focuses primarily on funding science and engineering research at universities; it funds nearly one-third of all federal funding for academic research. The NSF Strategic Plan outlines the major initiatives and priorities for NSF-supported science and engineering research for a period of four years. We examined NSF's strategic plan for 2014–2018 and 2018–2022 to assess the extent to which the strategic plan may have contributed to disparities in the lack of disciplinary and institutional diversity at ARCS. These prior plans discuss the importance of basic research and innovation needs for the future from a broad perspective, but do not identify climate change or climate interdisciplinary research as a primary focus. The lack of focus on climate change issues and expanding institutional diversity in NSF's strategic plan and programs is reflected in the funding we identified for NSF's ARCS. Climate change mitigation and related topics were only listed as a research focus for the Geosciences Directorate, which explains why nearly 80% of the NSF ARCS funding identified were from the Geosciences Directorate.

Diversity is mentioned in previous strategic plans, with a focus on improving the diversity of the STEM workforce and the NSF workforce. NSF discusses the importance of broader participation by supporting diversity initiatives in training and development. The two previous strategic plans do not address broader participation of diverse types of higher education institutions or the need to support climate change and environmental justice initiatives for communities that will be greatly impacted by the climate issues.

In FY22, the NSF was approved to establish the new Technology, Innovation, and Partnerships (TIP)

directorate. TIP was created to accelerate the translation of academic research to improve US competitiveness and develop a diverse workforce for future, high-wage jobs. TIP focuses on high growth sectors that require critical and emerging technologies but does not contain programming specifically dedicated to sustainable development needed for the energy transition (Mervis 2021b).

NSF's current strategic plan for 2022–2026 has made progress on climate change, interdisciplinary research, and diversity needs. The NSF addresses the urgent need for climate solutions based on scientific research, inclusion of underrepresented groups in STEM, and collaboration between social sciences, education, science, and engineering. This could be a promising sign; although strategy does not necessarily lead to implementation, it is a strong prerequisite for changing the direction of research.

4.2. America COMPETES Act

In 2021, there was a policy debate about the distribution of funds at the NSF in the Endless Frontier Act. The US Senate and House of Representatives took different approaches to the idea of diversity and allocation of research funds. The Senate's legislation provided geographic diversity, by directing funds toward neglected geographic regions, such as those defined by the Established Program to Stimulate Competitive Research (EPSCoR)[12]. The House legislation emphasized diversity by funding emerging research institutions across all states; these include minority-serving institutions (MSIs) and others outside of the top 100 research institutions (Mervis 2021a). The Endless Frontier Act did not pass as a standalone bill, but the 117th US Congress enacted the CHIPS and Science Act which included the America COMPETES Act, a bill that derived from the Endless Frontier Act.

The America COMPETES Act of 2022 received bipartisan support and focuses on strengthening innovation and research and development in the United States. NSF is required to provide 20% of funding in key programs to EPSCoR institutions. The bill also provides funding for MSIs, including HBCUs, HSIs, TCUs, and Alaska Native and Native Hawaiian institutions, to improve participation rates of underrepresented groups in STEM and workforce development. Under the America COMPETES Act, NSF's Early Career Awards include a diversity requirement to ensure that grantees represent a variety of higher education institutions. The Act also requires the National Academy of Sciences to prepare a report on potential barriers to increasing the number of underrepresented groups in STEM and identify strategies to bring more of these groups into the workforce at STEM.

While the America COMPETES Act of 2022 recognizes and authorizes funding opportunities for various types of institutions of higher education and for MSIs, there is no increase in funding or development of a specific program for energy transition under the NSF or the DOE, two of the largest federal funders of academic research.

4.3. Justice 40 Executive Order and the Inflation Reduction Act

In January of 2021, President Biden signed the Justice 40 Executive Order, which requires 40% of the benefit of federal investments related to climate change and related topics to go to communities negatively impacted by pollution. The Inflation Reduction Act that passed in August of 2022 is one of the acts that is required to follow the Justice 40 Executive Order.

The Inflation Reduction Act provides opportunities for higher education institutions to improve their energy efficiency through tax credits and investments. In addition, the bill provides funding to higher education institutions for programs and initiatives that support groups affected by hazardous environmental conditions. Several agencies, including the EPA, the Federal Highway Administration, the NOAA, and the DOE, have received new appropriations to set up grant programs to promote sustainability and help communities adapt to the impacts of climate change. Institutions of higher education can apply for these grant initiatives and tax incentives to support the energy transition. In order to establish whether Justice 40 is having the desired effect on academic research, we would need to examine future data from programs established under this initiative.

These are encouraging developments, and yet these new funding streams do not address disparities in academic research. Most of the resources being devoted to diversifying DOE funding is exclusively on STEM or workforce development. There is a missed opportunity to diversify research grants as well, which can include a student training component.

4.4. An alternative approach

Many of the programs and initiatives mentioned above are steps in the right direction. To address the grand challenge of climate change, federal agencies must focus on fostering collaboration and integrating knowledge across sectors and disciplines and engaging underrepresented communities. A more effective approach to addressing the energy transition and Black, Indengious and People of Color (BIPOC) community disparities will require a specific program with those goals at the center.

The National Institute for Health for almost 40 years has a program specifically designed to diversify the biomedical research workforce. Congress

[12] www.nsf.gov/od/oia/programs/epscor/nsf_oiia_epscor_EPSCoRstatewebsites.jsp.

Table 2. Success metrics of the Research Centers in Minority Serving Institutions program.

Research success	Workforce diversity	Local research initiatives	Training and development
Converted $900 million in program funding to $4 billion in additional research awards.	22 000 Science and health professional degrees awarded to Black and Hispanic students. Accounting for 1 out of 4 degrees for these groups.	RCMI centers enrolled 16 000 diverse research participants.	Provided training to 600 new clinical and translational research scholars at the RCMI centers.

Note: This information is between the time period 2002–2015 and was reported in Ofili *et al* (2021).

established the Research Centers in Minority Serving Institutions (RCMI) program in 1985 to diversify the biomedical research workforce (Ochillo *et al* 2003). Since its inception, RCMI has expanded its objectives to include development of infrastructure to increase clinical and community-based research capacity. The program supports health-related doctoral training in higher education institutions that serve underrepresented groups, and it funds institutions that provide health and clinical services to underserved communities. Table 2 highlights key metrics that demonstrate the success of RCMI program. A program like RCMI would be beneficial to addressing the lack of participation of the most marginalized groups of the climate crisis and ARCS.

The success of the RCMI program has led to other initiatives to encourage innovation and research collaborations within NIH. For one example, the RCMI Translational Research Network encourages collaborations and sharing of expertise across member RCMI institutions (Ofili *et al* 2019). Another example is in NIH's National Center for Advancing Translational Science (NCATS)' Clinical and Translational Science Awards (CTSA) program, which has led to several notable partnerships between research-intensive medical schools and MSIs, to provide training for researchers and facilitate community participation in research (Ofili *et al* 2013):

- Emory University & Morehouse School of Medicine[13]
- Georgetown University & Howard University[14]
- Vanderbilt University & Meharry Medical College[15]
- University of California, Los Angeles & Charles Drew University[16]
- Weill Cornell Medical College & Hunter College[17]

The lessons from RCMI and related programs can be usefully applied to climate solutions, given the strong parallels between health disparities and the disparities in harm done by climate change to underserved communities and people of color. Programs that fund research at MSIs on climate solutions—especially solutions that address inequities—are essential to build research capacity at these institutions. Funding for collaboration between MSIs and R1 schools can then further enhance the programs' impact by strengthening inter-university partnerships.

5. Conclusion

A broader approach to the research enterprise is needed for universities to contribute to the challenge of disastrous climate change. Diversifying the federal funding of ARCS can help accelerate climate mitigation and adaptation based on scientific research. Broadening participation with minority serving institutions and interdisciplinary research is critical in ensuring just energy transitions where marginalized communities will be able to participate in the changing economy. Communities of color are most affected by poor environmental conditions and funding ARCS can help universities rise to the challenge, while bringing about social and economic success for all members of society. We discuss two areas of priority to broaden participation across the academic research enterprise that we expect to be particularly impactful toward climate solutions.

1. ARCS funders and institutions must prioritize social science and encourage collaborations between social science, natural science, and engineering fields.
2. ARCS funding should be inclusive across multiple types of institutions beyond R1 universities, including MSIs.

These recommendations entail substantial change in ARCS funding and implementation. New investments in ARCS must not continue with the status quo funding approach, or even with small tweaks. They must break the mold, by including diverse researchers and institutions and prioritizing social science and transdisciplinary research.

Ultimately, change is required for funders and higher education institutions alike. Although federal funding agencies and Congress set the priorities for

[13] www.gactsa.org/.
[14] www.georgetownhowardctsa.org/.
[15] https://victr.vumc.org/.
[16] www.cdrewu.edu/research/Center/CTSI.
[17] Weill Cornell Medicine. Clinical & Translational Science Center. Retrieved December 2021, from https://ctscweb.weill.cornell.edu/.

resource allocation, they are informed in doing so by their perception of what is possible. As universities adjust their activities, bringing them more in line with the 'fourth purpose,' funders can make better use of the problem-solving capabilities in higher education. The need for impactful ARCS has never been more urgent, and so we call on all actors in the university research enterprise to consider how they can support this necessary transformation.

Data availability statement

The data that support the findings of this study are available upon reasonable request from the authors.

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