

# Impact Evaluation of Federal Energy Research and Development Through Small Businesses and Startups

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## ABSTRACT

The U.S. D.O.E.'s Office of Energy Efficiency and Renewable Energy (EERE) administers a significant portion of U.S. public funding for energy technology R&D, with a focus on development of new, high-risk, high-reward innovations. Small businesses are major drivers for this work, but to date no systematic study has been conducted to measure the impact of EERE's investments on small businesses' economic outcomes. To address this gap, in 2025, EERE will solicit an independent evaluator to employ a sharp regression discontinuity design (RDD) to evaluate the impact of its investments on small business innovators. In addition to characterizing over \$7.1 billion in funding awarded to small businesses 2006-2024 and analyzing EERE's impact, this evaluation will compare results across funding mechanisms, including regular financial assistance, Small Business Innovation Research (SBIR) grants, and prize awards. Results will be published in 2027.

Building on past studies, this evaluation will test EERE's impact on a suite of outcome indicators including product sales, employment, longevity, follow-on funding, speed to commercialization, and patenting, and citations while controlling for rival factors such as business type, timing, sector and geography. Hypotheses tested in past evaluations of similar programs will be tested on EERE's funding in particular, and this will be the first rigorous evaluation of the impact of EERE's regular financial assistance and prizes. Audiences for the results of this evaluation are broad, including DOE itself, other agencies and governments, researchers studying the impacts of federal funding on innovation, small business innovators, the international community, and the public.

## Background

Energy technology research and development (R&D) is broadly acknowledged as a key driver of energy technology innovation, efficacy and adoption. The U.S. has historically been one of the largest sources of public funding globally for clean energy research and development (R&D) in absolute terms and plays an outsized role internationally in funding energy innovation (Cunliff and Hart 2019). The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy's portfolio focuses on investments in research and development of innovative clean energy technologies bridging a number of sectors, including technologies in the geothermal, solar, water, wind, bioenergy, hydrogen and fuel cell, vehicle, advanced materials and manufacturing, building, and industrial efficiency and decarbonization spaces. EERE's support is delivered through various mechanisms including funding for individuals and organizations developing technologies, workforce training for a wide array of stakeholders, infrastructure development, and collaboration with innovators in conjunction with the U.S. national laboratory complex.

In addition to being among the largest sources of public funding of clean energy R&D globally, EERE's portfolio has been found through past evaluations to have expansive reach. A recent study conducted for EERE (1790 2022) found that EERE funding has had a strong influence on subsequent technological development, with a Citation Index metric revealing EERE-funded patents have been cited 67% more frequently than expected based on their age and technology (see Figure 1) and can be linked to almost 10% of subsequent patent families owned by the leading patenting organizations (98% of which are companies) in their respective technologies. Technologies funded through EERE's programs over the

past three decades of its existence – notably including key advances in renewable energy, vehicle and building technologies – are anecdotally known to have led to seismic advances in these market spaces. Although EERE has determined through analysis of patent citations that its technologies are highly cited (Figure 2), to date relatively little in the way of evaluation has been conducted to quantify the impact of EERE’s investments on technology commercialization, company growth and other key indicators of economic success.

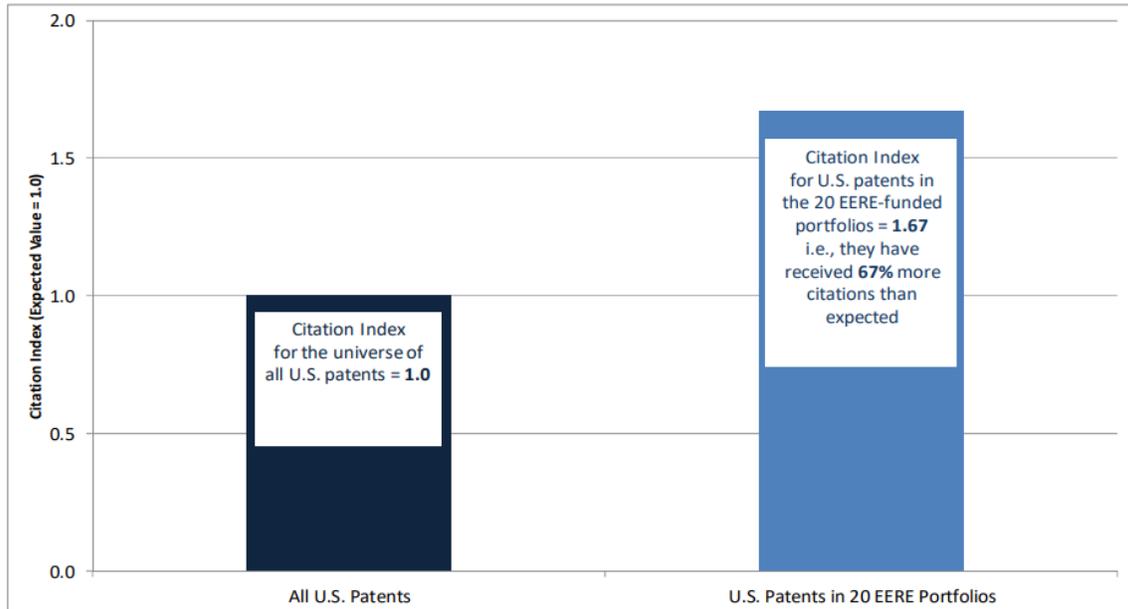


Figure 1: Overall Citation Index of U.S. Patents in Twenty EERE-funded Portfolios. Source: 1790 2022.

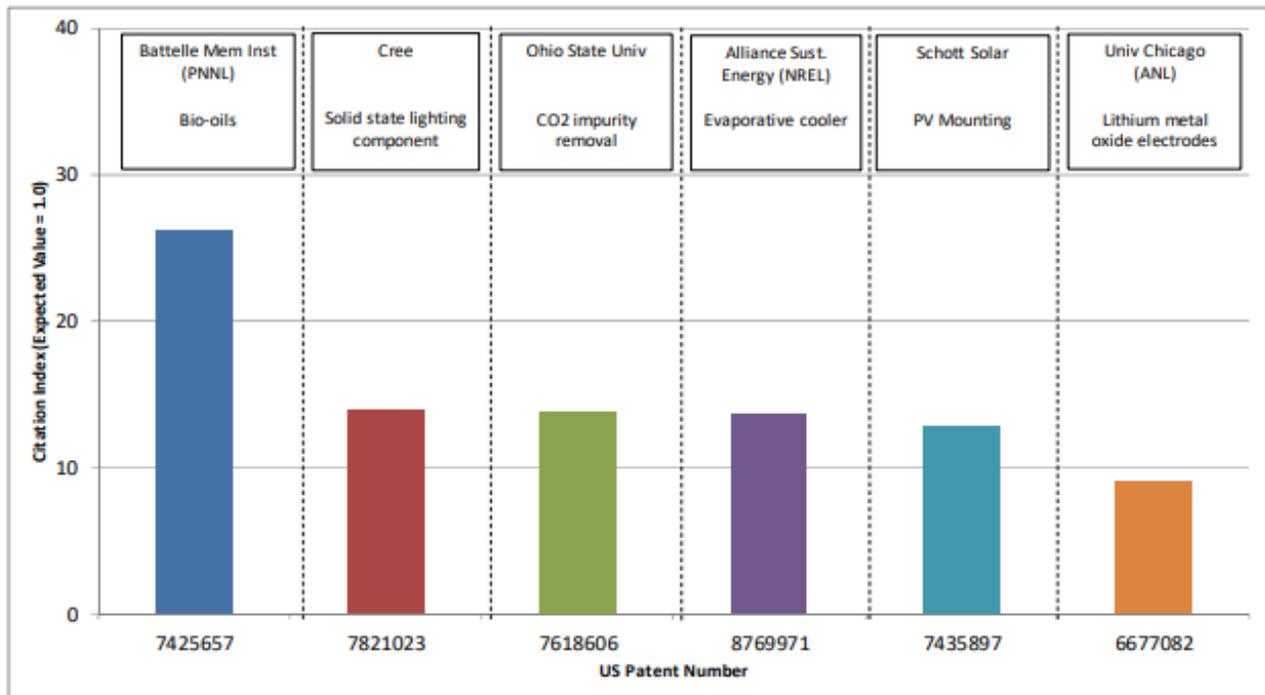
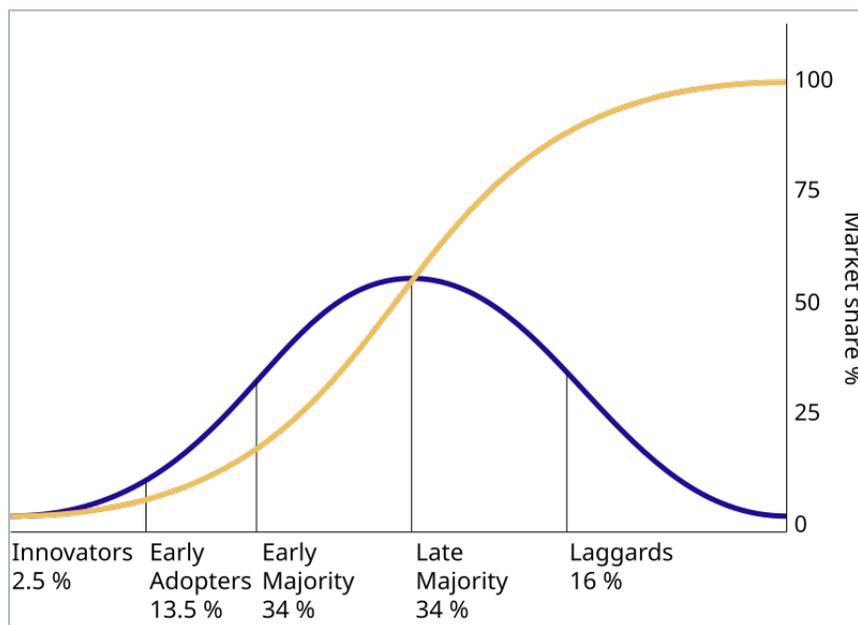


Figure 2: Examples of Highly-Cited EERE-funded Patents. Source: 1790 2022.

Small businesses and start-ups are major drivers of energy technology innovation and EERE’s investments in these companies represent a significant portion of its overall portfolio, with EERE providing over \$7.1 billion in funding to small businesses across more than 5,000 awards between 2006 and 2024. Much of the support EERE provides to small businesses comes in the form of financial assistance awards, SBIR and Small Business Technology Transfer (STTR) awards, and to a lesser extent prize awards and typically focuses on funding innovators in nascent technology markets conducting research and development as opposed to research in basic science or demonstrations, commercialization, large-scale loans or broad adoption of developed technologies (Figure 3).



**Figure 3:** The diffusion of innovations, from Everett Rogers Diffusion of Innovations 1962. With successive groups of consumers adopting the new technology (shown in blue), its market share (yellow) will eventually reach the saturation level. The blue curve is broken into sections of adopters. EERE’s portfolio focuses on investment in innovators developing new energy technologies that have not yet garnered broad adoption, at the far-left end of the diagram. *Source:* Wikipedia 2025.

Because of its portfolio’s reach and because of the scale of its support for small businesses there is great interest at DOE, in academia and elsewhere in assessing the impact on outcomes that better quantify how well EERE’s funding supports small businesses in growing their businesses, commercializing products and achieving other meaningful indications of success, but to date no systematic study has been conducted to measure the impact of EERE’s investments on its small business award recipients’ economic outcomes. To address this gap, in 2025, EERE will solicit an independent contractor to evaluate the impact of its investments on small business innovators. In addition to characterizing funding awarded 2006-2024 and analyzing EERE’s impact, this evaluation will compare results across funding mechanisms, including regular financial assistance, Small Business Innovation Research (SBIR) grants, and prize awards.

Prior program evaluations conducted by DOE, other governments and academic researchers have developed various approaches to quantifying the impacts of government funding on energy technology innovation driven by small businesses. Sabrina T. Howell’s seminal 2017 paper “Financing Innovation: Evidence from R&D Grants”, which evaluated SBIR awards from EERE as well as and other DOE offices, used a quasi-experimental regression discontinuity design (RDD) and funding application merit review data to show that federal R&D grants to private firms have statistically significant and economically large

effects on measures of innovative, financial and commercial success. Howell's follow-up 2019 paper "Analysis of the U.S. Department of Energy's Energy Efficiency & Renewable Energy and Fossil Energy SBIR Programs" further analyzed the impact of DOE SBIR funding on company revenue, jobs and wages for the same sample as her 2017 study. Other organizations and researchers (Lanahan, Joshi, Johnson 2021) have similarly produced recent studies of the impacts of federal funding on small businesses' economic outcomes, but to date none of these evaluations have studied EERE's small business investments across its overall portfolio.

EERE's new evaluation of small business investments will follow an RDD design adapted from the approach used in Howell's 2017 and 2019 studies and will test EERE's impact on small businesses across a number of key intended outcomes of its funding. Although EERE's SBIR and STTR awards were included in the target population used in Howell's studies, Howell evaluated DOE's SBIR and STTR grants as a whole (including other DOE offices and not just EERE) and did not include analysis of EERE's impact in particular. EERE's impact evaluation of small business investments will be the first evaluation to focus analysis on EERE's small business awards; will be the first evaluation of EERE's impacts across its portfolio through financial assistance awards and prizes; will be the first evaluation of the impact of its small business awards across a comprehensive set of known outcome indicators; and will be the first rigorous evaluation of EERE's impacts on product commercialization, a key goal of its funding.

This new evaluation draws on several other influences in addition to Howell. Leading-edge patent tracing methodologies pioneered by the Pacific Northwest National Laboratory (PNNL 2019) and 1790 Analytics LLC (1790 2022) will be used to validate and relate patenting data that will be used to quantify the patenting outcomes of award recipients and the impacts of EERE's funding on these outcomes. Evaluations conducted by private researchers (Lanahan, Joshi and Johnson 2021) and EERE itself have employed other quasi-experimental methods applicable and relevant to evaluating EERE small business awards and have tested hypotheses surrounding government funding for technology development – including investigating whether this funding creates jobs or spurs follow-on funding – but these hypotheses have not been validated for EERE in particular or for EERE as a whole. EERE's new evaluation seeks to synthesize and marry these methodologies, test many of these hypotheses as they pertain specifically to EERE's award recipients and collect findings that may be used to systematize future evaluations or potentially measure performance of its funding to small businesses.

EERE draws on a number of partners in executing this new evaluation, including DOE's Office of Science (SC) – which owns and administers data relating to DOE's SBIR funding – the DOE's Office of Scientific and Technical Information (OSTI) – which collects and validates patenting outcomes of DOE awards – DOE's Office of Technology Commercialization (OTC) – which drives programming that supports commercialization of developed technologies and has provided input into the objectives of this evaluation – the Pacific Northwest National Laboratory (PNNL) – which has piloted a method of ongoing validation of patenting and citation outcomes associated with EERE's funding and may support information collection – the National Renewable Energy Laboratory (NREL) – which administers data relating to EERE's prize awards – the U.S. Census Bureau's Center for Economic Studies – which EERE will partner with to obtain company revenue and job growth data – data vendor firms that specialize in aggregating business data surrounding businesses, and private researchers working in academia across the U.S. who will strengthen this evaluation by participating in independent review of this evaluation's plan and results. A professional, independent evaluation contractor will be solicited to lead this evaluation through a U.S. federal General Service Administration Master Award Schedule sub-schedule for Program Evaluation Services, a new federal resource launched in 2023 intended to support agencies in building evidence that has never before been used by EERE to source evaluation services.

While DOE itself anticipates using the findings from this study to inform future investment decisions, other audiences include Congress, other governments investing in technology innovation, advocacy groups working in the innovation and energy spaces, small business innovators, researchers and

the public. Because SBIR grants are offered by other federal agencies, including the U.S. Department of Transportation, National Science Foundation and Department of Defense, the findings from this evaluation are of interest to many stakeholders beyond the energy sector. Other nations and states that fund technology innovation may also benefit from adopting elements of this study's methodology in evaluating their own R&D portfolios.

While there is no generally accepted definition for a "start-up company", common definitions include new ventures founded to develop a unique product or service, and companies that rely on bootstrapping, seed funding or series A, B C and D funding rounds. This new study will focus chiefly on evaluating EERE funding for technology R&D projects led by small businesses and startup companies, using available secondary data to identify startups based on their size, age and/or funding structure. EERE may conduct other evaluations in the future to assess EERE's impact on medium-sized and large companies and will seek to draw from the results of this evaluation of small businesses and startups to inform future evaluations.

## Scope

In addition to characterizing the projects, funding recipients and technologies supported by EERE during the years covered by this evaluation, this study will seek to answer the overarching question "to what extent and due to what factors do small businesses that receive funding from EERE commercialize products, achieve greater revenue streams, grow to become larger companies, attract greater follow-on investment, have higher survival rates or exhibit other indicators of economic success compared to similarly qualified companies that applied for but did not receive EERE funding"? An independent evaluator will be solicited to employ a quasi-experimental econometric design to answer this question.

The evaluator will quantify the relationships between EERE funding and an array of outcome metrics theorized to be impacted by this funding based on past evaluations of similar programming while controlling for rival factors that may partially explain these outcomes. The target population will include more than 1,600 regular financial assistance awards, more than 3,000 SBIR and STTR awards and several hundred prize awards awarded between 2006 and 2024, as well as a counterfactual group of more than 5,000 financial assistance, SBIR and prize applicants that were found meritorious but not ultimately funded during the same period.

The key results of this evaluation will include:

- Characterization of the projects, award recipient businesses and technologies EERE funded 2006 through 2024, including stratifications by award year, technology area, technology readiness level at time of project start;
- Quantification of outcomes of interest achieved by funded recipients, including number of companies that achieved a first sale; increase in company employment; number of equity deals received; number of patents executed; number of companies for which a merger, acquisition or IPO was achieved; number of companies that still exist; stratifications of these outcomes by award year, technology area, technology readiness level at time of project start; and more;
- Statistical and causal analysis of the relationship between the dollar amount and duration of EERE's funding and some intended outcomes, including whether the company achieved a first sale, merger, acquisition or IPO; how quickly a company achieved a first sale, merger, acquisition or IPO; increase in company employment; number of equity deals received; forward-citation weighted patents achieved; whether the company still exists; and more;
- Analysis of the journeys companies take over time as they develop technologies, obtain follow-on investment and grow; and

- A proposed approach to longitudinally evaluating EERE’s investments in small businesses in the future, including internal reporting to DOE (not to be made public) identifying a subset of especially successful award recipients worth evaluating in greater depth in the future to evaluate the energy benefits, economic benefits and other benefits yielded by their technologies.

Whereas prior impact evaluations of technology innovation funding conducted by EERE and elsewhere have focused on measuring some but not all of the metrics suggested above and have focused on populations other than EERE’s overall portfolio of award recipients – for example, a 2022 EERE report studied the extent to which EERE funding of solar technology projects impacted follow-on funding but did so for only one of EERE’s ten technology focus areas; and a 2021 paper by Lanahan, Joshi and Johnson studied the extent to which SBIR grants result in increases in small business employment but did so for SBIR grants offered by several agencies, including but not limited to DOE – EERE’s evaluation of small business investments will test the hypotheses that these many outcomes are causally related to funding in the context of EERE and its overall portfolio, across funding mechanisms and technology areas.

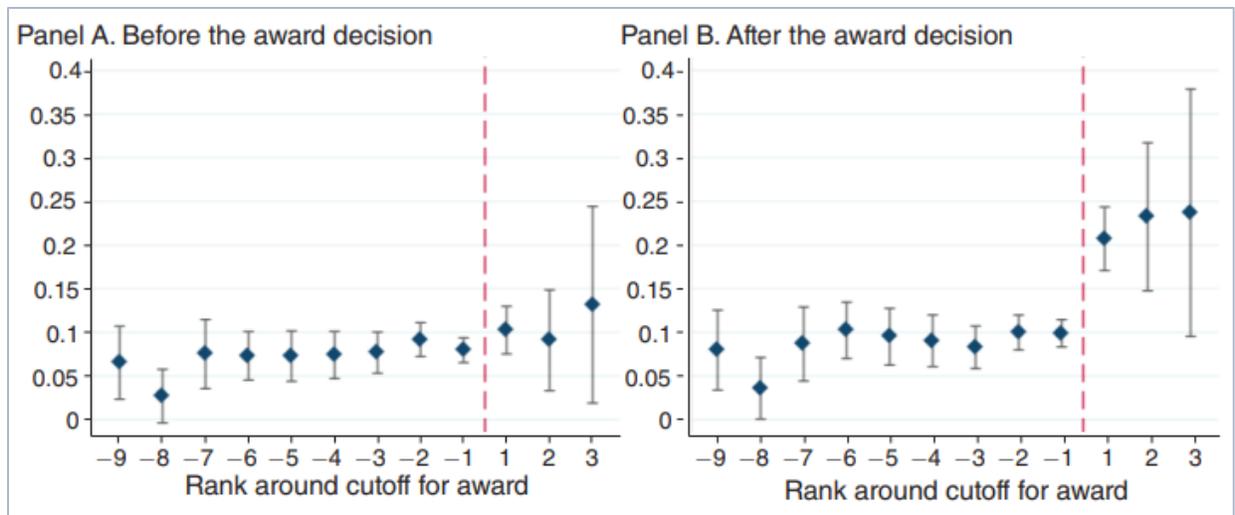
Because an array of data sources must be drawn from to quantify the outcomes achieved by EERE’s award recipients, data collection will be a significant element of the scope of this evaluation. The evaluator will draw on numerous sources (further detailed in the Data Sources and Processing section below) from within DOE, from publicly accessible online resources, from third-party data vendors, and through primary survey data collection from award recipients and a counterfactual group of meritorious applicants that did not receive funding.

Final reporting from this evaluation will include characterization of all projects, companies and technologies and measurements of economic and scientific outcomes for the sample. Statistical outputs and inference and causal analysis of outcomes will be reported for a smaller sample the evaluator will use in its quasi-experimental analysis. (Some awards may not be evaluable as part of the quasi-experimental analysis of impacts due to data gaps such as missing merit scores.) The initial plan for this evaluation and its final results will be peer-reviewed by a panel of independent, non-government experts in the fields of energy technology R&D programing and small business growth.

## **Methodology**

### **Choice of Quasi-Experimental Design**

To isolate the scale of the relationship between EERE funding and company outcomes and analyze the causal influence of EERE funding, EERE anticipates using a sharp regression discontinuity design (RDD) similar to the one used in Howell’s past evaluations of SBIR and STTR funding (Figure 4) – proposed by Jaffe in 2002 and similar to the RDD design used in EERE’s 2022 evaluation of its Solar Energy Technologies Office’s (SETO’s) financial assistance awards – to study EERE’s financial assistance, SBIR and STTR, and prize awards. A treatment group of award recipients will be compared to a counterfactual of applicants for EERE funding that were found meritorious for funding but were not ultimately funded immediately around the ‘cutoff’ threshold used in EERE’s review of submitted applications that represents the lowest acceptable merit score an application can achieve to be fundable. Applications will be selected for inclusion in the treatment and counterfactual groups in part based on the closeness of the scores they received during EERE’s review of their application so that applications deemed to have similar chances of success at the time of application are compared to mitigate bias.



**Figure 4:** Probability of Venture Capital Before and After DOE SBIR Grant By Rank, results from Howell’s study of DOE SBIR grants, Financing Innovation: Evidence from R&D Grants 2017. This figure shows the fraction of DOE SBIR applicants who received venture capital (VC) before and after their grant. Ninety-five percent confidence intervals shown. Panel A represents applicants found meritorious but not ultimately funded and Panel B represents awarded applicants. *Source:* Howell 2019.

Recognizing that the financial assistance and prize sample points used for this impact analysis may be limited for some funding mechanisms due to attrition during data collection and processing, the evaluator will consider other quasi-experimental designs such as differences-in-differences (DID) and Differences-in-Discontinuities (DiDC) as alternatives. Although the evaluator will attempt to use a counterfactual comprised of applicants for EERE funding opportunities that were found meritorious but not awarded, they may ultimately consider alternative counterfactuals, such as that used to evaluate impacts on SBIR grantees in Lanahan, Joshi and Johnson 2021, where appropriate. Dependent on data availability, findings during preliminary data analysis and reporting priorities, the evaluator may leverage data describing company sizes, ages, sectors, technology readiness levels (TRLs) and other characteristics to strengthen the comparison of the treatment and counterfactual groups by narrowing their analysis to firms with similar characteristics.

### Data Sources and Processing

The evaluator will draw on several data sources internal to DOE to obtain the data describing applicant and project company characteristics, contract details, contact information, merit scores and data describing the sectors, funded activities and goals for each application and project:

- EERE financial assistance award application and project data obtained from EERE’s internal data systems
- SBIR and STTR award application and project data obtained from U.S. DOE’s Office of Science’s internal data systems
- EERE-funded prize application and project data obtained from the National Renewable Energy Laboratory (NREL)’s internal data systems

EERE will also draw from third-party data sources to obtain data to measure outcomes achieved by EERE funding applicants and award recipients:

- Data measuring the extent to which technologies and research funded by EERE have been represented in patent applications and executed patents obtained from U.S. Patent and

Trademark Office (USPTO), the World Intellectual Property Organization (WIPO) and from U.S. DOE's Office of Scientific and Technical Information (OSTI)

- Data measuring the extent to which technologies and research funded by EERE have been cited in publications and patents, obtained from Web of Science and OSTI
- Data measuring the extent to which applicants' and award recipients' companies have grown in terms of revenue and employment, obtained from the U.S. Census Bureau
- Data measuring follow-on funding, exits (e.g. mergers, acquisitions) and company longevity and data validating other company characteristics obtained from USASpending.gov, Pitchbook and Dunn & Bradstreet

To collect data to measure the extent to which small businesses have achieved commercialization and exits (e.g. mergers, acquisitions) and other outputs and outcomes, EERE will conduct primary information collection from the small businesses in the treatment and counterfactual groups targeted by this evaluation. This information collected will also be used to validate applicants' company and project characteristics, output and outcomes as measured through other data sources.

A significant data structuring effort will be required to properly tie together the projects, companies, technologies, and the outcomes associated with them. To address this need EERE will employ leading-edge patent tracing methodologies pioneered by the Pacific Northwest National Laboratory (PNNL 2019) and 1790 Analytics LLC (2022) to validate and relate patenting data. Data structuring is further complicated because some companies may have been merged with or acquired by other firms, some companies and technologies may have changed names, and some technologies may have been abandoned in favor of similar successor technologies developed by the same company.

## Results

Due to the influence of EERE's investments there is broad interest in the results of this evaluation. Besides EERE's technology offices and EERE and DOE leadership, audiences include Congress, other federal agencies, other governments, advocacy groups working in the start-up growth and innovation spaces, researchers and the public at large. Additionally, because SBIR grants are offered by other federal agencies including the U.S. Department of Transportation (DOT), National Science Foundation (NSF) and Department of Defense (DOD), the findings are of interest to many stakeholders beyond the energy sector. Other nations and states that invest substantially in energy technology R&D may benefit from leveraging elements of the methodology used in this evaluation in evaluation of their own portfolios.

Findings and recommendations developed through this evaluation, including those that speak to the comparative impact of various funding mechanisms on and recipient geographic location on the outcomes of interest and those that speak to the impact of SBIR grants by phase, may be leveraged by EERE leadership to inform future investment strategy. Perhaps more importantly, this independent reporting that publicly characterizes and quantifies the impact of EERE's efforts over nearly two decades may help to prove the success of its programming and justify future federal funding for energy research and development.

Predictors	Bandwidth								
	15			20			30		
	$\beta$	SE	$p$	$\beta$	SE	$p$	$\beta$	SE	$p$
Funding ( $x_f$ )	0.07	0.49	0.88	-0.19	0.42	0.65	-0.26	0.38	0.50
Hub ( $x_H$ )	-0.64	0.33	0.06	-0.55	0.27	0.04	-0.24	0.23	0.29
Ranking ( $x_R$ )	-0.01	0.03	0.89	0.01	0.02	0.74	0.01	0.01	0.56
Funding: Hub Interaction	<b>1.52</b>	<b>0.54</b>	<b>0.004</b>	<b>1.65</b>	<b>0.44</b>	<b>&lt;0.001</b>	<b>1.21</b>	<b>0.40</b>	<b>0.002</b>
Funding: Ranking Interaction	0.01	0.06	0.91	0.02	0.04	0.57	0.02	0.03	0.51
Award Year ( $x_A$ )	<b>-0.20</b>	<b>0.06</b>	<b>0.001</b>	<b>-0.23</b>	<b>0.05</b>	<b>&lt;0.001</b>	<b>-0.24</b>	<b>0.05</b>	<b>&lt;0.001</b>
Age ( $x_A$ )	-0.03	0.03	0.24	-0.03	0.02	0.16	-0.03	0.02	0.12
Log of Previous Equity ( $x_E$ )	<b>0.89</b>	<b>0.20</b>	<b>&lt;0.001</b>	<b>0.88</b>	<b>0.17</b>	<b>&lt;0.001</b>	<b>0.88</b>	<b>0.15</b>	<b>&lt;0.001</b>
Hardware / Software ( $x_T$ )	0.61	0.38	0.11	0.80	0.33	0.02	<b>1.12</b>	<b>0.29</b>	<b>&lt;0.001</b>

**Figure 5:** Example regression analysis output from EERE’s 2022 evaluation of the impacts of its funding on follow-on equity deals, similar to the output that will be produced from EERE’s impact evaluation of investments in small businesses and startups. This output describes Beta weights ( $\beta$ ), standard errors, (SE), and probability values (p-values) associated with predictors in the regression discontinuity analysis predicting equity deals resulting from EERE funding for various choices of bandwidth (15, 20, and 30). A normalized ranking variable was used for all analyses. Bolded results are significant at the  $p < 0.01$  level. Funding refers to scale of EERE funding. Hub refers to whether the project was based in a geographic area known to be a solar technology innovation hub. Ranking refers to the applicant’s rank during merit review. Age refers to the applicant’s company’s age. Previous Equity refers to the amount of equity funding the applicant received previous to the sampled application. *Source:* EERE 2022.

The evaluator will include in their reporting a proposal for a longitudinal evaluation methodology that may inform a subsequent study that builds upon the methodology of the current one and additionally evaluates the impact of exceptionally scored applications and especially highly meritorious or successful technologies to assess energy, economic and other benefits to end-users. Such a future evaluation may employ a methodology similar to the one used in a recently published 2025 New York State Energy Research and Development Authority (NYSERDA) Product Development Impact Evaluation, which piloted an approach to identifying a sample of disruptive technologies to use as subjects for focused impact evaluation that could be leveraged in EERE’s context. Results from this evaluation may also support EERE in designing and implementing recurring data collection and performance measurement from small businesses.

Preliminary results from this study are expected to be developed in 2026 and final results are expected to be published for public consumption in 2027. Results from this evaluation will include only summary figures and statistics in order to anonymize reporting and will not reveal any information or results describing individual companies.

## Conclusions

EERE's upcoming impact evaluation of its investments in small businesses will evaluate over \$7.1 billion in public funding awarded to small businesses for R&D over a recent period of nearly two decades and aims to prove the value of U.S. federal investments in energy research and development while generating findings of value to DOE itself, other federal agencies, other governments, researchers, advocacy organizations, small businesses and the public. This study will leverage methods and re-test hypotheses from similar, past evaluations of public funding for innovation – such as whether these investments lead to new jobs or increased follow-on funding – to assess the impacts of EERE's funding on small businesses comprehensively, and will produce a longitudinal methodology that can be used to evaluate EERE's impacts on small businesses over time. Findings will support DOE, other governments and non-government organizations in optimizing its strategies for supporting small business innovators, a critical driver of energy innovation generally. Results from this evaluation are anticipated to be reported publicly in 2027.

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