

2022 Energy-Related Environmental Research (ERER)

Citation Analysis

Final Report

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NYSERDA Record of Revision

Document Title
2022 Energy-Related Environmental Research (ERER) Citation Analysis June 2023

Revision Date	Description of Changes	Revision on Page(s)
June 2023	Original Issue	Original Issue

NOTICE

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1 INTRODUCTION

1.1 Program Description

Since 2006, NYSERDA has worked with contractors to provide an analysis of the research funded by NYSERDA's Energy-Related Environmental Research program (ERER; formerly Environmental Monitoring, Evaluation, and Protection program (EMEP)). Since the program inception in 1998, NYSERDA contracted with Research Into Action, Inc. (RIA) and Clarivate Analytics (Clarivate) to create and update an Institutional Citation Report (ICR) for ERER. RIA completed four updates of the ICR since 2006, and during each update, analyzed all the ERER-funded research since the deployment of this program. In this updated 2023 report, NYSERDA contracted directly with Clarivate to collect the data and produce an updated analysis of the results of ERER-funded research. As the format of the current report is consistent with the 2009, 2013 and 2018 reports, the findings from these reports are compared to the 2022 results where applicable; 2006 results are not consistently included in these comparisons.

Using its *Web of Science*® bibliographic database, Clarivate algorithmically matches the records of authors with articles in the *Web of Science*. Clarivate does not guarantee a 100% match rate. For this ICR update, citation counts were created for matched projects from program inception in 1998 up to and including 2022. The papers fell into five key topic areas: air quality, alternative energy, climate change, cross-cutting, and ecosystems.

Obtaining an ICR allows the ERER program team to document if and how the research findings supported by the program are being communicated. ERER staff would like to confirm that program-sponsored projects are being cited in academic journals as a way to: 1) document the performance of research through citation metrics; 2) evaluate the outcomes of funding decisions; and 3) identify opportunities for future collaboration or information transfer. In response to this request, Clarivate provided customized spreadsheets created for each of the five key topic areas on behalf of NYSERDA. These spreadsheets document the results of the *Web of Science* analysis.

1.2 Summary of Evaluation Objectives and Methods

In February 2023, NYSERDA provided a list of 669 EREER papers to Clarivate. Of these papers, 450 were categorized into one of five topical areas: air quality, alternative energy, climate change, and cross-cutting and ecosystems. The topics areas funded by NYSERDA are determined by a stakeholder driven process to ensure that topics relevant to policymakers continue to be the focus of the works published by EREER-funded researchers.

Ultimately, Clarivate was able to match 450 of the 669 (67%) records in their *Web of Science* database (see Table 1). This rate was similar to the 61% match rate achieved in 2009 and 2013, and the 62% match rate achieved in 2018 (Table 1).

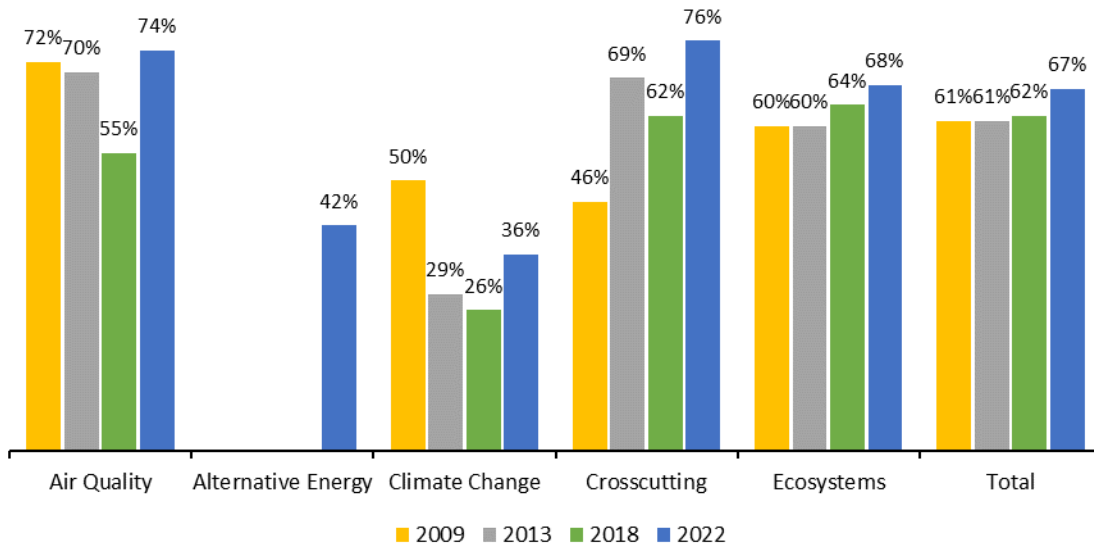
Table 1. Summary of Citation Analysis

Update Year	Years of EREER Research Covered	Matched Papers in Clarivate Database	Percent of Matched Papers in Database
2006	1998-2006	98	71%
2009	1998-2009	154	61%
2013	1998-2013	247	61%
2018	1998-2018	364	62%
2022	1998-2022	450	67%

In considering the remaining 219 non-matched articles, NYSERDA staff posited that many of these papers are likely to be either not published yet (under review), appear in a non-peer-reviewed publication (graduate theses, conference proceedings, websites), or were published in a journal outside of Clarivate’s scope. The EREER team does produce some non-published technical papers and data that are released on the NYSERDA website or partner websites (such as USGS) that are not captured by the *Web of Science* database.

As noted, Clarivate was able to match two-thirds of the articles published by the EREER program team. Figure 1 shows the proportion matched by category over the past four analyses.

Figure 1. Comparison of ERES Records to Clarivate/Thomson Results Over Time



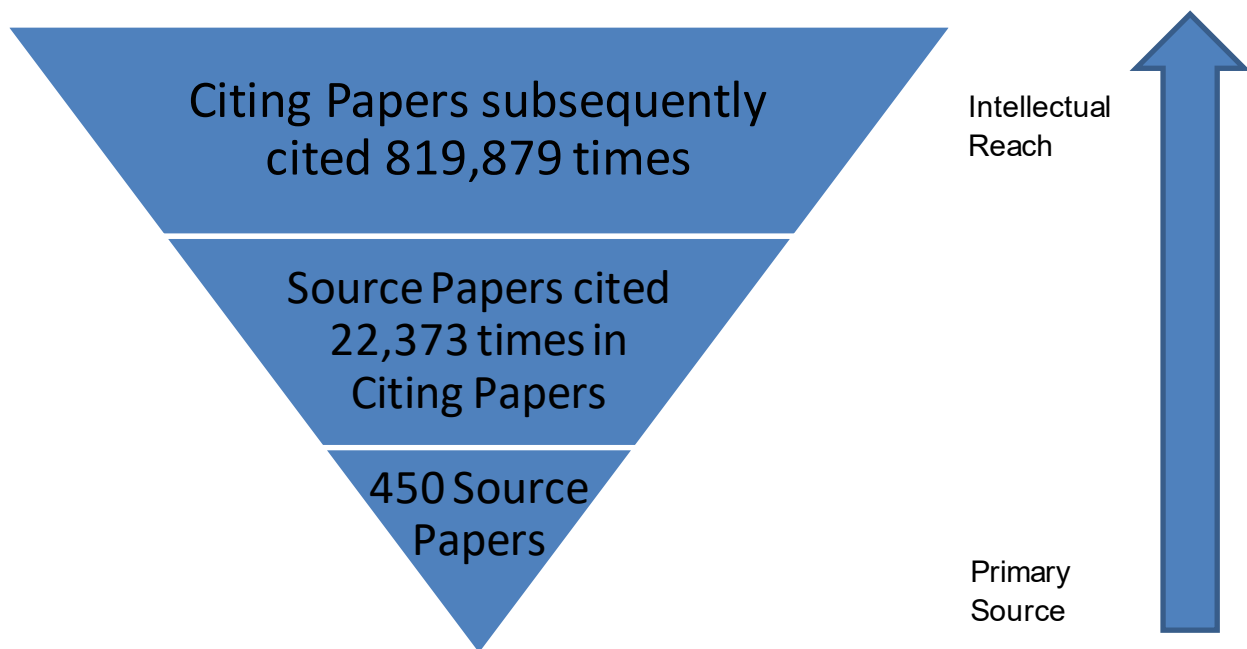
* Alternative energy was a new key topic area for the 2022 analysis

To further increase the distribution and availability of research projects funded by ERES, program staff encourage the researchers that receive ERES funding to publish their articles in open access journals. Open access journals provide access to published scientific work, typically without subscription requirements. In some cases, ERES funds have helped to increase the public availability of articles published in subscription-based journals. Researchers are also encouraged to present their results at conferences to ensure that research results are achieving the widest audience possible.

2 RESULTS

The EREER-funded papers continue to be cited and referenced in many journal articles. The 450 EREER-funded and categorized papers matched in the *Web of Science* database search are called source papers. These source papers, attributed to 1,172 authors, were cited 22,373 times between 1998 and 2022 in citing papers. These citing papers were in turn cited 819,879 times (Figure 2), representing a ratio of 1:50:1,822 from source papers, citing papers and citations of citing papers. These 2022 numbers show the intellectual reach increased more than ten-fold since 2013 when only 76,384 citations resulted from 5,833 citing papers. As of 2022, 97% of EREER-funded papers have been cited at least once and this value is consistent with the 2018 percentage of 93% and the 2013 percentage of 94%.

Figure 2. Intellectual Reach of EREER Funding as Matched to *Web of Science*® in 2022.



The intellectual reach of EREER-funded papers continues to expand. An ICR results in several other metrics that can be used to evaluate the reach and success of EREER program research publications. These metrics include a C-index and an H-Index, provided by research category and overall.

A C-Index communicates the actual citations relative to expected citations. A value of 1.0 would indicate that the EREER-funded papers were cited at the same rate as other papers in the *Web of Science* database and a score over one indicates the papers are cited more than other papers in the database. **ERER-funded papers appear to be cited at a higher rate than expected, as demonstrated by the mean C-Index value of 1.3.** This value is slightly higher than the 2018 C-Index score of 1.2 and is consistent with the 2013 C-index score (also 1.3). As shown in Table 2,

all but one of the key topic areas, cross-cutting being the exception, have C-index scores higher than 1.0. In the 2018 evaluation, two topic areas, climate change and cross-cutting both received C-Index scores below 1.0 (of 0.7 and 0.9 respectively), suggesting an increased citation rate for ERER-funded papers on climate change topics over the past few years, but that those papers classified as cross-cutting continue to see mixed citation results. This may be due to the fact that cross-cutting contains a mix of topics, some of which are likely of less interest thus bringing down the overall C-Index score.

Table 2. Summary Analytics

NYSERDA Topic	Number of Papers	Average Cites^a	Median Citations^b	H-Index^c	C-Index^d	Percentage Cited^e
2022 Results by Key Topic Area						
Air Quality	208	27	57.6	54	1.5	97.1%
Climate Change	8	15	30.6	7	1.7	100%
Cross-cutting	63	6	24.2	16	0.9	93.7%
Ecosystem	165	28	51.8	48	1.3	97.6%
Alternative Energy	5	7	15.2	4	1.1	100%
Overall Results by Evaluation Year						
2022 Overall Results	450	24	49.8	69	1.3	96.9%
2018 Overall Results	364	33.6	15	52	1.2	93%
2013 Overall Results	245	23.8	12	39	1.3	94%
2009 Overall Results	154	18.0	12.5	29	1.7	92%
2006 Overall Results	98	6.7	3	N/A	1.3	N/A

^a Total number of citations divided by number of source papers.

^b Half of the source papers received fewer citations; half received more.

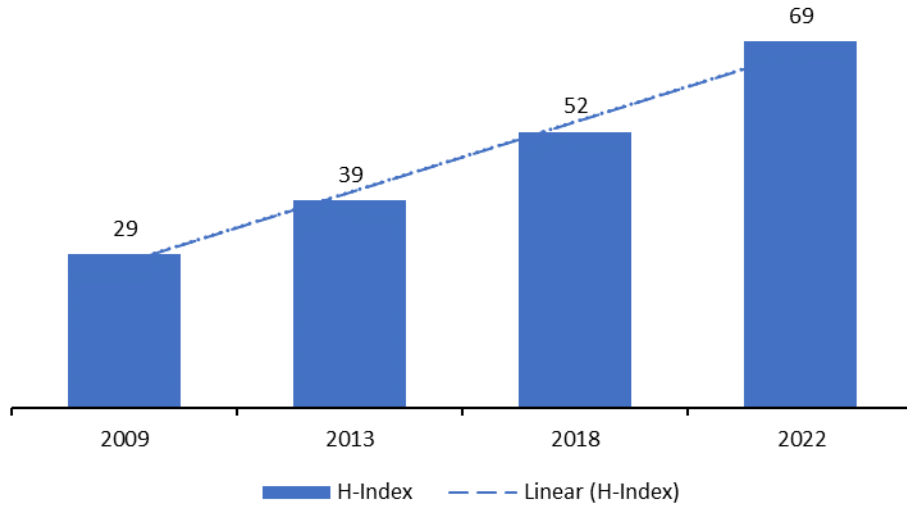
^c The number of papers (N) in a given dataset having N or more citations.

^d The sum of all actual citations divided by the sum of expected citations.

^e The portion of source papers cited at least one time.

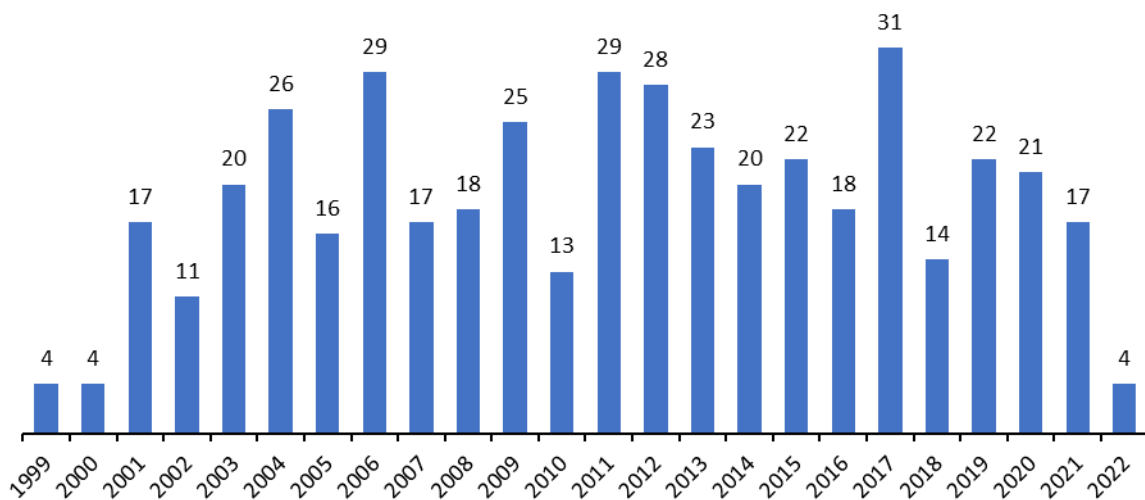
The second measure of intellectual reach is an H-Index. An H-Index is a statistic that reflects the number of papers cited at least that many times. In 2022, the 450 matched ERER source papers earned an H-Index of 69 – meaning that 69 of the source papers were cited at least 69 times each. **The increasing H-index from 2009 to 2022 is another sign that the program is continuing to expand its reach** (Figure 3).

Figure 3: Overall H-Index Over Time



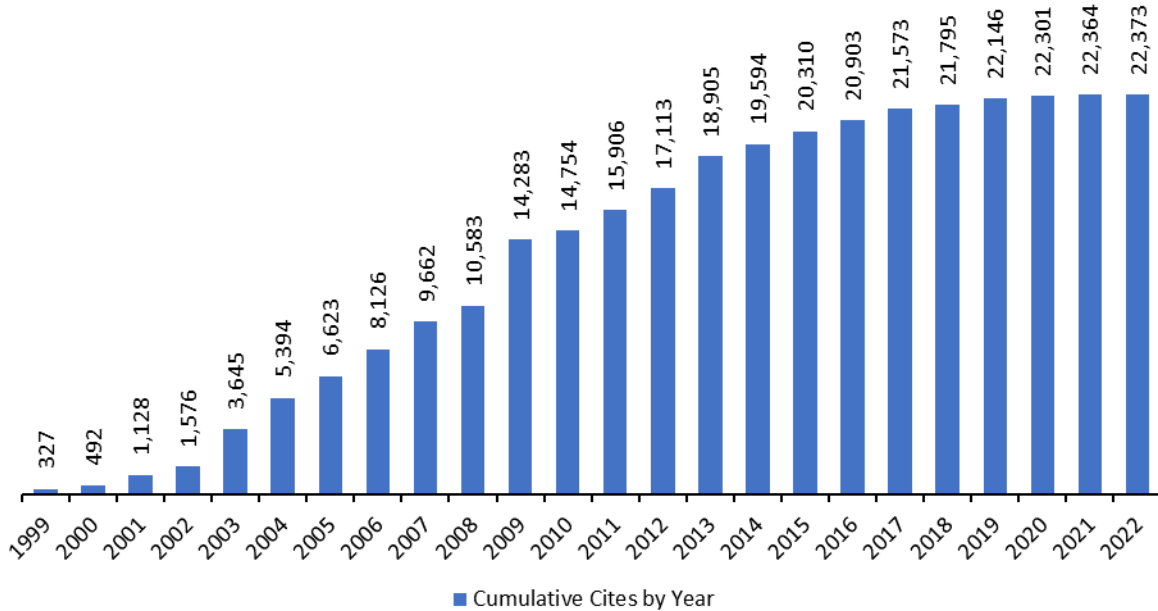
The number of ERES articles cited by publication year varies. The ICR also shows the number of articles published each year. Figure 4 shows that ERES articles were cited most frequently in 2017, with 31 cites, and then in 2006 and 2011, with 29 articles cited in both years. The relatively small number of citations in recent years (2021 and 2022 in particular) is a reflection of the time required for published work to be cited elsewhere.

Figure 4. Number of ERES Articles Cited by Publication Year



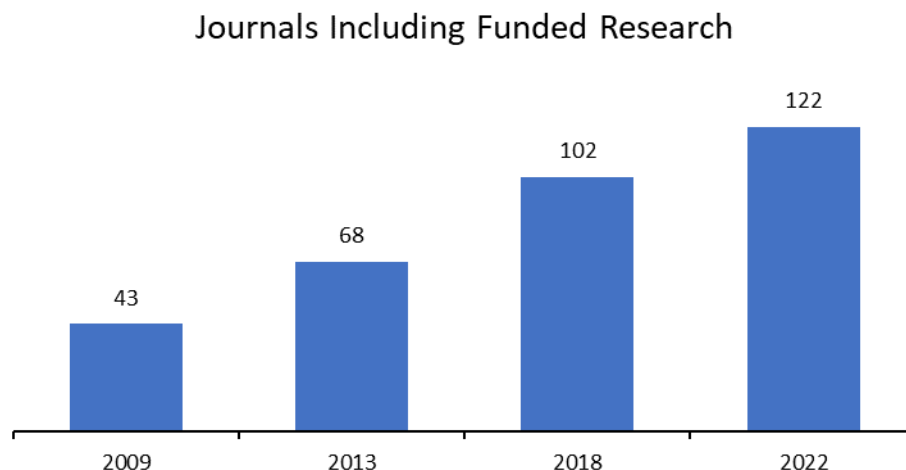
The cumulative number of citations increases each year following a similar trend seen in the 2009, 2013, and 2018 reports. From 1998-2022, ERES articles were cited 22,373 times in the *Web of Science* database with the largest increases occurring from 2008 to 2009. While there are fewer citations in recent years, this should be expected – the more recent the publication date, the less time there has been for citations to occur as papers citing more recent ERES articles will take time to be published (Figure 5).

Figure 5. Cumulative Number of Citations by Publication Year



ERES-funded research is reaching more journals than ever. Since the 2009 analysis, the number of journals that include funded papers has increased 284%, from 43 journals in 2009 to 122 in 2022 (Figure 6).

Figure 6. Number of Journals Including Funded Research



More journals are representing the bulk of published papers further suggesting greater diffusion of EREER-funded papers in the literature. In 2009, nine journals represented two-thirds of all papers, in 2013 this figure increased to 15 journals, in 2018 it increased to 21 journals, and in 2022 it rose to 22 journals representing two-thirds of papers funded by EREER research. Table 3 shows the 16 journals most used by EREER-funded research.

Table 3. Journals Publishing EREER-Funded Project Papers by Frequency 1998-2022

Journal	Papers	Cumulative Papers	Cumulative Percent
ATMOSPHERIC ENVIRONMENT	67	67	15%
ENVIRONMENTAL SCIENCE & TECHNOLOGY	33	100	22%
ECOTOXICOLOGY	29	129	29%
JOURNAL OF THE AIR & WASTE MANAGEMENT ASSOCIATION	20	149	33%
JOURNAL OF GEOPHYSICAL RESEARCH-ATMOSPHERES	17	166	37%
ENERGY & FUELS	13	179	40%
ENVIRONMENTAL POLLUTION	13	192	43%
HYDROLOGICAL PROCESSES	12	204	45%
AEROSOL SCIENCE AND TECHNOLOGY	10	214	48%
SCIENCE OF THE TOTAL ENVIRONMENT	10	224	50%
AEROSOL AND AIR QUALITY RESEARCH	9	233	52%
ATMOSPHERIC CHEMISTRY AND PHYSICS	9	242	54%
ECOLOGICAL APPLICATIONS	8	250	56%

ENVIRONMENTAL FLUID MECHANICS	7	257	57%
JOURNAL OF GEOPHYSICAL RESEARCH-BIOGEOSCIENCES	7	264	59%
BIOGEOCHEMISTRY	6	270	60%
All other Journals* (n=107)	-	180	40%

* Journals with 5 or less EREER-funded project citations were included in this category.

A large portion of EREER-funded papers continue to appear in the *Web of Science's* environmental sciences topic field. EREER research focuses on environmental issues related to air quality and ecosystem impacts, and this is evidenced in the papers published in environmental science and ecological fields. The field associated with the largest number of papers is Environmental Sciences followed by Meteorology and Atmospheric Sciences (Table 4).

Table 4. Articles by Clarivate Field

Field of Research	Papers	Rank
Environmental Sciences	151	1
Meteorology and Atmospheric Sciences	117	2
Engineering, Environmental	36	3
Engineering, Chemical	27	4
Engineering, Mechanical	15	5
Energy & Fuels	15	5
Geosciences, multidisciplinary	11	6
Public, environmental, and occupational health	11	6
Toxicology	10	7
Water Resources	9	8
Mechanics	7	9
Other categories (n=22)	44	-

3 CONCLUSIONS

ERER funding supports research that is being widely disseminated in the academic literature and beyond. This analysis captures only part of the academic reach of ERER, and these results indicate that the research is being utilized by academics at a greater rate than other literature in the field. The trend over time shows that the intellectual reach continues to expand, reaching more journals and scientists than ever before, and that an increasing number of ERER articles are being cited more often.

Conducting a similar citation analysis with another vendor such as Scopus would provide additional insights into the intellectual reach of the ERER-funded papers. However, it is unclear if the cost of pursuing this would be worth the extra effort. It is possible that other platforms, like the Elsevier abstract and citation database (used by Scopus) or Google Scholar, might include ERER work published in journals not included in Clarivate's Web of Science database and therefore might capture additional reach of the ERER research.

Recommendation: Consider the inclusion of an analysis of other publication databases to ensure that the full reach of NYSERDA-funded research is being captured by the citation analysis. While the Web of Science database contains data from peer reviewed journals, conferences and some books it does not include sources like website publications (i.e., on NYSERDA or USGS websites) or non-published technical papers. Additionally, the databases that offer access to the widest range of publications may change over time.

- **Response to recommendation:** Pending. Several other database options, including Scopus, Google Scholar and PubMed could help more fully capture the reach of the ERER publications, either in place of or in addition to Clarivate's Web of Science database. This can be decided when scoping for future citation analyses.

Recommendation: Continue to regularly engage with program staff to ensure metrics included in the citation analysis continue to meet program staff needs.

- **Response to recommendation:** Accepted. Program staff will be regularly consulted to ensure that the metrics and information provided by the citation analysis are in line with information useful to the team.