Bibliometrics Analysis for TSE Grant Publications

The National Center for Environmental Research (NCER) has awarded 91 Technology for a Sustainable Environment (TSE) grants since 1995. Thirty-six (40%) of the grantees have submitted their final reports. For these 36 grants, there were a total of 285 publications in the NCER database, and 124 of those publications have been cited 2,752 times.[1,2]

Summary. The publication rate for the TSE grants appears to be increasing with time, and the average citation rates for the TSE publications compare very favorably with those reported by *ISI Essential Science Indicators* (ESI) for the fields of engineering, chemistry, and materials science. The citation rates also appear to be increasing with time. Analysis of a representative sample of TSE publications projected a 2004 citation rate of 1,046 citations/year, which is considerably greater than the 306 citations per year for all years combined. This analysis also revealed at least one recent "hot paper" among the TSE publications.

There is a significant number of highly cited papers among the TSE publications. A review of the citations indicates that 34 (11.9%), 21 (7.4%), and 5 (1.8%) of the 285 publications qualified as highly cited when using the criteria for ESI highly cited publications (in the top 1%) in the fields of engineering, materials science, and chemistry, respectively. Six (2.1%) of the highly cited TSE publications fall within the top 0.10% and 4 (1.4%) within the top 0.01% of engineering publications tracked by ESI.

Nearly one-third of the TSE publications are published in very-high impact journals, i.e., top 10% of the 5,875 journals monitored by *ISI Journal Citation Report* (JCR), as indicated by the impact factor calculated by JCR. ISI reports that impact factor is the primary means employed for determining the prestige of journals. One-third of the TSE publications were published in journals with an immediacy index that ranked in the top 10% of the 5,867 journals reported by JCR, indicating that a significant number of TSE papers are published in journals that are cited quickly after publication.

Publication and Citation Rates. The average citation rates for the TSE grants are **above the average citation rates** for the fields of engineering and materials science, and **comparable** to those for the field of chemistry reported by ESI. The average citation rates in ESI are calculated for each year of the 10 year period (1993-2003), based on a cumulation of citations from the year of publication to the current year. Averages are calculated by adding up the number of citations and dividing by the number of papers in a particular field (ESI tracks 22 fields such as engineering, chemistry, and materials science). ESI also reports an average for the full 10-year period in "All Years". The average citation rate for TSE publications for all years (1995-2003) is 26.4 citations/publication, which is greater than the all years (1993-2003) average citation rates reported by ESI for the fields of engineering, chemistry, and materials science. Given the high

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[1] The 91 TSE grants (including completed and uncompleted) have yielded a total of 372 publications, of which 156 have been cited 2,984 times in the literature.

[2] This number of citations is probably lower than the actual number because 60% of the final reports have not yet been received and their publications (and associated citations) are not included in the database.

average citation rate for 1995 (because there are only two 1995 TSE publications and one of them has been cited 352 times), the **7.76** average citation rate for TSE publications published from 1997-2003 may be a more realistic number to compare to the all years average citation rates reported by ESI. This 7.76 average citation rate compares favorably with the 2.88, 7.57, and 3.85 all years average citation rates for engineering, chemistry, and materials science, respectively. These data are presented in Table 1.

Table 1. Average Citation Rates

Year	Average Citation Rates for TSE Publications	Average Citation Rates for Engineering Publications in ESI[a]	Average Citation Rates for Chemistry Publications in ESI[a]	Average Citation Rates for Materials Science Publications in ESI[a]
1995	176.00[b]	4.53	11.62	6.35
1996	20.00	4.15	10.70	5.86
1997	13.69	3.98	9.75	5.12
1998	8.77	3.29	8.75	4.59
1999	10.89	2.76	7.36	3.86
2000	3.88	2.12	5.83	3.10
2001	3.32	1.45	3.81	2.04
2002	1.41	0.63	2.01	0.93
2003	0.162	0.11	0.35	0.15
All Years (1993-2003)	26.46[c]	2.88	7.57	3.85
1996-2003	7.76[d]	2.31[e]	6.07[e]	3.21[e]

[a] Average citation rates for papers published by field, 1993-2003, ESI.
[b] The average citation rate is higher than would be expected because of the small number of total publications (i.e., 2), and the unusually high number of citations (i.e., 352) for one of the two publications in 1995.
[c] All years for this average citation rate is 1995-2003. The average is calculated by adding the citation rates for 1995-2003 and dividing by 9 years.
[d] The average is calculated by adding the rates for the years 1996-2003 and dividing by 8 years.
[e] The average citation rates for 1996-2003 for the fields of engineering, chemistry, and materials science are calculated by adding the rates for the years 1996-2003 and dividing by 8 years. These rates are not reported in *ISI Essential Science Indicators* but were derived from the ESI average citation rates reported by year.

There is some evidence that the citation rates are increasing with time. The 1995 grants have the greatest number of citations 7 grants (with final reports) produced 41 publications, of which 27 were cited 1,053 times in the literature. The citation rate for the 1995 grant publications is higher than the other years because of two very highly cited articles (one cited 352 times and another cited 148 times), and six additional highly cited articles. The 1995 rate also is expected to be

higher because the publications have been in the literature for a longer period, which generally increases the number of citations. The total number of citations for the more recent grants should be somewhat lower compared to the 1995 grants, especially those completed in 2001 or more recently because grantees often publish results 1 to 2 years following the completion of a grant (most of the 1998 grants were completed in 2002 and results will continue to be published through 2004 and possibly into 2005.

In examining trends in publication rates, the rates have increased, from 41 total publications in 1995 from 7 grants (average of 5.9 publications/grant) to 123 publications from 12 grants (10.2 publications/grant) in 1997. Most of the 1999 grants have not been completed yet so only three of the grants have submitted final reports; using the data for these three grants yields a rate of 13.3 publications/grant.

Hot Papers. Examination of the March-April 2004 citations of 32 of the TSE publications revealed one **hot paper.** The selection of hot papers in *ISI Essential Science Indicators* is based on selecting the top cited papers in different fields, but the time frame for citing and cited papers is much shorter papers must be no more than 2 years old and cited within a current 2-month time period. Papers are assigned to 2-month periods and thresholds are set for each period and field to select 0.1% of papers. The hot paper identified among the TSE publications sample was published in May 2002, and it was cited **five times** in the 2-month period from March-April 2004. This **exceeds the four-citation threshold** for a hot paper in the field of engineering, and is slightly less than the six-citation threshold for materials science publications.

Highly Cited TSE Publications. Analysis of the TSE citations indicates that **34 (11.9%)** of the 285 publications qualified as highly cited when using the criteria for *ISI Essential Science Indicators* (ESI) highly cited publications in the field of engineering. This means that **11.9%** of the TSE publications are included in the top **1%** of highly cited engineering publications tracked by ESI. **Five (1.8%)** of the TSE publications are included in the top **1%** of highly cited chemistry publications and **21 (7.4%)** of the TSE publications are included in the top **1%** of highly cited materials science publications tracked by ESI.

Six (2.1%) of the highly cited TSE publications fall within the top **0.10%** of highly cited engineering publications tracked by ESI, and **4 (1.4%)** fall within the top **0.01%** of the highly cited engineering publications tracked by ESI. **Four (1.4%)** of the TSE publications fall within the top **0.10%** of chemistry publications tracked by ESI, and **5 (1.8%)** of the TSE publications fall within the top **0.10%** of materials science publications tracked by ESI. These results are summarized in Table 2.

Table 2. Summary of Highly Cited Publications Analysis

# of Highly Cited TSE Publications in Top 1% of Publications in ESI			**# of Highly Cited TSE Publications in Top 0.10% of Publications in ESI**			**# of Highly Cited TSE Publications in Top 0.01% of Publications in ESI**		
Engineering	Chemistry	Materials Science	Engineering	Chemistry	Materials Science	Engineering	Chemistry	Materials Science
34 (11.9%)	5 (1.8%)	21 (7.4%)	6 (2.1%)	4 (1.4%)	5 (1.8%)	4 (1.4%)	0	0

Self-Citation Impact. In an attempt to quantify the impact of self-citation on the total number of citations, all citations by the primary author of the cited article were eliminated from the count. Five hundred eighty-four of the 2,752 (21.2%) citations are self-citations by the primary author. This number may be slightly higher than average; ISI reports that self-citations often represent about 13% of the citations that a journal receives.

Publication in High-Impact Journals. *ISI Journal Citation Report* (JCR) was used to determine if the TSE grantees are publishing in prestigious journals that have a high impact. Two measures were used to support this analysis. The first was the impact factor, which can be used to provide a gross approximation of the prestige of journals. Impact factor is a measure of the frequency with which the average article in a journal has been cited in a particular year or period. The annual JCR impact factor is a ratio between citations and recent citable items published. The impact factor is useful in clarifying the significance of absolute citation frequencies. It eliminates some of the bias of such counts, which favor large journals over small ones, or frequently issued journals over less frequently issued ones, and of older journals over newer ones. The impact factor also excludes self-citations. Table 3 presents a ranking by impact factor of the journals in which two or more TSE articles were published, with the exception of the one article in *Nature*, which was included because Nature ranks very high among all JCR journals for both impact factor and immediacy index.

Table 3. Journals Ranked by Impact Factor

Journal Name	# of TSE Articles in Journal	Impact Factor	Relative Ranking Among 5,876 JCR Journals
Nature	1	30.432	5
Accounts of Chemical Research	2	15.901	31
Journal of the American Chemical Society	12	6.201	172
Chemistry A European Journal	2	4.238	323
Chemical Communications	12	4.038	351
Macromolecules	18	3.751	394
Organic Letters	6	3.715	404
Journal of Physical Chemistry B	3	3.611	426
Langmuir	2	3.248	515
Journal of Organic Chemistry	21	3.217	524
Environmental Science & Technology	2	3.123	549
Total	81		

Eighty-one (28.4%) of the 285 TSE publications were published in very high-impact journals as determined by their impact factor ranking in the top 10% of the 5,875 journals monitored by *ISI Journal Citation Report*.

The second measure used in the analysis was the immediacy index, which is the average number of times a journal s current articles are cited in the current year. This provides some indication of how quickly articles in a particular journal are cited (i.e., hot topics). Table 4 presents a ranking by immediacy index of the journals in which 2 or more TSE articles were published, with the exception of the one article in *Nature*, which was included because Nature ranks very high among all JCR journals for both impact factor and immediacy index.

Table 4. Journals Ranked by Immediacy Index

Journal Name	# of TSE Articles in Journal	Immediacy Index	Relative Ranking Among 5,876 JCR Journals
Nature	1	7.504	4
Accounts of Chemical Research	2	1.350	125
Journal of the American Chemical Society	12	1.201	157
Organic Letters	6	0.819	291
Chemistry A European Journal	2	0.792	308
Journal of Organic Chemistry	21	0.711	372
Macromolecules	18	0.672	400
Synlett	3	0.618	457
Green Chemistry	14	0.612	466
Chemical Communications	12	0.609	469
Journal of Physical Chemistry B	3	0.579	510
Total	94		

Ninety-four (33.0%) of the 285 TSE publications were published in journals with an immediacy index that ranked in the top 10% of the 5,867 journals reported by JCR.