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Influence of Proceedings Papers on Citation Impact in Seven Sub-fields of Sustainable Energy Research 2005-11

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Abstract

This paper analyses the following seven sub-fields of Sustainable Energy Research with respect to the influence of proceedings papers on citation patterns across citing and cited document types, overall sub-field and document type impacts and citedness: the Wind Power, Renewable Energy, Solar and Wave Energy, Geo-thermal, Bio-fuel and Bio-mass energy sub-fields. The analyses cover peer reviewed research and review articles as well as two kinds of proceeding papers from conferences published 2005-09 in (a) book series or volumes and (b) special journal issues excluding meeting abstracts cited 2005-11 through Web of Science.

Central findings are: The *distribution* across document types of cited vs. citing documents is *highly asymmetric*. Predominantly proceedings papers from both proceeding volumes as well as published in journals cite research articles (60-76 %). Largely, journal-based proceedings papers are cited rather than papers published in book series or volumes and have field impacts corresponding to research articles. With decreasing proceedings paper dominance in research fields the ratio of proceeding paper volumes over journal-based proceedings papers decreases significantly and the percentage of proceedings papers in journals citing journal-based proceedings papers over all publications citing journal-based proceedings papers decreases significantly (from 26.3 % in Wind Power to 4 % in Bio Fuel). Further, the segment of all kinds of proceedings papers (the combined proceedings paper types) citing all proceedings papers over all publications citing all kinds of proceedings papers decreases significantly (from 36.1 % in Wind Power to 11.3 % in Bio Fuel). Simultaneously and significantly the field citedness increases across the seven research fields.

The distribution of citations from review articles shows that *novel knowledge* essentially derives directly from research articles (53-72 %) – to a much less extent from proceedings publications published in journals (13-9 %). The publication profiles of research articles and proceedings papers in proceedings paper dominant sub-fields demonstrate substantial variety with respect to WoS categories (Wave and Solar Energy) and author countries (Wind Power and Wave Energy).

Keywords

Document types; proceedings papers; research articles; review articles; citation impact; citedness; sustainable energy research; renewable resources

Classification Code: Q2

Introduction

Commonly journal articles in the form of peer reviewed research articles and review articles are regarded the main vehicles for scientific communication in the natural science, bio-medical and some social science fields (Waltman et al., 2012). However, in several engineering fields as well as for computer science and other social science disciplines peer reviewed conference proceedings papers form the main scientific communication channel.

With the inclusion of conference proceeding publications (CPCI-S and CPCI-SSH) in the Thomson-Reuters Web of Science citation index (WoS), and by application of the WoS Analytic Tools, it is possible to extract and observe how conference proceedings papers actually perform during a shorter time period compared to journal articles in selected research fields in a controlled manner.

The present analysis investigates seven fields of Sustainable Energy research published 2005-09 with a citation window of max. seven years (2005-2011): the Wind Power and Renewable Energy subfields representing strong conference paper dependence (40-65 % of publications); Solar and Wave Energy subfields signifying medium conference dependence (26-39 %); and Geo-thermal, Bio-fuel and Bio-mass energy fields demonstrating low conference dependence (< 25 %). The analysis distinguishes between two kinds of proceedings papers[1] published in a) (special) journal issues or b) in book series/volumes, research articles and review articles. Other types containing editorials, book reviews, errata, meeting abstracts, etc. as defined in WoS are omitted, as is monographic material. As for journals WoS does not cover all conferences in the analysed energy fields. However, according to (Thomson Reuters, ISI) the "most important and influential" conferences and conference proceeding volumes of the sustainable energy fields, e.g. published in book series by ACM, IEEE and similar institutional sponsors, are covered and checked in a sample of records from the two proceedings paper groups extracted from WoS. The time slot analysed (2005-2009) corresponds to the period in which WoS through CPCI-S&SSH has indexed its highest volume of proceedings papers with its peak at 479,000 papers in 2006, according to analyses by Ingwersen & Larsen (2013, p. 1016).

In an earlier study, the Research Evaluation and Policy Project (REPP) at the Australian National University (ANU), Bourke & Butler (1996) established a database covering all the publications from the Institute of Advanced Studies (IAS) and examined in detail citations in the journal literature accruing to all types of publications, including proceedings papers. The present study also observe the opposite citation flow, from proceedings papers to journal articles. Later studies of conference paper citation impact have demonstrated the feasibility of proceedings papers, e.g. Butler & Visser (2006) who investigated the degree to which WoS contributes adequate data with respect to a variety of document source types, including conference proceeding and meeting publications. Butler & McAllister (2009) examined metrics-based models for evaluating research in Chemistry and found that any metrics approach to performance evaluation has to use a discipline-specific suite of indicators. This proposal correlates to a very recent study by Mutz, Bornmann & Daniel (2013). They used a multi-level latent class analysis to define the kinds of research outputs in the shape of document types that can typically be expected from certain disciplines. Martins et al. (2011) tested comprehensive conference paper indicators in the Electrical Engineering and Computer Science fields, comparing to journal-based indicators. How proceeding paper citations are distributed across a range of document types in computer science was investigated by Wainer, de Oliveira & Anido (2011). They studied the references from all (predominantly proceeding) papers published in the ACM digital library 2006. They found that around 40% of the references were to earlier conference proceedings papers, around 30% were to journal papers, and around 8% were references to books.

Based on the latter findings founded on *reference analyses* one might form the hypothesis that in strong conference-dependent fields the proceedings papers themselves are the main contributor to the impact of the field or, at least, constitute a major supplier of citations to proceedings papers. In the present study this is measured by means of contingency tables and compared to citation impact and citedness scores across the four document types involved.

[1] In the remaining of the paper the notion 'proceeding papers' excludes the WoS document category 'Meeting abstracts'.

One might also speculate that review articles in such conference-dominant disciplines would tend to cite conference papers, regardless publishing mode, rather than journal articles. However, a recent study of the conference-dominated engineering field Wind Power research 1995-2011 (Sanz-Casado et al., 2013) demonstrates that these hypotheses and ideas might not hold true for all conference-dependent fields. Hence the motivation for the present *citation-based* analyses, which aim at observing the characteristics of citations given to defined source documents of various types. Characteristics of the citing documents are, for instance, document type and their citation patterns. An earlier study has presented some of these analyses (Ingwersen et al., 2013), which the present investigation extends in depth as well as range. If proceedings papers do play a crucial role in the knowledge distribution and crediting process they ought to be taken more into account, for instance in research evaluation studies.

The paper is organized as follows. The data collection and analysis methods are described, followed by the findings of the investigation. Initially we show the distribution of publications over the four document types across the seven selected Sustainable Energy research fields. This is followed by the distribution of citations, impact and citedness, including the distribution of citing documents, over the four document types in the seven fields. The findings are related to the degree of proceedings paper dependency for each of the seven fields as well as country and subject category characteristics. A discussion section and conclusions complete the article.

Methodology

The study made use of the already existing retrieval strategies and profiles developed and tested in the context of the SAPIENS project for the use in Web of Science (WoS). The SAPIENS Project (Scientometric Analyses of the Productivity and Impact of Eco-economy of Spain) has as main goal the analysis of scientific and technological capacities of Eco-economy in Spain 1995–2009, cited 1995–2011, seen in a global context through quantitative and qualitative R&D indicators and is reported in Sanz-Casado et al. (2013).

The seven Energy research fields were extracted online in December 2012, October 2013 and January 2014 through WoS. Elaborated search profiles were executed[2]. The following WoS citation databases were applied: SCI-EXPANDED, SSCI, CPCI-S, CPCI-SSH. For each field the online set of publications 2005-09 was divided into the four document types examined in this study and analyzed by means of the WoS Analytic Tools for cited countries and WoS categories as well as citation distributions 2005-11.

The distribution of document types across the seven selected fields is displayed on Table 1. A smaller share of documents (average 7 %) is indexed as proceedings paper as well as journal article within each field. A check demonstrated that they commonly were proceedings papers published in thematic or special journal issues indexed by WoS. They are isolated as 'PP in journals' by means of refine and exclusion commands in WoS Analytic Tools. Thus they do not overlap with the research articles. Likewise proceedings papers published in book series or volumes are isolated as 'PP in volumes'.

Further, each sub-disciplinary set was sorted according to citation scores and the exact citedness ratio observed, Tables 2-4. Intermediate analyses and calculations were necessary for each set of a document type to 1) exclude the 2012-14 citations, 2) limit the citing set of publications to the required time period, and 3) define and logically isolate the distribution across the four document types of the citing set of publications. Thus no overlaps exist at

[2] Example of search profile for Wind Power: TS=("wind power" OR "wind turbine*" OR "wind energy*" OR "wind farm*" OR "wind generation" OR "wind systems") AND PY=(2005-2009). Refined by: Document Types=(PROCEEDINGS PAPER OR ARTICLE OR REVIEW) AND [excluding] Web of Science Categories=(ASTRONOMY ASTROPHYSICS).

document level in the contingency tables in which the four document types are exclusive. However, the exact number of citations from those types citing the original set cannot be secluded in Wos.

In case of sets too large for WoS to handle when generating online citation reports, i.e. sets above 10,000 items, the set was logically divided into subsets for which the analyses were aggregated later. The field of Solar Energy constitutes such a large set (26,697 documents). In total the analyses deal with almost 60,000 source documents (Table 1) and almost 700,000 citations. WoS Analytic Tools were also applied to extract the top-10 countries as well as the top-10 WoS categories published in the research articles and 'PP in volumes' per energy field.

We have applied χ^2 statistical tests and correlation coefficient analysis to observe the significance of the trend results across the seven fields based on data from the contingency tables as well as on the results from each contingency table analysis and the Cramer's V in order to measurer the association degree using the "vcd" package implemented in R Software (Meyer et al., 2012).

Findings

Table 1. Document type distribution 2005–09 in seven sub-fields of Energy research organized in decreasing order of proceedings paper dominance (WoS, Jan. 2014). % in bold signifies shares of proceedings papers.

	Wind Power		**Renewable**		**Wave Energy**		**Solar Energy**		**Geo-Thermal**		**Bio Mass**		**Bio Fuel**		**Total**	
Doc. Type	Publ.	%	Publ.	%	Publ.	%	Publ.	%	Publ.	%	Publ.	%	Publ.	%	Publ.	%
Res. Article	2449	34.4	3284	45.9	861	59.9	16733	62.7	1868	71.0	3752	75.5	6871	74.6	35818	60.5
PP in volumes	4181	**58.7**	2844	**39.8**	459	**31.9**	6011	**22.5**	407	**15.5**	534	**10.7**	991	**10.8**	15427	**26.0**
PP in journals	305	**4.3**	493	**6.9**	95	**6.6**	3062	**11.5**	199	**6.6**	344	**6.9**	620	**6.7**	5117	**8.6**
Review Art.	189	2.7	532	7.4	23	1.6	891	3.3	156	5.9	339	6.8	731	7.9	2861	4.8
Total	7124	100	7153	100	1438	100	26697	100	2630	100	4969	100	9213	100	59223	100

Table 1 displays a five-year snap shot of the seven sustainable energy fields. It demonstrates the degree of dependency of both types of proceedings papers, which characterizes each field (percentages in bold). Evidently Wind Power research is mostly published through the proceedings paper channels (63 %); but also the Renewable Energy and Wave Energy fields are quite dependent on proceedings paper output (46.7 % and 38.5 %). The engineering aspects of those fields are probably the reason for this dependency – see example Table 7. The remaining Energy fields under analysis are more science-like in their publication profiles being increasingly research article dominant.

Table 2. Citations, citation impact and citedness scores, seven Renewable Energy fields. (WoS, Jan., 2014).

	Wind Power			**Renewable Energy**			**Wave Energy**			**Solar Energy**		
Doc. Type	Citations	C/P	Citedness	Citations	C/P	Citedness	Citations	C/P	Citedness	Citations	C/P	Citedness
Res. Article	24400	10.0	0.99	35849	10.9	0.88	6258	7.3	0.90	297808	17.8	0.95
PP in volumes	801	0.2	0.17	509	0.2	0.15	162	0.4	0.27	1993	0.3	0.22
PP in journals	4029	13.3	0.92	5976	12.1	0.86	597	6.3	0.79	29565	9.7	0.84
Review Art.	3319	17.6	0.98	11786	22.2	0.98	252	11.0	1.0	48859	54.8	0.98
Total	32549	4.6	0.5	54120	7.6	0.59	7269	5.1	0.68	378225	14.2	0.77

	Geo-Thermal			**Bio Mass**			**Bio Fuel**			**All fields**		
Doc. Type	Citations	C/P	Citedness	Citations	C/P	Citedness	Citations	C/P	Citedness	Total	C / P	Citedness
Res. Article	14026	7.5	0.91	37993	10.1	0.93	108284	15.8	0.93	524618	14.6	0.93
PP in volumes	228	0.6	0.22	132	0.2	0.20	280	0.3	0.20	4105	0.3	0.20
PP in journals	1861	9.4	0.93	3891	11.3	0.92	8810	14.2	0.93	54729	10.7	0.88
Review Art.	2651	17.0	0.96	9188	27.1	0.98	33774	46.2	0.97	109829	38.4	0.98
Total	18766	7.1	0.81	51204	10.3	0.86	151148	16.4	0.86	693281	11.7	0.72

A closer look at Table 1 reveals a particular trend: The ratio of 'PP in volumes' over 'PP in journals' decreases significantly with decreasing proceedings paper dominance in the research fields. From 13.7 in Wind Power (58.7/4.3) over 5.8 in Renewable Energy, 2.0 in Solar Energy to 1.6 in Bio Mass research ($\chi 2 = 25.795$; $\alpha = .01$; CV= 16.912; DF=6).

Citation impact patterns and proceedings paper field dominance

Citation impact is calculated by dividing the number of citations, Table 2, by number of publications, Table 1. Citedness is the ratios directly observed in WoS. According to Table 2 the citation impact varies substantially from document type to document type and across the seven sustainable Energy fields. However, in all the seven fields the 'PP in volumes' citation impact and citedness scores are extremely low (0.2 – 0.6; 0.15 – 0.27).

Fig. 1 summarizes the development of the citation impact scores for each discipline and each document type as well as a combined research and review article impact score, named 'Journal Impact'. The 'Journal Impact' equals the diachronic citation impact of a given field when the proceedings papers are omitted from a research evaluation analysis. The seven fields are sorted according to decreasing proceedings paper dominance.

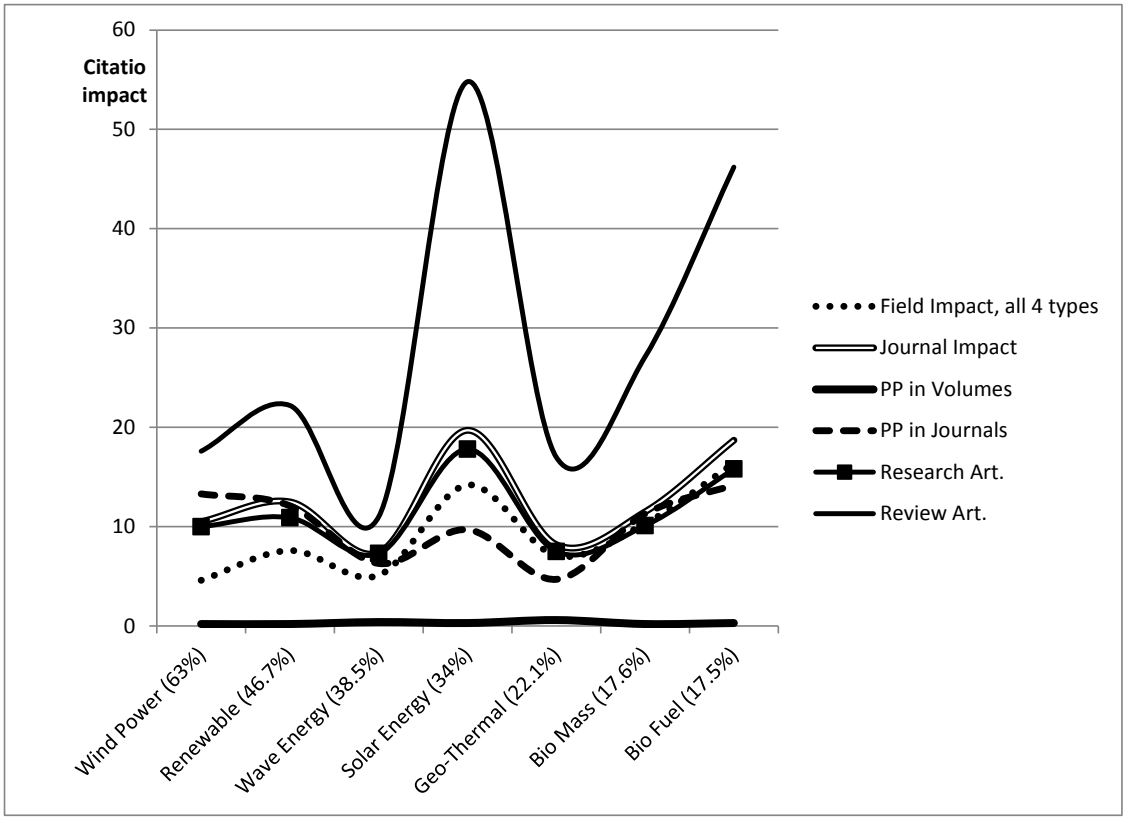

Fig. 1. Document type-related citation impact scores, seven Energy fields 2005-09(11) (WoS, Jan. 2014)

Fig. 1 indicates the importance of inclusion of the proceedings papers in research evaluation analyses. Whilst the overall field impact, the 'Journal Impact' and the research article impact scores for the two article-dominant energy fields (Bio-mass; and Bio-fuel) are quite close in values, the five other energy fields demonstrate an often wide gap between field impact and 'Journal Impact' scores. Although this trend is not statistically significant the observations suggest that in the proceedings paper dominant fields of Wind Power and Renewable Energy, as well as in the Wave Energy sub-field, the gap may occur owing to the

negative influence of the numerous but low-cited 'PP in volumes' publications. In two of these fields the impact of 'PP in journals' is even higher than that of the research articles and thus contribute positively to the field impact – see also Fig. 2 for the overall pattern.

In Solar Energy (medium proceedings paper dependent) and Geo-thermal Energy (low proceedings-dependency) both types of proceedings papers influence negatively on the field impact – Table 2; Fig.1. If 'PP in journals' and 'PP in volumes' are omitted from a citation-based evaluation of the Energy research fields the resulting impact scores are fairly accurate in the two article-dominant fields but, for different reasons, substantially misleading in the latter five fields.

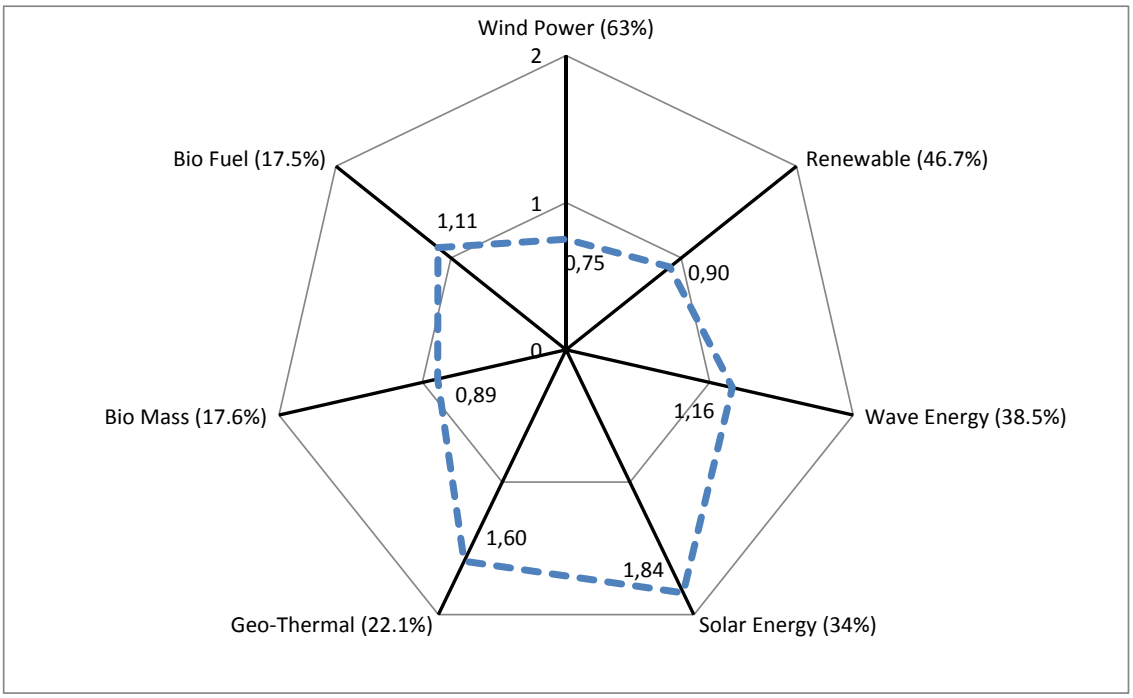

Fig. 2. Ratios of research article impact over 'PP in journals' citation impact for seven renewable energy fields ordered in decreasing proceedings paper dependency clockwise from 12 o'clock (WoS, Jan., 2014)

Fig. 2 summarizes the ratios of the citation impact scores of research articles over the 'PP in journals' type in the seven energy fields. In the highly proceedings paper dominant disciplines (Wind Power and Renewable Energy) as well as in the article-prevailing Bio Mass field the 'PP in journals' type supersedes research articles in impact. Otherwise the latter document type commonly has the higher impact scores, in particular as concern the Solar and Geo-thermal energy disciplines with ratios of 1.84 and 1.5 respectively.

Further, Table 2 demonstrates that the citedness values of 'PP in journals' constantly are very high compared to the citedness of the 'PP in volumes' type. Fig. 3 depicts the citedness scores for each field as well as for the two proceedings paper types and research articles. The general trend is a continuous significant increase of field citedness with increasing article dependency, from 50 % in Wind Power to 86 % in Bio Fuel ($\chi 2$ = 16.208; α=.05; CV= 12.592; DF=6; correlation coefficient R^2=97.12). The citedness scores for the research articles and the two proceedings paper types demonstrate some variation but no particular patterns.

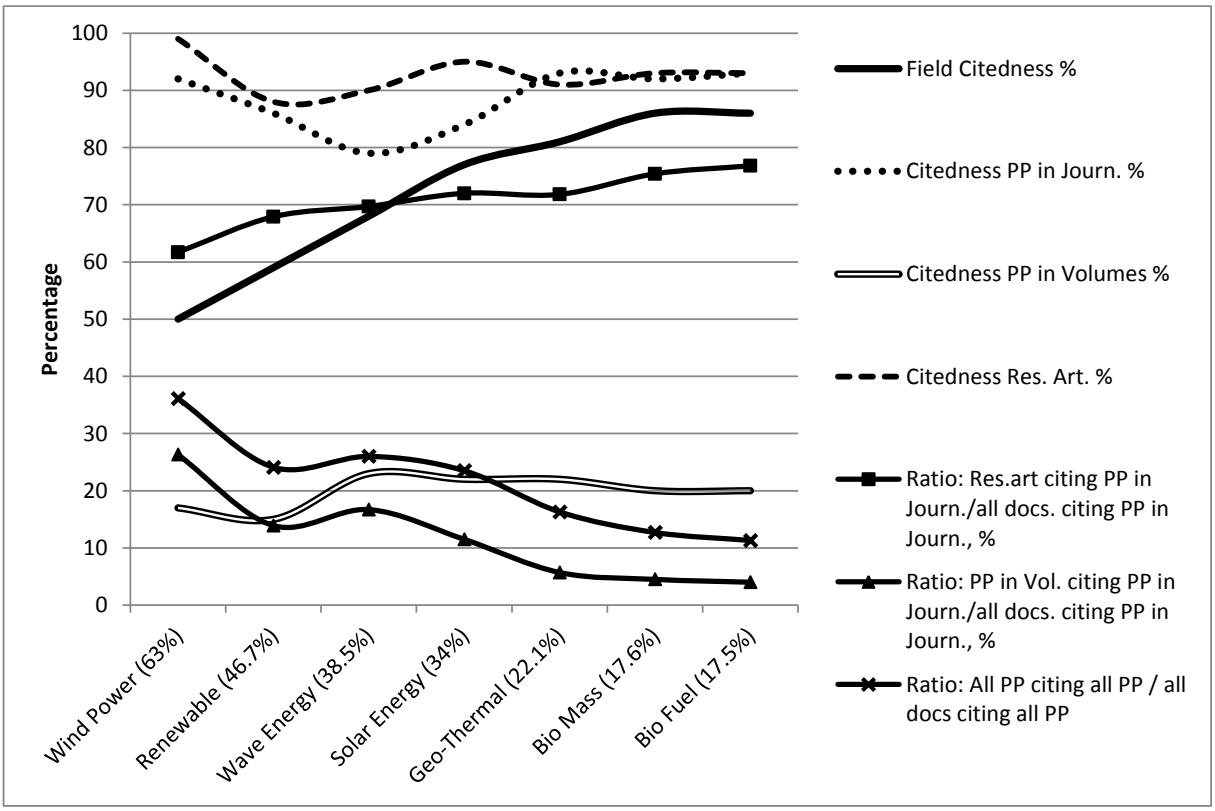

Fig. 3. Citedness per research field for document types and selected ratios of document types citing 'PP in journals' (WoS, Jan., 2014).

Citations to and from document types

Tables 3 through 5 demonstrate the distribution of citations from the pool of citing publications to each of the four different types of source (cited) documents across the seven fields, displayed in descending order of conference dominance.

Table 3. Highly conference-dominant Energy fields. Distribution of citing publications 2005-11 to documents published 2005-09; (3a): absolute numbers; (3b): citing ratios; analysis at document level (WoS, Jan. 2014)

Table 3a.	*Wind Power Research*					*Renewable Energy Research*				
Cited:	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***
Res.Articles	7552	3180	398	676	11806	17664	2660	881	2413	23618
PP in volumes	288	315	19	18	640	191	224	24	25	464
PP in journals	1888	806	198	170	3062	3249	666	351	522	4788
Review Art.	1639	400	94	413	2546	6822	754	339	1349	9264
Total	11367	4701	709	1277	18054	27926	4304	1595	4309	38134

Table 3b.	*Wind Power Research (63 % conferences)*					*Renewable Energy Research (46.7 % conferences)*				
Cited:	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***
Res.Articles	0.66	0.68	0.56	0.53	0.65	0.63	0.62	0.55	0.56	0.62
PP in volumes	0.03	0.07	0.03	0.01	0.04	0.01	0.05	0.02	0.01	0.01
PP in journals	0.17	0.17	0.28	0.13	0.17	0.12	0.15	0.22	0.12	0.13
Review Art.	0.14	0.09	0.13	0.32	0.13	0.24	0.18	0.21	0.31	0.24
	1	1	1	1	1	1	1	1	1	1

Table 4. Medium conference-dominant Energy fields. Distribution of citing publications 2005-11 to documents published 2005-09; (4a): absolute numbers; (4b): citing ratios; analysis at document level (WoS, Jan. 2014).

Table 4a.

	Wave Energy Research					*Solar Energy Research*				
Cited:	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***
Res.Articles	3855	461	224	242	4782	108461	9532	5809	7339	131141
PP in volumes	85	37	10	12	144	925	608	141	91	1765
PP in journals	372	89	40	33	534	14747	2352	2225	1146	20470
Review Art.	151	30	9	47	237	27653	1438	1091	3171	33353
Total	4463	617	283	334	5697	151786	13930	9266	11747	186729

Table 4b.

	Wave Energy Research (36.1 % conferences)					*Solar Energy Research (34 % conferences)*				
Cited:	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***
Res.Articles	0.86	0.75	0.79	0.72	0.84	0.71	0.68	0.63	0.62	0.70
PP in volumes	0.02	0.06	0.04	0.04	0.03	0.01	0.04	0.02	0.01	0.01
PP in journals	0.08	0.14	0.14	0.10	0.09	0.10	0.17	0.24	0.10	0.11
Review Art.	0.03	0.05	0.03	0.14	0.04	0.18	0.10	0.12	0.27	0.18
	1	1	1	1	1	1	1	1	1	1

Table 5. Low conference-dominant Energy fields. Distribution of citing publications 2005-11 to documents published 2005-09; (5a): absolute numbers; (5b): citing ratios; analysis at document level (WoS, Jan.

Table 5a.

	Geo-Thermal Energy					*Bio Mass*					*Bio Fuel*				
Cited:	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***
Res.Articles	7987	450	424	971	9832	21625	812	913	2818	26168	33460	1559	1556	3665	40240
PP in volumes	145	31	10	18	204	63	36	9	4	113	153	80	18	26	277
PP in journals	1141	91	161	166	1590	2513	151	242	425	3331	5242	272	436	875	6825
Review Art.	1642	138	123	403	2306	5438	244	307	1238	7227	16097	649	686	2787	20414
Total	10915	710	718	1558	13932	29639	1243	1471	4485	36918	54952	2560	2696	7353	67756

Table 5b.

	Geo-Thermal Energy (19.2 % conferences)					*Bio Mass Energy Research (17.6 % conferences)*					*Bio Fuel Energy Research (17.5 % conferences)*				
Cited:	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***	***Citing Art***	***Citing PP in Vol***	***Citing PP in J***	***Citing Rev***	***Citing Docs.***
Res.Articles	0.73	0.63	0.59	0.62	0.71	0.73	0.65	0.62	0.63	0.71	0.61	0.61	0.58	0.50	0.59
PP in volumes	0.01	0.04	0.01	0.01	0.01	0.002	0.029	0.006	0.001	0.003	0.003	0.031	0.007	0.004	0.004
PP in journals	0.10	0.13	0.22	0.11	0.11	0.08	0.12	0.16	0.09	0.09	0.10	0.11	0.16	0.12	0.10
Review Art.	0.15	0.19	0.17	0.26	0.17	0.18	0.20	0.21	0.28	0.20	0.29	0.25	0.25	0.38	0.30
Mean / Total	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

The central (vertical) trend is that in all the analysed sustainable energy fields both types of proceedings papers essentially cite *research articles*. Between 55 % and 84 % of all the citing publications cite research articles. The 'PP in journals' type only cites 'PP in journals' at a smaller scale across the seven fields (11 % - 28 %) and virtually no citations go to 'PP in volumes' papers. The 'PP in volumes' type itself only scarcely cites 'PP in journals' (11 % - 17 %). With respect to degree of proceedings paper dominance only one weak vertical pattern is observable: with decreasing proceedings paper dominance the percentage of 'PP in volumes' citing *both* types of proceedings papers decreases gradually from 21 % (Wind Power) to 14.1 % (Bio Fuel) ($\alpha > 0.05$).

The Tables 3b-5b inform that only between 10 % (in most fields) and 13 % (Wind Power) of the citing review articles target 'PP in journals'; almost none goes to the 'PP in volumes' type. Most of the citations given by review articles extent to research articles, which thus can be regarded as the most significant source of novel knowledge in the Renewable Energy fields. Overall, we can see from the χ^2 test statistics of tables 3b-5b that no or very weak associations exist between the type of document citing and document cited. Only three areas (Wind Power, $\chi^2 = 33.309$, Wave Energy, $\chi 2 = 18.989$ and Solar Energy, $\chi 2 = 23.053$) have a significant dependence ($\alpha < 0.05$; DF=9; CV=16.919). However, in the last two the intensity of this association is small, as measured by Cramer's V (V = 0.126 and V = 0.139 respectively). Only in the field of Wind Power the strength of the association is higher (V = 0.17). This result is related to the greater weight of the 'PP in journals' discussed above.

However, one may in addition use the data Tables 3b-5b to calculate the share of citations given to 'PP in journals' from the different document types (i.e., calculating the *horizontal* ratios, not shown on tables). Figures 3-4 display two fairly strong significant trends with respect to decreasing proceedings paper dominance of fields – and thus increasing article dependency: (1) the segment of *all* proceedings papers citing *all* proceedings papers over all publications citing proceedings papers (i.e. the combined 'PP in volumes' and 'PP in journals') decreases slowly but significantly (from 36.1 % in Wind Power (315+19+806+198/3062+640) to 11.3 % in Bio Fuel); (2) the percentage of 'PP in volumes' citing 'PP in journals' over all publications citing 'PP in journals' decreases significantly (from 26.3 % (Wind Power: 806/3062) to 4 % (Bio Fuel)).

Fig. 4 demonstrates the two correlations in scatter plot. Both displays high R^2 scores and their χ^2 tests show dependency between the 2 x two variables ($\alpha = 0.01$; CV= 16.812; DF=6): (1) $\chi^2 = 21.152$; (2) $\chi 2 = 33.059$.

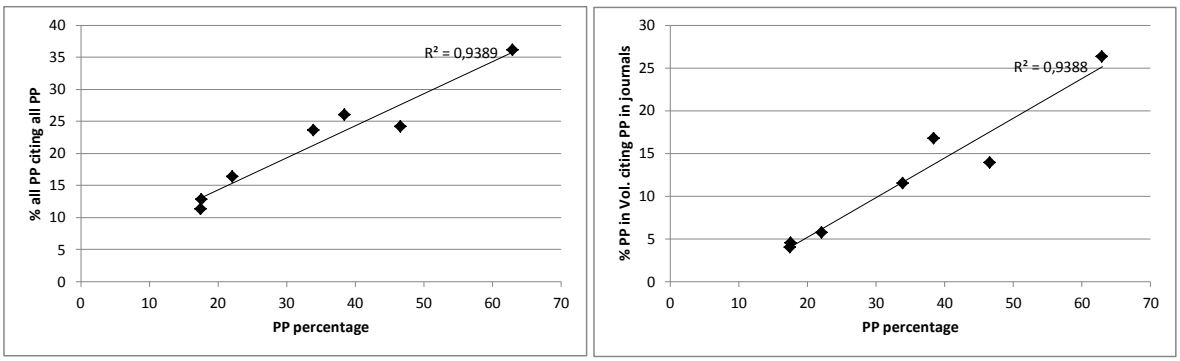

Fig. 4. The correlation between the percentage of all PP citing all PP over all publications citing all PP (left); and the percentage of 'PP in volumes' citing 'PP in journals' over all publications citing 'PP in journals' (right).

A third trend displaying a similar but weak pattern concerns the increase in the percentage of research articles citing 'PP in journals over all publications citing 'PP in journals', from 61.7 % in Wind Power (1888/3062) to 76.8 % in Bio Fuel ($\chi^2 = 2.148$). The testing shows that the pattern might be due to random variation.

Country and subject matter characteristics of Energy publication types

The idea behind the analyses of top-10 publishing countries and WoS categories for research articles vs. the 'PP in volumes' type is to observe possible profiles discrepancies between the two prevailing document types. As long as the pair of country (or topical) profiles derived from research articles and 'PP in volumes' are very similar for a field, the two document types behave correspondingly with respect to a) production and b) top research foci. If, notwithstanding, discrepancies are noticeable they may signify reasons for certain citation phenomena or other anomalies observed.

Except for Wind Power and Wave Energy, Table 6, the country profiles in all the remaining five sustainable Energy fields demonstrate quite similar arrays as well as productivity shares for the two document types. In those five fields research articles and 'PP in volumes' contribute proportionally to the overall field citation impact, i.e., the same countries publishing research articles obtain simply far less citations to their 'PP in volumes' type.

In *Wind Power* P R China constitutes the outlier in the publication profile 2005-2009 by producing 21 % of the world 'PP in volumes' publications (as indexed by WoS). China only publishes 5 % of the research articles in the field during the same analysis period. For the 'PP in volumes' category produced in China and indexed by WoS the citation impact is almost

zero (.09). This is a main reason why the field impact for 'PP in volumes' type in Wind Power is very low (Table 2: 0.17) and the overall field impact is correspondingly deflated (4.6). The Wind Power citation impacts for the top-7 countries in the 'PP in volumes' type are compared to the corresponding impact scores for research articles and 'PP in journals', Table 7. In contrast to the 'PP in volumes' type the Chinese impact in the other document types are more significant but still insubstantial compared to the other top-countries' 'PP in journals' scores, which constantly supersede the corresponding research article impact values.

Table 6. Country profiles for Wind Power and Wave Energy publications 2005-09. Prominent variance in bold+italics (WoS, jan., 2014)

Wind Power field 2005-09						**Wave Energy field 2005-09**					
Res. Articles	2449		**PP in Volumes**	4181		**Res. Articles**	861		**PP in Volumes**	554	
Country	No.	%	*Country*	No.	%	*Country*	No.	%	*Country*	No.	%
USA	396	16.2	***P R CHINA***	***885***	***21.2***	USA	280	32.5	USA	80	17.4
ENGLAND	196	8.0	USA	508	12.2	ENGLAND	83	9.6	JAPAN	32	7.0
DENMARK	189	7.7	JAPAN	269	6.4	PEOPLES R CH	62	7.2	PEOPLES R CHIN	31	6.8
CANADA	171	6.9	GERMANY	242	5.8	AUSTRALIA	59	6.9	ENGLAND	29	6.3
GERMANY	165	6.7	CANADA	194	4.6	JAPAN	50	5.8	***PORTUGAL***	***29***	***6.3***
SPAIN	165	6.7	DENMARK	129	3.1	FRANCE	47	5.5	SOUTH KOREA	24	5.2
JAPAN	128	5.2	SPAIN	129	3.1	CANADA	46	5.3	CANADA	21	4.6
P R CHINA	122	5.0	INDIA	127	3.0	GERMANY	39	4.5	***SCOTLAND***	***18***	***3.9***
TURKEY	111	4.5	ENGLAND	119	2.8	INDIA	34	3.9	AUSTRALIA	15	3.3
SCOTLAND	87	3.6	FRANCE	102	2.4	ITALY	29	3.4	ITALY	14	3.1

Table 7. Wind Power impact scores for top-7 countries, sorted by number of publ. in 'PP in Volumes' column, Table 6 (WoS, Jan., 2014). Top and bottom scores in bold.

Wind Power	**PP in Volumes**	**PP in Journals**	**Research Articles**
P R CHINA	***0.09***	***7.04***	10.23
USA	0.20	15.13	12.52
JAPAN	0.13	16.09	***7.11***
GERMANY	0.45	9.52	8.85
CANADA	0.30	15.91	10.90
SPAIN	0.24	24.00	***14.09***
DENMARK	***0.47***	***30.77***	13.04

In *Wave Energy* research the US 'PP in volumes' production is less dominant than research articles. In this field Portugal and Scotland are important 'PP in volumes' producers, compared to their position outside top-10 as research article providers. As in Wind Power this energy field displays a pattern of far less impact for the 'PP in volumes' type compared to research articles and the 'PP in journals' type.

Table 8 displays the prominent variances with respect to the pairs of topical profiles using WoS Subject Categories. The most significant differences are found in the Wave and Solar Energy fields. Wind Power and, to an extent, the Bio Mass Energy areas demonstrate minor discrepancies with respect to the ranking and kind of categories. In the remaining three Energy fields (Renewable Energy, Geo-Thermal and Bio Fuel) research articles and the 'PP in volumes' type demonstrate very similar profiles implying that the same categories contribute proportionally to the overall field citation impact scores.

Table 8. Topical profiles for Wave and Solar Energy fields 2005-09. Significant variance in bold+*italics* (WoS, Jan., 2014)

Wave Energy field 2005-09						Solar Energy field 2005-09					
Research Articles	861		**PP in Volumes**	459		**Research Articles**	16733		**PP in Volumes**	6011	
WoS Categories	No.	%	*WoS Categories*	No.	%	*WoS Categories*	No.	%	*WoS Categories*	No.	%
OCEANOGRAPHY	241	28.0	***ENGINEERING OCEAN***	***209***	***45.5***	PHYSICS APPLIED	4660	27.8	***ENERGY FUELS***	***2806***	***46,7***
GEOSCIENCES MULTIDISCIPL.	191	22.2	***ENGINEERING MECHANICAL***	***149***	***32.5***	MATERIALS SCIENCE MULTIDISCIPL	4619	27.6	***ENGINEERING ELECTR. ELECTRONIC***	***1975***	***32,9***
ENGINEERING OCEAN	127	14.8	***ENGINEERING MARINE***	***112***	***24.4***	CHEMISTRY PHYSICAL	2905	17.4	PHYSICS APPLIED	1125	18,7
ENGINEERING CIVIL	112	13.0	***ENGINEERING ELECTR. ELECTRONIC***	***107***	***23.3***	ENERGY FUELS	2631	15.7	***MATERIALS SCIENCE MULTIDISCIPL.***	***960***	***16,0***
ENVIRONMENTAL SCIENCES	97	11.3	***ENERGY FUELS***	***100***	***21.8***	CHEMISTRY MULTIDISCIPLINARY	1751	10.5	***OPTICS***	***782***	***13,0***
GEOGRAPHY PHYSICAL	84	9.8	***ENGINEERING PETROLEUM***	***67***	***14.6***	PHYSICS CONDENSED MATTER	1738	10.4	MATERIALS SCIENCE COAT. FILMS	523	8,7
METEO. ATMOS. SCIENCES	82	9.5	ENGINEERING CIVIL	50	10.9	NANOSCIENCE NANOTECH.	1561	9.3	***CONSTRUCTION BUILDING TECH.***	***520***	***8,7***
GEOCHEMISTRY GEOPHYSICS	73	8.5	ENVIRONMENTAL SCIENCES	35	7.6	METEOROLOGY ATMOSPH. SC.	870	5.2	***ENGINEERING MECHANICAL***	***449***	***7,5***
ENERGY FUELS	66	7.7	***AUTOMATION CONTROL SYSTEMS***	***31***	***6.8***	ENVIRONMENTAL SCIENCES	737	4.4	NANOSCIENCE NANOTECHNOLOGY	442	7,4
ENGINEERING MARINE	57	6.6	***WATER RESOURCES***	***28***	***6.1***	ELECTROCHEMISTRY	570	3.4	***ENGINEERING ENVIRONMENTAL***	***299***	***5,0***

The observed profile differences in the two energy fields; Table 7, are mainly constituted by a stronger connection to and higher weights of the *engineering* categories in the 'PP in volumes' array of topics compared to that of research articles. The latter displays more citation-rich science-related subject areas. This is evident in the Wave Energy field with Oceanography vs. Engineering Ocean as top-categories and in Solar Energy by Engineering Electrical & Electronic other engineering categories in 'PP in volumes', Table 8. In Wind Power (not shown) the area Engineering Electrical & Electronic is ranked second in the research articles (27.2 % world shares) but as top-category in the array of 'PP in volumes' (64.6 %). In addition, 'PP in volumes' in Wind Power deals uniquely and heavily with Automation and Control Systems and several low-cited Computer Science sub-categories. In the Bio Mass field (not shown) the Environmental and Mechanical Engineering fields are ranked 3-4 among the 'PP in volumes' publications but do not form part of the top-10 categories in research articles.

Discussion

The presented findings concern the Core Web of Science citation index[3]. In other citation index configurations the resulting trends and patterns might thus differ slightly. According to analyses of CPCI-S and CPCI-SSH (Ingwersen & Larsen, 2013, p. 1016) the amount of both types of proceedings papers in the indexes peaked 2006 followed by a steady decline. However, since the present analysis covers a snap shot of 2005-09 publications surrounding the peak and not time series we do not regard this phenomenon to have profound influence on the findings. The decline after 2006 seems equally distributed across the fields.

The initial hypothesis that in strong proceedings paper dominant fields the proceeding papers themselves are the main contributor to the impact of the field or, at least, are the major supplier of citations to proceedings papers, does not hold entirely. Only the 'PP in journals' type in part behaves in accordance with our hypothesis: on the field impact, not as a major contributor of citations to the two proceedings paper types – and the 'PP in journals' type constitutes only on average 8.6 % of the renewable energy publications.

The distribution of citations is *highly asymmetric*: All the document types investigated, including the two proceedings paper types, predominantly provide citations to the *research articles* – less to 'PP in journals' and almost none to the 'PP in volumes' type. The 'PP in volumes' publications may consequently be regarded a significant (negative) player in the scientific communication process and thus a crucial factor in research evaluation, Fig. 1. With the exception of the proceedings paper dominant fields of Wind Power and Renewable Energy, and the Bio Mass field, in which the impact of 'PP in journals' surpasses that of research articles, the 'PP in journals' type contributes negatively in the four other disciplines to the overall field impact.

[3] Excluding the recent addition of book citation indexing.

The following statistically significant trends are observed with *decreasing proceedings paper dominance* (and thus increasing journal article dependency) in the seven Renewable Energy fields:

a) The probability increase that the field's overall *citedness* increase, Fig. 3, Table 2;
b) The ratio of 'PP in volumes' over 'PP in journals' decreases (from 13.7 in Wind Power to 1.6 in Bio Fuel, Table 1);
c) The percentage of 'PP in volumes' *citing* 'PP in journals' over all publications citing 'PP in journals' decreases (from 26.3 % in Wind Power to 4 % in Bio Fuel, Fig. 3, 4 and Tables 3-5); and
d) The segment of all proceedings papers (the combined 'PP' types) *citing* all proceedings papers over all publications citing all proceedings papers decreases (from 36.1 % in Wind Power to 11.3 % in Bio Fuel), Fig. 3, 4 and Tables 3-5. This maximum share is close to the 40 % found by Wainer, de Oliveira & Anido (2011) in their reference analysis on the ACM Computer Science digital library.

These trends heavily contrast the initial hypotheses and speculations on proceedings paper citation provision in conference-dominant fields. It is noticeable that in the citedness game the country profiles may be influential. For instance, the Chinese focus on internationally scarcely cited 'PP in volumes' type in Wind Power, Table 6, may indeed affect the overall impact of the field: A similar case is observed by He & Guan (2008) for proceedings papers in Chinese Computer Science. Probably, in fields with research article topical profiles concentrated on highly cited science-related categories and proceedings papers focussed on citation poorer engineering aspects the latter document type influences negatively on the field citedness as well as citation impact.

Conclusions

Based on the findings it is recommendable not simply to rely on journal article analyses in *comparative* research assessment studies. All the research and innovation-producing types of documents should be taken into account in research evaluation. Such analyses should include proceedings papers – because this document type does have significant (negative or positive) influence on the overall citation impact of a research field, in particular in proceedings-dominant fields. In such fields the 'PP in journals' proceedings type may indeed positively support the overall impact score even though the 'PP in volumes' type commonly (in the Renewable Energy disciplines) influences negatively the outcome owing to a fundamental scarcity of citations. This recommendation may probably extend even to all engineering-like fields, but should be further investigated. At the same time the findings demonstrate that both types of proceedings papers and their impact pattern alone is *not* a good predictor of a highly or medium proceedings-dependent field's overall impact.

For the Renewable Energy research fields, which encompass scientific as well as technological and innovative engineering subject areas, the findings demonstrate that with decreasing proceedings paper dominance a field's proceedings paper citedness increase and increasingly citations to proceedings papers derive from journal sources in a quite asymmetric manner.

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