An Approach for Selecting a Scientific Framework for the Economics of Renewable Energies

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Abstract

The economic growth has been expanded based on the consumption of energy from fossil fuels, such as coal, petroleum, natural gas and the uranium. Much has been alleged on global warming due to carbon dioxide and other greenhouse gas emissions coming from fossil fuels, as a consequence renewable energy sources is a top subject on the political agenda. This work treats the selection of a theoretical framework for the research on Economics of Renewable Energy. this research addresses the application of a method for selecting references in a case study of the Economics of Renewable Energy. The method is designed to identify references with high academic relevance in scientific databases using a bibliometric analysis to sift the selected articles. Journals "Energy Policy" and "Renewable Energy" are the most significant vehicles of scientific knowledge conveyance as they are both highlighted on the Bibliographic Portfolio and on the references of the portfolio.

Keywords: Renewable Energy; Economy; Portfolio.

1 Introduction

The work presented in this paper treats the selection of a theoretical framework for the research on Economics of Renewable Energy. This framework will be a background for a larger project to be carried out by the authors on this field.

The selection of a bibliographic portfolio for reference is of fundamental importance for any thorough scientific research. Notwithstanding, this research addresses the application of a method for selecting references in a case study of the Economics of Renewable Energy. The method is designed to identify references with high academic relevance in scientifc databases using a bibliometric analysis to sift the selected articles (Tasca et al, 2010). Bibliometric analysis is a process of disclosure of quantitative statistical data of a defined set of articles for information management and scientific knowledge of a given subject, conducted by counting the documents (Tasca et al, 2010).

This paper presents the method and the results based on a bibliometric analysis. Accordingly, it introduces opportunities for research as well as clues for a research question and objectives. Besides the introduction, this paper presents the theoretical framework, the methodology procedures, the main results and the conclusions of the paper.

2 Theoretical Framework

The economic expansion and demographical growth place pressure on the natural resources on our planet. Among the necessary natural resources the energy is one of the most important, a crucial element for human life and therefore for every nation's development. As far as now the economic growth has been expanded based on the consumption of energy from fossil fuels, such as coal, petroleum, natural gas and the uranium, accounting for 87% of the world's energy consumption in 2008 (IEA, 2010).

Despite vigorous growth rate the renewable energy sources accounts only for 2.8% of the world's total electricity energy production in 2010, while the combined wind and solar electricity generation alone is

estimated to account for approximately only 0.8% (REN21, 2010). Nonetheless a lack of substantial share of clean energy on the energy producing framework clearly evinces the economic barriers faced on investments within RE sources when compared to fossil fuels and the uranium. On the other hand, the percentage of electricity generation from RE sources for the three years moving average growth of 14% in 2009 indicates a low but growing mark though (US Pew, 2010).

The investment analysis of RE encompasses the decisions about capital expenditure with long-termed ventures, with the objective of making appropriate economic returns for private and public investors. An economic issue that arises at this point regards to the optimal investment portfolio for RE, a comprehensively study for the case of Spain is made by Muñoz et al (2009).

Investment analysis models for infrastructure ventures are proposed by Diniz (2003), while selection of projects for investment is backed by Kopittke (1978). The project financing is crucial for long-term investment (Cunha, 1981) and should be prepared by the entrepreneurs (Túlio, 2006).

The economic return is intimately related to the risk and so it is necessary to evaluate and minimise it as much as possible as treated by Markowitz (1952) and Hochheim (1986). The application of mitigation models such as postulated by Cleijne et al (2004) and Santa-Catarina (2008) is important for the planning of RE ventures.

3 Methodological Procedures

3.1 Methodological Framework

The research is descriptive; therefore, aims to identify a portfolio of relevant articles on the economics of renewable energy, and for this portfolio literature highlight the most outstanding articles, authors and journals. As to the nature of the article is characterized as a theoretical study of illustration, therefore, seeks to understand the research that serve as a practical guide Alavi & Carlson, cited by Rosa et al (2009). The data collection of these is primary and secondary origin. The primary concerns the definition of keywords and search sites defined by the researcher and the secondary with respect to international scientific papers.

As for the research approach is characterized as qualitative and quantitative, for seeking to obtain more knowledge about renewable energy economy through quantitative literature review and the implementation phase of the bibliometric analysis is the identification of where (s) variable (lo) and count their occurrences in a defined set of articles (Bibliographic Portfolio). As to the technical procedures characterized by the documentary analysis and action research. As for the results of the research has been the portfolio bibliographic and bibliometric analysis.

3.2 Selection Process

A procedure for the theoretical revision of papers can be defined with the following steps (Ensslin et al, 2010): a) Assortment of a Rough Set of Articles; b) Filtering articles from the Rough Set of Articles; c) Bibliometric Analysis; and d) Identification of opportunities, objectives and a research question

4 Results

4.1 Database Research Process

4.1.1 Rough set of Articles

Prior to start searching for scientific published literature on a given subject, it is recommended to establish previously an organised methodology for this search. A representative sample for the universe of all scientific material is therefore essential.

For current research it was obtained from the available databases on (CAPES, 2011) the ones related to the following knowledge areas "Engineering" and "Energy".

It was then decided to select four representative databases, whose description was aligned with economics of renewable energies, among the available 48 databases that resulted from the search. The authors of the present work believe these four databases delineate properly all the most important contributions to the mentioned topic. The selected databases are the following:

a) Web of Knowledge: It has more than 10,000 frequent publications, that publish only the most cited articles. Web of knowledge is also a citation index, which shows the number of times one article is cited in scientific publications.

b) Scopus: It is a database of publications with broad gamma of frequent publications (8,000) in all scientific areas. Scopus has more than 41 millions of published registers worldwide.

c) Compendex: Also known by Engineering Village, Compendex has a substantial number of frequent publications on its database (5,600), as well as 12 millions of published registers. It is a multidisciplinary database on the engineering publishing since 1884.

d) Inspec: It is also an important database with more than 5,000 frequent publications and 11 million of published registers. Inspec's database encompasses the areas of physics, engineering, mechanics and electric, electronic, information and technology sciences.

Having the above-defined framework of databases we were able to get trough the first step on the process of bibliographic selection, which is using key words for search articles.

A special attention was given to the use of the key words as they have direct impact on the final results. Two axes of key words were established to get full correlation with the research topic. One axe deals with economics and the other treats with renewable energies. The table 1 below explicit the first set of related key words utilized on the research.

Table 1: Set of key words. Source: Authors.

Set of Key-words utilized		
Economics Axe		R.E. Axe
"Investment Analysis"	AND	"Renewable Energy"
"Economic Returns"		"Wind Power"
"IRR"		"Alternative Energy"
"Internal Rate of Return"		
"Portfolio Management"		

Because of the poor number of results the key words "Investment Analysis", "Portfolio Management" and "Economic Returns" was giving, they were substituted by "Investment", "Earnings", "Economic Analysis" respectively.

The total number of results that came within the 15 final searches was 7,127 registers as shown in table 2. From such search the combined key words "Investment" with "Renewable Energy" was the one returning the most number of registers (3,205).

The conducted current research and analysis was developed in March and April 2011, so numbers herein can be changed as time goes by.

Table 2: Key word search results. Source: Authors.

Economic Axe	**R.E. Axe**	**ISI Web**	**Scopus**	**Compendex**	**Inspec**
	Renewable Energy	171	1563	1307	164
Investment	Wind Power	57	643	570	108
	Alternative Energy	18	374	97	15

	Renewable Energy	8	34	61	3
Earnings	Wind Power	4	22	27	8
	Alternative Energy	0	11	2	1
	Renewable Energy	127	402	328	90
Economic Analysis	Wind Power	21	185	143	68
	Alternative Energy	7	111	20	8
	Renewable Energy	17	29	32	16
IRR	Wind Power	3	13	13	13
	Alternative Energy	2	6	2	1
	Renewable Energy	24	40	48	20
Internal Rate of Return	Wind Power	4	18	17	16
	Alternative Energy	2	11	2	0
	Total	**465**	**3462**	**2669**	**531**
		7127			

4.2 Filtering articles from the Rough Set of Articles

The Rough Set of Articles is then submitted for a filter for duplicates. The total number of 1,702 articles was suppressed from the list as their counterparts were found.

Following that, we carried out a title alignment filtering process on the remaining articles of the list. Only the articles whose title were well connected with the topic of the current research were left on the list, being all the rest suppressed. The final total number from this step was 1,411 remaining articles.

The results from the four databases were put together. A filter for duplicates was applied again, in order to find duplicates among databases. A total number of 592 articles were suppressed from the main list at this stage from what resulted in 819 eligible articles.

After that, it was identified on Google Scholar, 2011 the number of times that each article is cited on literature, so scientific reconnaissance can be testified. In this process it has been noticed that a number of articles could not be found on Google Scholar, were confirmed to be a book or conference proceedings. These types of publishing papers are not considered suitable to be part of the portfolio, as they have not been picked up for publishing throughout a selection process. Therefore, a final number of 677 articles were kept on portfolio with a total of 6,748 citations.

These selected articles, which are not duplicates, neither are conference proceedings or books, but are title aligned, representing a very rich scientific contribution for the topic to be studied. Although, for practical reasons, this number of articles shall be once again dramatically reduced because of the time needed for reading the papers at later stage. Thus, a 61% cut factor was adopted to take the most cited articles as a representative sample from the list of selected articles.

The cut-factor applied on the list retained only the articles having at least 21 citations on literature, so at total 4.116 citations were kept on the main list. This number of citations resulted in 90 articles that were kept on the list. The chart 1 evinces the 61% cut factor.

In addition, two routes are defined for the analysis that follows: (i) the articles with scientific recognition advance through the standard process (ii) the articles without scientific recognition so far goes through a recap process.

(i) Standard Process: The 90 articles with scientific recognition are analysed on the basis of their abstract content and citation number. The 30 most cited articles, which are abstract aligned, are retained at this stage.

(ii) Recap Process: the 587 articles rejected from the scientific recognition process are still analysed with an alternative route.

It has to be considered that new articles have not got the time to attain reconnaissance from the scientific community, as it shall be a delay between the article's publication date and its impact. Also, the authors with premium recognition, the ones that theirs articles are listed on the main list, may also have issued quality material on the literature that are still not recognised by the public.

Subsequently, we conducted a search on the rejected articles finding those whose publishing year were newer than 2009, as well as those articles whose authors are listed on the main list of recognised articles. We found that 101, 64 and 29 articles were matched with date year 2009, 2010 and 2011 respectively, with a total number of 194 articles fitted in the first criteria while 38 articles matched on the author's criteria. All of these articles are abstract checked, for a final retention of 5 articles from the recap process.

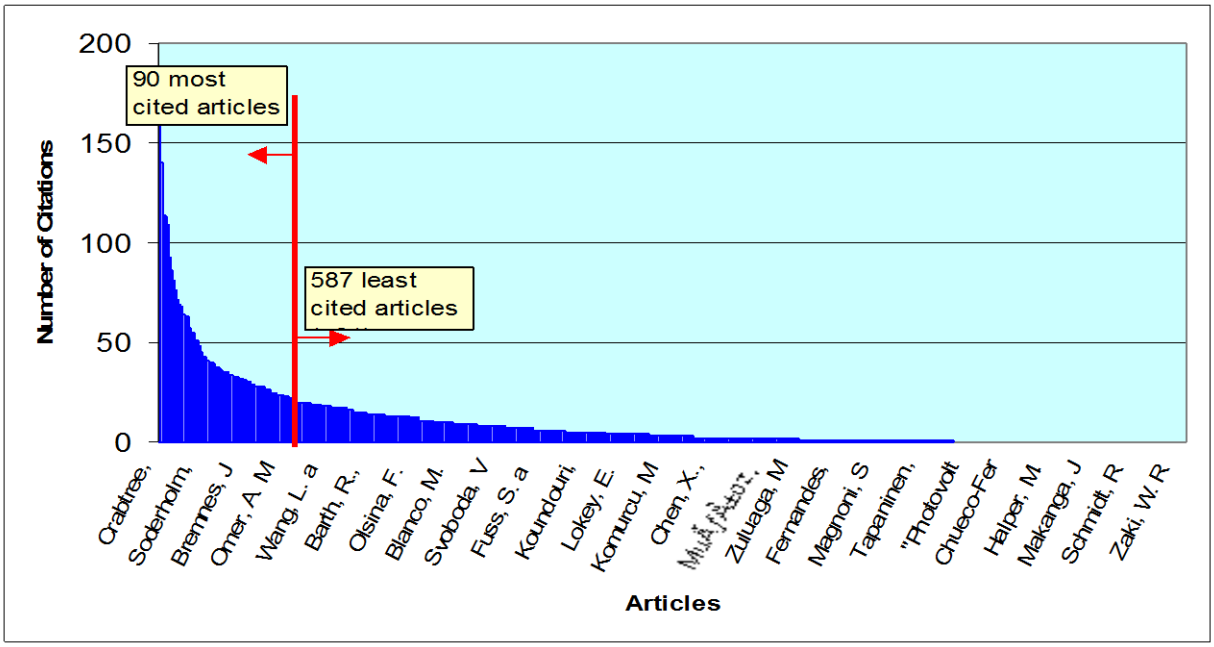

Chart 1: Illustration of the cut factor on the full list of titled aligned articles for the research topic "Economics of Renewable Energy"

The articles retained from the Standard Process and those from the Recap Process are then put together, when they finally are read for full content alignment. At this final stage we found that 2 articles could only be fully accessed upon payment, these articles are suppressed from the list, as the authors believe it should not be a further payment for specific scientific research (the public academic institutions access to international databases are already paid by Brazilian government through CAPES). All the remaining 33 articles were content aligned, thus we accounted for 33 articles, which are altogether called now on the Bibliographic Portfolio.

4.3 Bibliometric Analysis

To better comprehend the behaviour of an academic transmitted knowledge area, bibliometric techniques are applied to measure, map, interpret, evaluate and collect indicators of scientific output. Bibliometric is a technique for quantitative analysis, producing statistics used to measure the production and dissemination of scientific knowledge (ARAUJO, 2006).

The bibliometric analysis of the current research topic was made upon the following points of view: a) Bibliometric analysis of the selected articles; and b) Bibliometric analysis of the references of the selected articles.

4.3.1 Bibliometric Analysis of the selected articles

The Bibliographic Portfolio was defined throughout a sift process where a personal view specially weights on the selection of articles. As a result, it is reasonable that different personal views would result in different Bibligraphic Portfolios. It is rather a boundary requisite than a limitation of the method.

The bibliometric analysis of the selected articles is based herein on 3 points of observation: (i) the scientific reconnaissance of articles; (ii) relevance of journals and; (iii) relevance of authors.

(i) The scientific reconnaissance of articles, by the number of citations as shown in Table 3;

Table 3: Bibliographic Portfolio. Source: Authors.

L.	Year	Author(s)	Article Title	Cit.
a	2004	Crabtree, G. W., M. S. Dressel	"The hydrogen economy."	187
b	2005	Junginger, M., A. Faaij, et al.	"Global experience curves for wind farms."	140
c	2005	Lund, H.	"Large-scale integration of wind power into different energy systems."	114
d	2005	Caputo, A. C., M. Palumbo, et	"Economics of biomass energy utilization in combustion and gasification	109
e	2001	Dornburg, V. and A. P. C. Faa	"Efficiency and economy of wood-fired biomass energy systems in relati	93
f	2005	Bird, L., M. Bolinger, et al.	"Policies and market factors driving wind power development in the Uni	86
g	2007	de Vries, B. J. M., D. P. van V	"Renewable Energy sources: Their global potential for the first-half of th	81
h	2005	Khan, M. J. and M. T. Iqbal	"Pre-feasibility study of stand-alone hybrid energy systems for applicatio	76
i	2006	Nelson, D. B., M. H. Nehrir, et	"Unit sizing and cost analysis of stand-alone hybrid wind/PV/fuel cell po	69
j	2006	Bergmann, A., M. Hanley, et a	"Valuing the attributes of Renewable Energy investments."	68
k	2007	Bresesti, P., W. L. Kling, et al.	"HVDC connection of offshore wind farms to the transmission system."	63
l	2002	Ibenholt, K.	"Explaining learning curves for wind power."	63
m	2003	Lund, H. and E. Munster	"Modelling of energy systems with a high percentage of CHP and wind	60
n	2005	Domac, J., L. K. Richards, et a	"Socio-economic drivers in implementing bioenergy projects."	55
o	2004	Murphy, J. D. and E. McKeogl	"Technical, economic and environmental analysis of energy production f	55
p	2005	Kaldellis, J. K.	"Social attitude towards wind energy applications in Greece."	48
q	2006	Bueno, C. and J. A. Carta	"Wind powered pumped hydro storage systems, a means of increasing th	45
r	2002	Celik, A. N.	"Optimisation and techno-economic analysis of autonomous photovoltai	43
s	2006	Lund, H.	"Large-scale integration of optimal combinations of PV, wind and wave	43
t	2002	Wu, C. Z., H. Huang, et al.	"An economic analysis of biomass gasification and power generation in C	41
u	2004	Bremnes, J. B.	"Probabilistic wind power forecasts using local quantile regression."	40
v	2004	Geller, H., R. Schaeffer, et al.	"Policies for advancing energy efficiency and Renewable Energy use in B	40
w	2003	Celik, A. N.	"Techno-economic analysis of autonomous PV-wind hybrid energy syste	39
x	2003	Rehman, S., T. O. Halawani, et	"Wind power cost assessment at twenty locations in the Kingdom of Sau	39
y	2007	Swider, D. J.	"Compressed air energy storage in an electricity system with significant	38
z	2006	Lund, H. and E. Munster	"Integrated energy systems and local energy markets."	37
aa	2007	Soderholm, P., K. Ek, et al.	"Wind power development in Sweden: Global policies and local obstacle	37
ab	2006	Bernal-Agustin, J. L. and R. D	"Economical and environmental analysis of grid connected photovoltaic	36
ac	2010	Kubiszewski, I., C. J. Clevelan	"Meta-analysis of net energy return for wind power systems."	20
ad	2009	Poullikkas, A.	"Economic analysis of power generation from parabolic trough solar the	5
ae	2009	Muñoz, J. I., A. A. Sanchez de	"Optimal investment portfolio in renewable energy: The Spanish case."	3
af	2011	De Jonghe, C., E. Delarue, et a	"Determining optimal electricity technology mix with high level of wind	1
ag	2010	Talavera, D. L., G. Nofuentes,	"The internal rate of return of photovoltaic grid-connected systems: A c	1

The descriptive work of "The Hydrogen Economy" is the article on selected portfolio with the most number of citations on literature, followed by "Global Experience Curves for Wind Farms", which treats the decline of wind power costs with learning.

(ii) Relevance of journals, as analysed in chart 2

Both journals "Energy Policy" and "Renewable Energy" have 9 articles each, while the third most published journal on the selected portfolio has only 3 articles. Consequently, it can be assumed that these two papers compose the most important publication vehicle within the Bibliographic Portfolio.

Despite journals "Energy Policy" and "Renewable Energy" have same quantity of articles published on portfolio they have different impact on scientific literature though, as far as the articles published in "Energy Policy" has about 37% more citations on academy.

(iii) Relevance of authors, as evinced in chart 3

The chart 3 highlights Henrik Lund with 4 articles published within the Bibliographic Portfolio. In special, his work on the integration of wind power into different energy systems has caused significant impact on the literature. The chart clearly evinces Mr. Lund as the prevailing author for the selected portfolio.

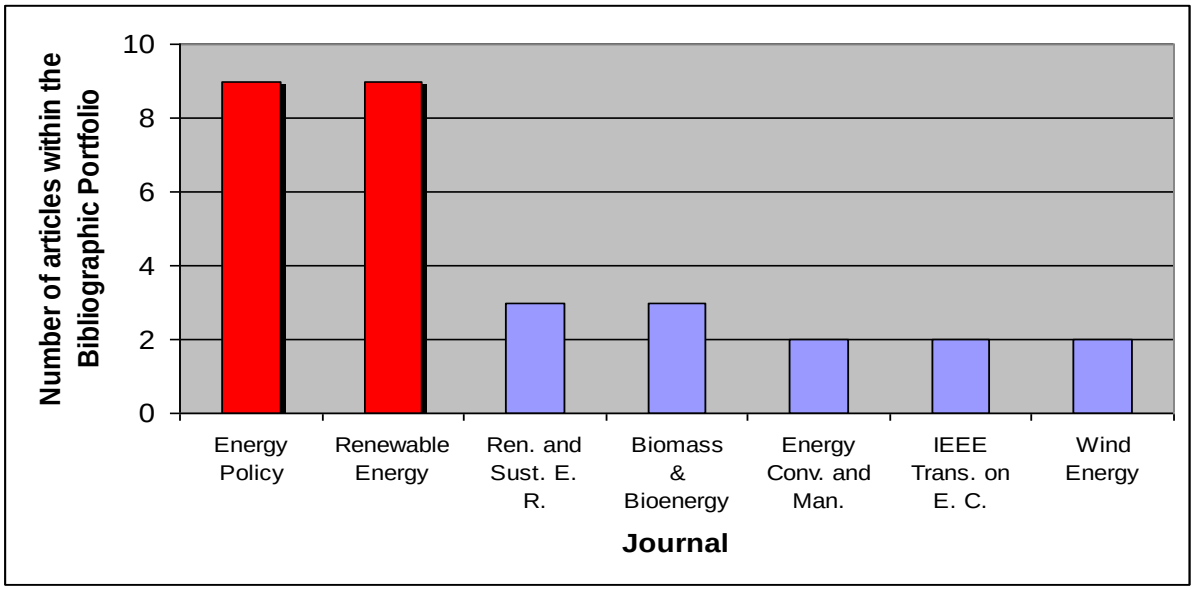

Chart 2: The number of publications per journal, showing only journals having more than 2 articles

4.3.2 Bibliometric analysis of the references of the selected articles

A scientific study is a result of a constructivist process, which the accumulation of knowledge supported by previous works, researches and personal experiences underpin it. The attainment of leading knowledge advancement is not made from the zero, there is always a background that explain the directions, the means and the obtained results.

In this sense, it is important to build a wider comprehension of the actual status of the Economics of Renewable Energy as presented on our portfolio. A good manner to do this is to analyse the references containing in each article. For this purpose, a bibliometric analysis is made on the references of all the articles of the Bibliographic Portfolio in order to create an overview of the groundwork culminating into the presented papers.

The bibliometric analysis of the references of the selected articles of the portfolio is drawn on the following points of observation: (i) the scientific reconnaissance; (ii) the relevance of journals and; (iii) the relevance of authors.

(i) the scientific reconnaissance, is evinced on chart 4.

The legendary work of Harry Markowitz with the "Portfolio Selection" has no less than 13,134 citations. It is the most impacting article from the references of the articles of the Bibliographic Portfolio. Together with the works of Lancaster, K. with the "A new approach to consumer theory" and Artzner et al with the "Coherent measures of risk" they represent together almost 50% of all scientific impact of the 353 articles containing within the bibliographic references of the Bibliographic Portfolio.

(ii) Relevance of journals, as illustrated on chart 5

Again the journals "Energy Policy" and "Renewable Energy" have the most number of articles. Also journals "Solar Energy" and "Energy" deserve attention as they have more than 30 articles each.

(iii) Relevance of authors, as evinced in chart 6

The chart 6 highlights author Henrik Lund as having the most number of articles within the bibliographic references of the Bibliographic Portfolio, at the same time he also is the author with most number of articles within the Bibliographic Portfolio as seen before.

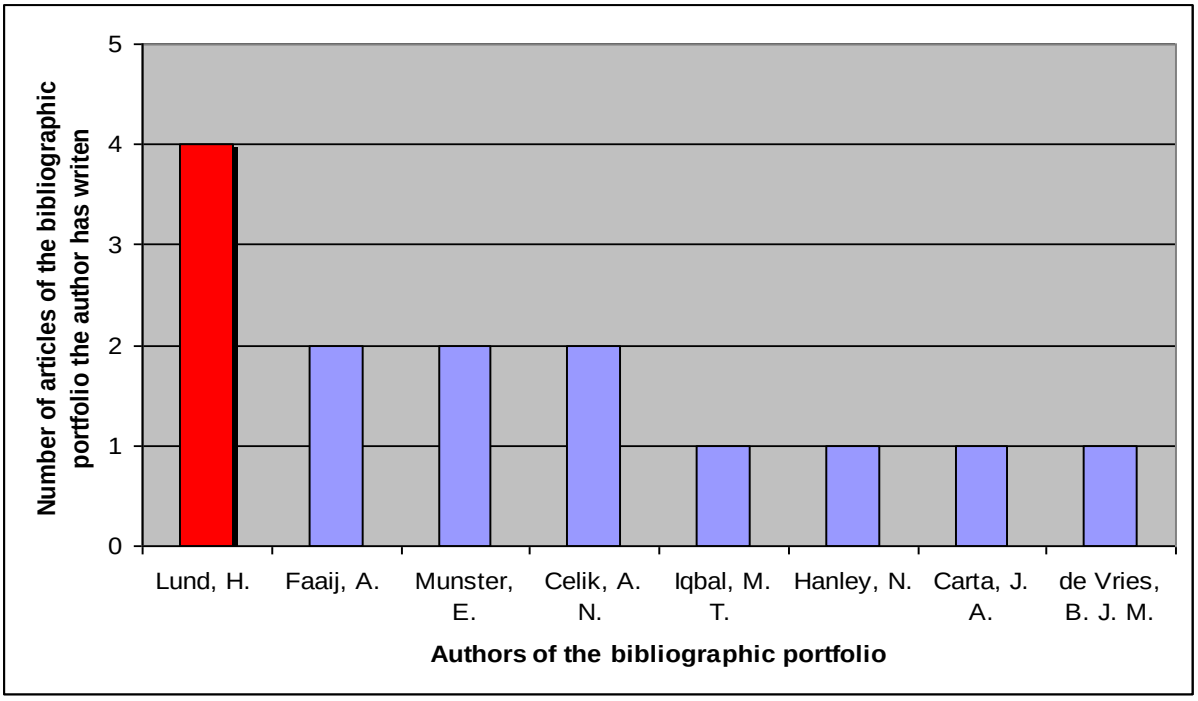

Chart 3: The number of articles per author within the bibliographic portfolio, showing only the 8 authors with most number of articles

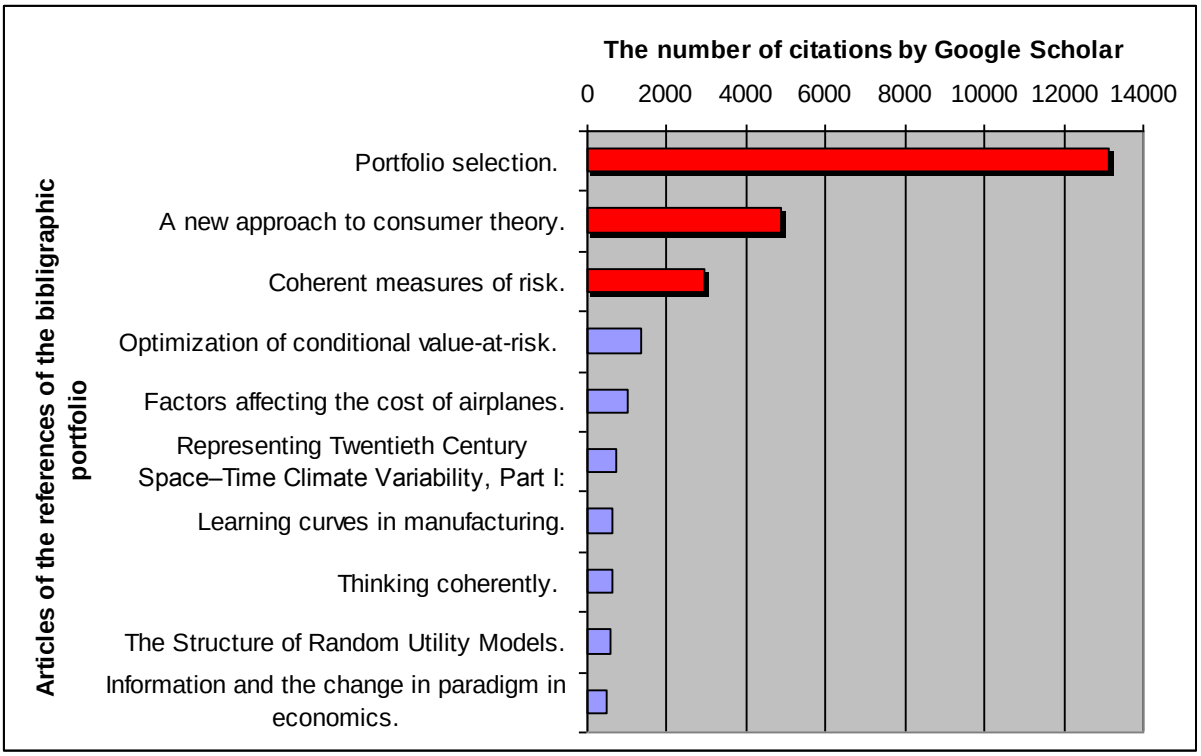

Chart 4: The number of citations for the articles within the references of the Bibliographic Portfolio, showing only the articles with more than 450 citations

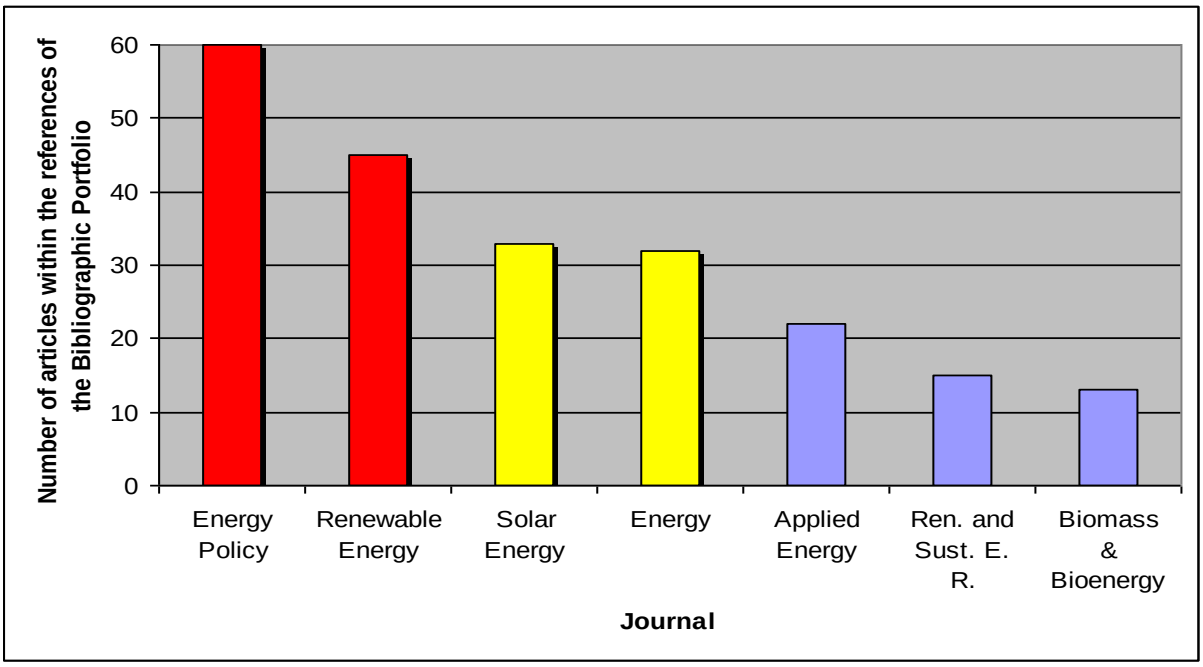

Chart 5: The number of publications per journal, showing only journals having more than 13 articles

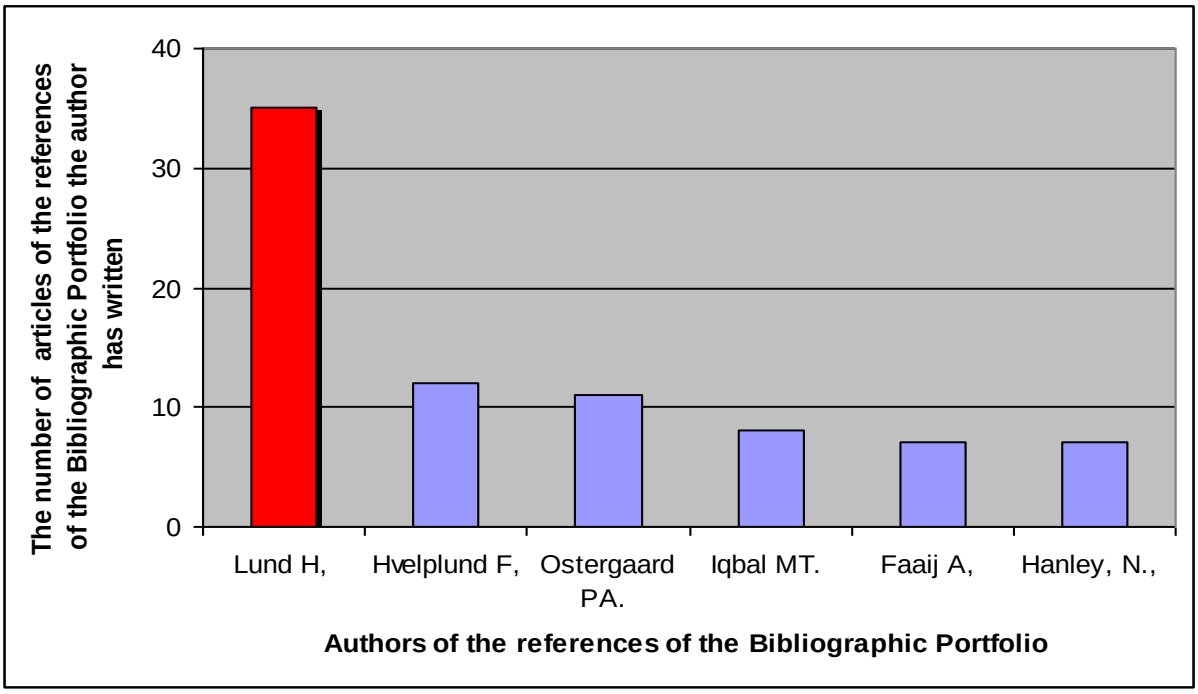

Chart 6: The number of articles per author within the references of the Bibliographic Portfolio, showing only the authors with more than 7 articles

5 Conclusions

The application of a novel approach for bibliographic selection permitted to establish a rich theoretical framework for the research of Economics of Renewable Energy, which contains 33 relevant articles with 1,875 academic citations in total. Much of the framework, 12 articles, regards to Wind Power signifying that it is the main subtopic of the portfolio, while 6 articles relates to Stand-Alone Systems, discussing the integration of different RE sources to a closed electric system. Biomass has 5 articles as well as Renewable Energy treated in general, papers mainly addressing the problem of the composition mix of RE in large-

scale systems. Completing the framework there are 3 articles for Solar Power, 1 article for Hydrogen and also 1 article for Distributed Electricity.

The article "The Hydrogen Economy" is the most impacting article from the bibliographic framework containing alone 183 citations. Also, it can be concluded that Mr. Nick Hanley is the author from the Bibliographic Portfolio with the most impacting work in all articles analysed as he has written the important article "Using the Choice Experiments to Value the Environment", which is listed on the references of the article from Muñoz et al, 2009 and has 351 citations on literature.

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