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Bibliometric Analysis of Recent Literature on Energy Generation Under Rankine Cycle

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Abstract : In this article, a bibliometric study was carried out on the research presented in the last decade on the Rankine cycle for the generation of energy through a gas-based power cycle. Tools such as HistCite were used to manage metadata, which included data such as authors' names, titles, abstracts, publication dates, document types, addresses and references cited. These data were analyzed and found results such as the significant increase in authors from 24 in the first year to a total of 438 in the last year. Another important outcome to mention is the country most cited in the study period. China with a total of 5887 citations led this measurement, thus achieving results to make visible the behavior of the studies conducted to the Rankine cycle.
Keywords : Rankine cycle, efficiency, energy, impact factor, bibliometrics, efficiency, energy.

1.Introduction

The exponential growth of the world population in recent decades[1], highlighting this phenomenon in developing countries has led to an increase in global energy demand[2]. This demand in turn leads researchers to direct their studies towards improving energy efficiency[3-7].One of the forms of generation is power cycles. For example, the Rankine cycle is one of these, which is why we have sought to optimize its economic and operational performance[8-11], combined with other technologies such as the use of a nitrogen expander to improve turbine efficiency by 72% 76.3%(10). In other research they have used different methods using solar waterfalls[12] and the combination with concentrated solar energy[13] where an additional heat source was introduced for the cycle to increase power production. Combined cooling, heating and power cycles have also been proposed for a regenerative Rankine cycle and an absorption cooling cycle[14]. In addition, it was demonstrated that the use of biomass as a renewable energy source in organic Rankine cycles can be used

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perfectly in various applications (heating, sanitary hot water, industrial drying processes, absorption cooling, etc.) and/or electrical and mechanical energy[15-18]. With the aim of making the most of the Rankine cycles, waste heat recovery has been treated[19-27], in other investigations, results were obtained about expansion valves for waste heat recovery showing low costs, low operating speeds and fluid capacity in two phases[28].

Innovative methods used in the Rankine cycle such as combining with a stand-alone refrigeration system seems to be a feasible option for exploiting thermal energy in places where electricity supply is unreliable[29]. It was observed that the application of waterfalls in a Rankine cycle is an option to improve the performance of this product[30-34].

The above described, added to the behavior shown, in which the per capita consumption of energy worldwide is observed between 1971 and 2014, shows that it is of vital importance to identify the contribution of different authors, institutions and countries in the advances presented in this important technology, since the Rankine cycle can be an alternative energy generation. An important method of evaluating the publications dealing with this topic is bibliometric analysis. These analyses show, for example, that for a review of energy research incorporated into buildings, the words life cycle assessment are the most commonly used keywords in 398 documents analysed[35], and in one on photovoltaic systems the most cited countries are the United States and the United Kingdom[36]. A similar study has also been carried out on the research on the incineration of waste in energy, where it can be seen that China produced 15.71% of all relevant articles, followed by Japan with 11.37% and the USA with 7.97% [37]. Also in China, the most important topics in terms of fuels were sodium oxide fuel cells, lithium-ion batteries and hydrogen[38]. This shows us the important data that can be obtained by doing this type of analysis.

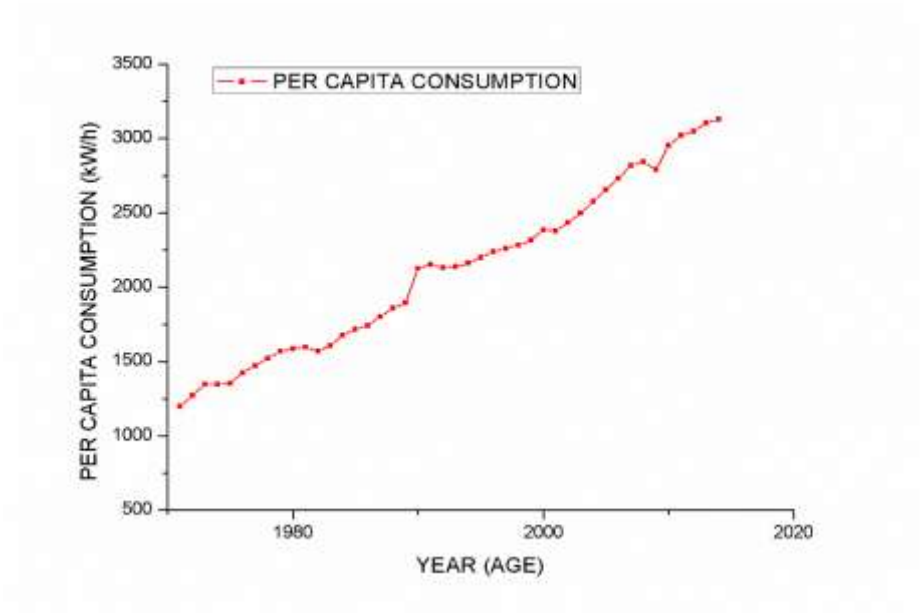

Figure 1 Per capita consumption in the world over the years.

The main contribution of this work is directed towards the qualitative and quantitative evaluation of world trends focused on the development of Rankine cycles, reviewing documents in the periods shared between 2007 and 2017. By doing a bibliometric review based on the metadata found on this topic in that period of time, the HistCite tool was also used to process the data found.

2. Materials and Methods

In the data collection method, the search phrase "Rankine cycle" was used to search titles and keywords between 2007 and 2017. This search was done using the WOS search engine, from which all metadata were obtained. This search yielded 843 papers including authors' names, titles, abstracts, publication dates, types of papers, addresses and references cited. Territories were treated as countries, similarly, the contributions of

different organizations were determined by the authors' addresses and uncooperative research publications were applied when the authors' addresses came from the same research organization.

These documents were evaluated taking into account the types of documents, languages, thematic categories, journals, countries, research organizations, titles, author keywords and other keywords, H index and impact factor.

The impact factor of each of the main journals involved in the study was consulted. For this purpose, we searched for information in the editorial to which each journal is subscribed and took the data of the impact factor for both 2016 and the last 5 years. In addition, we consulted Scimago and took the data from the H index which helps us with the quality measurement of the most published journals, this data will help us to dazzle therefore the quality and reliability of publications.

3. Results and Discussion

Los 843 documentos relacionados con el ciclo Rankine publicados en la última década se categorizaron en 5 tipo. El 92.4% fueron artículos, el4.27% fueron artículos del procedimiento, el 2.49% fueron review, el 0.47% fueron correcciones y el 0.35% fueron materiales de editorial.

Research publications in the Rankine cycle show an increase over the years, showing a growth very similar to an exponential one, reaching its highest peak in 2015 as shown in **Error! Reference source not found.**.

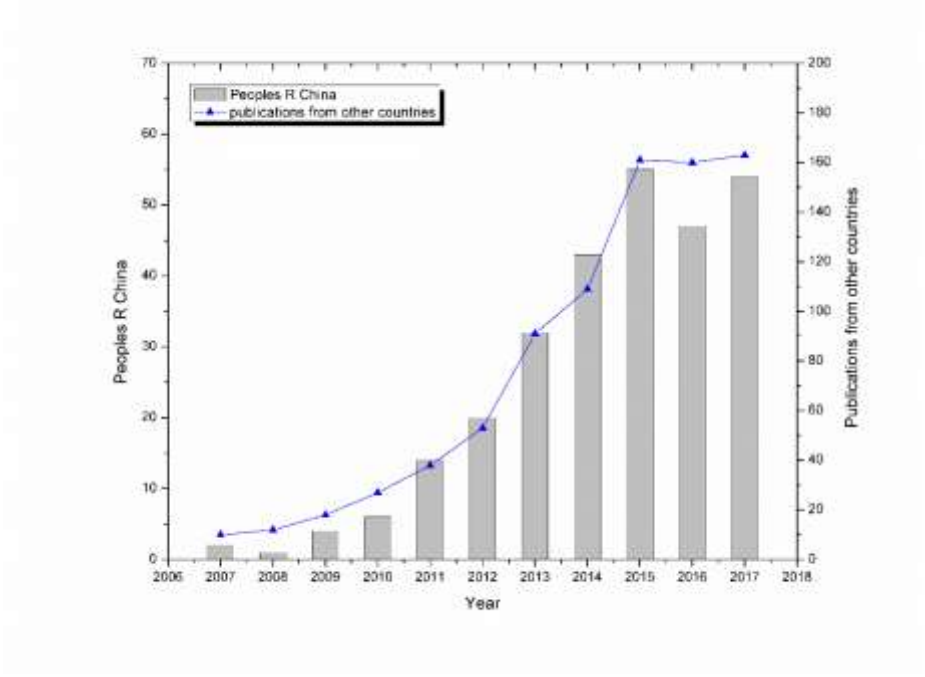

Figure 2 Number of publications per year.

This behavior exposes how at the beginning of the research period only 10 articles were presented and only 24 authors worked on this topic. At the end of the decade of study, the number of publications increased significantly to 163 publications, the authors reached 438 as shown in **Error! Reference source not found.**, which also reflects the increase in the number of citations on the subject until 2013, after this year is observed a decrease in the global and local number of citations.

Table1Characteristics of the publications.

Publicación Year	Record	TLCS	TGCS	Number Authors
2007	10	387	1163	24
2008	12	121	422	34
2009	18	643	1690	43
2010	27	551	1600	61
2011	38	809	1954	105
2012	53	741	1787	156
2013	91	1159	2934	264
2014	109	784	1850	319
2015	161	807	1917	436
2016	160	286	882	433
2017	163	59	212	438

In **Error! Reference source not found.**. The behavior of the publications in the different journals was observed, in this one the impact factor of each journal was added in 2016. The percentage shown is based on a total of 591 publications that are those published by the 9 journals included. On the other hand, the biggest impact factor does not coincide with the magazine that publishes a little bit about the quality of these publications, in the same way that the highest h-Index has the lowest percentage in the list.

Table 2 Top 9 magazines with the highest production between 2007 and 2017

Journal	TP	Porcent	R	If (2016)	If 5-Year	h-Index
ENERGY	173	29,2724196	1	4,52	5,182	134
APPLIED THERMAL ENGINEERING	115	19,4585448	2	3,356	3,634	112
ENERGY CONVERSION AND MANAGEMENT	106	17,9357022	3	5,589	5,472	139
APPLIED ENERGY	70	11,8443316	4	7,182	7,5	125
ENERGIES	49	8,29103215	5	2,262	2,707	47
JOURNAL OF ENGINEERING FOR GAS TURBINES AND POWER	26	4,39932318	6	1,534	NA	66
RENEWABLE ENERGY	23	3,89170897	7	4,357	4,825	134
INTERNATIONAL JOURNAL OF ENERGY RESEARCH	15	2,53807107	8	2,598	NA	69
RENEWABLE & SUSTAINABLE ENERGY REVIEWS	14	2,36886633	9	8,05	9,122	176

As far as countries are concerned, the majority of articles come from China and in most of the years they have more publications, always followed by USA, UK, Italy and Iran. As for citations, the overall total of citations (TGCS) and the local total (TLCS) in most cases is proportional to the number of publications except UK and Iran where these results are lower. **Error! Reference source not found.** shows that in the year 2015 China contributed 40% of the production of articles only being surpassed by the year 2016 where its contribution was 48.27% showing that it is an important focus of research on the subject.

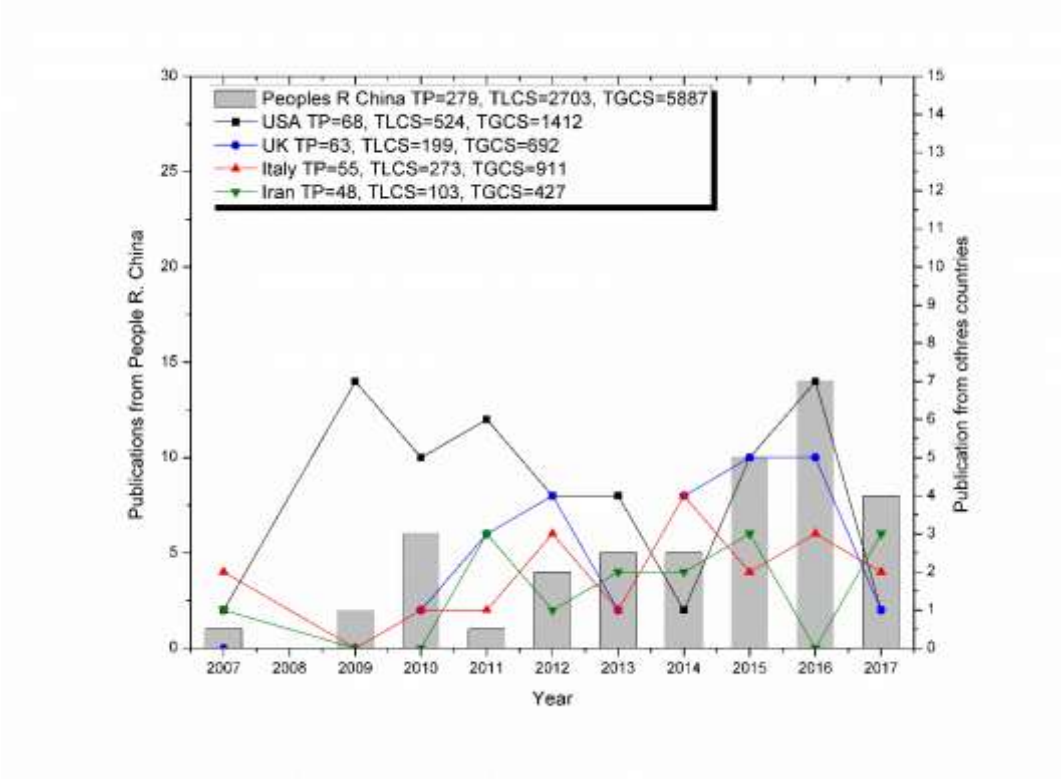

Figure 3 Annual country publications.

Error! Reference source not found. Publications in journals per year shows results by reference to the behavior of journals that publish on the subject. In general, as in the rest of the results, there is an increase as the years go by, being Energy the magazine that I publish most, showing a peak of publications in the year 2015 where I contribute 45.28% of the articles. In addition, this magazine is second in the list of h-Index being surpassed only by Energy Conversion And Management with a value of 139 against 134 Energy, showing a high reliability and credibility of the publications on the subject being analyzed. Energy Conversion And Management is also the fastest-growing magazine in publications reflecting this in 2014 to 2017, with 2015 being the fastest growing year with 47.36%. The trend continued in all the years except for 2011, when the number of articles decreased from 3 publications to only one, this behavior attracted a lot of attention.

Likewise, the Energy magazine in 2008 where it did not publish any publications on the subject and in general only 4 articles were published, where only Applied Thermal Engineering and Applied Energy contributed with 3 and one article respectively.

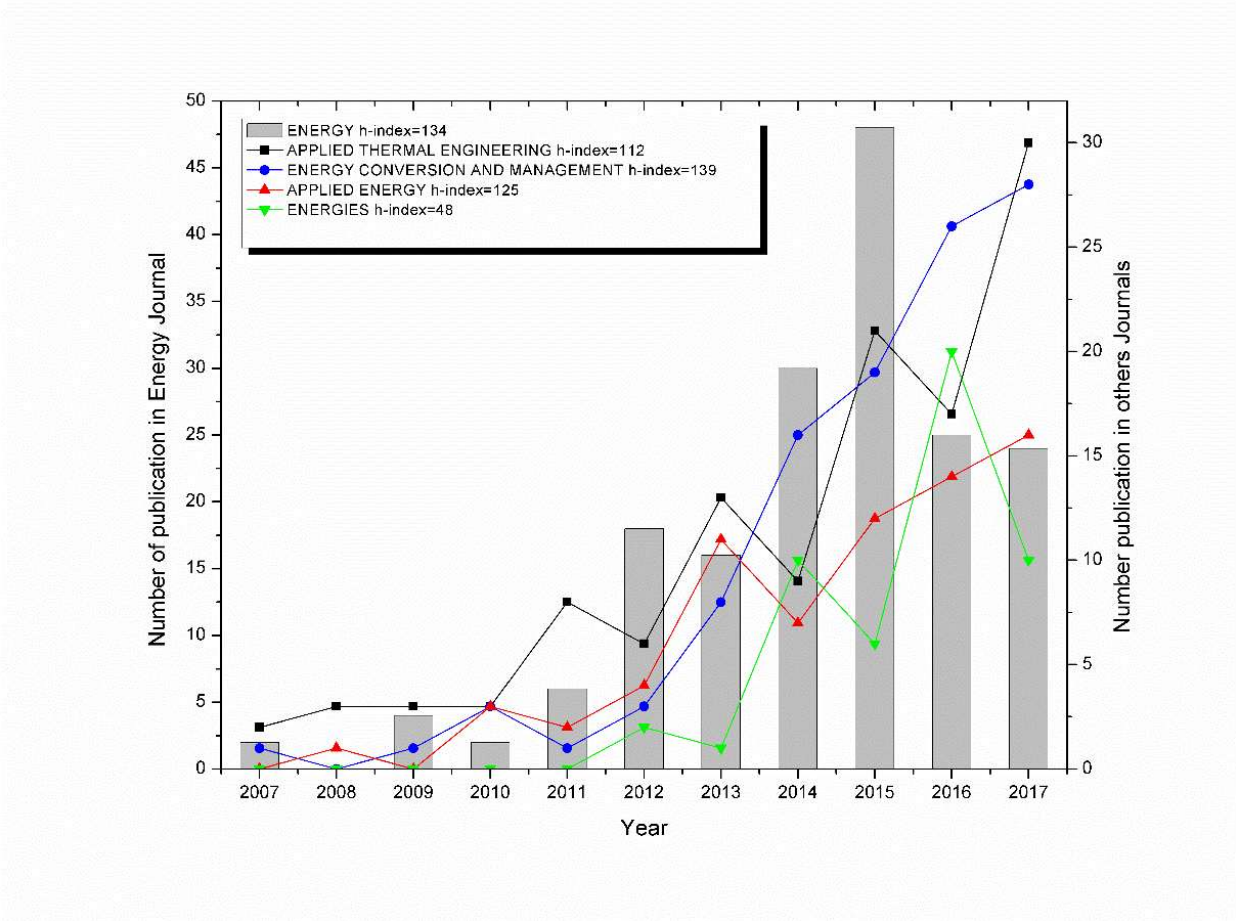

Figure 4 Publications in journals per year.

As for institutions, initially those that had more contributions in the time of study did not present any publication, only until 2009 began to present activity in the institutions shown in **Error! Reference source not found.**. In the year 2010 Tianjin University of China presented 4 publications, after this year it always kept leading only being equalized in 2013 by Xi An Jiao Tong University also from China. This institution was the first of its kind to appear in the time frame studied.

Tianjin University presented its highest performance in 2017, publishing a total of 17 articles throughout the year. And its greatest contribution in the total number of publications was in 2016, where it contributed 51.85% of the publications. Another important indicator that dominates this institution are the total global citations with a number of 763 citations showing not only that it is important in number of publications but also demonstrate quality by being constantly cited for articles that touch on this topic.

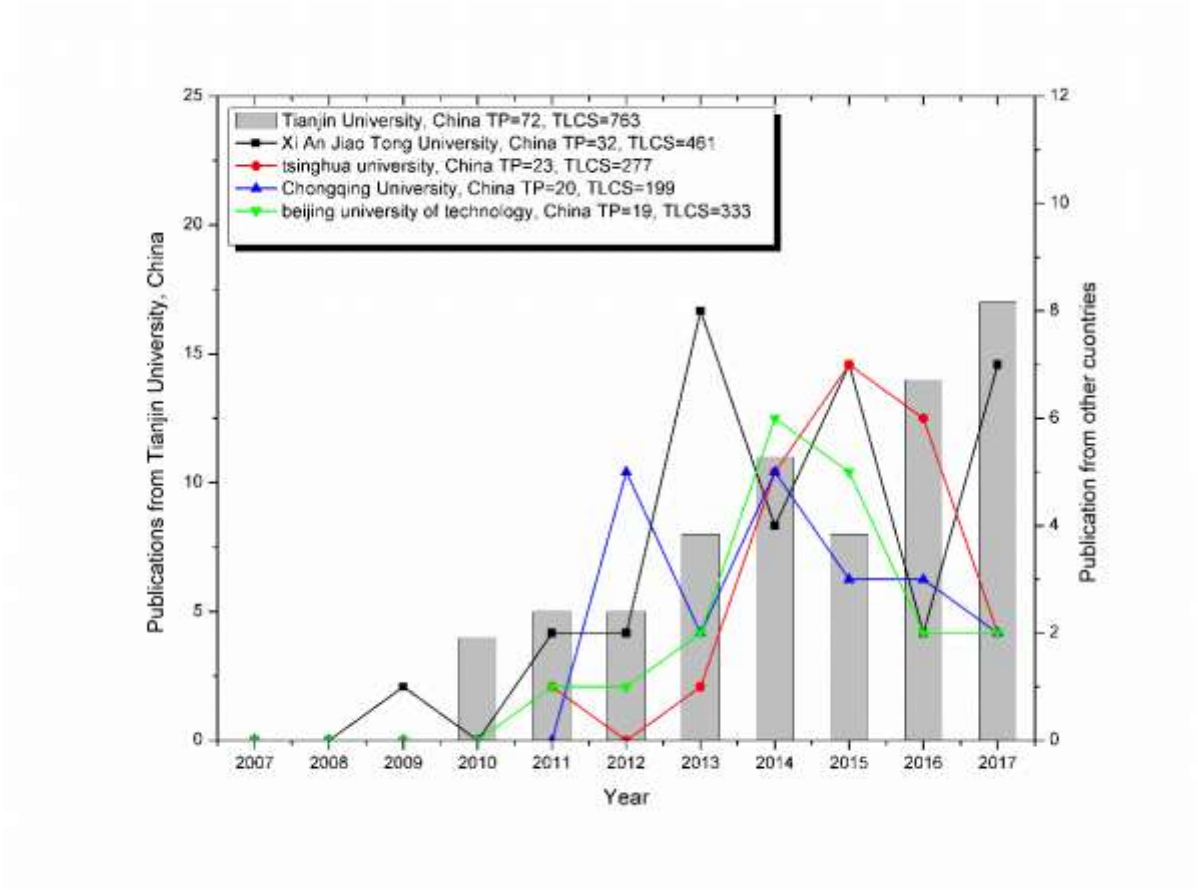

Figure 5 Institutions' publications by year.

4. Conclusion

Finally, it can be concluded that research on the Rankine cycle is increasing in both quantity and quality of publications. This increase is due to the global needs for energy generation.

China is the country with the highest number of citations in its work duplicating the USA in this item being also the first in research on the subject, exceeding more than 4 times the publications made by the USA. These results speak very clearly about the quality of the work presented by China and the significant impact that its work has on the world.

On the other hand, the high number of studies presented by China can be explained by the large population present in this country which has a direct impact on the increasing energy needs. This sparks the interest of researchers in the study seeking a positive impact for Chinese society.

References

1. G. F. Mulligan and J. P. Crampton, “Population growth in the world’s largest cities,” Cities, vol. 22, no. 5, pp. 365–380, Oct. 2005.
2. B. Mundial, “Consumo Energetico Per Capita,” 2017.
3. H. Du, L. Wei, M. A. Brown, Y. Wang, and Z. Shi, “A bibliometric analysis of recent energy efficiency literatures: An expanding and shifting focus,” Energy Effic., vol. 6, no. 1, pp. 177–190, 2013.
4. M. A. Ehyaei et al., “Potential use of cold thermal energy storage systems for better efficiency and cost effectiveness,” Energy Build., vol. 42, no. 12, pp. 2296–2303, 2010.
5. K. E. N’Tsoukpoe, T. Osterland, O. Opel, and W. K. L. Ruck, “Cascade thermochemical storage with internal condensation heat recovery for better energy and exergy efficiencies,” Appl. Energy, vol. 181, pp. 562–574, 2016.

6. V. Letschert, L. B. Desroches, J. Ke, and M. McNeil, "Energy efficiency - How far can we raise the bar? Revealing the potential of best available technologies," Energy, vol. 59, pp. 72–82, 2013.
7. X. Shi, "Setting effective mandatory energy efficiency standards and labelling regulations: A review of best practices in the Asia Pacific region," Appl. Energy, vol. 133, pp. 135–143, 2014.
8. H. Xi, M. J. Li, Y. L. He, and Y. W. Zhang, "Economical evaluation and optimization of organic Rankine cycle with mixture working fluids using R245fa as flame retardant," Appl. Therm. Eng., vol. 113, pp. 1056–1070, Feb. 2017.
9. Y. R. Li, M. T. Du, C. M. Wu, S. Y. Wu, C. Liu, and J. L. Xu, "Economical evaluation and optimization of subcritical organic Rankine cycle based on temperature matching analysis," Energy, vol. 68, pp. 238–247, Apr. 2014.
10. K. M. Khalil, S. Mahmoud, R. K. Al-Dadah, and A. B. Ennil, "Investigate a hybrid open-Rankine cycle small-scale axial nitrogen expander by a camber line control point parameterization optimization technique," Appl. Therm. Eng., vol. 127, pp. 823–836, Dec. 2017.
11. H. Yu, J. Eason, L. T. Biegler, and X. Feng, "Process integration and superstructure optimization of Organic Rankine Cycles (ORCs) with heat exchanger network synthesis," Comput. Chem. Eng., vol. 107, pp. 257–270, Dec. 2017.
12. P. Li et al., "Modeling and optimization of solar-powered cascade Rankine cycle system with respect to the characteristics of steam screw expander," Renew. Energy, vol. 112, pp. 398–412, Nov. 2017.
13. M. Astolfi, L. Xodo, M. C. Romano, and E. Macchi, "Technical and economical analysis of a solar-geothermal hybrid plant based on an Organic Rankine Cycle," Geothermics, vol. 40, no. 1, pp. 58–68, Mar. 2011.
14. S. Anvari, H. Taghavifar, and A. Parvishi, "Thermo- economical consideration of Regenerative organic Rankine cycle coupling with the absorption chiller systems incorporated in the trigeneration system," Energy Convers. Manag., vol. 148, pp. 317–329, Sep. 2017.
15. F. Vélez, J. J. Segovia, M. C. Martín, G. Antolín, F. Chejne, and A. Quijano, "A technical, economical and market review of organic Rankine cycles for the conversion of low-grade heat for power generation," Renew. Sustain. Energy Rev., vol. 16, no. 6, pp. 4175–4189, Aug. 2012.
16. M. Uris, J. I. Linares, and E. Arenas, "Techno-economic feasibility assessment of a biomass cogeneration plant based on an Organic Rankine Cycle," Renew. Energy, vol. 66, pp. 707–713, Jun. 2014.
17. M. Jradi and S. Riffat, "Experimental investigation of a biomass-fuelled micro-scale tri-generation system with an organic Rankine cycle and liquid desiccant cooling unit," Energy, vol. 71, pp. 80–93, Jul. 2014.
18. M. Uris, J. I. Linares, and E. Arenas, "Feasibility assessment of an Organic Rankine Cycle (ORC) cogeneration plant (CHP/CCHP) fueled by biomass for a district network in mainland Spain," Energy, vol. 133, pp. 969–985, Aug. 2017.
19. F. Yang, H. Cho, H. Zhang, and J. Zhang, "Thermoeconomic multi-objective optimization of a dual loop organic Rankine cycle (ORC) for CNG engine waste heat recovery," Appl. Energy, vol. 205, pp. 1100–1118, Nov. 2017.
20. V. Chintala, S. Kumar, and J. K. Pandey, "A technical review on waste heat recovery from compression ignition engines using organic Rankine cycle," Renew. Sustain. Energy Rev., vol. 81, pp. 493–509, Jan. 2018.
21. A. Ahmed, K. Khodary Esmaeil, M. A. Irfan, and F. Abdulrahman Al-Mufadi, "Design Methodology of Organic Rankine Cycle for Waste Heat Recovery in Cement Plants," Appl. Therm. Eng., vol. 129, pp. 421–430, Jan. 2017.
22. X. Hou, H. Zhang, F. Yu, H. Liu, F. Yang, and Y. Xu, "Free piston expander-linear generator used for organic Rankine cycle waste heat recovery system," Appl. Energy, vol. 208, no. 100, pp. 0–1, Dec. 2017.
23. B. Dong, G. Xu, T. Li, X. Luo, and Y. Quan, "Parametric analysis of organic Rankine cycle based on a radial turbine for low-grade waste heat recovery," Appl. Therm. Eng., vol. 126, pp. 470–479, 2017.
24. S. Seyedkavoosi, S. Javan, and K. Kota, "Exergy-based optimization of an organic Rankine cycle (ORC) for waste heat recovery from an internal combustion engine (ICE)," Appl. Therm. Eng., vol. 126, pp. 447–457, 2017.
25. M. Preißinger, J. A. H. Schwöbel, A. Klamt, and D. Brüggemann, "Multi-criteria evaluation of several million working fluids for waste heat recovery by means of Organic Rankine Cycle in passenger cars

and heavy- duty trucks," Appl. Energy, vol. 206, no. July, pp. 887–899, 2017.
26. M. H. Yang, R. H. Yeh, and T. C. Hung, "Thermo-economic analysis of the transcritical organic Rankine cycle using R1234yf/R32 mixtures as the working fluids for lower-grade waste heat recovery," Energy, vol. 140, pp. 818–836, 2017.
27. D. Budisulistyo and S. Krumdieck, "A novel design methodology for waste heat recovery systems using organic Rankine cycle," Energy Convers. Manag., vol. 142, pp. 1–12, 2017.
28. M. Imran, M. Usman, B. S. Park, and D. H. Lee, "Volumetric expanders for low grade heat and waste heat recovery applications," Renew. Sustain. Energy Rev., vol. 57, pp. 1090–1109, May 2016.
29. "Parametric study of a novel organic Rankine cycle combined with a cascade refrigeration cycle (ORC-CRS) using natural refrigerants," Appl. Therm. Eng., vol. 127, pp. 378–389, Dec. 2017.
30. T. Chen, W. Zhuge, Y. Zhang, and L. Zhang, "A novel cascade organic Rankine cycle (ORC) system for waste heat recovery of truck diesel engines," Energy Convers. Manag., vol. 138, pp. 210–223, Apr. 2017.
31. G. Shu, G. Yu, H. Tian, H. Wei, X. Liang, and Z. Huang, "Multi-approach evaluations of a cascade-Organic Rankine Cycle (C-ORC) system driven by diesel engine waste heat: Part A – Thermodynamic evaluations," Energy Convers. Manag., vol. 108, pp. 579–595, Jan. 2016.
32. K. Kim, U. Lee, C. Kim, and C. Han, "Design and optimization of cascade organic Rankine cycle for recovering cryogenic energy from liquefied natural gas using binary working fluid," Energy, vol. 88, pp. 304–313, Aug. 2015.
33. G. Yu, G. Shu, H. Tian, Y. Huo, and W. Zhu, "Experimental investigations on a cascaded steam-/organic-Rankine-cycle (RC/ORC) system for waste heat recovery (WHR) from diesel engine," Energy Convers. Manag., vol. 129, pp. 43–51, 2016.
34. P. Li, J. Li, G. Pei, and J. Ji, "A cascade organic Rankine cycle power generation system using hybrid solar energy and liquefied natural gas," Sol. Energy, vol. 127, pp. 136–146, 2016.
35. R. Zeng and A. Chini, "A review of research on embodied energy of buildings using bibliometric analysis," Energy Build., vol. 155, pp. 172–184, Nov. 2017.
36. I. S. Yulineth Cardenas, Guillermo Valencia, "Análisis cienciométrico de la investigación de sistemas fotovoltaicos integrados a edificios desde el año 2000 a 2017," Rev. Espac., vol. 38 (N° 47), pp. 1–12, 2017.
37. Y. Wang, N. Lai, J. Zuo, G. Chen, and H. Du, "Characteristics and trends of research on waste-to-energy incineration: A bibliometric analysis, 1999–2015," Renew. Sustain. Energy Rev., vol. 66, pp. 95–104, Dec. 2016.
38. H. Q. Chen et al., "Chinese energy and fuels research priorities and trend: A bibliometric analysis," Renew. Sustain. Energy Rev., vol. 58, pp. 966–975, May 2016.

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