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Research Article

The Sustainable Development Goals, Sustainability and Clean Energy in Africa: A Review from the Perspective of Theory and Practice

Afrika'da Sürdürülebilir Kalkınma Hedefleri, Sürdürülebilirlik ve Temiz Enerji: Teori ve Uygulama Perspektifinden Bir İnceleme

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Abstract

This study examines the issue of access to clean and affordable energy in the context of the Sustainable Development Goals in Africa. Although Africa is rich in renewable energy resources, much of the continent still lacks access to electricity and clean cooking technologies. This situation is a major obstacle to the continent's economic development, education, health and social equality. The research examined 337 scientific studies in detail by searching the Web of Science (WoS) and Scopus databases using the keywords 'Africa' and 'energy', and analysed them using CiteSpace scientific mapping software. The results show that micro-grids, solar and wind energy, energy financing and regional policy harmonisation are critical. Strengthening international financing mechanisms, increasing public-private partnerships and supporting community-based energy projects are required for a clean energy transformation in Africa. This study provides a theoretical and practical projection of Africa's energy future, and the recommendations outlined above could accelerate the transition to sustainable energy in Africa. Addressing financing constraints, policy misalignment, and technology adaptation is critical to advancing energy transformation in the region. These literature-based recommendations can help bridge the gap between theoretical research and practical implementation.

Keywords: *Energy, Africa, Sustainability, Sustainable Development, CiteSpace*

Öz

Bu çalışma, Afrika'da sürdürülebilir kalkınma amaçları kapsamında temiz ve erişilebilir enerjiye erişim konusunu incelemektedir. Afrika, zengin yenilenebilir enerji kaynaklarına sahip olmasına rağmen, büyük bir kısmı hala elektrik ve temiz pişirme teknolojilerine erişimden yoksundur. Bu durum, kıtanın ekonomik kalkınması, eğitim, sağlık ve toplumsal eşitlik gibi alanlarda büyük engeller oluşturmaktadır.

Araştırmada, Web of Science (WoS) ve Scopus veri tabanlarında "Africa" ve "Energy" anahtar kelimeleriyle yapılan taramalar sonucu 337 bilimsel çalışma detaylı olarak incelenmiş, CiteSpace bilimsel haritalama programı kullanılarak analiz edilmiştir. Bulgular, mikro şebeke sistemleri, güneş ve rüzgar enerjisi kullanımı, enerji finansmanı ve bölgesel politika uyumlarının kritik öneme sahip olduğunu göstermektedir.Afrika'da temiz enerji dönüşümü için uluslararası finansman mekanizmalarının güçlendirilmesi, kamu-özel ortaklıkların artırılması ve topluluk bazlı enerji projelerinin desteklenmesi gerekmektedir. Bu çalışma, Afrika'nın enerji geleceğine dair teorik ve uygulamalı bir projeksiyon sunmaktadır.

Anahtar Kelimeler: *Enerji, Afrika, Sürdürülebilirlik, Sürdürülebilir Kalkınma, CiteSpace*

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1. Introduction

In line with the United Nations' 2030 Agenda for Sustainable Development and the African Union's Agenda 2063, ensuring access to energy is essential for the African continent to achieve its development goals. Access to electricity and clean energy is recognised as a foundational element that directly impacts numerous sustainable development goals, including education, health, gender equality, and economic growth (UN, 2023), and is not limited to the energy sector alone. As of 2023, around 750 million people worldwide still lack access to electricity. Over 80% of this group lives in sub-Saharan Africa (International Energy Agency (IEA, 2023a). The situation is even more critical in rural areas, where the electricity access rate is only 30%, compared to 81% in urban areas (World Bank, 2023a). Furthermore, around 1 billion people in the region still lack access to clean cooking fuels, which poses serious risks to public health and environmental sustainability (IEA, 2023b). The African continent boasts an enormous renewable energy potential, particularly with regard to solar, wind and hydroelectric resources. However, significant investment is needed to realise this potential. Currently, despite accounting for around 20% of the global population, Africa receives just 2% of worldwide renewable energy investment (Time, 2023). In order to develop the continent's energy infrastructure and achieve sustainable energy goals, it is estimated that approximately 25 billion US dollars will be needed in annual investments by 2030 (IEA, 2023a). Access to energy is a key part of Africa's sustainable development process. Achieving Sustainable Development Goal 7 (SDG7) will have a positive impact on many areas, including poverty reduction and gender equality, across the continent. However, these goals cannot be achieved without the implementation of comprehensive policies backed by financial support from donor countries and multilateral development organisations, as well as theoretical solutions. In this study, it is aimed to present the projection of accessible and clean energy target for the African region in terms of theoretical and applied studies within the scope of sustainable development goals. For this purpose, academic studies on energy for the African region and published in journals scanned in the Web Of Science database were analysed in detail.

2. Methodology

The methodological process regarding the research process related to the purpose of the study is shown in

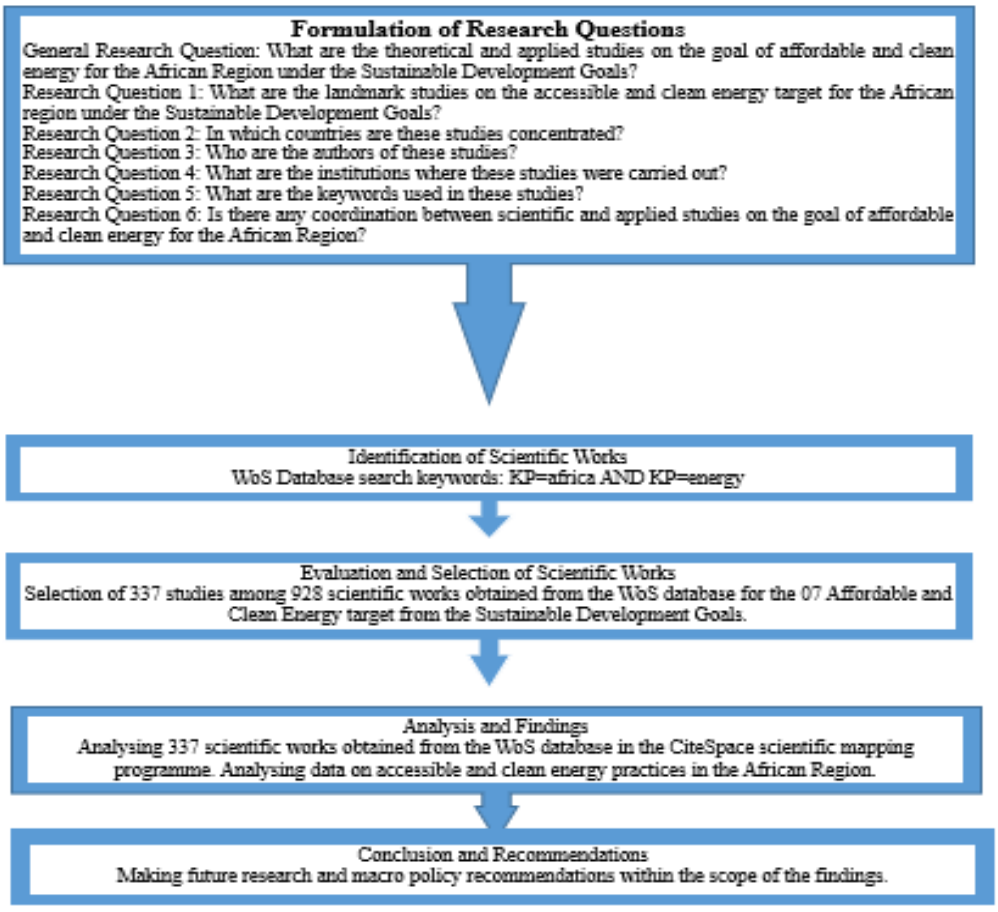


Figure 1: Methodological Process of the Research

As a result of the search in the WoS database on 02/09/2024 by typing the keywords 'KP=africa AND KP=energy' in the advanced search section, 928 scientific works published between 1991-2024 were accessed. Among the scientific works accessed, 889 of them are articles. When the scientific works are analysed on the basis of science field categories, the first 5 science categories with the highest number of publications can be listed as Energy Fuels (305 publications), Environmental Sciences (246 publications), Green Sustainable Science Technology (200 publications), Environmental Studies (162 publications) and Economics (104 publications). The United States (148 publications), the United Kingdom (136 publications), the People's Republic of China (128 publications), South Africa (116 publications) and Germany (93 publications) are the top five countries with the highest number of studies on accessible and clean energy for the African region in the context of sustainable development. The distribution of scientific works published in the journals scanned in the WoS bibliographic database in the field of sustainable development goals is shown Table 1:

Table 1: Number of Publications Involving Sustainable Development Goals

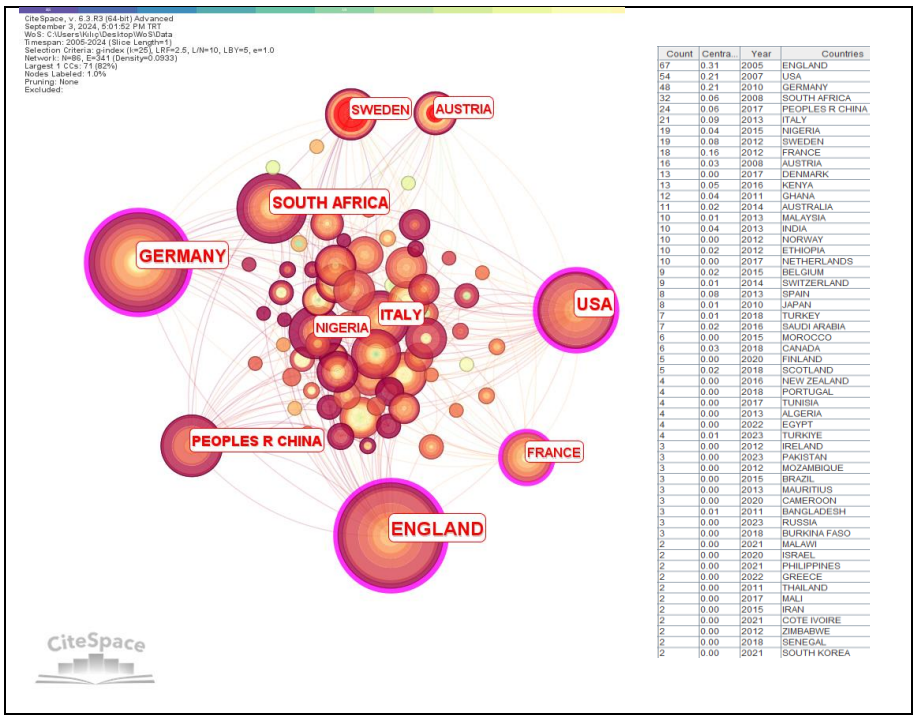
Sustainable Development Goals	Number of Publications
07 Affordable And Clean Energy	337
13 Clımate Actıon	320
15 Lıfe On Land	99
03 Good Health And Well Beıng	76
01 No Poverty	61
11 Sustaınable Cıtıes And Communıtıes	48
12 Responsıble Consumptıon And Productıon	47
06 Clean Water And Sanıtatıon	40
08 Decent Work And Economıc Growth	23
02 Zero Hunger	22
10 Reduced Inequalıty	21
14 Lıfe Below Water	20
09 Industry Innovatıon And Infrastructure	17
05 Gender Equalıty	2
16 Peace And Justıce Strong Instıtutıons	2
04 Qualıty Educatıon	1

It can be said that academic studies involving the African region on energy are concentrated in the field of accessible and clean energy and sustainable development goals expressed as climate action. In accordance with the purpose of the study, 337 scientific works on sustainable development goals on the basis of accessible and clean energy involving the African region have been analysed in detail with the help of CiteSpace scientific mapping programme and the results of the analysis are given in the following section.

2.1.CiteSpace Image Map: WoS dataset

CiteSpace is a programme that provides visual maps of the intellectual development processes of scientific works on the basis of sub-disciplines. The programme depicts scientific works according to their co-citation performance in the visualisation process. The network analysis obtained based on the co-citation performance of scientific works allows a detailed analysis of the most studied topics in a particular field of science, the authors with the highest number of co-citations, the institutions and countries where these authors are located, and the keywords used in publications. hus, it is possible to obtain a wide range of information on the intellectual development process of the researched field of science. The country, author, keyword and

institution-based analysis of 337 scientific works published in journals indexed in the WoS bibliographic database within the scope of the sustainable development goal on accessible and clean energy involving the African region, covering the years 2005-2024, is summarised in the images below:

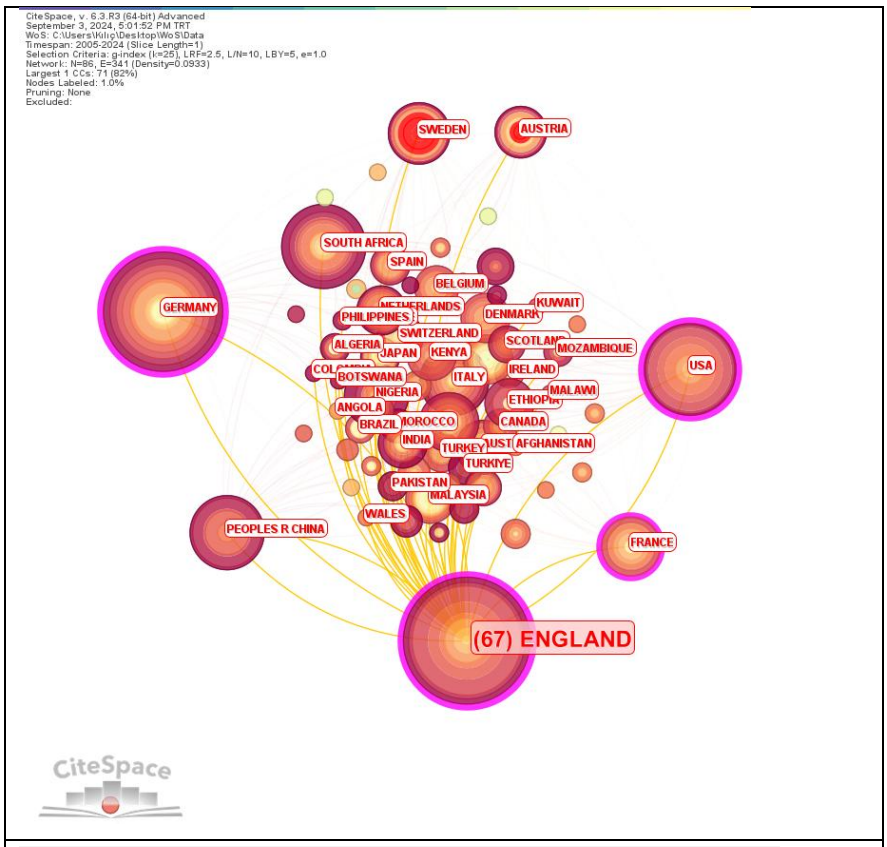


Count	Centra...	Year	Countries
67	0.31	2005	ENGLAND
54	0.21	2007	USA
48	0.21	2010	GERMANY
32	0.06	2008	SOUTH AFRICA
24	0.06	2017	PEOPLES R CHINA
21	0.09	2013	ITALY
19	0.04	2015	NIGERIA
19	0.08	2012	SWEDEN
18	0.16	2012	FRANCE
16	0.03	2008	AUSTRIA
13	0.00	2017	DENMARK
13	0.05	2016	KENYA
12	0.04	2011	GHANA
11	0.02	2014	AUSTRALIA
10	0.01	2013	MALAYSIA
10	0.04	2013	INDIA
10	0.00	2012	NORWAY
10	0.02	2012	ETHIOPIA
10	0.00	2017	NETHERLANDS
9	0.02	2015	BELGIUM
9	0.01	2014	SWITZERLAND
8	0.08	2013	SPAIN
8	0.01	2010	JAPAN
7	0.01	2018	TURKEY
7	0.02	2016	SAUDI ARABIA
6	0.00	2015	MOROCCO
6	0.03	2018	CANADA
5	0.00	2020	FINLAND
5	0.02	2018	SCOTLAND
4	0.00	2016	NEW ZEALAND
4	0.00	2018	PORTUGAL
4	0.00	2017	TUNISIA
4	0.00	2013	ALGERIA
4	0.00	2022	EGYPT
4	0.01	2023	TURKIYE
3	0.00	2012	IRELAND
3	0.00	2023	PAKISTAN
3	0.00	2012	MOZAMBIQUE
3	0.00	2015	BRAZIL
3	0.00	2013	MAURITIUS
3	0.00	2020	CAMEROON
3	0.01	2011	BANGLADESH
3	0.00	2023	RUSSIA
3	0.00	2018	BURKINA FASO
2	0.00	2021	MALAWI
2	0.00	2020	ISRAEL
2	0.00	2021	PHILIPPINES
2	0.00	2022	GREECE
2	0.00	2011	THAILAND
2	0.00	2017	MALI
2	0.00	2015	IRAN
2	0.00	2021	COTE IVOIRE
2	0.00	2012	ZIMBABWE
2	0.00	2018	SENEGAL
2	0.00	2021	SOUTH KOREA

Figure 2: Country Network Analysis

Source: CiteSpace 6.3 R3, 2024.

When Figure 2 is analysed, it can be said that there are 86 countries in which 337 publications on accessible and clean energy, including the African region, have been published and 341 co-citation networks between publications in these countries. The top three countries with the highest number of publications are the UK (67 publications), the USA (54 publications) and Germany (48 publications). The network analysis of 67 publications published in the UK is given in Figure 3.



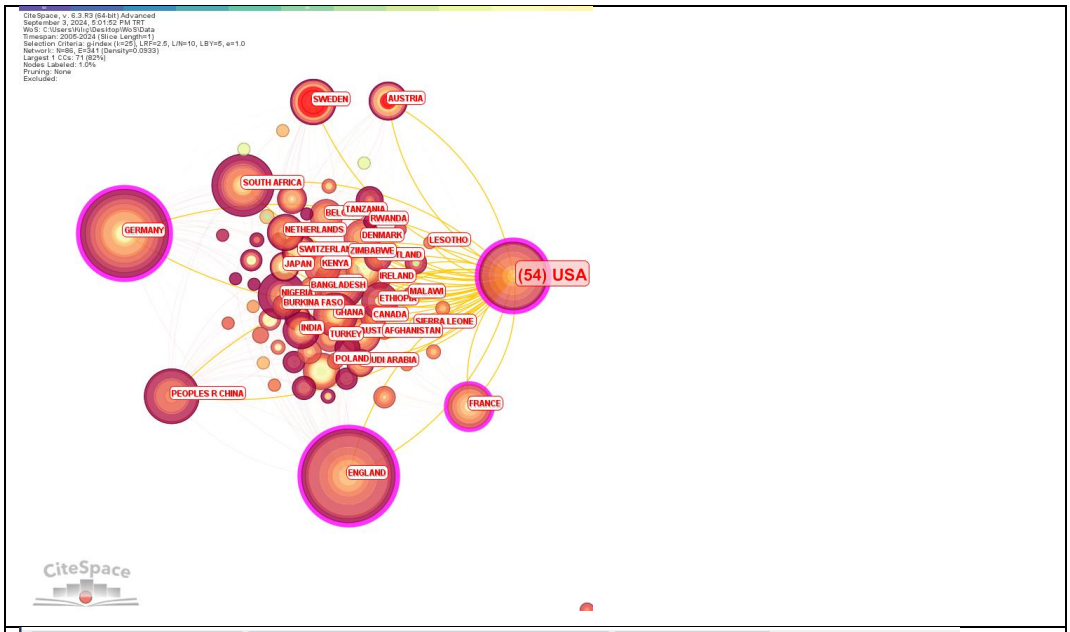
The History of Appearance | Articles Published in this Country in 67 Records | Neighboring Nodes

#	Citations	Citing Article
1.	229	McCollum DL, 2018, ENVIRON RES LETT, V13, P0, DOI 10.1088/1748-9326/aaafe3
2.	105	Lacey-Barnacle M, 2020, ENERGY SUSTAIN DEV, V55, P122, DOI 10.1016/j.esd.2020.01.010
3.	103	Geall S, 2018, ENERGY RES SOC SCI, V41, P238, DOI 10.1016/j.erss.2018.04.035
4.	101	Aliyu AS, 2015, RENEW SUST ENERG REV, V48, P336, DOI 10.1016/j.rser.2015.03.098
5.	90	Gasparatos A, 2015, RENEW SUST ENERG REV, V45, P879, DOI 10.1016/j.rser.2015.02.006
6.	77	Adenle AA, 2015, J ENVIRON MANAGE, V161, P261, DOI 10.1016/j.jenvman.2015.05.040
7.	52	Alova G, 2021, NAT ENERGY, V6, P158, DOI 10.1038/s41560-020-00755-9
8.	51	Amankwah-Amoah J, 2016, TECHNOL FORECAST SOC, V102, P90, DOI 10.1016/j.techfore.2015.02
9.	51	Ockwell D, 2018, ENERGY RES SOC SCI, V44, P122, DOI 10.1016/j.erss.2018.04.033
10.	46	Ikeme J, 2005, ENERG POLICY, V33, P1213, DOI 10.1016/j.enpol.2003.11.018
11.	45	Lei Y, 2019, ENVIRON IMPACT ASSES, V77, P122, DOI 10.1016/j.eiar.2019.04.005
12.	44	Farjana SH, 2018, RENEW SUST ENERG REV, V91, P409, DOI 10.1016/j.rser.2018.03.105
13.	43	Sovacool BK, 2019, GLOBAL ENVIRON CHANG, V59, P0, DOI 10.1016/j.gloenvcha.2019.101985
14.	39	Candelise C, 2021, WORLD DEV, V141, P0, DOI 10.1016/j.worlddev.2021.105390
15.	38	Sovacool BK, 2019, REV INT POLIT ECON, V26, P49, DOI 10.1080/09692290.2018.1511449
16.	31	Power M, 2019, ENVIRON PLAN C-POLIT, V37, P498, DOI 10.1177/2399654418784598
17.	30	Sovacool BK, 2021, ENERGY STRATEG REV, V38, P0, DOI 10.1016/j.esr.2021.100723
18.	29	Mukelabai MD, 2022, RENEW SUST ENERG REV, V167, P0, DOI 10.1016/j.rser.2022.112705
19.	28	Broto VC, 2017, INT DEV PLANN REV, V39, P229, DOI 10.3828/idpr.2017.9
20.	27	Trotter PA, 2018, ENERG POLICY, V117, P108, DOI 10.1016/j.enpol.2018.02.013
21.	26	Gregory J, 2019, ENERG POLICY, V125, P145, DOI 10.1016/j.enpol.2018.10.026
22.	26	Musango JK, 2020, ENERGY RES SOC SCI, V70, P0, DOI 10.1016/j.erss.2020.101715
23.	25	Ockwell D, 2019, SUSTAINABILITY, V11, P0, DOI 10.3390/su11072105
24.	24	Byrne R, 2018, ENERGY RES SOC SCI, V44, P6, DOI 10.1016/j.erss.2018.03.028
25.	24	Akbas B, 2022, RENEW SUST ENERG REV, V156, P0, DOI 10.1016/j.rser.2021.111935
26.	23	Mukoro V, 2022, ENERGY RES SOC SCI, V88, P0, DOI 10.1016/j.erss.2022.102530
27.	23	Sovacool BK, 2016, RENEW SUST ENERG REV, V58, P107, DOI 10.1016/j.rser.2015.12.219
28.	21	Batidzirai B, 2021, ENERGY RES SOC SCI, V74, P0, DOI 10.1016/j.erss.2021.101975
29.	21	Hensengerth O, 2018, ENERG POLICY, V114, P499, DOI 10.1016/j.enpol.2017.12.039
30.	20	Smith C, 2021, ONE EARTH, V4, P104, DOI 10.1016/j.oneear.2020.12.015
31.	19	Stritzke S, 2021, ENERG POLICY, V148, P0, DOI 10.1016/j.enpol.2020.111934
32.	18	Abdullahi D, 2017, IOP C SER EARTH ENV, V83, P0, DOI 10.1088/1755-1315/83/1/012015
33.	18	Welfle A, 2020, BIOMASS BIOENERG, V142, P0, DOI 10.1016/j.biombioe.2020.105757
34.	15	Antwi SH, 2021, SCI AFR, V11, P0, DOI 10.1016/j.sciaf.2020.e00679
35.	14	Nerini FF, 2016, ENERG POLICY, V98, P544, DOI 10.1016/j.enpol.2016.09.029
36.	14	Cheng X, 2021, ENVIRON DEV, V40, P0, DOI 10.1016/j.envdev.2021.100679
37.	13	Trotter PA, 2018, ENERGY RES SOC SCI, V43, P61, DOI 10.1016/j.erss.2018.05.020
38.	12	Korkovelos A, 2020, SUSTAINABILITY, V12, P0, DOI 10.3390/su12030777
39.	12	Gebreslassie MG, 2022, ENERGY SUSTAIN SOC, V12, P0, DOI 10.1186/s13705-022-00348-2
40.	11	Nuru JT, 2022, ENERGY RES SOC SCI, V83, P0, DOI 10.1016/j.erss.2021.102352
41.	10	Hussain S, 2023, SUSTAIN ENERGY TECHN, V55, P0, DOI 10.1016/j.seta.2022.102922
42.	9	Radley B, 2022, ENERGY RES SOC SCI, V89, P0, DOI 10.1016/j.erss.2022.102673
43.	8	Trotter PA, 2017, J ENERGY SOUTH AFR, V28, P27, DOI 10.17159/2413-3051/2017/v28i3a2451
44.	7	Koasidis K, 2022, ENERGY SUSTAIN DEV, V68, P457, DOI 10.1016/j.esd.2022.05.003
45.	7	Ockwell D, 2021, ENERGIES, V14, P0, DOI 10.3390/en14144362
46.	6	Lonergan KE, 2023, JOULE, V7, P469, DOI 10.1016/j.joule.2023.02.004
47.	6	Brunet C, 2022, ENERGY STRATEG REV, V44, P0, DOI 10.1016/j.esr.2022.101010
48.	5	Nolan C, 2020, J POLIT ECOL, V27, P775
49.	5	Trotter PA, 2019, ENERG POLICY, V128, P900, DOI 10.1016/j.enpol.2019.01.035
50.	4	Shittu E, 2019, SUSTAINABILITY, V11, P0, DOI 10.3390/su11247213
51.	4	Mottram H, 2022, ENERGY RES SOC SCI, V93, P0, DOI 10.1016/j.erss.2022.102829
52.	4	Bamisile O, 2023, ENERGY STRATEG REV, V49, P0, DOI 10.1016/j.esr.2023.101157
53.	4	Yaguma P, 2022, ENVIRON RES COMMUN, V4, P0, DOI 10.1088/2515-7620/aca9ad

Figure 3: Country Network Analysis (England)

Source: CiteSpace 6.3 R3, 2024.

Figure 3 shows that 67 publications published in the UK between 2005 and 2024 received 1726 co-citations from scientific works published in 39 different countries. The main countries in which the scientific works are included are Ireland, Malaysia, South Africa, Pakistan, Italy, Egypt, Egypt, Mobambique, Brazil, Denmark, Germany, Algeria, Japan, Colombia, Austria, People's Republic of China, Greece, Canada, Canada, Netherlands, USA, India, Australia, Australia, England, Switzerland, Spain, France, Sweden and Bostwana. The article titled 'Connecting the sustainable development goals by their energy inter-linkages' published by McCollum et al. in Environmental Research Letter in 2018 has the highest number of co-citations among the publications. The article was co-cited 229 times. In the article, the interactions between energy-related sustainable development goals and non-energy-related sustainable development goals were analysed. Thus, it is aimed to present a large-scale evaluation of the energy literature within the scope of sustainable development goals. As a result of the findings of the study, it is thought that potential areas of future work for both policy-making and scientific communities will be pointed out (McCollum et al., 2018). The network analysis of 54 publications published in the USA is presented in Figure 4:



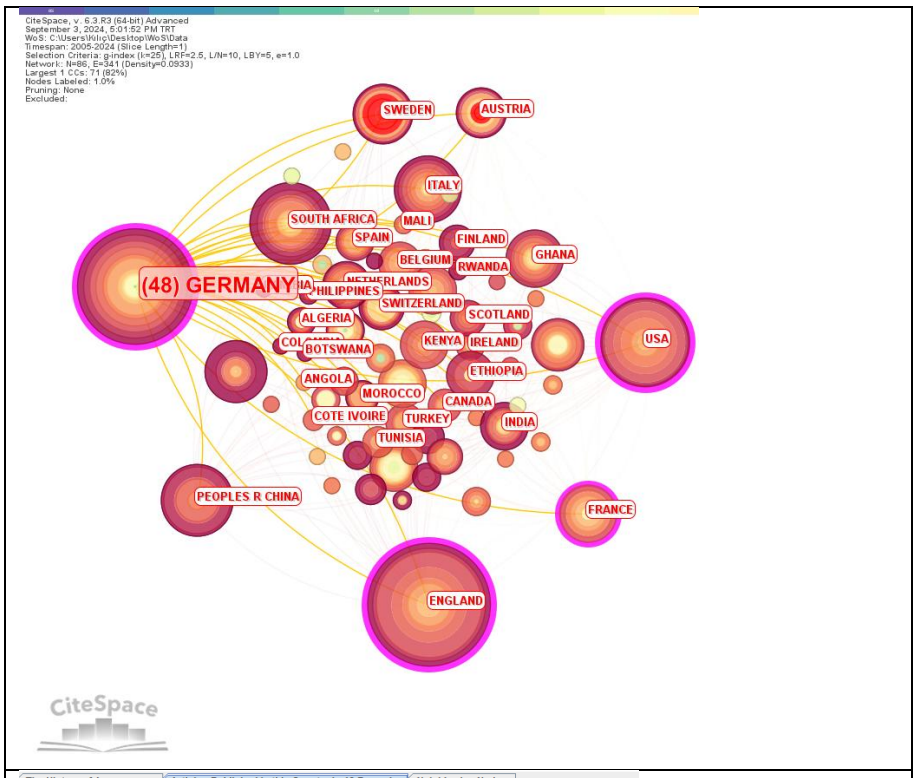
The History of Appearance | Articles Published in this Country in 54 Records | Neighboring Nodes

#	Citations	Citing Article
1.	253	Kirubi C, 2009, WORLD DEV, V37, P1208, DOI 10.1016/j.worlddev.2008.11.005
2.	229	McCollum DL, 2018, ENVIRON RES LETT, V13, P0, DOI 10.1088/1748-9326/aaafe3
3.	163	Bazilian M, 2012, UTIL POLICY, V20, P1, DOI 10.1016/j.jup.2011.11.002
4.	143	Jacobson A, 2007, WORLD DEV, V35, P144, DOI 10.1016/j.worlddev.2006.10.001
5.	128	Elavarasan RM, 2021, APPL ENERG, V292, P0, DOI 10.1016/j.apenergy.2021.116665
6.	108	Adenle AA, 2020, ENERG POLICY, V137, P0, DOI 10.1016/j.enpol.2019.111180
7.	93	Li W, 2020, NAT MATER, V19, P1326, DOI 10.1038/s41563-020-0720-x
8.	88	Peters J, 2019, ENERG POLICY, V132, P27, DOI 10.1016/j.enpol.2019.05.016
9.	84	Lohri CR, 2016, RENEW SUST ENERG REV, V59, P1514, DOI 10.1016/j.rser.2016.01.088
10.	70	Urpelainen J, 2015, ENERGY SUSTAIN DEV, V24, P70, DOI 10.1016/j.esd.2014.10.005
11.	65	Steri S, 2020, NAT SUSTAIN, V3, P710, DOI 10.1038/s41893-020-0539-0
12.	46	Nock D, 2020, APPL ENERG, V264, P0, DOI 10.1016/j.apenergy.2020.114583
13.	41	Grossmann WD, 2013, RENEW SUST ENERG REV, V25, P831, DOI 10.1016/j.rser.2012.08.018
14.	40	Sergi B, 2018, ENERGY RES SOC SCI, V41, P59, DOI 10.1016/j.erss.2018.04.011
15.	35	Wikramanayake ED, 2017, ENERGY, V138, P647, DOI 10.1016/j.energy.2017.07.062
16.	34	Smith MG, 2014, REV POLICY RES, V31, P17, DOI 10.1111/ropr.12061
17.	26	Kemeny P, 2014, ENERGY SUSTAIN DEV, V23, P228, DOI 10.1016/j.esd.2014.09.005
18.	26	Grossmann WD, 2014, RENEW SUST ENERG REV, V32, P983, DOI 10.1016/j.rser.2014.01.003
19.	25	Boateng GO, 2020, SOC SCI MED, V258, P0, DOI 10.1016/j.socscimed.2020.113068
20.	24	Nunez-Jimenez A, 2022, INT J HYDROGEN ENERG, V47, P35553, DOI 10.1016/j.ijhydene.2022.08.170
21.	24	Akbas B, 2022, RENEW SUST ENERG REV, V156, P0, DOI 10.1016/j.rser.2021.111935
22.	24	Ptak T, 2019, ENERGY RES SOC SCI, V48, P116, DOI 10.1016/j.erss.2018.09.010
23.	23	Schwerhoff G, 2019, CLIM POLICY, V19, P108, DOI 10.1080/14693062.2018.1459293
24.	23	Sovacool BK, 2016, RENEW SUST ENERG REV, V58, P107, DOI 10.1016/j.rser.2015.12.219
25.	20	Toma Y, 2010, GCB BIOENERGY, V2, P52, DOI 10.1111/j.1757-1707.2010.01039.x
26.	18	Oluoch S, 2021, ENERG ECON, V98, P0, DOI 10.1016/j.eneco.2021.105256
27.	14	Jacome V, 2018, WORLD DEV, V105, P262, DOI 10.1016/j.worlddev.2018.01.007
28.	14	Grossmann W, 2015, P NATL ACAD SCI USA, V112, P3663, DOI 10.1073/pnas.1316781112
29.	14	Gill-Wiehl A, 2022, RENEW SUST ENERG REV, V153, P0, DOI 10.1016/j.rser.2021.111778
30.	12	Korkovelos A, 2020, SUSTAINABILITY, V12, P0, DOI 10.3390/su12030777
31.	11	Nuru JT, 2022, ENERGY RES SOC SCI, V83, P0, DOI 10.1016/j.erss.2021.102352
32.	11	Burleson G, 2019, ENERGY RES SOC SCI, V52, P68, DOI 10.1016/j.erss.2019.02.009
33.	10	Van Buskirk R, 2021, ENERGIES, V14, P0, DOI 10.3390/en14144293
34.	10	Tomala J, 2021, ENERGIES, V14, P0, DOI 10.3390/en14196037
35.	9	Falchetta G, 2020, ENERG J, V41, P255, DOI 10.5547/01956574.41.3.gfal
36.	9	Karplus VJ, 2019, ECON ENERGY ENV POL, V8, P1, DOI 10.5547/2160-5890.8.1.vkar
37.	7	Mpholo M, 2020, ENERG POLICY, V140, P0, DOI 10.1016/j.enpol.2020.111381
38.	6	Lonergan KE, 2023, JOULE, V7, P469, DOI 10.1016/j.joule.2023.02.004
39.	6	Sackey CV, 2022, ENVIRONMENTAL RESEARCH: INFRASTRUCTURE AND SUSTAINABILITY, V2, P0, [illegible]
40.	6	Iychettira KK, 2021, ENERGY RES SOC SCI, V77, P0, DOI 10.1016/j.erss.2021.102069
41.	5	Peters R, 2024, NATURE REVIEWS EARTH ENVIRONMENT, V5, P137, DOI 10.1038/s43017-023-005[illegible]
42.	3	Myers CW, 2019, AFR GEOGR REV, V38, P326, DOI 10.1080/19376812.2018.1436077
43.	2	Asiedu E, 2021, ENERG ECON, V104, P0, DOI 10.1016/j.eneco.2021.105605
44.	2	Klug TW, 2022, ENERG POLICY, V170, P0, DOI 10.1016/j.enpol.2022.113226
45.	2	Ukoba K, 2024, HELIYON, V10, P0, DOI 10.1016/j.heliyon.2024.e28009
46.	2	Wamalwa F, 2023, ENERGY SUSTAIN DEV, V77, P0, DOI 10.1016/j.esd.2023.101345
47.	1	Kannan S, 2023, ENERGY SUSTAIN DEV, V76, P0, DOI 10.1016/j.esd.2023.101276
48.	1	Akhmetov A, 2018, ENG J-THAIL, V22, P27, DOI 10.4186/ej.2018.22.1.27
49.	1	Patel SN, 2022, ECON ENERGY ENV POL, V11, P27, DOI 10.5547/2160-5890.11.1.spat
50.	1	Suri D, 2020, 2020 20TH IEEE INTERNATIONAL CONFERENCE ON ENVIRONMENT AND ELECTRICA[illegible]
51.	0	Osende B, 2011, NANOTECHNOLOGY 2011: ADVANCED MATERIALS, CNTS, PARTICLES, FILMS AND[illegible]
52.	0	Lakhtakia A, 2017, 2017 INTERNATIONAL CONFERENCE ON ELECTROMAGNETICS IN ADVANCED A[illegible]
53.	0	Osende B, 2011, CLEAN TECHNOLOGY 2011: BIOENERGY, RENEWABLES, STORAGE, GRID, WASTE[illegible]
54.	0	Nikandrova A, 2017, J REGUL ECON, V51, P41, DOI 10.1007/s11149-016-9313-7

Figure 4: Country Network Analysis (USA)

Source: CiteSpace 6.3 R3, 2024.

When Figure 4 is analysed, it is seen that 54 publications published in the USA between 2007-2024 received 2012 co-citations from scientific works published in 35 different countries. The main countries where scientific works are published are Ireland, South Africa, Bangladesh, Italy, Egypt, Poland, Denmark, Germany, Austria, Japan, People's Republic of China, France, Burkina Faso, Zimbabwe, Tanzania, Malawi, Lesotho, Kenya, Sierra Leone, Nigeria, and Rwanda. Among the publications, the one with the highest co-citation performance is the article titled 'Community-Based Electric Micro-Grids Can Contribute to Rural Development: Evidence from Kenya' published by Kirubi et al. in World Development in 2009. The article received 253 co-citations. The authors of the article work at the University of California and Humboldt State University. The paper explains the mechanisms through which rural electrification can contribute to rural development. Through a detailed case study of a community-based electrified micro-grid in rural Kenya, it is explained that the provision of access to electricity (use of electrical equipment and tools) by small and micro enterprises increased productivity per worker and income levels by 20 to 70 per cent, depending on the product produced. According to Kirubi et al. (2009), access to electricity increases the productivity of agricultural activities and also generates social benefits as a wide range of infrastructure in the village compound, such as schools, markets and water pumps, benefit from electricity. It is argued that access to electricity in social and commercial spheres will generate growth in incomes, leading to higher social and economic benefits for rural communities. It is also stated that it is possible for electricity consumption to cover the costs incurred as a result of income-generating productive uses (Kirubi et al., 2009). The network analysis of 48 publications published in Germany is presented in Figure 5:



The History of Appearance | Articles Published in this Country in 48 Records | Neighboring Nodes

#	Citations	Citing Article
1.	229	McCollum DL, 2018, ENVIRON RES LETT, V13, P0, DOI 10.1088/1748-9326/aaafe3
2.	128	Pietzcker RC, 2014, APPL ENERG, V135, P704, DOI 10.1016/j.apenergy.2014.08.011
3.	121	Lewandowski I, 2015, GLOB FOOD SECUR-AGR, V6, P34, DOI 10.1016/j.gfs.2015.10.001
4.	88	Peters J, 2019, ENERG POLICY, V132, P27, DOI 10.1016/j.enpol.2019.05.016
5.	68	Friebe CA, 2013, ENERG POLICY, V52, P760, DOI 10.1016/j.enpol.2012.10.038
6.	66	Sharma N, 2016, FOOD ENERGY SECUR, V5, P165, DOI 10.1002/fes3.87
7.	65	Sterl S, 2020, NAT SUSTAIN, V3, P710, DOI 10.1038/s41893-020-0539-0
8.	57	Falchetta G, 2019, J CLEAN PROD, V231, P1399, DOI 10.1016/j.jclepro.2019.05.263
9.	57	Jung C, 2018, ENERG CONVERS MANAGE, V156, P403, DOI 10.1016/j.enconman.2017.11.059
10.	57	Ondraczek J, 2014, RENEW SUST ENERG REV, V30, P604, DOI 10.1016/j.rser.2013.10.010
11.	53	Ayeng'o SP, 2018, SOL ENERGY, V162, P140, DOI 10.1016/j.solener.2017.12.049
12.	52	Alova G, 2021, NAT ENERGY, V6, P158, DOI 10.1038/s41560-020-00755-9
13.	46	Aghahosseini A, 2023, APPL ENERG, V331, P0, DOI 10.1016/j.apenergy.2022.120401
14.	45	Lei Y, 2019, ENVIRON IMPACT ASSES, V77, P122, DOI 10.1016/j.eiar.2019.04.005
15.	41	Elgendy E, 2010, ENERGY, V35, P2461, DOI 10.1016/j.energy.2010.02.040
16.	38	Sovacool BK, 2019, REV INT POLIT ECON, V26, P49, DOI 10.1080/09692290.2018.1511449
17.	28	Attig-Bahar F, 2021, ENERGY REP, V7, P7374, DOI 10.1016/j.egyr.2021.10.087
18.	27	Schinko T, 2019, ENERGY SUSTAIN SOC, V9, P0, DOI 10.1186/s13705-018-0186-8
19.	26	Lilliestam J, 2014, ENERG POLICY, V66, P234, DOI 10.1016/j.enpol.2013.10.078
20.	24	Akbas B, 2022, RENEW SUST ENERG REV, V156, P0, DOI 10.1016/j.rser.2021.111935
21.	23	Schwerhoff G, 2019, CLIM POLICY, V19, P108, DOI 10.1080/14693062.2018.1459293
22.	21	Batidzirai B, 2021, ENERGY RES SOC SCI, V74, P0, DOI 10.1016/j.erss.2021.101975
23.	19	Boamah F, 2020, ANN AM ASSOC GEOGR, V110, P145, DOI 10.1080/24694452.2019.1629869
24.	19	Holstenkamp L, 2019, RENEW SUST ENERG REV, V109, P307, DOI 10.1016/j.rser.2019.04.047
25.	16	Amars L, 2017, LOCAL ENVIRON, V22, P86, DOI 10.1080/13549839.2016.1161607
26.	15	Backhaus K, 2015, ENERGY, V82, P905, DOI 10.1016/j.energy.2015.01.100
27.	14	Pujades E, 2019, SCI TOTAL ENVIRON, V659, P599, DOI 10.1016/j.scitotenv.2018.12.103
28.	13	Cremonese L, 2023, INT J HYDROGEN ENERG, V48, P19422, DOI 10.1016/j.ijhydene.2023.01.350
29.	12	Hermwille L, 2021, EARTH SYST GOV-NETH, V8, P1, DOI 10.1016/j.esg.2020.100054
30.	12	Falk J, 2021, ENERGY ECOL ENVIRON, V6, P513, DOI 10.1007/s40974-021-00216-3
31.	12	del Rio P, 2023, ENERG POLICY, V173, P0, DOI 10.1016/j.enpol.2022.113305
32.	10	Schone N, 2022, J SUSTAIN DEV ENERGY, V10, P0, DOI 10.13044/j.sdewes.d9.0400
33.	10	Pujades E, 2020, ENERGIES, V13, P0, DOI 10.3390/en13092353
34.	9	Sessa V, 2021, ENERGIES, V14, P0, DOI 10.3390/en14113338
35.	9	Karplus VJ, 2019, ECON ENERGY ENV POL, V8, P1, DOI 10.5547/2160-5890.8.1.vkar
36.	7	Hoffmann H, 2015, REG ENVIRON CHANGE, V15, P1181, DOI 10.1007/s10113-014-0596-x
37.	6	Lonergan KE, 2023, JOULE, V7, P469, DOI 10.1016/j.joule.2023.02.004
38.	5	Peters R, 2024, NATURE REVIEWS EARTH ENVIRONMENT, V5, P137, DOI 10.1038/s43017-023-005
39.	3	Perez PV, 2022, EARTH, V3, P652, DOI 10.3390/earth3020038
40.	2	Klug TW, 2022, ENERG POLICY, V170, P0, DOI 10.1016/j.enpol.2022.113226
41.	2	Trotter PA, 2022, WORLD DEV PERSPECT, V25, P0, DOI 10.1016/j.wdp.2021.100376
42.	1	Winkler B, 2015, PAPERS OF THE 23RD EUROPEAN BIOMASS CONFERENCE: SETTING THE COUR
43.	1	Simberg-Koulumies N, 2024, LOCAL ENVIRON, V29, P40, DOI 10.1080/13549839.2023.2249497
44.	1	Lewandowski I, 2017, KNOWLEDGE-DRIVEN DEVELOPMENTS IN THE BIOECONOMY: TECHNOLOG
45.	0	Chigbu UE, 2023, LAND, V12, P0, DOI 10.3390/land12091709
46.	0	Benasla M, 2024, ENERGY REP, V11, P39, DOI 10.1016/j.egyr.2023.11.039
47.	0	Tamasiga P, 2024, INT J SUSTAIN ENERGY, V43, P0, DOI 10.1080/14786451.2024.2362334
48.	0	Minas AM, 2024, RENEW SUST ENERG REV, V199, P0, DOI 10.1016/j.rser.2024.114457

Figure 5: Country Network Analysis (Germany)

Source: CiteSpace 6.3 R3, 2024.

Figure 5 shows that 48 publications published in Germany between 2010 and 2024 received 1558 co-citations from scientific works published in 33 different countries. The main countries where the scientific works are published are Ireland, South Africa, Italy, Egypt, Tunisia, Germany, Algeria, Austria, Colombia, Colombia, Scotland, Peoples R China, Philippines, Mali, Namibia, Switzerland, England, Angola, Spain, Ghana, Cote Ivoire, Turkey, Morocco, Belgium, France, Rwanda, Kenya, India, Finland, Bostwana, USA and Canada. The article titled 'Connecting the sustainable development goals by their energy inter-linkages' published by McCollum et al. in Environmental Research Letter in 2018 has the highest number of co-citations among the publications.

Figure 6 and Table 2 show the countries where the landmark publications are located and the data on the number of authors, institutions, keywords and co-citations for the publications with the highest co-citation performance in these countries.

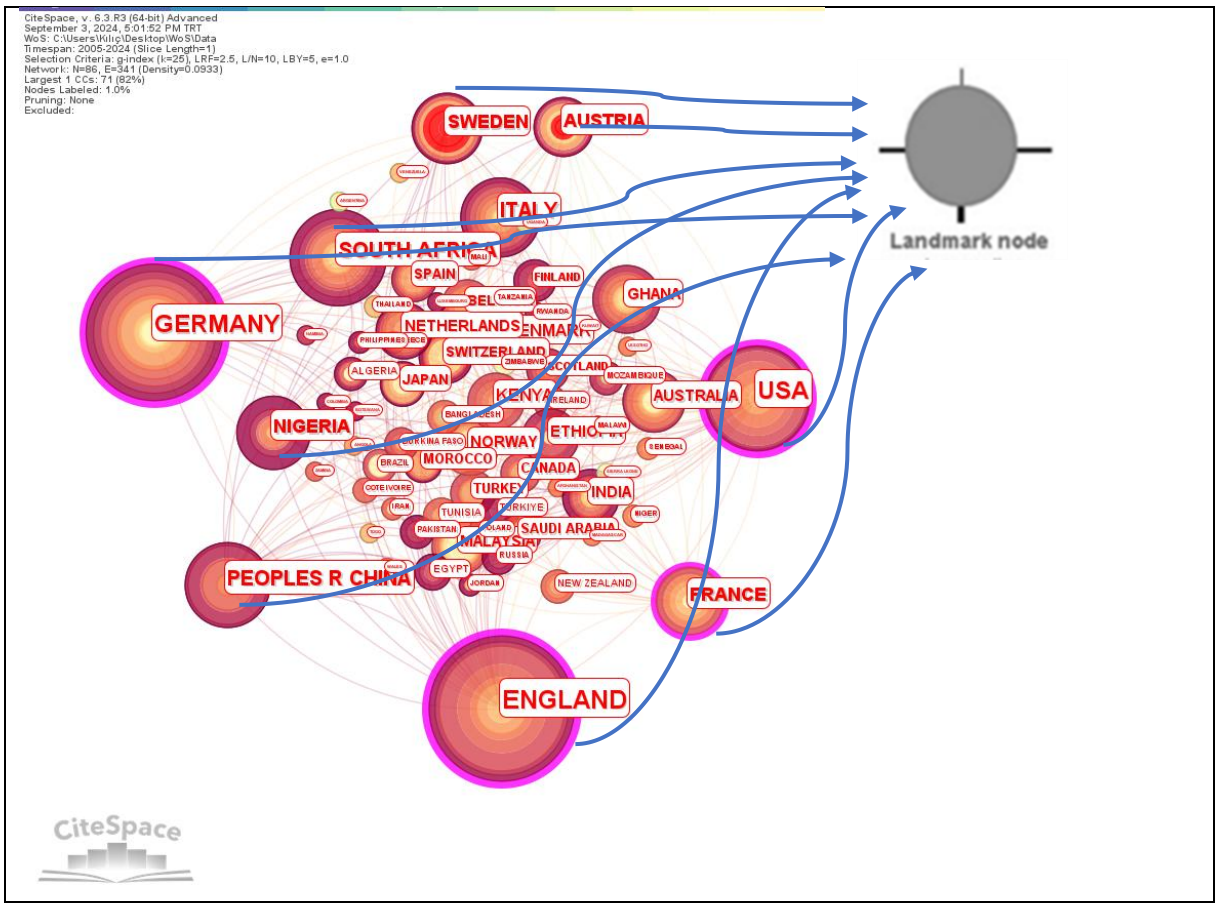


Figure 6: Country Network Analysis (Landmark Node)

Source: CiteSpace 6.3 R3, 2024.

Table 2: Literature on Landmark Scientific Works

Author Name, Institution Name, Country, Year of Publication, Number of Co-Citations	**Publication Title**	**Keywords**	**Results**
Charles Kirubi, Daniel, M. Kammen, Andrew Mills, University of California, Arne Jacobson, Humboldt State University, USA, 2009,	Community-Based electric micro-grids can contribute to rural development: Evidence from Kenya	rural electrification, rural development, Kenya, Africa	The study presents a detailed case study of a micro-grid that provides community-based electricity access in rural Kenya. The importance of small and micro-scale enterprises in rural areas gaining access to electricity and generating income from their production is emphasized. In addition to the commercial benefits that access to electricity provides for agricultural activities, it also creates social benefits by meeting the electricity needs of various social infrastructures such as schools, markets and water pumps in rural areas. It is argued that

253 co-citations.			access to electricity in social and commercial areas will create higher social and economic benefits for rural communities by increasing incomes.
David L. McCollum, Luis Gomez Echeverri, Sebastian Busch, Shonali Pachauri,Simon Parkinson, Joeri Rogelj, Volker Krey, Jan C. Minx, Mans Nilsson, Anne-Sophie Stevance, Keywan Riahi, International Institute for Applied Systems Analysis, Austria, University of Tennessee, USA, University of Victoria, Canada, Mercator Research Institute on Global Commans and Climate Change, Germany, University of Leeds, UK, Stockholm Environment Institute, Sweden, International Council for Science, France, 2018, 229 co-citations.	Connecting the sustainable development goals by their energy inter-linkages.	energy, sustainable development goals, systems analysis, integrated assessment	This article examines the interactions between energy-related and non-energy-related goals among the sustainable development goals. Thus, a broad review of the energy literature in the context of sustainable development goals is presented. The findings suggest potential areas of future work for both policy makers and the scientific community.

Morgan Bazilion, Patrick Nussbaumer, Hans-Holger Rogner, Abeeku Brew-Hammond, Vivien Foster, Shonali Pachauri, Eric Williams, Mark Howells, Philippe Niyongabo, Lawrence Musaba, Brian O. Gallachoir, Mark Radka, Daniel M. Kammen, United Nations Industrial Development Organization, Austria, İnternational Atomic Enegy Agency, Austria, The Energy Center, Ghana, The World Bank, USA, International Institute for Applied Systems Analsis, Austria, KTH Technical University, Sweden, African Union Commission, Ethiopia,	Energy access scenarios to 2030 for the power sector in sub-Saharan Africa	Energy access Power system planning Electricity scenarios	The paper aims to inform policy makers and investors on energy system designs for the goal of achieving universal access to modern energy services in Africa by 2030. To this end, several high-level, transparent and economic scenarios for the Sub-Saharan African power sector are presented. The long-term scenarios assume a roughly three-fold increase in existing installed power generation capacity by 2030. However, the authors note that even at modest electricity consumption levels, a more than ten-fold increase would be required to achieve full access. This assumption corresponds to an average annual growth rate of about 13%, compared to the historical growth rate of 1.7% over the last two decades.

Southern African Power Pool, Zimbabwe, University College Cork, Ireland, United Nations Environment Programme, France, 2012, 163 co-citations.			
Arne Jacobson, Humboldt State University, USA, 2007, 143 co-citations.	Connective Power: Solar Electrification and Social Change in Kenya	solar energy, rural development, Africa, Kenya	The paper discusses three main arguments for rural electrification with solar energy under unsubsidized market conditions in Kenya. The first claim is that the energy accessible through solar power is demanded by the rural middle class. The second claim is that while solar electricity is economically productive and plays a role in supporting educational activities, it is also in high demand for television, radio, cell phone charging, etc. The third claim is that solar electrification is more closely related to increased television use, expansion of markets, rural-urban communication and increasing rural-urban connectivity than to poverty alleviation, sustainable development or the use of solar technology.
Robert Carl Pietzcker, Daniel Setter, Susanne Manger, Gunnar Luderer, Potsdam Institute for Climate Impact Research, DLR-German Aerospace Center, Technische Universitat, Germany, 2014, 128 co-citations.	Using the sun to decarbonize the power sector: The economic potential of photovoltaics and concentrating solar power	Solarpower Variable renewable electricity System integration Energy system modeling Solar resources potential Storage	In this paper, the state-of-the-art energy-economy-climate model REMIND1.5 based on solar energy technology is discussed. Current values for current and future costs of solar technologies are calculated. A simplified representation of the system integration costs of variable renewable energies, suitable for large-scale energy economic models, is also presented. Assuming that global warming stabilizes at20C, solar energy becomes the dominant source of electricity, and PV and CSP technologies can provide 48% of total electricity between 2010 and 2100. The study emphasizes that solar energy-based technologies have stabilizing effects on electricity prices, and that electricity prices will rise significantly if PV and CSP technologies are not used. The study also compares the advantages of PV and CSP technologies. Accordingly, it is

			stated that PV is cheaper on a direct technology basis, but its costs will exceed the costs of CSP technology in case of high supply. The study claims that solar electricity generation will play an important role in cost-effectively achieving a strict20Cclimate target.
Shihong Zeng, Yuchen Liu, Chau Liu, Xin Nan, Beijing University of Technology, China, 2017, 114 co-citations	A review of renewable energy investment in the BRICS countries: History, models, problems and solutions	BRICS countries CO2 emissions Investment and financing Renewable energy	The paper examines the history of renewable energy development in BRICS countries. It discusses the inadequacy of financing channels, investment incentives for small and medium-sized enterprises, and wrong government policies on financing in BRICS countries. In response to these findings, the expansion of capital markets, financial leasing services and build-operate-transfer or build-own-operate projects are suggested as solutions. According to the authors, the implementation of a financial citizen participation model similar to Germany and the European Union emissions trading system could be beneficial. The financial citizen participation model means that private individuals, legal entities and agribusinesses invest in renewable energy infrastructure through equity capital. In addition, a regional reserve ratio monetary policy is also suggested to achieve regional development in renewable energy.
Ademola, A. Adenle, School of Global Environmental Sustainabilty, USA, Graduate School of Technology Management, South Africa, Africa Sustainability and Innovation Academy, Nigeria, 2020, 108 co-citations.	Assessment of solar energy technologies in Africa-opportunities and challenges in meeting the 2030 agenda and sustainable development goals	Sustainable development goals Africa Policymakers	This article aims to identify trends in the adoption of solar energy in African countries. To this end, meta-analyses of literature on the performance of solar energy technologies have been conducted. These are supported by expert interviews and data from the World Bank/Global Environment Facility. Three case studies from Ghana, Kenya and South Africa are used in the study. It examines the benefits and challenges of using solar technologies to meet sustainable development goals in Africa and presents policy recommendations for their use.

Abubakar Sadiq Aliyu, Joseph O. Dada, İbrahim Khalil Adam, Universiti Tenologi, Malaysia, University of Manchester, UK, Elizade University, Nasarawa State University, Nigeria, 2015, 101 co-citations,	Current status and future prospects of renewable energy in Nigeria	Nigeria electricitycrisis Renewableenergy resources Biomass Solar energy Hydropower Wind energy	The article provides a detailed review of the development of energy resources in Nigeria. To this end, the current status and future expectations of energy resources in Nigeria were examined, as well as the obstacles to developing them on a large scale. The current government policies and legislation were examined, and recommendations were made to accelerate the adoption of renewable energy sources in Nigeria. The study also compares the development of renewable energy in Nigeria with that in other sub-Saharan African countries. It is anticipated that this study will encourage further research into resolving Nigeria's energy crisis through renewable energy.
Y.S. Mohammed, M.W. Mustafa, N. Bashir, A.S. Mokhtar, Universiti Teknologi, Malaysia, 2013, 95 co-citations	Renewableenergyresourcesfordistributedpowergeneration in Nigeria:Areviewofthepotential	Renewable energy Distributed Generation Potential Nigeria	The paper argues that more than a quarter of the human population globally is facing an energy crisis, especially those living in rural areas of developing countries. In Nigeria, the study notes that while access to modern energy sources is severely constrained, the population has consistently relied on combustible biomass derived from forest wood and coal derivatives for primary energy consumption. The authors found that Nigeria has both renewable and non-renewable energy sources, but mostly utilizes traditional bioenergy sources. In this context, the study examines in detail the potential of major renewable energy sources in Nigeria, namely biomass, solar, wind and hydro.
Kate Louw, Beatrice Conradie, Mark Howells, Marcus Dekenah, University of Cape Town, School of Economics, South Africa, International Atomic Energy Agency, Austria,	Determinants of electricity demand for newly electrified low-income African households	Electrification Determinants Consumption	The paper aims to identify the factors that influence the decisions of low-income rural households when choosing between fuel types for electricity consumption. The study assumes that factors embedded in economic demand, such as price and household income, influence fuel type choice, but external factors, such as tastes and preferences, as well as distance to suppliers, are also assumed to influence fuel type choice. The analysis reveals that income, wood as a fuel type, iron ownership and credit are influential in determining electricity consumption levels in low-income households. The findings show that easily obtained credit has an impact on the electricity consumption of low-income households.

2008, 91 co-citations			
A. Gasparatos, G.P. von Maltitz, F.X. Johnson, L. Lee, M. Mathai, J. A. Puppim de Oliveira, K.J. Willis, University of Tokyo, Japan, University of Oxford, UK, Council for Scientific and Industrial Research, South Africa, Stockholm Environment Institute, Sweden, United Nations University, Japan, Royal Botanical Gardens Kew, UK, Nelson Mandela Metropolitan University, South Africa, Getulio Vargas Foundation, Brazil, 2015, 90 co-citations	Biofuels in sub-Sahara Africa: Drivers, impacts and priority policy areas	Biofuels Sub-Sahara Africa Sugarcane Jatropha Sustainability impacts Biofuel policies	This article aims to analyse the available information on the effects of biofuels in Africa, identifying priority policy areas to enhance the sustainability of biofuels on the continent. The findings suggest that the impact of biofuels can be either positive or negative, depending on various factors such as the raw materials used, the environmental impact of production, socio-economic considerations, and the policies in place during production, use and trade. The authors state that careful planning can help mitigate negative impacts. However, agricultural, institutional and market failures are said to be the most significant barriers to the feasibility and sustainability of biofuel investments in Africa.
Stefano Mandelli, Jacopo Barbieri, Lorenzo Mattarolo, Emanuela Colombo, UNESCO	Sustainable energy in Africa: A comprehensive data and policies review	Africa Energy situation Energy policies Energy Indicators for Sustainable Development	The paper aims to describe Africa's current energy situation in terms of the concept of sustainable development using the latest data and to examine the consistency of energy policies promoted by local actors with sustainable development goals. Data from the National Energy Agency, the Energy Development Index and Sustainable

Chair in Energy for Sustainable Develonment, Italy, 2014, 88 co-citations			Development Indicators were used to analyze data on Africa's current energy situation. In the study, the energy policies and action plans developed by different local actors in the African continent were evaluated and their consistency with the energy analysis was revealed.
Dimitrios Mentis, Manuel Welsch, Francesco Fuso Nerini, Oliver Broad, Mark Howells, Morgan Bazilian, Holger Rogner, KTH Royal Institute of Technology, Sweden, International Institute for Applied Systems Analysis, Austria, 2015, 84 co-citations	A GIS-based approach for electrification planning—A case study on Nigeria	Electrification planning GIS Energy access	In this paper, a Geographic Information Systems based methodology is developed for use in electrification planning and strategies. The methodology includes the most appropriate electrification options from grid extensions to mini-grid and off-grid solutions. Within the scope of the methodology, a case study was conducted in Nigeria. The case study includes a range of parameters such as population density, existing and planned transmission networks and power plants, economic activity, grid-based electricity tariffs, technology costs for mini-grid and off-grid systems, and fuel costs for consumers. The analysis found that for a given level of energy access, grid connections would be the most appropriate option for most new connections in Nigeria. It was also found that grid extension would be the least cost option for about 86% of the newly electrified population in Nigeria by 2030. In rural areas with lower population density, it is suggested that a mini-grid using a combination of solar, wind, hydro and diesel technologies would be a more economical option, depending on local resource availability.
Francis Kemausuor, George Yaw Obeng, Abeeku Brew-Hammond, Alfred Duker, Kwame Nkrumah Univerity of Science and Technology, Ghana, 2011, 82 co-citations	A review of trends, policies and plans for increasing energy access in Ghana	Trends, Policies, Plans, Energy access Ghana	The paper examines trends, policies, plans and programs to increase access to energy in Ghana. In particular, it focuses on the types of fuels used for electricity and cooking, as well as renewable energy sources. The study finds that although the government in Ghana has historically placed policies and plans for the provision of energy services at the top of the national development agenda, there is still a great need for services to accelerate energy access in rural and urban areas. The study emphasizes that in order to achieve energy access, clear targets must be set, including financing mechanisms, strategies must be clearly defined, and a national energy policy must be in place to ensure access to energy for a broad cross-section of the population.

Constantinos Taliotis, Abhishek Shivakumar, Eunice Ramos, Mark Howells, Dimitris Mentis, Vignesh Sridharan, Oliver Broad, Linus Mofor, KTH Royal Institute of Technology, Sweden, United Nations Economic Commission for Africa, Ethiopia, 2016, 79 co-citations.	An indicative analysis of investment opportunities in the African electricity supply sector — Using TEMBA (The Electricity Model Base for Africa)	OSeMOSYS African electricity supply Electricity trade Cost-optimization TEMBA	The paper argues that although Africa is a resource-rich continent, it lacks the needed energy infrastructure. The paper examines indicative scenarios for power plant investments based on the potential for electricity trade. For this purpose, OseMOSYS is used as a cost optimization tool for long-term energy planning. OSeMOSY is used to develop least-cost system configurations. The electricity supply systems of 47 countries were modeled individually and interconnected through trade links to create TEMBA ("The Electricity Model Base for Africa"). A scenario comparison to 2040 shows that an improved grid network can change Africa's power generation mix and reduce the cost of electricity generation. Major power generation projects need political and financial support.
Navin Sharma, Babita Bohra, Namita Pragya, Rodrigo Ciannella, Phil Dobie, Sarah Lehmann, World Agroforestry Centre, Kenya, India, Intern at GIZ, Germany, 2016, 66 co-citations.	Bioenergy from agroforestry can lead to improved foodsecurity, climate change, soil quality, and rural development.	Agroforestry, bioenergy, biofuels, foodsecurity, livelihood	The paper assesses the potential of the bioenergy ecosystem to deliver multiple benefits, including co-production of food, animal feed and organic fertilizers, while meeting indicators of economic, social and environmental sustainability. Bioenergy systems are argued to be useful in mitigating climate change, increasing energy access and reducing rural poverty. It is also argued that with adequate technical assistance and land management, they can increase farm yields and incomes, strengthen food security, contribute to improved carbon sequestration and provide land clearing. However, the risks associated with bioenergy production include over-reliance on monoculture plantations, the negative impacts of land use changes, and some of the negative effects of using cereal crops as feedstock. However, it is emphasized that agroforestry systems and practices can mitigate many of these risks and play an important role in the sustainable production of various bioenergy outputs, including productive solid biomass, biogas, liquid biofuels and dendpower. In this context, the study analyzes promising perennial crops, production models and value chains

			based on bioenergy production experiences in sub-Saharan Africa, developing Asia and Latin America. The authors provide detailed assessments of key challenges and potential solutions for wider adoption of integrated food-energy approaches.
Sebastion Sterl, Inne Vanderkelen, Celray James Chawanda, Daniel Russo, Robert J. Brecha, Ann van Griensven, Nicole P.M. van Lipzig, Wim Thiery, Vrije Universiteit Brussel, Department of Earth and Environmental Sciences, Belgium, University of Bonn, International Renewable Energy Agency, Germany, University of Dayton, USA, Climate Analytics, Germany, IHE-Delft Institute for Water Education, Netherlands, 2020, 65 co-citations.	Smart renewable electricity portfolios in West Africa	Smart renewable electricity West Africa Renewable energy policy	The paper proposes a new model to explore the complementarities of hydropower, solar and wind power. Through smart management of existing and future hydropower plants in West Africa, solar and wind energy will support significant grid integration. It is emphasized that the use of solar and wind energy can limit natural gas consumption while avoiding the ecologically harmful overuse of hydropower. The study explains that aggregating regional resources and planning the transmission grid to spatially and temporally expand hydro-solar-wind synergies is crucial to make the most of West Africa's renewable energy potential. The authors state that by 2030, renewable electricity will be 10% cheaper than electricity from natural gas, with renewable energy sources, solar and wind, contributing around 50%.
T. Kousksou, A. Allouhi, M. Belattar, A. Jamil, T. El Rhafiki, Y. Zeraouli,	Morocco's strategy for energy security and low-carbon growth	Renewable energy Energy efficiency Low-carbon Morocco	The paper analyzes in detail the current state of the Moroccan energy sector and the challenges it will face in the future. The latest strategies implemented by the government for sustainable development are reviewed and evaluated. The

Universite de Pau et des Pays de l'Adour, France, Universite Sidi Mohamed Ibn Abdelah Route, Ecole Nationale Superieure d'Arts et Metiers, Morocco, 2015, 61 co-citations			transition to renewable energies is at the top of the list of national policy implications for energy security and low carbon economy in the government strategies developed within the scope of sustainable development. The study also proposes a methodological tool for prioritizing alternative energy sources for power generation. The analysis revealed that wind energy is the most suitable alternative energy generation source for Morocco.

Considering Figure 5 and Table 2 together, it can be said that the landmark scientific works on accessible and clean energy for the African Region within the scope of sustainable development goals are concentrated in the USA, Germany, England, Italy, France, Peoples R China, South Africa, Sweden and Austria. The most used keywords as publications with high co-citation performance include renewable energy, electricity scenarios, solar energy, sub-Saharan Africa, energy access, energy system modeling, solar resources potential storage, electrification, sustainability impacts, energy policies, sustainable development, electrification planning, smart renewable electricity, energy efficiency. Institutions where landmark scientific work has taken place include the University of California, Humboldt State University, International Institute for Applied Systems Analysis, University of Tennessee, Mercator Research Institute on Global Commands and Climate Change, University of Leeds, Stockholm Environment Institute, International Atomic Energy Agency, United Nations Industrial Development Organization, African Union Commission, Postdam Institute for Climate Impact Research, Technical University, Beijing University of Technology, Institute of Technology Management. Some of the authors of the most highly cited landmark scientific works include Charles Kirubi, Daniel M. Kammen, Andrew Mills, Arne Jacobson, David L. McCollum, Luis Gomez Echeverri, Sebastian Busch, Shonali Pachauri, Simon Parkinson, Joeri Rogelj, Volker Krey, Jan C. Minx, Mans Nilsson, Anne-Sophie Stevance, Keywan Riahi, Morgan Bazilion, Patrick Nussbaumer, Hans-Holger Rogner, Abeeku Brew-Hammond, Vivien Foster, Shonali Pachauri, Eric Williams, Mark Howells, Philippe Niyongabo, Lawrence Musaba, Brian O. Gallachoir, Mark Radka and Daniel M. Kammen. The main topics studied in the landmark scientific works include micro-grid, access to electricity, bibliographic analyses of energy literature, general access to modern energy services, increasing power generation capacity in Sub-Saharan Africa by 2030, alternative renewable energy sources such as solar, wind, hydro and bioenergy, and the energy-economy-climate model in which solar energy-based technologies provide electricity price stabilization, Trends in the adoption of solar energy in African countries, preferred fuel types for electricity consumption in rural areas, biofuel investments and increasing sustainability in the African region, trends, policies, plans and programs to increase access to energy in African countries, electrification, energy infrastructure and electricity trade in the African region. In the following sections provide detailed data on on-the-ground policies and practices on access to affordable and clean energy in the African region.

3. 'Accessible and Clean Energy' Goal in Practice

In this paper, which aims to present the projection of the accessible and clean energy target for the African region within the scope of sustainable development goals in terms of theoretical and practical studies, the main reason for considering the African region is the high energy potential of Africa and the problem of access to energy that contradicts this potential. In particular, although the African region has vast, renewable energy resources, a large number of people do not have access to electricity and clean cooking solutions. This lack of access imposes limitations on education, gender equality, economic growth and development(World Bank, 2023b). In this context, among the 17 sustainable development goals developed to ensure a better future worldwide by 2030, an important target for the African region is Sustainable Development Goal 7, which aims to achieve 'Accessible and Clean Energy'.

The goal of accessible and clean energy includes the following key elements:

Energy Access: In many parts of Africa, millions of people still lack access to modern energy services.

Today, it is known that 43 per cent of the total population of Africa does not have access to electricity and this population lives predominantly in Sub-Saharan Africa. More than 80 per cent of those without electricity live in rural areas. It is estimated that 970 million people across Africa do not have access to clean cooking, and it is estimated that universal access to clean cooking could reduce more than 500,000 premature deaths. The goal of universal access to modern energy for sustainable development across Africa requires an investment of USD 25 billion per year. This requires investment incentives and increased support from national and international organisations(IEA,2022).

Renewable Energy: The renewable energy resources (solar, wind, hydroelectric, geothermal, etc.) that Africa has today are rich and diverse. This target aims to increase the use of renewable energy sources and reduce fossil fuel dependency.

Africa faces more severe climate change than most other regions of the world, despite having the least responsibility for the global climate challenge. Africa, with about one-fifth of the world's population, accounts for less than 3 per cent of the world's energy-related carbon dioxide (CO2) emissions to date and has the lowest per capita emissions. Despite this, almost all African countries are parties to the Paris Agreement on Climate Change. The agreement requires Africa's growing energy demand to be met by clean and renewable energy sources (IEA, 2022).

At this point, Africa has significant resources in terms of renewable energy, including solar, wind, hydropower and geothermal, with 60% of the global solar resources, but expanding and modernising the electricity infrastructure is important for sustainable development.

Energy Efficiency: Improving energy efficiency is important to reduce the link between economic growth and energy consumption. This includes the adoption of energy-efficient technologies and practices.

Although Africa has the world's lowest levels of modern energy use per capita, the demand for energy increases as the population and income levels rise, and the increase in demand brings about an increase in energy prices. Energy subsidies are important in this region where access to clean energy is problematic. Difficulties in energy investments and financing have a negative impact on subsidies. The key to preventing price increases while energy demand increases is to increase energy efficiency. Increasing efficiency is possible by renewing existing infrastructure and improving energy performance, strengthening energy efficiency policies and implementing renewable energy and other clean energy technologies. This will be possible by solving the financing problem (IEA, 2022).

Sustainable Energy Policies: Governments are encouraged to develop clean energy solutions and policies in co-operation with the private sector and civil society.

Investment and Financing: Providing the necessary financing for renewable energy projects and infrastructure is a critical factor. In this context, it is aimed to increase investments at local and international level.

This goal plays a critical role for Africa's economic development and social progress and is an important foundation for sustainable development. Since increasing energy access will have positive impacts in many areas such as health, education, economic opportunities and gender equality, financing this energy access is another important issue for Africa. Under the Sustainable Africa Scenario (SAS), Africa needs to more than double its energy investments in the next decade to achieve its energy and climate goals. International financial institutions and multilateral development banks have a major role in financing this increase. In particular, multilateral development banks prioritising financial flows to Africa and increasing concessional financing could provide a solution(IEA, 2023b).

4. Conclusion and Discussion

The goal of accessible and clean energy, which is among the sustainable development goals in ensuring education, gender equality, economic growth and development, which are among the main problems of the African continent, has been the subject of many academic studies in theory and solutions have been proposed. However, in 2024, more than 600 million people across the African continent have problems accessing electricity and about 1 billion people have problems accessing clean cooking materials. This situation shows

that theory and practice are not in parallel. The main reason for this is the problems experienced in providing the necessary financing for the solution, although solution proposals are produced for Africa.

Financing and investment strategies Recommendations

Renewable energy investment in Africa is not progressing fast enough, largely due to financial constraints. The International Energy Agency (IEA, 2023b) stresses that Africa needs at least $25 billion of additional investment per year to realise its clean energy transformation. In this context, recommendations can be made under the following headings

- Green Bonds and Carbon Markets: Carbon credit trading can be popularised to support clean energy projects in Africa (Aliyu et al., 2015).
- Increasing private investment: Private equity funds can be channeled into clean energy projects to reduce reliance on government subsidies (McCollum et al., 2018).
- Multilateral development banks: Institutions such as the World Bank and the African Development Bank can increase the viability of projects by providing low-interest financing (Bazilian et al., 2012).

Policy and regulatory recommendations

Lack of regional coordination is a major barrier to sustainable energy transitions in Africa (Taliotis et al., 2016). Local governments need to focus on policy harmonisation. In this context, the following recommendations can be made:

Harmonise energy policies: Following the example of Morocco's policies to enhance energy security, similar strategies can be adopted at the regional level (Kousksou et al., 2015).

Cross-border cooperation: The integration of hydropower, solar and wind energy in West Africa can reduce the cost of electricity trade (Sterl et al. (2020)),

Investor-friendly regulations: To increase energy investment in Africa, governments can introduce more stable and predictable regulations (Sharma et al. (2016).

Technology development and R&D

Innovative technologies and local manufacturing capacity are critical to solving Africa's energy crisis (Mohammed et al., 2013). Recommendations:

- Solar and hybrid systems: Jacobson (2007) shows that solar energy systems in Kenya have made a significant contribution to the local economy.
- Smart grids: Mentis et al. (2015) found that the implementation of smart grids in Nigeria could significantly improve access to electricity in rural areas.
- Energy storage technologies: Pietzcker et al. (2014) highlight the need for energy storage systems to optimise the use of solar and wind energy.

Social and economic participation

The success of energy projects depends on community participation and social dynamics (Louw et al., 2008). Recommendations:

- Community-based energy projects: Kirubi et al. (2009) show that micro-grids in Kenya have significantly improved rural development.
- Inclusion of women in the energy sector: Adenle (2020) suggests that supporting women entrepreneurs in the renewable energy sector could accelerate the uptake of clean energy.
- Financial access in rural areas: Gasparatos et al. (2015) argue that increasing household participation in biofuel projects could reduce income inequality.

Education and capacity building

The development of the energy sector in Africa requires a skilled workforce and technical expertise (Mandelli et al., 2014). Recommendations:

- Technical training programmes: Kemausuor et al. (2011) show that vocational training programmes in Ghana increased the adoption of renewable energy.
- University-industry collaboration: Sterl et al. (2020) emphasise the need to integrate academic research into local energy projects.
- Public awareness campaigns: Aliyu et al. (2015) highlight the importance of awareness programmes to change energy consumption habits.

The recommendations outlined above could accelerate the transition to sustainable energy in Africa. Addressing financing constraints, policy misalignment, and technology adaptation is critical to advancing energy transformation in the region. These literature-based recommendations can help bridge the gap between theoretical research and practical implementation.

5. Final Notes

A comprehensive strategy based not only on technical solutions, but also on a strong financial, political and social foundation is essential for Africa's transition to sustainable energy. The recommendations presented in the literature suggest that the widespread use of green bonds, the promotion of private sector investment, and the harmonisation of regional energy policies are feasible strategies with high impact potential in the short term. In the medium term, technological adaptation and the development of local production capacity are important steps that will contribute to energy independence. Social recommendations, such as community-based energy projects and the inclusion of women in the sector, will ensure an inclusive and sustainable energy transition. Additionally, vocational training programmes and public awareness campaigns will facilitate the adoption of energy policies at the local level by raising awareness and knowledge among the population. Simultaneously implementing these recommendations could create a leverage effect in achieving development goals while providing a solution to Africa's energy crisis. However, success depends on multi-stakeholder cooperation and determined political action.

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Araştırma Makalesi

The Sustainable Development Goals, Sustainability and Clean Energy in Africa: A Review from the Perspective of Theory and Practice

Afrika'da Sürdürülebilir Kalkınma Hedefleri, Sürdürülebilirlik ve Temiz Enerji: Teori ve Uygulama Perspektifinden Bir İnceleme

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Genişletilmiş Özet

Birleşmiş Milletler'in 2030 Sürdürülebilir Kalkınma Gündemi ve Afrika Birliği'nin 2063 Gündemi ile uyumlu olarak, Afrika kıtasının kalkınma hedeflerine ulaşması için enerjiye erişimin sağlanması hayati önem taşımaktadır. Elektrik ve temiz enerjiye erişim, eğitim, sağlık, cinsiyet eşitliği ve ekonomik büyüme dahil olmak üzere birçok sürdürülebilir kalkınma hedefini doğrudan etkileyen temel bir unsur olarak kabul edilmektedir (BM, 2023) ve sadece enerji sektörüyle sınırlı değildir. 2023 itibariyle, dünya çapında yaklaşık 750 milyon insan hala elektriğe erişememektedir. Bu grubun %80'inden fazlası Sahra altı Afrika'da yaşamaktadır (Uluslararası Enerji Ajansı (IEA, 2023a). Durum, elektrik erişim oranının kentsel alanlarda %81 iken kırsal alanlarda sadece %30 olduğu kırsal bölgelerde daha da kritiktir (Dünya Bankası, 2023a). Ayrıca, bölgede yaklaşık 1 milyar insan hala temiz pişirme yakıtlarına erişememektedir ve bu durum halk sağlığı ve çevresel sürdürülebilirlik için ciddi riskler oluşturmaktadır (IEA, 2023b). Afrika kıtası, özellikle güneş, rüzgar ve hidroelektrik kaynaklar açısından muazzam bir yenilenebilir enerji potansiyeline sahiptir. Ancak, bu potansiyeli gerçekleştirmek için önemli yatırımlara ihtiyaç vardır. Şu anda, küresel nüfusun yaklaşık %20'sini oluşturan Afrika, dünya yenilenebilir enerji yatırımlarının sadece %2'sini almaktadır (Time, 2023). Kıtanın enerji altyapısını geliştirmek ve sürdürülebilir enerji hedeflerine ulaşmak için 2030 yılına kadar yıllık yaklaşık 25 milyar ABD doları yatırım gerekeceği tahmin edilmektedir (IEA, 2023a). Enerjiye erişim, Afrika'nın sürdürülebilir kalkınma sürecinin önemli bir parçasıdır. Sürdürülebilir Kalkınma Hedefi 7'nin (SKH-7) gerçekleştirilmesi, kıtada yoksulluğun azaltılması ve cinsiyet eşitliği dahil birçok alanda olumlu etki yaratacaktır. Ancak, bu hedefler, teorik çözümlerin yanı sıra donör ülkeler ve çok taraflı kalkınma kuruluşlarının mali desteğiyle desteklenen kapsamlı politikaların uygulanması olmadan gerçekleştirilemez. Bu çalışmada, sürdürülebilir kalkınma hedefleri kapsamında teorik ve uygulamalı çalışmalar açısından Afrika bölgesi için erişilebilir ve temiz enerji hedefinin projeksiyonu sunulması amaçlanmıştır. Afrika bölgesinin ele alınmasının ana nedeni, Afrika'nın yüksek enerji potansiyeli ve bu potansiyelle çelişen enerjiye erişim sorunudur. Özellikle, Afrika bölgesi geniş yenilenebilir enerji kaynaklarına sahip olmasına rağmen, çok sayıda insan elektrik ve temiz pişirme çözümlerine erişememektedir. Bu erişim eksikliği, eğitim, cinsiyet eşitliği, ekonomik büyüme ve kalkınmaya sınırlamalar getirmektedir (Dünya Bankası, 2023b). Bu bağlamda, 2030 yılına kadar dünya çapında daha iyi bir gelecek sağlamak için geliştirilen 17 sürdürülebilir kalkınma hedefi arasında, Afrika bölgesi için önemli bir hedef, "Erişilebilir ve Temiz Enerji"yi sağlamayı amaçlayan Sürdürülebilir Kalkınma Hedefi 7'dir. Bu amaçla, Afrika bölgesi için enerji konusunda Web Of Science veritabanında taranan dergilerde yayınlanan akademik çalışmalar ayrıntılı olarak analiz edilmiştir. "Africa" ve "energy" anahtar kelimeleriyle Web of Science (WoS) ve Scopus veri tabanlarında yapılan taramalar sonucunda ulaşılan 928 bilimsel çalışma arasından erişilebilir ve temiz enerjiyle ilişkili olan 337 tanesi detaylı olarak incelenmiş ve CiteSpace bilimsel haritalama yazılımı aracılığıyla analiz edilmiştir. CiteSpace, alt disiplinlere dayalı olarak bilimsel çalışmaların entelektüel gelişim süreçlerinin görsel haritalarını sunan bir programdır. Program, görselleştirme sürecinde bilimsel çalışmaları ortak atıf performanslarına göre gösterir.

Bilimsel çalışmaların ortak atıf performansına dayalı olarak elde edilen ağ analizi, belirli bir bilim alanında en çok çalışılan konuların, en fazla ortak atıf alan yazarların, bu yazarların bulunduğu kurum ve ülkelerin ve yayınlarda kullanılan anahtar kelimelerin ayrıntılı bir analizini sağlar. Bu analizler, Afrika bölgesinde erişilebilir ve temiz enerji hedefiyle ilgili çalışmaların yoğunlaştığı ülkeleri, başlıca yazarları, kurumları ve anahtar kavramları ortaya koymuştur. Öne çıkan çalışmalarda, mikro şebekeler, güneş ve rüzgar enerjisi, enerji finansmanı, bölgesel politika uyumları ve kamu-özel ortaklıkları önemli yer tutmaktadır.

Sürdürülebilir kalkınma hedefleri kapsamında Afrika Bölgesi için erişilebilir ve temiz enerji konusunda önemli bilimsel çalışmaların ABD, Almanya, İngiltere, İtalya, Fransa, Çin Halk Cumhuriyeti, Güney Afrika, İsveç ve Avusturya'da yoğunlaştığı söylenebilir. Yüksek ortak atıf performansı gösteren yayınlarda en çok kullanılan anahtar kelimeler arasında yenilenebilir enerji, elektrik senaryoları, güneş enerjisi, Sahra altı Afrika, enerji erişimi, enerji sistemi modellemesi, güneş enerjisi potansiyeli depolama, elektrifikasyon, sürdürülebilirlik etkileri, enerji politikaları, sürdürülebilir kalkınma, elektrifikasyon planlaması, akıllı yenilenebilir elektrik ve enerji verimliliği bulunmaktadır. Önemli bilimsel çalışmaların yapıldığı kurumlar arasında Kaliforniya Üniversitesi, Humboldt Eyalet Üniversitesi, Uluslararası Uygulamalı Sistem Analizi Enstitüsü, Tennessee Üniversitesi, Mercator Küresel Emirler ve İklim Değişikliği Araştırma Enstitüsü, Leeds Üniversitesi, Stockholm Çevre Enstitüsü, Uluslararası Atom Enerjisi Ajansı, Birleşmiş Milletler Sınai Kalkınma Örgütü, Afrika Birliği Komisyonu, Postdam İklim Etkisi Araştırma Enstitüsü, Teknik Üniversitesi, Pekin Teknoloji Üniversitesi, Teknoloji Yönetimi Enstitüsü bulunmaktadır. En çok atıf alan bilimsel çalışmaların yazarları arasında Charles Kirubi, Daniel M. Kammen, Andrew Mills, Arne Jacobson, David L. McCollum, Luis Gomez Echeverri, Sebastian Busch, Shonali Pachauri, Simon Parkinson, Joeri Rogelj, Volker Krey, Jan C. Minx, Mans Nilsson, Anne-Sophie Stevance, Keywan Riahi, Morgan Bazilion, Patrick Nussbaumer, Hans-Holger Rogner, Abeeku Brew-Hammond, Vivien Foster, Shonali Pachauri, Eric Williams, Mark Howells, Philippe Niyongabo, Lawrence Musaba, Brian O. Gallachoir, Mark Radka ve Daniel M. Kammen bulunmaktadır. Bu önemli bilimsel çalışmalarda incelenen başlıca konular arasında mikro şebeke, elektriğe erişim, enerji literatürünün bibliyografik analizi, modern enerji hizmetlerine genel erişim, Sahra Altı Afrika, güneş, rüzgar, hidro ve biyoenerji gibi alternatif yenilenebilir enerji kaynakları ve güneş enerjisi tabanlı teknolojilerin elektrik fiyatlarının istikrarını sağladığı enerji-ekonomi-iklim modeli yer almaktadır. Afrika ülkelerinde güneş enerjisinin benimsenmesindeki eğilimler, kırsal alanlarda elektrik tüketimi için tercih edilen yakıt türleri, biyoyakıt yatırımları ve Afrika bölgesinde sürdürülebilirliğin artırılması, Afrika ülkelerinde enerjiye erişimi artırmaya yönelik eğilimler, politikalar, planlar ve programlar, Afrika bölgesinde elektrifikasyon, enerji altyapısı ve elektrik ticaretidir.

Çalışmada yer alan teorik ve uygulamalı çalışmalar kapsamında Sürdürülebilir Kalkınma Hedefi 7 (Erişilebilir ve Temiz Enerji)'nin Afrika için uygulanabilirliğinin, birçok sistematik engelle karşı karşıya olduğu belirlenmiştir. Bunlar arasında: Finansal Kısıtlar; Afrika kıtası, dünya nüfusunun %20'sine sahip olmasına rağmen küresel yenilenebilir enerji yatırımlarının yalnızca %2'sini almaktadır (Time, 2023). Yıllık 25 milyar dolarlık yatırım ihtiyacı; mevcut bağışçı ve kamu finansman mekanizmalarıyla karşılanamamaktadır. Politika Uyumsuzluğu ve Bölgesel Koordinasyon Eksikliği; Ülkeler arası enerji politikalarında koordinasyon eksikliği, sınır ötesi enerji projelerinin yaygınlaşmasını engellemektedir (Taliotis vd., 2016). Marakeş Anlaşması ve Fas örneği; uyumlu politika oluşturmanın bölgesel enerji güvenliği için model teşkil edebileceğini göstermektedir. Teknoloji ve Ar-Ge Eksikliklerik; Solar, hibrit sistemler, enerji depolama çözümleri ve akıllı şebeke uygulamaları Afrika'da yeterince yaygın değildir. Jacobson (2007) ve Mentis vd., (2015)'nin çalışmaları, kırsal alanlarda bu teknolojilerin ekonomik ve sosyal faydalarını açıkça ortaya koymaktadır. Toplumsal Katılım ve Sosyo-Ekonomik Faktörler; Kadınların enerji sektörüne entegrasyonu, yerel topluluk temelli enerji projeleri (Kirubi vd., 2009), yoksul kesimlerin finansal katılımı enerji erişiminin başarısını doğrudan etkilemektedir. Enerji yatırımlarının sosyal kabulü, sürdürülebilirliğin anahtarıdır. Sıralanan bu engellere karşılık sunulabilecek politika ve strateji önerileri ise şu şekilde ifade edilebilir: Finans ve Yatırım Önerileri; Yeşil Tahviller ve Karbon Piyasaları: Karbon kredisi ticareti teşvik edilmelidir. Özel Yatırımların Artırılması: Kamu-özel iş birliği modelleri güçlendirilmelidir. Çok Taraflı Kalkınma Bankaları: Dünya Bankası ve Afrika Kalkınma Bankası gibi kurumlar düşük faizli krediler sağlamalıdır. Politika Uyumu ve Bölgesel Entegrasyon; Enerji politikaları bölgesel düzeyde uyumlaştırılmalı, sınır ötesi iş birlikleri artırılmalıdır. Yatırımcı dostu düzenlemeler hayata geçirilmelidir (Sharma vd., 2016).Teknoloji Gelişimi ve Ar-Ge; Akıllı şebekeler ve enerji depolama sistemleri yaygınlaştırılmalıdır. Yerli üretim desteklenmeli, teknolojik transfer kolaylaştırılmalıdır. Sosyal Katılım ve Eşitlik; Kadın girişimciler desteklenmeli, kırsal mikro-şebekeler güçlendirilmelidir. Enerji okuryazarlığı artırılmalı, kamu bilinçlendirme kampanyaları düzenlenmelidir. Eğitim ve Kapasite Geliştirme; Teknik eğitim programları, üniversite-sanayi iş birliği projeleri ve farkındalık kampanyaları oluşturulmalıdır (Mandelli vd., 2014; Kemausuor vd., 2011).

Bu çalışma, Afrika'da sürdürülebilir enerjiye geçişin yalnızca teknolojik ve finansal değil, aynı zamanda politik, sosyal ve kültürel bir dönüşüm gerektirdiğini ortaya koymaktadır. Yapılan CiteSpace analizleri, teorik bilgi üretiminin yoğun olduğunu ancak uygulamada bu bilgilerin sınırlı kaldığını göstermektedir.Gerekli finansman, bölgesel politik uyum, teknoloji transferi ve yerel katılım sağlanmadan enerji dönüşümünün başarılı olması mümkün değildir. Bu bağlamda önerilen stratejilerin eş zamanlı ve entegre şekilde uygulanması, Afrika'nın sürdürülebilir kalkınma hedeflerine ulaşmasını hızlandırabilir. Ancak bu süreçte kararlılık, çok paydaşlı iş birliği ve uzun vadeli vizyon belirleyicidir.