Circular Economy

Scientific Knowledge in Time and Space

The Netherlands Edition | 2010 – 2023

Dr. Serdar Türkeli

Citation: Türkeli S. (2024). Circular Economy – Scientific Knowledge in Time and Space. The Netherlands Edition. 2010–2023. United Nations University - MERIT, Maastricht. Accessible upon request: https://lab.unu-merit.nl/circular-economy-central/

Contents

EXECUTIVE SUMMARY

#1 | Circular economy (CE) scientific research in the Netherlands (NL) ranks **10th** (n: **1024**) in the world with respect to the bulk number of scientific publications indexed by Web of Science Core Collection, it ranks **5th** with **h-index 100**, which means **100 scientific publications received more than 100 citations** and ranks the **1st** in terms of average citations received **(~48 citations on average per scientific publication)**. **~4.3%** of the CE content published in the world is produced by CE scientific research in the Netherlands (up to 31st December 2023).

#2 | More than ~**81%** of scientific publications from the Netherlands on circular economy are Open Access (World Average: **~59%)**. **~6%** of Open Access scientific publications in the world are from the Netherlands.

#3 | More than **36%** of CE publications are produced **in the last 2 years (2022, 2023**), and more than **72% in the last 4 years (2020, 2021, 2022, 2023)**, which indicates the up-to-date scientific research in the CE domain in the Netherlands.

#4 | **1024** CE scientific publications contributed to the writing of **29773** scientific publications (articles citing CE literature without self-citations). Multiplier value is **~29**, which is the highest in the world.

#5 | The Netherlands performs highly in Science Citation Index Expanded (SCI-EXPANDED) which lists top science and technology journals. **Top performer in the world is DELFT UNIVERSITY OF TECHNOLOGY (n: 309**). In the NL, it is followed by **WAGENINGEN UNIVERSTIY RESEARCH (n:155)** and **UTRECHT UNIVERSITY (n:109)**

#6 | The Netherlands has collaborated with **87 countries/territories out of 154 countries active in publishing on CE**, nearly **half of the countries**, which produced CE scientific publications, with a global coverage extending **to new collaborators in Latin America, East Asia, Africa, Middle East.**

#7 | Co-authorship **collaborations with top 10 countries increased around 70%** in the last two to three years. **17 new countries/regions** are also collaborated with the Netherlands in the last 2 years.

#8 | Top 3 authors: Bocken NMP (**50**), Kirchherr J. (**24**), Balkenende R. (**21**),

#9 | Top 5 institutes are **DELFT UNIVERSITY OF TECHNOLOGY (309), 30% of NL; WAGENINGEN UNIVERSITY RESEARCH (155), ~15% of NL; UTRECHT UNIVERSITY (109), ~10%; UNIVERSITY OF TWENTE (74), ~7.2%; LEIDEN UNIVERSITY (65), ~6.4%**

#10 | A variety of University-University cooperation at national, international level, University- Industry (Avantium, Homie BV), University – Agency (e.g. PBL, TNO), University- Government (e.g. RIVM, Waternet) **are present**.

#11 | For Top 3 CE publishing journals, **Journal of Cleaner Production, Sustainability,** and **Resources Conservation and Recycling**

#12 | **Water Research, Entomology, Urban Studies, Education Educational Research, Electrical Electronic Engineering** related to circular economy are differentiating scientific areas for the Netherlands from the world.

#13 | **Metallurgy and Metallurgical Engineering, Polymer Science** related scientific research areas and journals **(e.g., Materials)** can be targeted.

#14 | Industries that CE scientific research relates to are widespread and in most categories the number of publications is increasing (also using classification of Merli (2018)).

#15 | **Fashion, ICT and maritime sectors/industries started to draw** more attention from CE scientific research given observable industrial activities are relatively high in the NL. In synch with EU policies 2014/2015; 2019/2020 (EU, and national e.g., PBL) growth in scientific knowledge production is visible in certain sectors.

#16 | The number of publications in each circularity strategy is increasing (PBL, 2019). **Remanufacturing** is the least written topic in the NL. **Rethink** and **Refuse** are the least mentioned expressions. **NL: Recycle (309); Reduce (226); Recover (175); Reuse (127); Repair (51), Remanufacture (31); Rethink (14), Refuse (4).**

#17 | The number of publications in **Policy, Regulation, Directive** are increasing. Low scale of attention is paid to renewable energy in relation to CE (multiple system transitions). **The CE literature emphasizing a gap also focus on institutional (n:65), policy (n:43); social (n:34), knowledge (n:32) technical (n:21) and finance (n:20) aspects.**

#18 | **Digital economy and CE interaction** is emerging, yet still needs to be paid more attention**.**

#19 | CE scientific research in the NL **benefit from various institutional reports at national, international and global level,** such as Ellen Macarthur Foundation, 2013, Circ ec ec bus rat a (international); Potting j., 2017, circular ec measuring PBL (national); European Commission, 2015, clos loop an EU act (supranational); Ellen Macarthur Foundation, 2015, growth circ ec vis c; (international); ISO, 2006, Env. Management life (International); European Commission, 2015, clos loop EU act plan (Supranational); Ellen Macarthur Foundation, 2015, circular ec business; and World Commission on environment and development, 1987, our common future (Global) are the main institutional references cited by the CE literature written in the NL.

#20 | More activity in **SDG 5 Gender Equality** and CE and **SDG 17 Partnerships for the Goals** and CE is needed.

#21 |CE Education relies on **Design Education, Science Education, Hands-on Learning/manipulatives and Engineering Education**, computational and social education method also relates itself to CE education.

#22 |The Netherlands is leading in **circular economy transition and circular business model research** and scientific knowledge production yet circular economy and renewable energy interaction receives less attention. This indicates an emphasis on **multiple system transitions** at policy (research) level.

#23 |**Reporting** and **just transitions** are leading domains of prospective CE knowledge deepening.

#24 | **A systemic view (supply, demand, finance, institutions) on CE transition and policy** indicates specific supply side, support to supply side, demand side and institutional policy instruments, such as obtaining bank finance for circular business model innovation (e.g., Toxopeus et al., 2021), helpdesk for businesses, increasing consumer involvement (e.g., Sijtsema et al., 2020), product passport systems for traceability of products and their components (e.g., Van Capelleveen et al., 2023), and the increasing role of local authorities (e.g.; Yu et al.; 2015).

#25 |With respect to ICER and National CE Program product categories, the Netherlands has a leading position in circular economy and **housing domain**, yet there is still room for circularity research and improvements for **plastic in construction, plastic in agriculture, textile, disposables, PV, and batteries.**

SECTION 1

1. Dynamics of Circular Economy Scientific Publications

Between **1999** and **2024 (31st December 2023)**, that is ~**25** years, a quarter century, worldwide, in **155** countries and territories[1], in total **23,562** scientific publications (SP)[2] have been produced in the core domain of circular economy (CE)[3] and been indexed[4] by Thomson Reuters Web of Science Core Collection[5]. The Netherlands started producing CE scientific publications in **2010**, with Veenstra, A., Wang, C., Fan, W., & Ru, Y. (2010). *An analysis of E-waste flows in China.* The International Journal of Advanced Manufacturing Technology, 47(5-8), 449-459, which is an international collaboration between *Erasmus University Rotterdam, Rotterdam, the Netherlands* and *Beijing Jiaotong University, School of Economics & Management, Beijing, Peoples Republic China.*

1.1. The Number of Scientific Publications in Time

The share of the total number of scientific publications with at least one (**1**) co-author affiliated with at least one (**1**) organisation in the Netherlands (NL, Latitude from 50.77083 to 53.35917 and longitude from 3.57361 to 7.10833)[6] is **(n: 1024),** which corresponds to **~4.3%** of all CE scientific publications worldwide. This share is **~0.2%** higher only if journal articles are considered, NL (**n: 777**) / Worldwide (**n: 17165**), **~4.5%.**

Table 1.1 - Share of CE Scientific Publications from the NL in Total Worldwide

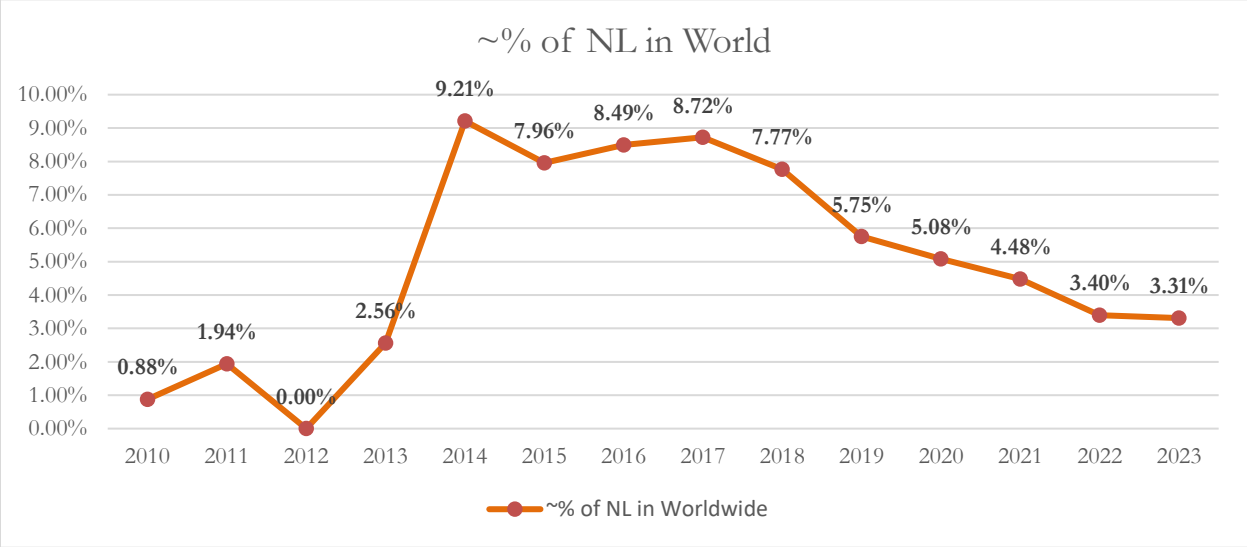
Year	Worldwide # of SP	Yearly % in Total SP	NL # of SP	Yearly % in NL	~% of NL in Worldwide
2010	114	0.48%	1	0.10%	0.88%
2011	103	0.44%	2	0.20%	1.94%
2012	96	0.41%	0	0.00%	0.00%
2013	78	0.33%	2	0.20%	2.56%
2014	76	0.32%	7	0.68%	9.21%
2015	113	0.48%	9	0.88%	7.96%
2016	318	1.35%	27	2.64%	8.49%
2017	596	2.53%	52	5.08%	8.72%
2018	965	4.10%	75	7.32%	7.77%
2019	1808	7.67%	104	10.16%	5.75%
2020	2950	12.52%	150	14.65%	5.08%
2021	4839	20.54%	217	21.19%	4.48%
2022	5799	24.61%	197	19.24%	3.40%
2023	5465	23.19%	181	17.68%	3.31%
Total	**23562**	**100.00%**	**1024**	**100.00%**	**4.35%**

Temporal breakdown above (Table 1.1.) shows an increase in the total number of publications worldwide and in the Netherlands with slight reductions in 2022 and 2023. In the Netherlands more than ~**36%** of scientific publications are

[1] See the data file for the full list with number of publications and share in cumulative circular economy publications.
[2] Scientific publications (SP) here mean Articles 17,165; Review Articles 3,571; Proceeding Papers 2,373; Editorial Material 517; Early Access 374; Meeting Abstract 37; Correction 30; Data Paper 20; News Item 20; Retracted Publication 19; Book Review 17; Letter 8; Book Chapters 7; Retraction 4; Art Exhibit Review 1; Meeting 1
[3] Core domain of Circular Economy is reached by the query: **TOPIC:** ("*circular* *econom*") *OR* **TITLE:** ("*circular* *econom*") (Türkeli et al., 2018)
[4] Web of Science Core Collection hosts 6 main citation indices: These are Science Citation Index Expanded (SCI-EXPANDED) --1988-present; Social Sciences Citation Index (SSCI) --1988-present; Arts & Humanities Citation Index (A&HCI) --1988-present; Conference Proceedings Citation Index- Science (CPCI-S) --1990-present; Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH) --1990-present; Emerging Sources Citation Index (ESCI) --2015-present. The first 3 are worldwide recognized core citation indices of scientific and technological knowledge production, the latter 3 indices are conference and emerging sources indices that pass the quality criteria of Web of Science, Thomson Reuters for citation indexing.
[5] Thomson Reuters Web of Science Core Collection is the strictest science citation index in eligibility criteria for inclusion of sources (journals, publishers, conferences…) into its list of Core Collection composed of six citation indices, compared to SCOPUS and Google Scholar (Türkeli et al., 2018)
[6] Source: https://latitudelongitude.org/nl/

produced in the last **2** completed years **(2022, 2023**) and **~73%** in the last **4** years, which are positive indicators in terms of still emerging content and up-to-date scientific knowledge production dynamics, yet a decline in the share of CE publications from the Netherlands in Total CE Scientific Publications worldwide is also observed (Figure 1.1):

Figure 1.1 – Share of CE Publications in the Netherlands in Total CE Publications Worldwide

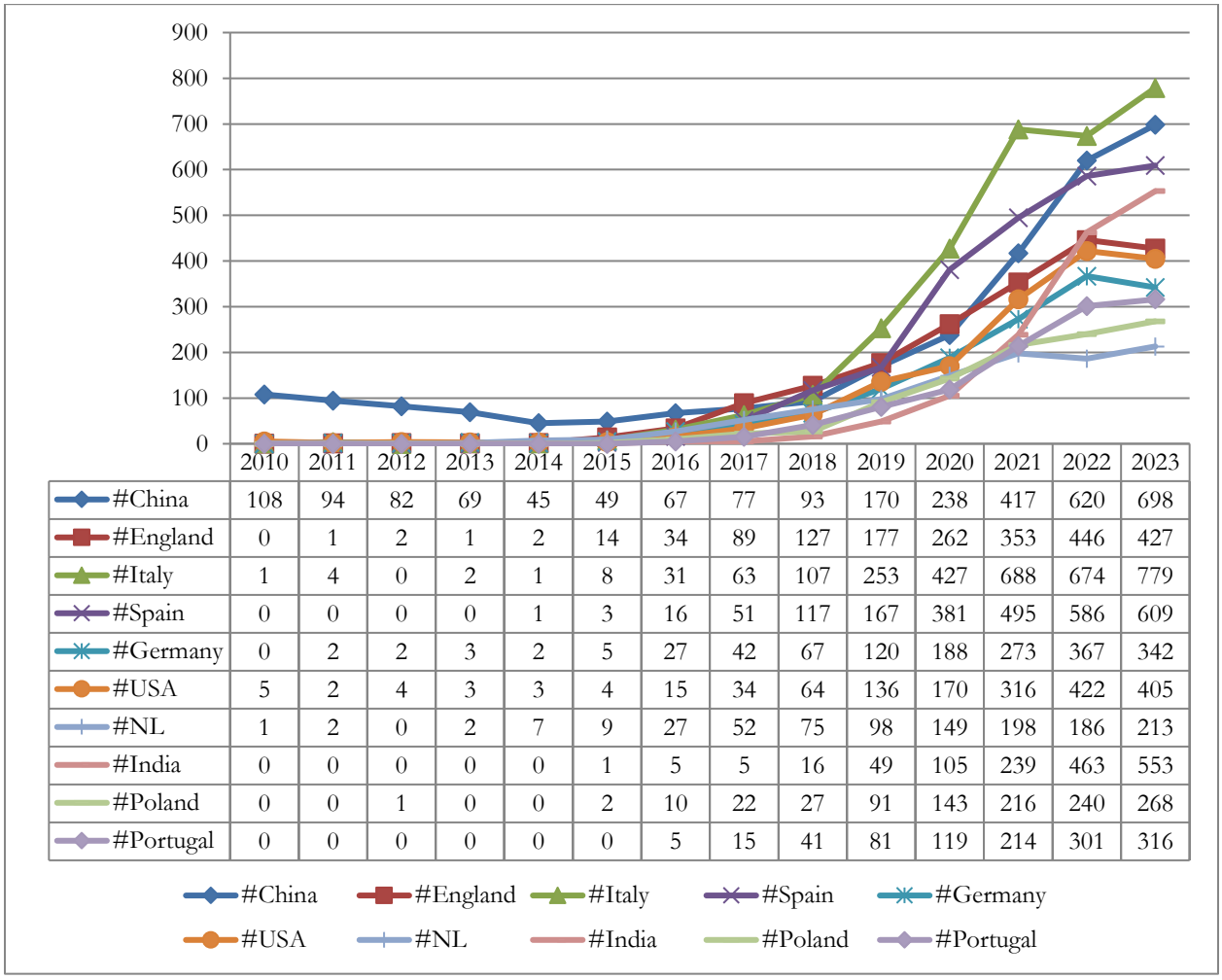


On average **~4.3%** of the CE content published in the world is produced by CE scientific research in the Netherlands (from 1 January 2010 up to 31st December 2023).

Analysis of this decline requires a comparative analysis (Figure 1.2) to assess the relative performance of other countries, and a received citation analysis (Table 1.2) to conclude on the necessity of a science policy intervention regarding a CE scientific knowledge domain, publication support. Therefore, a comparative analysis of these top performing countries is beneficial.

In detail, in this timeframe of app. **25** years, with **3093** scientific publications, **Peoples Republic of China (~13.1%), and Italy, 3069 (~13%); Spain, 2454 (~10.4%); England, 1985 (~8.4%); Germany, 1460 (~%6.2); USA, 1619 (~6.9%); India 1522 (6.5%); Brazil 1116 (4.7%); Portugal 1102 (4.7%)** produced more scientific publications than **the Netherlands** (see full list in datasheet) which is in the **10th** place.

Figure 1.2 – Top Performing Countries | Worldwide Share in Total (2010-2023)



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
#China	108	94	82	69	45	49	67	77	93	170	238	417	620	698
#England	0	1	2	1	2	14	34	89	127	177	262	353	446	427
#Italy	1	4	0	2	1	8	31	63	107	253	427	688	674	779
#Spain	0	0	0	0	1	3	16	51	117	167	381	495	586	609
#Germany	0	2	2	3	2	5	27	42	67	120	188	273	367	342
#USA	5	2	4	3	3	4	15	34	64	136	170	316	422	405
#NL	1	2	0	2	7	9	27	52	75	98	149	198	186	213
#India	0	0	0	0	0	1	5	5	16	49	105	239	463	553
#Poland	0	0	1	0	0	2	10	22	27	91	143	216	240	268
#Portugal	0	0	0	0	0	0	5	15	41	81	119	214	301	316

Table 1.2 - Scientific Impact: Citation Analysis of Top 10 Countries

Countries/ Territories	#	h-index	Average citation per item	Sum of times cited	# Without self-citations	# Citing Articles	# Without self-citation	Multiplier (Articles contributed to writing of other articles via being cited)
PEOPLES R CHINA	**3093**	**123**	**26.41**	**81685**	**77012**	**55959**	**54561**	**17.6**
ITALY	**3069**	**109**	**24.45**	**75035**	**69184**	**49591**	**47845**	**15.6**
ENGLAND	**1985**	**131**	**41.79**	**82944**	**77416**	**48840**	**47587**	**24.0**
SPAIN	**2454**	**87**	**20.09**	**49313**	**46646**	**37624**	**36482**	**14.9**
GERMANY	**1460**	**90**	**26.57**	**38795**	**37288**	**29371**	**28718**	**19.7**
USA	**1619**	**106**	**33.18**	**53725**	**51297**	**39529**	**38769**	**23.9**
NETHERLANDS	**1024 (10th)**	**100 (5th)**	**48.03 (1st)**	**49178 (6th)**	**46554 (6th)**	**30400 (6th)**	**29773 (6th)**	**29.1 (1st)**
INDIA	**1522**	**94**	**27.49**	**41846**	**39147**	**29913**	**29128**	**19.1**
BRAZIL	**1116**	**60**	**21.05**	**23489**	**22009**	**17101**	**16540**	**14.8**
PORTUGAL	**1102**	**62**	**19.12**	**21072**	**20334**	**18151**	**17739**	**16.1**

Although the Netherlands ranks **10th (n: 1024)** in the world with respect to the bulk number of scientific publications indexed by Web of Science Core Collection, it ranks **5th** with h-index **100**, which means 100 scientific publications received more than 100 citations and **ranks 1st in terms of average citations received (~47.78 citations) per scientific publication in the domain of circular economy.**

1024 CE scientific publications from the Netherlands contributed to the writing of **29624** scientific publications (articles citing CE literature). Multiplier value is the highest, ~**28.97.** This multiplier value is lower ~17.6 for China; ~15.6 for Italy, ~24 for England, ~14.9 Spain. CE scientific publications in the Netherlands contribute more publications in related domains to be produced (Table 1.2 without Self Citations column divided by # column)

1.2 Citation Indices Performance

Science Citation Index Expanded covers more than **8500** notable and significant journals, across **150** disciplines, from 1900 to the present. These are alternatively described as the world's leading journals of science and technology, because of a rigorous selection process. In SCI Expanded: **Increasing performance of the NL in time is observable in Table 1.3.** Science policy support for *Conferences and Conference Proceedings, especially in Natural Sciences, and then Social Sciences & Humanities* is needed. This involves support for developing quality standards for conference organization, documentation and (open access) publishing proceedings, and finally submitting Conference Proceedings for Coverage in CPCI[7] (Table 1.3).

Table 1.3- Breakdown of Citation Indices (2019 – 2023)

*** w/o sc: without self-citations, #: number of articles**

Citation Index	Worldwide (#)	NL (#)	NL (%)	h-index	Avg. cit. received. per item	w/o sc Sum Times Cited	w/o sc (#) Articles	Comparison 2- Yearly
Science Citation Index Expanded (SCI-EXPANDED)	2650	209	7.90%	40	30.11	6044	4126	Accumulative up to 2019
	9655	**537**	**5.56%**	***63***	***35.41***	***17932***	***11724***	Accumulative up to 2022
	17299	**788**	**4.56%**	**99**	**57.88**	**43753**	**28.286**	Accumulative up to 2024
Social Sciences Citation Index (SSCI)	1124	115	10.20%	30	36.57	4007	2525	Accumulative up to 2019
	3883	**336**	**8.65%**	***50***	***38.57***	***12004***	***7.171***	Accumulative up to 2022
	5717	**422**	**7.38%**	**78**	**70.32**	**28.34**	**16.296**	Accumulative up to 2024
Conference Proceedings Citation Index- Science (CPCI-S)	997	26	2.60%	*5*	*2.77*	*71*	*70*	Accumulative up to 2019
	1444	**33**	**2.29%**	***6***	***5.36***	***176***	***169***	Accumulative up to 2022
	1901	47	2.47%	8	7.28	335	323	Accumulative up to 2024
Emerging Sources Citation Index (ESCI)	412	21	5.10%	*5*	*18.62*	*382*	*379*	Accumulative up to 2019
	1244	**44**	**3.54%**	***9***	***5.89***	***245***	***216***	Accumulative up to 2022
	2743	97	3.54%	17	10.88	1028	925	Accumulative up to 2024
Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH)	521	16	3.00%	*2*	*1.63*	*26*	*23*	Accumulative up to 2019
	672	**23**	**3.42%**	***4***	***2.3***	***53***	***50***	Accumulative up to 2022
	794	30	3.78%	7	3.77	107	100	Accumulative up to 2024
Arts & Humanities Citation Index (A&HCI)	36	3	8.30%	2	2.33	7	7	Accumulative up to 2019
	52	**7**	**13.46%**	***4***	**4.71**	**33**	**32**	Accumulative up to 2022
	80	9	11.25%	4	7.11	64	62	Accumulative up to 2024

[7] Source: Web of Science, Accessible: https://clarivate.com/webofsciencegroup/essays/web-science-conference-proceedings-selection-process/

Collaboration of the Netherlands at country level in Time

The Netherlands has collaborated with **87** countries/territories out of **154**, **more than half of the active countries in CE domain**, which produced CE scientific publications.

Top Collaborators: (see Table 1.4)

New collaborators: **BRUNEI; ALBANIA; LATVIA; MOLDOVA; NIGERIA; BAHAMAS; BULGARIA; EGYPT; NORTH MACEDONIA; QATAR; REP CONGO; RWANDA; SRI LANKA; SYRIA; THAILAND; UGANDA; URUGUAY** are relatively recent and new collaborators of **the Netherlands** in CE domain in the last 2 years.

Not Yet Collaborated CE publishing countries/territories are (67): ALGERIA, ANDORRA, ANGOLA, ARMENIA, AZERBAIJAN, BAHRAIN, BELARUS, BENIN, BHUTAN, BOLIVIA, BOSNIA HERCEG, BOTSWANA, CAMEROON, CAPE VERDE, COTE IVOIRE, CUBA, DJIBOUTI, DOMINICAN REP, EL SALVADOR, FAROE ISLANDS, FIJI, FRENCH GUIANA, GAMBIA, GEORGIA, GHANA, GREENLAND, GRENADA, GUYANA, HONDURAS, JORDAN, KAZAKHSTAN, KOSOVO, KYRGYZSTAN, LIBYA, LITHUANIA, MACEDONIA, MADAGASCAR, MALAWI, MALDIVES, MALI, MAURITIUS, MONACO, MONTENEGRO, MOZAMBIQUE, NAMIBIA, NIGERIA, NORTH KOREA, NORTH SUDAN, OMAN, PALESTINE, PANAMA, PAPUA N GUINEA, PERU, SAN MARINO, SENEGAL, SOLOMON ISLANDS, SOUTH SUDAN, SUDAN, TANZANIA, TIMOR LESTE, TOGO, TRINIDAD TOBAGO, TUNISIA, UGANDA, UZBEKISTAN, VANUATU, VENEZUELA, YEMEN, ZAMBIA, ZIMBABWE.

Table 1.4 - Top 25 Collaborators of the Netherlands in CE Science (2010-2023 31st December)

Countries/Regions publishing with NL (co-authorship)	Record Count	% of 1024
NETHERLANDS	1024	100.0%
ENGLAND	117	11.4%
ITALY	104	10.2%
GERMANY	101	9.9%
PEOPLES R CHINA	79	7.7%
BELGIUM	79	7.7%
SPAIN	69	6.7%
SWEDEN	64	6.3%
USA	60	5.9%
DENMARK	58	5.7%
FRANCE	51	5.0%
FINLAND	41	4.0%
AUSTRIA	40	3.9%
SWITZERLAND	33	3.2%
PORTUGAL	32	3.1%
AUSTRALIA	27	2.6%
CANADA	27	2.6%
NORWAY	26	2.5%
BRAZIL	20	2.0%
GREECE	19	1.9%
JAPAN	17	1.7%
IRELAND	14	1.4%
SCOTLAND	14	1.4%
SOUTH AFRICA	13	1.3%
POLAND	12	1.2%
INDIA	11	1.1%

*Please see the data file for the full list

*Numbers denotes the number of scientific publications co-authored with a researcher affiliated with an organisation in the indicated country.

1.3. Dynamics of Circular Economy Journals

Worldwide **3967** publication titles have published **23534** scientific publications in CE domain. Researchers affiliated with an organisation in the Netherlands are published in **377** of them. The journals in which more than **one (1)** CE article published and co-authored with at least **one (1)** researcher in the Netherlands are listed in Figure 2.1 and Table 2.1 below (See data file for full Journal list).

Figure 2.1 - Top 25 Journals of CE Science (2010-2023) in the world

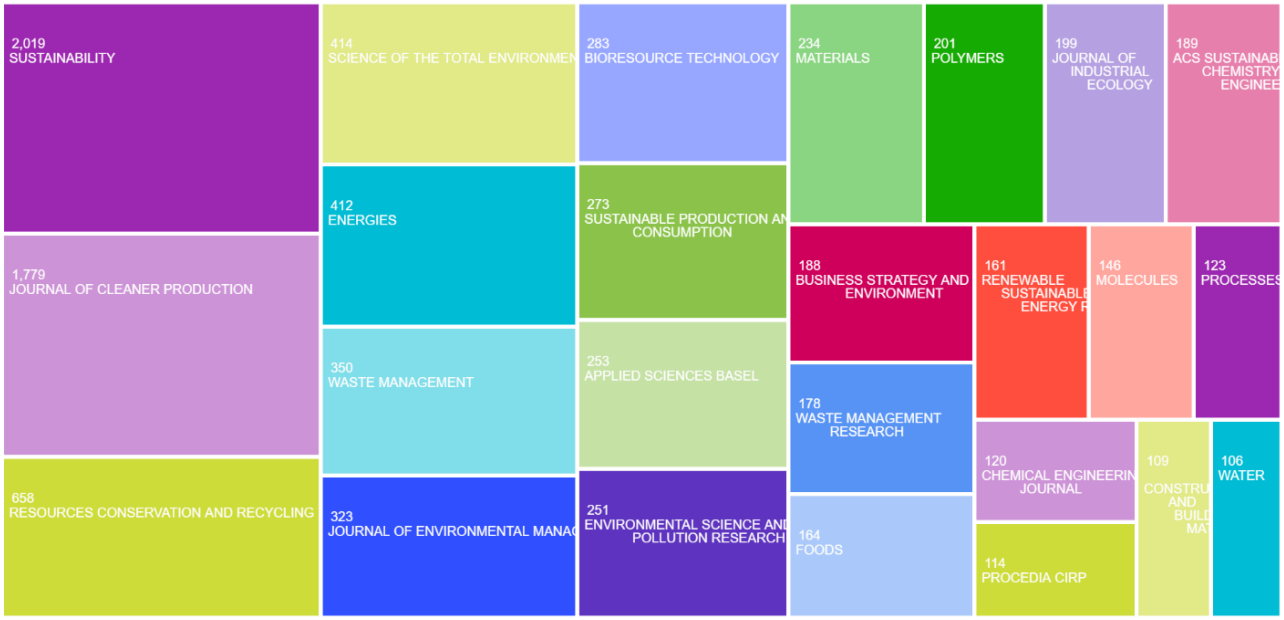


Table 1.5 CE publications from the NL and Top Journal Distributions

NL 2010-2023	#	%
JOURNAL OF CLEANER PRODUCTION	141	13.76%
SUSTAINABILITY	110	10.73%
RESOURCES CONSERVATION AND RECYCLING	75	7.32%
JOURNAL OF INDUSTRIAL ECOLOGY	37	3.61%
SUSTAINABLE PRODUCTION AND CONSUMPTION	28	2.73%
BUSINESS STRATEGY AND THE ENVIRONMENT	17	1.66%
JOURNAL OF ENVIRONMENTAL MANAGEMENT	16	1.56%
SCIENCE OF THE TOTAL ENVIRONMENT	14	1.37%
WASTE MANAGEMENT	14	1.37%
PRODUCT LIFETIMES AND THE ENVIRONMENT PLATE	12	1.17%
ENVIRONMENTAL INNOVATION AND SOCIETAL TRANSITIONS	11	1.07%
ECOLOGICAL ECONOMICS	10	0.98%
ACS SUSTAINABLE CHEMISTRY ENGINEERING	9	0.88%
ENERGIES	9	0.88%
GREEN CHEMISTRY	9	0.88%
CHEMOSPHERE	8	0.78%
JOURNAL OF INSECTS AS FOOD AND FEED	8	0.78%

1.3.1. The Number of Publications (articles) per Journal in Time

Publication Year	2010	2011	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	Grand Total
Grand Total	1	1	1	6	5	17	26	49	72	121	154	145	178	776
JOURNAL OF CLEANER PRODUCTION		1		2		8	4	11	13	18	24	17	20	118
SUSTAINABILITY				1		2		7	11	23	30	23	2	99
RESOURCES CONSERVATION AND RECYCLING						1	3	7	5	15	11	8	6	56
JOURNAL OF INDUSTRIAL ECOLOGY				1	1		4		2	3	5	8	10	34
SUSTAINABLE PRODUCTION AND CONSUMPTION											7	8	11	26
BUSINESS STRATEGY AND THE ENVIRONMENT										3	3	3	6	15
WASTE MANAGEMENT				1		1		1	2	1	2	4	2	14
JOURNAL OF ENVIRONMENTAL MANAGEMENT							1	2	1	1	3	1	2	11
ECOLOGICAL ECONOMICS								1	1	2	3	1	2	10
ACS SUSTAINABLE CHEMISTRY & ENGINEERING						1		2	1	1	1	1	2	9
ENVIRONMENTAL INNOVATION AND SOCIETAL TRANSITIONS								2		1	1	1	4	9
SCIENCE OF THE TOTAL ENVIRONMENT								1	1		2	1	4	9
ENERGIES								1	2	1	1	2	1	8
CHEMOSPHERE											3	3	1	7
GREEN CHEMISTRY							1			4	1		1	7
FRONTIERS IN SUSTAINABILITY												2	4	6
URBAN PLANNING									5			1		6
WATER RESEARCH			1					1	2	2				6
BIORESOURCE TECHNOLOGY					1						1	1	2	5
CHEMICAL ENGINEERING JOURNAL									1	1			3	5
RESOURCES CONSERVATION & RECYCLING ADVANCES											1	1	3	5
TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE							1			1		2	1	5
ENVIRONMENT INTERNATIONAL						1						3		4
ENVIRONMENTAL SCIENCE & TECHNOLOGY							1					1	2	4
FRONTIERS IN BUILT ENVIRONMENT											2	1	1	4
RENEWABLE & SUSTAINABLE ENERGY REVIEWS											2	1	1	4
ACS APPLIED MATERIALS & INTERFACES										1			2	3
BIOTECHNOLOGY FOR BIOFUELS							1				2			3
BUILDINGS									1			1	1	3
CONSTRUCTION MANAGEMENT AND ECONOMICS											1	1	1	3
CURRENT OPINION IN GREEN AND SUSTAINABLE CHEMISTRY										1	1		1	3
ENVIRONMENT DEVELOPMENT AND SUSTAINABILITY					1								2	3
FOOD ADDITIVES AND CONTAMINANTS PART A-CHEMISTRY ANALYSIS CONTROL EXPOSURE & RISK ASSESSMENT							1			1		1		3
INTERNATIONAL JOURNAL OF LIFE CYCLE ASSESSMENT									2		1			3
INTERNATIONAL JOURNAL OF PRODUCTION ECONOMICS									2	1				3
JOURNAL OF ENVIRONMENTAL PLANNING AND MANAGEMENT										1	1		1	3
JOURNAL OF ENVIRONMENTAL POLICY & PLANNING									1	1			1	3
PHILOSOPHICAL TRANSACTIONS OF. THE ROYAL SOCIETY A-MATHEMATICAL PHYSICAL AND ENGINEERING SCIENCES							1			2				3
WASTE MANAGEMENT & RESEARCH						1							2	3

In the Netherlands, for Top 3 CE Journals:

- **Journal of Cleaner Production**
- **Sustainability**
- **Resources Conservation and Recycling**

1.4. The Number of Publications per Research Field ("Science Categories")

Worldwide CE is studied under **195** science categories; research from the Netherlands contributes **105** science categories. The science categories in which more than (~%1) of CE scientific publication published and co-authored with at least **(1)** one researcher in the Netherlands are listed in table below (See Data file for full list). The key findings are Materials Science Multidisciplinary Chemistry/Chemical Engineering for CE are relatively weak (at natural resources economy and engineering interface) in the Netherlands[8].

Table 1.6- Number of Publication per Research Field

Web of Science Categories	Record Count	% of W: 23563	Web of Science Categories	Record Count	% of 1024	W %	Result
Environmental Sciences	8943	37.954	Environmental Sciences	538	52.539	37.954	NL MORE
Green Sustainable Science Technology	6301	26.741	Green Sustainable Science Technology	405	39.551	26.741	NL MORE
Engineering Environmental	4438	18.835	Engineering Environmental	311	30.371	18.835	NL MORE
Environmental Studies	3354	14.234	Environmental Studies	225	21.973	14.234	NL MORE
Energy Fuels	2089	8.866	Energy Fuels	50	4.883	8.866	NL LESS
Engineering Chemical	1553	6.591	Business	49	4.785	3.972	NL MORE
Materials Science Multidisciplinary	1553	6.591	Management	41	4.004	5.237	NL LESS
Chemistry Multidisciplinary	1347	5.717	Chemistry Multidisciplinary	40	3.906	5.717	NL LESS
Management	1234	5.237	Engineering Chemical	34	3.32	6.591	NL LESS
Biotechnology Applied Microbiology	965	4.095	Biotechnology Applied Microbiology	31	3.027	4.095	NL LESS
Business	936	3.972	Construction Building Technology	28	2.734	2.61	NL MORE
Food Science Technology	755	3.204	Food Science Technology	28	2.734	3.204	NL LESS
Engineering Civil	654	2.776	Water Resources	25	2.441	1.761	NL MORE
Economics	647	2.746	Agriculture Multidisciplinary	23	2.246	0.692	NL MORE
Physics Applied	640	2.716	Economics	22	2.148	2.746	NL LESS
Construction Building Technology	615	2.61	Regional Urban Planning	22	2.148	1.235	NL MORE
Engineering Industrial	613	2.602	Engineering Civil	21	2.051	2.776	NL LESS
Chemistry Physical	579	2.457	Materials Science Multidisciplinary	21	2.051	6.591	NL LESS
Polymer Science	551	2.338	Engineering Industrial	19	1.855	2.602	NL LESS
Operations Research Management Science	518	2.198	Urban Studies	19	1.855	0.675	NL MORE
Engineering Multidisciplinary	502	2.13	Multidisciplinary Sciences	18	1.758	1.727	NL MORE
Engineering Manufacturing	495	2.101	Ecology	14	1.367	0.645	NL MORE
Metallurgy Metallurgical Engineering	454	1.927	Operations Research Management Science	14	1.367	2.198	NL LESS
Agricultural Engineering	416	1.765	Engineering Manufacturing	13	1.27	2.101	NL LESS
Water Resources	415	1.761	Entomology	11	1.074	0.221	NL MORE

*W: World, please see the data file for the full list and comparisons

[8] Science Categories analysis can be extended to detect non-performing categories and potential partners.

1.5. Industries Covered and Investigated by CE Scientific Publications.

Intuitively, in the Netherlands, and around the world, in the domain of CE scientific research, "waste" is the core focus. Throughout years, one can observe an increasing trend in many industries (Table 1.7). Table 1.7 provides temporal dynamics of certain industries in the domain of CE scientific knowledge. The years 2015, 2017, and 2019 are visible quantitative shift years in terms of publication numbers in the NL for various sectors.

Table 1.7 - Industrial and sectorial domains: Industries and Extension in Time 2010-2023

Keyword	2023	2022	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
"critical material*"	1	1	1				2017 (1)	2016 (1)	2015 (1)					
"rare earth" OR REE	1	2	1	1	2019 (1)	2018 (3)	2017 (1)	2016 (1)	2015 (1)					
urban*	30	29	27	26	2019 (23)	2018 (15)	2017 (9)	2016 (3)	2015 (1)		2013 (1)			
secondhand OR second-hand OR "second hand"	-	3	2					2016 (1)						2010 (1)
education	14	19	24	11	2019 (11)	2018 (8)	2017 (5)	2016 (2)	2015 (1)	2014 (1)				
ICT OR IOT OR digital	20	17	2	5	2019 (7)		2017 (2)	2016 (1)	2015 (1)					
bioenergy OR bio-energy	4	1	2	1	1	2018 (6)	2017 (2)	2016 (2)						
services	14	9	9	11	2019 (7)	2018 (5)	2017 (4)	2016 (2)	2015 (2)	2014 (2)				
agri* OR food or bio*	81	79	83	51	2019 (33)	2018 (31)	2017 (14)	2016 (9)	2015 (3)	2014 (1)	2013 (2)			
water OR wastewater	26	44	35	34	2019 (19)	2018 (19)	2017 (5)	2016 (5)	2015 (2)		2013 (1)			
technolog*	61	89	69	61	2019 (43)	2018 (29)	2017 (16)	2016 (10)	2015 (4)	2014 (1)	2013 (2)			2010 (1)
waste	84	89	74	75	2019 (44)	2018 (35)	2017 (22)	2016 (14)	2015 (5)	2014 (2)	2013 (2)			2010 (1)
chemi*	28	37	38	29	2019 (13)	2018 (12)	2017 (7)	2016 (5)	2015 (1)		2013 (1)			
manufactur*	14	10	27	13	2019 (15)	2018 (7)	2017 (9)	2016 (1)	2015 (1)		2013 (1)			
packag* OR plastic*	30	37	17	19	2019 (8)	2018 (5)	2017 (4)	2016 (4)	2015 (1)					
electric* OR electronic	13	20	11	4	2019 (4)	2018 (6)	2017 (3)	2016 (5)	2015 (2)	2014 (1)				2010 (1)
energy	47	55	57	43	2019 (25)	2018 (24)	2017 (14)	2016 (11)	2015 (4)	2014 (1)	2013 (1)			
autom* OR car OR vehicle OR transport OR logistic*	18	16	19	20	2019 (12)	2018 (8)	2017 (2)	2016 (4)	2015 (1)					
metal*	14	11	12	7	2019 (8)	2018 (6)	2017 (2)	2016 (1)	2015 (1)					
construction	26	29	20	14	2019 (9)	2018 (6)	2017 (2)	2016 (2)						
touris*	1	1	-	-	2019 (1)	2018 (2)		2016 (1)						
textile	-	4	6	2	2019 (3)	2017 (2)		2016 (1)						
mining OR mine	4	8	6	5	2019 (3)		2017 (4)				2013 (1)			
machine*	4	7	6	1	2019 (1)	2018 (1)	2017 (2)							
aluminum	-	-	1	1	2019 (1)		2017 (1)							
steel	3	6	6	2	2019 (4)	2018 (1)	2017 (1)							
engineer*	24	23	27	16	2019 (14)	2018 (11)	2017 (12)	2016 (5)	2015 (2)					
iron	1	4	2	2	2019 (1)	2018 (2)								
fashion	3	6	3	1	2019 (2)									
maritime*	-	2	1	4		1								

1.6 Top Authors and Top Institutes

1.6.1 Top Authors

Authors with 10 or more publication in CE domain:

Table 1.8– Top Authors in the NL

Authors	2010-2024 Record Count	% of 1,025
Bocken N	50	4.878
Kirchherr J	24	2.341
Balkenende R	21	2.049
Fraccascia L	21	2.049
Tukker A	20	1.951
Mugge R	19	1.854
Bakker C	17	1.659
Vermeulen WJV	17	1.659
Yazan DM	17	1.659
De Jong M	11	1.073
Gruis V	11	1.073
Konietzko J	11	1.073
Kopnina H	11	1.073
Sprecher B	11	1.073
Van Timmeren A	11	1.073
Wandl A	11	1.073
Peck D	10	0.976
Van Der Voet E	10	0.976

*please see the data file for the full list

1.6.2. Top Organisations

University | Government | Agency

Business | Other NGOs, Assocs.

Table 1.9 – Top Organisations in NL and collaborators (n > 10)

Affiliations 2010-2024	Record Count	% of 1,024	% of 647	2022->2024
DELFT UNIVERSITY OF TECHNOLOGY	309	30.176	32.921	LESS
WAGENINGEN UNIVERSITY RESEARCH	156	15.234	14.219	MORE
UTRECHT UNIVERSITY	109	10.645	9.428	MORE
UNIVERSITY OF TWENTE	74	7.227	7.728	LESS
LEIDEN UNIVERSITY	65	6.348	6.646	LESS
LEIDEN UNIVERSITY EXCL LUMC	65	6.348	6.646	LESS
MAASTRICHT UNIVERSITY	52	5.078	4.019	MORE
ERASMUS UNIVERSITY ROTTERDAM	40	3.906	3.246	MORE
UNIVERSITY OF AMSTERDAM	40	3.906	3.864	MORE
ERASMUS UNIVERSITY ROTTERDAM EXCL ERASMUS MC	38	3.711	3.246	MORE
VRIJE UNIVERSITEIT AMSTERDAM	38	3.711	3.555	MORE
LUND UNIVERSITY	34	3.32	4.482	LESS
NETHERLANDS ORGANIZATION APPLIED SCIENCE RESEARCH	34	3.32	3.091	MORE
UNIVERSITY OF GRONINGEN	34	3.32	2.782	MORE
EINDHOVEN UNIVERSITY OF TECHNOLOGY	29	2.832	2.937	LESS
GHENT UNIVERSITY	28	2.734	3.246	LESS
RADBOUD UNIVERSITY NIJMEGEN	23	2.246	2.164	MORE
SAPIENZA UNIVERSITY ROME	21	2.051	2.318	LESS
SWISS FEDERAL INSTITUTES OF TECHNOLOGY DOMAIN	19	1.855	0.927	MORE
VITO	18	1.758	0.927	MORE
IHE DELFT INSTITUTE FOR WATER EDUCATION	17	1.66	1.7	LESS
UNIVERSITY OF CAMBRIDGE	17	1.66	1.236	MORE
KU LEUVEN	16	1.563	1.7	LESS
AALBORG UNIVERSITY	14	1.367	1.546	LESS
CENTRE NATIONAL DE LA RECHERCHE SCIENTIFIQUE CNRS	13	1.27	1.855	LESS
ETH ZURICH	13	1.27	0.464	MORE
TECHNICAL UNIVERSITY OF DENMARK	13	1.27	1.546	LESS
HELMHOLTZ ASSOCIATION	12	1.172	0.927	MORE
KWR WATER RES INST	12	1.172	0.927	MORE
NORWEGIAN UNIVERSITY OF SCIENCE TECHNOLOGY NTNU	12	1.172	0.927	MORE
POLYTECHNIC UNIVERSITY OF MILAN	12	1.172	1.236	LESS
TECHNICAL UNIVERSITY OF BERLIN	12	1.172	0.927	MORE
FUDAN UNIVERSITY	11	1.074	0.773	MORE

PBL NETHERLANDS ENVIRONM ASSESSMENT AGCY	11	1.074	0.773	MORE
UNIVERSITY OF LONDON	11	1.074	0.773	MORE
UNIVERSITY OF MANCHESTER	11	1.074	1.082	LESS

*Please see the data file for the full list

.

1.7. Collaboration between Organisations

Table – Top Collaborators (4 or more)

Collaborators A	Collaborator B	Collab ID	Weight of Links in Network
215 - delft univ technol	569 - lund univ	1566	24
833 - sapienza univ rome	1221 - univ twente	4893	20
546 - leiden univ	669 - netherlands org appl sci res tno	3632	16
215 - delft univ technol	546 - leiden univ	1557	13
215 - delft univ technol	336 - fudan univ	1501	10
215 - delft univ technol	278 - erasmus univ	1485	9
215 - delft univ technol	1031 - univ cambridge	1696	9
215 - delft univ technol	1082 - univ ghent	1712	9
215 - delft univ technol	1238 - univ witwatersrand	1768	9
4 - aalborg univ	215 - delft univ technol	26	8
215 - delft univ technol	578 - maastricht univ	1571	8
726 - pbl netherlands environm assessment agcy	1222 - univ utrecht	4505	8
814 - roskilde univ	1031 - univ cambridge	4832	8
814 - roskilde univ	1222 - univ utrecht	4836	8
1031 - univ cambridge	1222 - univ utrecht	5523	8
1127 - univ messina	1222 - univ utrecht	5814	8
38 - amsterdam inst adv metropolitan solut ams	215 - delft univ technol	336	7
160 - city univ hong kong	814 - roskilde univ	1118	7
160 - city univ hong kong	1031 - univ cambridge	1120	7
160 - city univ hong kong	1222 - univ utrecht	1122	7
215 - delft univ technol	256 - eindhoven univ technol	1481	7
278 - erasmus univ	336 - fudan univ	2057	7
546 - leiden univ	1222 - univ utrecht	3703	7
569 - lund univ	578 - maastricht univ	3805	7
215 - delft univ technol	533 - lappeenranta univ technol	1552	6
215 - delft univ technol	1000 - univ amsterdam	1685	6
215 - delft univ technol	1222 - univ utrecht	1763	6
215 - delft univ technol	1294 - waternet	1781	6
696 - nova univ lisbon	1222 - univ utrecht	4401	6

747 - polytech univ bari	833 - sapienza univ rome	4590	6
747 - polytech univ bari	1221 - univ twente	4591	6
37 - amsterdam inst adv metropolitan solut	215 - delft univ technol	332	5
215 - delft univ technol	1268 - vrije univ amsterdam	1774	5
525 - kwr water res inst	1222 - univ utrecht	3495	5
1262 - vito	1268 - vrije univ amsterdam	6005	5
5 - aalto univ	215 - delft univ technol	65	4
148 - chongqing univ	546 - leiden univ	1042	4
215 - delft univ technol	410 - imperial coll london	1522	4
215 - delft univ technol	554 - linkoping univ	1559	4
215 - delft univ technol	691 - norwegian univ sci & technol	1597	4
215 - delft univ technol	1135 - univ naples federico ii	1731	4
215 - delft univ technol	1170 - univ politecn cataluna	1746	4
256 - eindhoven univ technol	1152 - univ oulu	1962	4
291 - european commiss	1284 - wageningen univ & res	2206	4
496 - karl franzens univ graz	1222 - univ utrecht	3318	4
533 - lappeenranta univ technol	569 - lund univ	3549	4
546 - leiden univ	1268 - vrije univ amsterdam	3708	4
669 - netherlands org appl sci res tno	1222 - univ utrecht	4285	4
744 - politecn bari	833 - sapienza univ rome	4548	4
744 - politecn bari	1221 - univ twente	4549	4
958 - top inst food & nutr	1277 - wageningen food & biobased res	5266	4
1000 - univ amsterdam	1222 - univ utrecht	5408	4
1001 - univ antwerp	1262 - vito	5424	4
1078 - univ g dannunzio	1222 - univ utrecht	5657	4

*Please see the data file for the full list

1.8. Findings from CE Science for CE Policy in the Netherlands

1.8 The Number of Publications per Circularity Strategy (using the categories Refuse and Rethink, Reduce, Reuse, Repair, Recycle, Recover)

Table 1.12 – PBL (2019) Circularity Strategy in Time (2010-2019,2010-2022, 2010-2023)

Circularity Strategy	NL (#) 2019	World (#) 2019	NL (%) 2019	NL (#) 2022	World (#) 2022	NL (%) 2022	NL (#) 2023	World (#) 2023	NL (%) 2023
refuse	0	23	0.0%	3	66	4,5%	109	4	3.7%
rethink	2	29	6.9%	7	102	6,9%	201	14	7,0%
reduce	27	816	3.3%	138	3819	3,6%	7022	223	*3.2%*
reuse	31	653	4.7%	82	2098	3,9%	2840	127	4.4%
remanufactur*	15	198	7.6%	24	455	5,3%	672	31	4.6%
repair	15	98	15.3%	37	309	12,0%	431	51	11.8%
recycl*	68	1428	4.8%	200	4435	4,5%	7539	310	4.1%
recover*	44	891	4.9%	118	2977	4,0%	5173	174	3.7%

Note: Using PBL (2019). Queries uses Asterix e.g., remanufactur* to capture remanufacture, remanufacturing etc.

The Netherlands is leading in circular economy transition and business model scientific knowledge production yet circular economy and renewable energy interaction receives less attention at policy level (Table 1.13).

Table 1.13 – Other Environmental Themes and Policies in Time (2010-2019,2010-2022, 2010-2023)

Query (relevant keywords for other environmental themes and policies)	NL (#) 2019	World (#) 2019	NL (%) 2019	NL (#) 2022	World (#) 2022	NL (%) 2022	NL (#) 2023	World (#) 2023	NL (%) 2023
framework	74	744	9.90%	192	2587	7.40%	283	4365	6.48%
policy	72	862	8.40%	177	2108	8.40%	278	3190	8.71%
"business model*"	38	340	11.20%	108	1057	10.20%	147	1960	8.70%
regulation	8	109	7.30%	14	299	4.70%	27	515	5.24%
"EC" or EU or "European Union" OR "Europe" OR "European Commission"	94	1066	8.80%	243	3012	8.10%	331	4671	7.09%
directive	1	77	1.30%	5	143	3.50%	9	197	4.57%
“climate change”	21	236	8.90%	48	801	6.00%	91	1582	5.75%
“renewable energy”	12	231	5.20%	23	670	3.40%	33	1231	*2.68%*
transition*	57	514	11.10%	170	1711	9.90%	90	364	24.73%

The Number of Publications per Circularity Strategy 2010-2023

Results: NL 2010-2023: Recycle (n:309); Reduce (n:226); Recover (n:175); Reuse (n:127); Repair (n:51), Remanufacture(n:31); Rethink (n:14), Refuse (n:4).

NL Share in the World total: Repair (~12%); Rethink (~7%); Remanufacture (~4.6%)

Table 1.14 – Circularity Strategy 2010-2023 (Accumulative)

Circularity Strategy	Total number of Scientific Publications in the World	Line Up of Number of Publications
Rethink *Rethink**	**201**	**ITALY 34** **USA 23** **GERMANY 20** **ENGLAND 17** **PEOPLES R CHINA 16** **BRAZIL 14** **NETHERLANDS 14, 6.965%** **PORTUGAL 13** **SPAIN 13** **ROMANIA 11** **FINLAND 10** **AUSTRALIA 9**
Refuse ***Refus****	**109**	**POLAND 22** **ITALY 17** **USA 16** **ENGLAND 12** **INDIA 8** **BRAZIL 7** **HUNGARY 5** **PEOPLES R CHINA 5** **PORTUGAL 5** **SPAIN 5** **AUSTRIA 4** **FRANCE 4** **NETHERLANDS 4, *3.670%*** **GERMANY 3**
Reuse ***reuse***	**2840**	**ITALY 447** **SPAIN 293** **ENGLAND 277** **PEOPLES R CHINA 262** **USA 225** **GERMANY 165** **BRAZIL 141** **INDIA 134** **NETHERLANDS 127, 4.366%**
Repair	**431**	**ENGLAND 59** **NETHERLANDS 51, 11.833%** **ITALY 43** **GERMANY 38** **SPAIN 37** **SWEDEN 33** **USA 31** **BELGIUM 26** **PEOPLES R CHINA 25** **FRANCE 23** **AUSTRIA 20**
Recycle	**7539**	**PEOPLES R CHINA 1,057** **ITALY 883** **SPAIN 675** **USA 660** **ENGLAND 651** **GERMANY 622** **INDIA 431** **AUSTRALIA 332** **POLAND 313** **NETHERLANDS 310, 4.112%** **BRAZIL 290** **FRANCE 280**

Reduce	**7022**	**ITALY 975** **PEOPLES R CHINA 940** **SPAIN 804** **ENGLAND 573** **USA 526** **INDIA 473** **GERMANY 421** **BRAZIL 346** **PORTUGAL 329** **POLAND 314** **AUSTRALIA 296** **SWEDEN 246** **FRANCE 228** **NETHERLANDS 223, *3.176%*** **CANADA 202**
Recover	**5173**	**ITALY 820** **SPAIN 607** **PEOPLES R CHINA 557** **ENGLAND 454** **USA 410** **INDIA 358** **GERMANY 306** **BRAZIL 263** **POLAND 252** **PORTUGAL 247** **AUSTRALIA 229** **SWEDEN 227** **NETHERLANDS 174, *3.364%*** **FRANCE 165** **BELGIUM 153** **CANADA 153**
Remanufacture	**672**	**PEOPLES R CHINA 113** **ITALY 79** **ENGLAND 77** **SWEDEN 69** **USA 62** **GERMANY 52** **INDIA 52** **FRANCE 37** **NETHERLANDS 31, 4.613%**

The Number of Publications using the NPCE wording 2010-2023

NL: Reconsider (n:2; ~5.7%); Substitute (n:25, ~2.8%), Narrowing the Loop (n:2, ~12.5%); Slowing the Loop (n:3, ~7.7%); Closing the Loop (n:54, ~4.8%),

Table 1.15 - Number of publications using the NPCE wording instead of the R-ladder categories.

NPCE	Total in the world	Line Up of Number of Publications
Substitute	**878**	**ITALY 145** **SPAIN 127** **PEOPLES R CHINA 82** **GERMANY 70** **USA 67** **PORTUGAL 63** **ENGLAND 60** **INDIA 54** **BRAZIL 40** **SWEDEN 39** **FRANCE 36** **POLAND 36** **BELGIUM 31** **DENMARK 28** **GREECE 26** **CANADA 25** **NETHERLANDS 25, 2.847%** …
Reconsider	**35**	**ITALY 7** **SPAIN 6** **ENGLAND 5** **GERMANY 3** **PEOPLES R CHINA 3** **AUSTRIA 2** **FINLAND 2** **FRANCE 2** **JAPAN 2** **NETHERLANDS 2, 5.714%** …
Narrow *Loop AND Narrow**	**16**	**AUSTRALIA 2** **NORWAY 2** **SWEDEN 2** **NETHERLANDS 2, 12.5%** **CANADA 1** **ENGLAND 1** **FINLAND 1** **FRANCE 1** **GERMANY 1** **PEOPLES R CHINA 1** **POLAND 1** **USA 1** **SWITZERLAND 1** …
Close ***Loop AND Clos****	**1133**	**ENGLAND 143** **PEOPLES R CHINA 142** **ITALY 123** **USA 105** **SPAIN 86** **GERMANY 85** **INDIA 79** **AUSTRALIA 60** **DENMARK 60** **FRANCE 58** **NETHERLANDS, 54, 4.766%** …
Slow ***Loop AND Slow****	**39**	**POLAND 5** **SPAIN 5** **ENGLAND 4** **NORWAY 4** **NETHERLANDS 3, 7.692%** **PEOPLES R CHINA 2** **INDIA 3** **SWEDEN 3** **DENMARK 2** …

Table 1.16 - Most cited (3 or more) references in the NL

Cited Reference	Citations	Total Link Strength
geissdoerfer m, 2017, j clean prod, v143, p757, doi 10.1016/j.jclepro.2016.12.048	180	4282
kirchherr j, 2017, resour conserv recy, v127, p221, doi 10.1016/j.resconrec.2017.09.005	200	4130
ghisellini p, 2016, j clean prod, v114, p11, doi 10.1016/j.jclepro.2015.09.007	147	3697
bocken nmp, 2016, j ind prod eng, v33, p308, doi 10.1080/21681015.2016.1172124	126	3259
blomsma f, 2017, j ind ecol, v21, p603, doi 10.1111/jiec.12603	79	2263
korhonen j, 2018, ecol econ, v143, p37, doi 10.1016/j.ecolecon.2017.06.041	80	1931
murray a, 2017, j bus ethics, v140, p369, doi 10.1007/s10551-015-2693-2	70	1930
lewandowski m, 2016, sustainability-basel, v8, doi 10.3390/su8010043	61	1894
reike d, 2018, resour conserv recy, v135, p246, doi 10.1016/j.resconrec.2017.08.027	66	1874
kirchherr j, 2018, ecol econ, v150, p264, doi 10.1016/j.ecolecon.2018.04.028	57	1753
lieder m, 2016, j clean prod, v115, p36, doi 10.1016/j.jclepro.2015.12.042	63	1707
bocken nmp, 2014, j clean prod, v65, p42, doi 10.1016/j.jclepro.2013.11.039	54	1697
tukker a, 2015, j clean prod, v97, p76, doi 10.1016/j.jclepro.2013.11.049	59	1683
chertow mr, 2000, annu rev energ env, v25, p313, doi 10.1146/annurev.energy.25.1.313	55	1652
urbinati a, 2017, j clean prod, v168, p487, doi 10.1016/j.jclepro.2017.09.047	44	1570
zink t, 2017, j ind ecol, v21, p593, doi 10.1111/jiec.12545	51	1523
lüdeke-freund f, 2019, j ind ecol, v23, p36, doi 10.1111/jiec.12763	46	1507
mcdowall w, 2017, j ind ecol, v21, p651, doi 10.1111/jiec.12597	45	1273
bocken nmp, 2018, environ innov soc tr, v28, p79, doi 10.1016/j.eist.2018.02.001	36	1225
pieroni mpp, 2019, j clean prod, v215, p198, doi 10.1016/j.jclepro.2019.01.036	32	1200
[anonymous], 2004, bus. strateg. environ., doi [10.1002/bse.414 10.1002/bse.414]	39	1149
kalmykova y, 2018, resour conserv recy, v135, p190, doi 10.1016/j.resconrec.2017.10.034	36	1101
linder m, 2017, bus strateg environ, v26, p182, doi 10.1002/bse.1906	32	1094
boons f, 2013, j clean prod, v45, p9, doi 10.1016/j.jclepro.2012.07.007	33	1089
korhonen j, 2018, j clean prod, v175, p544, doi 10.1016/j.jclepro.2017.12.111	39	1056
geissdoerfer m, 2018, j clean prod, v190, p712, doi 10.1016/j.jclepro.2018.04.159	32	1043
rizos v, 2016, sustainability-basel, v8, doi 10.3390/su8111212	31	1014
henry m, 2020, j clean prod, v245, doi 10.1016/j.jclepro.2019.118528	26	1010
stubbs w, 2008, organ environ, v21, p103, doi 10.1177/1086026608318042	28	1003

*please see the data file for the full list

SECTION 2

2.1 Gap Analysis:

Several gaps across different domains are detected in relation to CE. These gaps emphasize the need for trans-disciplinary research and cross-sectoral collaboration to develop and implement scientific, technological and policy solutions effectively with respect to circular economy transition and vice versa. **The literature emphasizing a gap also focus on institutional (n:65), policy (n:43); social (n:34), knowledge (n:32) technical (n:21) and finance (n:20) aspects.**

Examples:

1.**Urban Environments:** Identified as a key area requiring more attention, e.g., urban mining of End-of-Life products and landfill mining of historic (and future) urban waste streams (Jones et al., 2013)[9]

2.**Chemicals:** A significant number of research gaps were identified in this area. e.g., analyzing the structure and functioning of the Dutch mission-oriented innovation system, Reike et al. (2023) shows that (1) there is a good match between the formal Dutch circular textile mission and system actor perceptions; (2) system actors have formed structures around three dominant solution trajectories in the Dutch system: secondhand, mechanical recycling, and chemical recycling; (3) these trajectories expose distinct key virtuous and vicious cycles, which characterize (4) the entire system as formative (Reike et al., 2023)[10].

3.**Climate Change:** Highlighted as a major area needing further research. e.g., Guerrero-Cruz et al., (2021) identify knowledge gaps that may lead to opportunities to harness further the biotechnological benefits of methanotrophs in methane mitigation and to produce valuable bioproducts enabling a bio-based and circular economy (Guerrero-Cruz et al., 2021)[11].

4.**Biodiversity Loss and Health:** Recognized as under-researched and crucial for future studies. E.g., Biodiversity loss and health; transport, mobility, sustainable solutions, and health; energy transition and health; waste and the circular economy and health; ethics and philosophy and health were areas that were acknowledged as under-researched (combined n = 27 gaps) (Huss et al., 2022).

5.**Transport, Mobility, Sustainable Solutions, and Health:** Areas where more research is needed to develop sustainable solutions (Huss et al., 2022).

6.**Energy Transition and Health:** Acknowledged as an area with significant gaps that require investigation (Huss et al., 2022).

7.**Waste and the Circular Economy and Health:** Identified as under-researched but essential for the circular economy transition (Huss et al., 2022).

8.**Ethics and Philosophy and Health:** Recognized as needing more research to understand the ethical implications of environmental health issues (Huss et al., 2022)[12].

9.**Material Circularity:** Gaps exist in understanding the circularity of materials, including generated waste and stock depletion, e.g., a holistic methodology covering the macro (material impact), meso (supply chain) and micro level (design) is still to be fully developed (Cottafava and Ritzen, 2021)[13].

10.**Physical Properties and Standardization in Building Law:** Lack of standardization and research in modern construction methods, particularly in earthen construction, e.g., Research gaps regarding physical properties, missing standardisation concerning building law and modern construction methods, and a limited number of manufacturers are hindering a wide application of earthen construction worldwide (Schweiker et al., 2021)[14].

11. **Social Value and Resource Circularity:** Under investigated trade-offs and synergies between social value and resource circularity, Starke et a. (2022)[15] emphasizes that to date, it remains underexplored in the circular bioeconomy (CBE) literature how actor-based contestations and controversies develop throughout a transition process (Starke et al., 2022).

---

[9] Jones, P. T., Geysen, D., Tielemans, Y., Van Passel, S., Pontikes, Y., Blanpain, B., ... & Hoekstra, N. (2013). Enhanced Landfill Mining in view of multiple resource recovery: a critical review. Journal of Cleaner Production, 55, 45-55.

[10] Reike, D., Hekkert, M. P., & Negro, S. O. (2023). Understanding circular economy transitions: The case of circular textiles. Business Strategy and the Environment, 32(3), 1032-1058.

[11] Guerrero-Cruz, S., Vaksmaa, A., Horn, M. A., Niemann, H., Pijuan, M., & Ho, A. (2021). Methanotrophs: discoveries, environmental relevance, and a perspective on current and future applications. *Frontiers in microbiology*, *12*, 678057.

[12] Huss, A., Peters, A., Zhao, T., Barouki, R., Kogevinas, M., Vermeulen, R., & Matthies-Wiesler, F. (2022). Setting the European environment and health research agenda–under-researched areas and solution-oriented research. Environment international, 163, 107202.

[13] Cottafava, D., & Ritzen, M. (2021). Circularity indicator for residential buildings: Addressing the gap between embodied impacts and design aspects. *Resources, Conservation and Recycling*, *164*, 105120.

[14] Schweiker, M., Endres, E., Gosslar, J., Hack, N., Hildebrand, L., Creutz, M., ... & Roswag-Klinge, E. (2021). Ten questions concerning the potential of digital production and new technologies for contemporary earthen constructions. *Building and Environment*, *206*, 108240.

[15] Starke, J. R., Metze, T. A., Candel, J. J., Dewulf, A. R., & Termeer, K. J. (2023). 'Green future'versus 'Planetary boundaries'? Evolving online discourse coalitions in European bioeconomy conflicts. *Journal of Cleaner Production*, *425*, 139058.

2.2. Education and skills

Circular Economy and Education Scientific Research in the Netherlands

Worldwide **3645** scientific publications of **23556** total (~15%) is about CE Education, **135** out of **1023** are from the Netherlands **(~13%), 3.7%** of CE education related publications are from the NL, below ~**4.3%** of overall contribution. Circular economy education, skills and training should be invested more in the Netherlands.

Query search within all fields: Skill* OR Education OR Train*.

Table 2.2.1 Number of Scientific Publications in the NL on CE Education, Skills, and Trainings

	Total Publications	Citing Articles	Without self-citations	Times Cited	Times Cited Without self-citations	Average citation per item	H-Index
NL	135	6,055	6,010	7,039	6,943	52.14	42

Table 2.2.2 Scientific Micro-Topics where more effort (citation relations) is needed for CE Education

Citation Topics Micro NL	Record Count	% of 135 (NL)	% of 3,645 (World)	Position
6.115.1554 E-waste	51	37.778	21.317	Good
6.3.385 Corporate Social Responsibility	5	3.704	3.182	Good
6.73.1507 Environmental Concern	5	3.704	2.058	Good
3.83.416 Anaerobic Digestion	4	2.963	3.182	More Effort Needed
3.83.466 Activated Sludge	4	2.963	0.494	Good
6.115.880 Renewable Energy	4	2.963	1.097	Good
3.91.920 Selenium	3	2.222	0.11	Good
6.115.1181 Life Cycle Assessment	3	2.222	2.99	More Effort Needed
6.263.1720 Edible Insects	3	2.222	0.988	Good
2.165.679 Additive Manufacturing	2	1.481	0.741	Good
2.90.27 Adsorption	2	1.481	1.18	Good
3.16.2410 Terpenes	2	1.481	0.11	Good
3.171.477 Microalgae	2	1.481	1.975	More Effort Needed
3.45.397 Nitrous Oxide	2	1.481	0.192	Good
3.60.357 Bisphenol A	2	1.481	0.219	Good
3.83.2268 Struvite	2	1.481	1.043	Good
4.224.715 Design Education	2	1.481	0.466	Good
6.3.2135 Sharing Economy	2	1.481	1.043	Good
1.197.957 Atp Synthase	1	0.741	0.027	Good
10.144.2123 Environmental History	1	0.741	0.027	Good
2.160.2038 Flow Chemistry	1	0.741	0.357	Good
2.241.270 Nanofiltration	1	0.741	0.412	Good
2.62.52 Supercapacitor	1	0.741	0.329	Good
2.74.1823 Cu2o	1	0.741	0.027	Good
2.89.72 Vapor-liquid Equilibria	1	0.741	0.027	Good
3.40.635 Ecosystem Services	1	0.741	0.439	Good

3.45.473 Phosphorus	1	0.741	0.165	Good
3.51.2333 Zootechnical Additives	1	0.741	0.027	Good
3.51.799 Animal Welfare	1	0.741	0.027	Good
3.60.1654 Phthalates	1	0.741	0.192	Good
3.60.2078 Microplastics	1	0.741	2.058	More Effort Needed
3.83.1206 Constructed Wetlands	1	0.741	0.329	Good
3.83.1487 Microbial Fuel Cell	1	0.741	0.466	Good
3.87.1386 Clostridium Acetobutylicum	1	0.741	0.576	Good
3.87.2131 Bioenergy	1	0.741	0.247	Good
3.87.269 Cellulose	1	0.741	1.207	More Effort Needed
4.17.128 Deep Learning	1	0.741	0.137	Good
4.224.1040 Industry 4.0	1	0.741	1.372	More Effort Needed
4.322.1428 Remote Laboratory	1	0.741	0.027	Good
4.84.1014 Minlp	1	0.741	0.741	More Effort Needed
6.110.580 Crime	1	0.741	0.027	Good
6.115.1244 Municipal Solid Waste	1	0.741	4.993	More Effort Needed
6.115.284 Thermal Comfort	1	0.741	0.165	Good
6.153.558 Climate Change Adaptation	1	0.741	0.11	Good
6.263.898 Farmers	1	0.741	0.219	Good
6.3.726 Entrepreneurship	1	0.741	0.274	Good
6.86.149 Gentrification	1	0.741	0.027	Good
7.139.89 Gasification	1	0.741	2.277	More Effort Needed
7.229.774 Bioleaching	1	0.741	0.384	Good

Table 2.2.3 Micro-Topics Citation relations with CE Education in the World

Educational Aspects	Number of Publications
4.224.715 Design Education	6
6.11.295 Science Education	6
5.318.2228 Hands-on Learning/manipulatives	3
6.11.1506 Engineering Education	3
10.290.2219 Art Education	1
4.224.599 Project Scheduling	1
4.284.1027 Augmented Reality	1
4.322.1428 Remote Laboratory	1
6.10.502 Data Envelopment Analysis	1
6.11.1526 Computational Thinking	1
6.11.1859 Assurance Of Learning	1
6.11.2145 Geography Education	1
6.11.2357 Transformative Learning	1
6.11.31 Self-regulated Learning	1
6.294.1807 Foresight	1
6.3.2 Knowledge Management	1
6.3.343 Social Movements	1
6.321.2444 Open Data	1

2.3 SDGs

More activity in *SDG 5 Gender Equality* and CE and *SDG 17 Partnerships for the Goals* and CE is needed. Attention to *SDG 11 Sustainable Cities and Communities* may require more emphasis (5.4% in NL vs. 10.2% in the World).

Table 2.3.1 SDGs and CE research

SDGs	NL	% NL	World	% World
12 Responsible Consumption and Production	574	56.441%	11,077	47.265%
13 Climate Action	153	15.044%	2,421	10.330%
06 Clean Water and Sanitation	63	6.195%	1,892	8.073%
02 Zero Hunger	58	5.703%	1,102	4.702%
07 Affordable and Clean Energy	58	5.703%	1,418	6.051%
11 Sustainable Cities and Communities	55	5.408%	2,391	10.202%
03 Good Health and Well Being	40	3.933%	1,332	5.684%
14 Life Below Water	29	2.852%	752	3.209%
09 Industry Innovation and Infrastructure	24	2.360%	767	3.273%
15 Life on Land	10	0.983%	356	1.519%
01 No Poverty	3	0.295%	92	0.393%
04 Quality Education	2	0.197%	67	0.286%
10 Reduced Inequality	1	0.098%	31	0.132%
16 Peace and Justice Strong Institutions	1	0.098%	3	0.013%

For Methodology, please see Sustainable Development Goals – InCites Benchmarking & Analytics (zendesk.com)

SECTION 3

Admixing percentages, certification, reporting, just transitions are leading domains for prospective CE knowledge deepening.

Table 3.1. Sixty-two (62) Links within the CE Scientific literature

Link Id	Main Query (CE) Refined by	World	NL	Share	Position
1	energy	8483	280	3.30%	Below Average
2	climate change	1582	91	5.75%	Above Average
3	biodiversity	282	18	6.38%	Above Average
4	biodiversity loss	37	5	13.51%	Above Average
5	biodiversity degradation	25	0	0.00%	Below Average
6	soil	1432	39	2.72%	Below Average
7	soil pollution	34	0	0.00%	Below Average
8	air	736	24	3.26%	Below Average
9	air pollution	109	1	0.92%	Below Average
10	water	4949	179	3.62%	Below Average
11	water pollution	85	7	8.24%	Above Average
12	environmental impact	1563	64	4.09%	Below Average
13	environmental degradation	147	3	2.04%	Below Average
14	supply security	13	1	7.69%	Above Average
15	critical raw materials	162	9	5.56%	Above Average
16	just transition	31	1	3.23%	Below Average
17	policy	3190	278	8.71%	Above Average
18	policy measure	52	7	13.46%	Above Average
19	policy instrument	16	0	0.00%	Below Average
20	regulatory instrument	10	1	10.00%	Above Average
21	regulatory measure	22	2	9.09%	Above Average
22	financial instrument	10	0	0.00%	Below Average
23	financial measure	3	0	0.00%	Below Average
24	stimulation	48	4	8.33%	Above Average
25	policy tool	25	1	4.00%	Below Average
26	policy RB communication	107	10	9.35%	Above Average
27	policy RB awareness	212	12	5.66%	Above Average
28	policy RB awareness raising	8	0	0.00%	Below Average
29	policy RB knowledge sharing	3	1	33.33%	Above Average
30	policy RB education	424	20	4.72%	Above Average
31	policy RB advice OR advise	15	3	20.00%	Above Average
32	matchmaking	3	1	33.33%	Above Average
33	helpdesk	2	1	50.00%	Above Average
34	taxation	55	3	5.45%	Above Average
35	tax	162	6	3.70%	Below Average

36	subsidy	105	9	8.57%	Above Average
37	funding	3234	211	6.52%	Above Average
38	fund	9291	452	4.86%	Above Average
39	covenant	7	0	0.00%	Below Average
40	voluntary	78	8	10.26%	Above Average
41	voluntary agreement	2	0	0.00%	Below Average
42	benchmarking	106	2	1.89%	Below Average
43	certification	104	4	3.85%	Below Average
44	certification system	4	0	0.00%	Below Average
45	quality mark	0	0	0	0
46	standard	1416	62	4.38%	Above Average
47	standardisation	127	11	8.66%	Above Average
48	product passport	14	3	21.43%	Above Average
49	admixing	1	0	0.00%	Below Average
50	reporting	220	7	3.18%	Below Average
51	sustainability reporting	31	1	3.23%	Below Average
52	circular reporting	1	0	0.00%	Below Average
53	machine learning	198	8	4.04%	Below Average
54	predictive repair	0	0	0	0
55	maintenance analytics	0	0	0	0
56	energy transition	177	20	11.30%	Above Average
57	climate transition policies	1	0	0.00%	Below Average
58	climate transition goals	1	0	0.00%	Below Average
59	health	2261	100	4.42%	Above Average
60	emission	3325	130	3.91%	Below Average
61	Scope 3	7	0	0.00%	Below Average
62	Predictive maintenance	14	2	14.29%	Above Average

The position is calculated based on the share of the NL (~4.3% as benchmark) in total number of publications in CE domain in the world as of 30th September 2024, RB: Refined By.

3.1 Linking the Circular Economy (CE) transition to various policy instruments/tools along with examples.

Various policy tools are being used to support the transition to a circular economy.

Linking the CE transition to policy instruments/tools (limited): stimulating instruments/measures, financial instruments, regulatory instruments.

Linking the CE transition to policy instruments/tools (extended): communication (e.g. awareness raising), knowledge sharing (e.g. education, advise, matchmaking, helpdesk), finance (e.g. taxation, funding/subsidy), regulatory instruments (e.g. covenant, voluntary agreement, benchmarking, certification system/quality mark, CE standards, product passport, admixing percentage, sustainability/circular reporting)

A systemic view (supply, demand, finance, institutions) on CE transitions indicates specific supply side, support to supply side, demand side and institutional policy instruments, such as obtaining bank finance for circular business model innovation (e.g., Toxopeus et al., 2021), helpdesk for businesses, increasing consumer involvement (e.g., Sijtsema et al., 2020), product passport systems for traceability of products and their components (e.g., Van Capelleveen et al., 2023), and the increasing role of local authorities (e.g.; Yu et al.; 2015).

Policy Instrument/Tool, Description, Examples, References

Communication Awareness raising campaigns to inform and educate the public and stakeholders about the benefits and practices of the circular economy. Public awareness campaigns on the importance of reducing waste and promoting recycling. Sijtsema et al. (2020) discuss the importance of raising awareness for consumer involvement in CE. **Communication:** Public awareness campaigns on the importance of reducing waste and promoting recycling to increase public participation and support for CE initiatives.

Reference: *Sijtsema, S.J., Snoek, H.M., van Haaster-de Winter, M.A., & Dagevos, H. (2020) on Consumer involvement in the circular economy and the role of awareness raising; e.g.* Sijtsema, S. J., & Snoek, H. M. (2023). Involving consumers in food product development: Perspectives on the application of circular food design. *Frontiers in Sustainable Food Systems*, *7*, 1069278.

Knowledge Sharing: Education, advice, matchmaking, and helpdesk services to facilitate the exchange of information and best practices among stakeholders. Establishing a helpdesk for businesses to get advice on implementing CE practices. Yu et al. (2015) highlights the role of local authorities in providing knowledge and promoting eco-industrial development. **Knowledge Sharing:** Establishing a helpdesk for businesses to get advice on implementing CE practices, providing a platform for knowledge exchange and support.

Reference: *Yu, C., Dijkema, G.P.J., & de Jong, M. (2015) on the role of local authorities and helpdesk e.g.* Yu, C., Dijkema, G. P., & de Jong, M. (2015). What makes eco-transformation of industrial parks take off in China?. *Journal of Industrial Ecology*, *19*(3), 441-456.

Finance/Financial instruments such as taxation, funding, and subsidies to incentivize CE practices. Subsidies for companies that adopt circular business models, such as using recycled materials. Toxopeus et al. (2021) discuss the strategies for firms to obtain bank finance for circular BMI.

Finance: Providing subsidies for companies that adopt circular business models, such as using recycled materials, to financially support the transition to CE.

Reference: *Toxopeus, H., Achterberg, E., & Polzin, F. (2021) on Strategies for firms to obtain bank finance for circular business model innovation, e.g.* Toxopeus, H., Achterberg, E., & Polzin, F. (2021). How can firms access bank finance for circular business model innovation?. *Business Strategy and the Environment*, *30*(6), 2773-2795.

Regulatory Instruments : Policies and regulations to enforce CE practices, such as covenants, voluntary agreements, benchmarking, certification systems, CE standards, product passports, admixing percentages, and sustainability/circular reporting. Implementing a product passport system to enhance the traceability of products and their components. Van Capelleveen et al. (2023) discuss the role and characteristics of product passports in CE. **Regulatory Instruments**: Implementing a product passport system to enhance the traceability of products and their components, ensuring compliance with CE standards, and facilitating recycling and reuse.

Reference: *Van Capelleveen, G., Vegter, D., Olthaar, M., & Van Hillegersberg, J. (2023) on Product passports and their role in the circular economy,* e.g. van Capelleveen, G., Vegter, D., Olthaar, M., & van Hillegersberg, J. (2023). The anatomy of a passport for the circular economy: a conceptual definition, vision and structured literature review. *Resources, Conservation & Recycling Advances*, *17*, 200131.

3.2 Linking the Circular Economy (CE) transition to various societal challenges.

Linking the CE transition to societal challenges being circular economy & energy/climate change, CE & biodiversity (biodiversity loss and degradation), CE & environment (e.g., soil, water air pollution/ environmental impact, environmental degradation) and CE & supply security/critical raw materials, CE & just transition

Circular economy can address a range of societal challenges by promoting sustainable practices, reducing environmental impact, and ensuring resource security. Societal challenges, explanations and examples:

CE & Energy/Climate Change: Combining sustainable consumption with CE reduces resource throughput and emissions, tackling resource scarcity and climate change. Future business models for sustainable consumption e.g., in clothing reducing overall consumption levels and consumer effort[16].

CE & Biodiversity (Biodiversity loss and degradation): CE initiatives can help preserve biodiversity by reducing the extraction of raw materials and waste. Deployment of circular ecosystems to inspire policy changes and promote sustainable practices among entrepreneurs[17].

CE & Environment (Soil, water, air pollution): The CE model reduces environmental impact by minimizing waste and encouraging recycling and reuse. E.g., experiences from the Energy & Raw Materials Factory in the Netherlands recovering materials and improving water quality[18].

CE & Supply Security/Critical Raw Materials: CE can enhance supply security by ensuring materials are reused and recycled, reducing dependency on raw material imports.Framework for evaluating circularity strategies in industries such as high-pressure turbine components and MRI machines[19].

CE & Just Transition: CE supports a fair transition by creating sustainable job opportunities and reducing environmental inequalities. Civil society actors engage with CE through citizen initiatives and organized community efforts[20].

[16] Tunn, V. S., Bocken, N. M., van den Hende, E. A., & Schoormans, J. P. (2019). Business models for sustainable consumption in the circular economy: An expert study. Journal of cleaner production, 212, 324-333.
[17] Berghuis, E., Loorbach, D., van Vulpen, A., Verkuijl, M., van Orden, C., & Greer, R. (2023). Coming together for transition? Entrepreneurial ecosystems for a circular economy. International Review of Applied Economics, 37(3), 372-388.
[18] Kehrein, P., Van Loosdrecht, M., Osseweijer, P., Garfí, M., Dewulf, J., & Posada, J. (2020). A critical review of resource recovery from municipal wastewater treatment plants–market supply potentials, technologies and bottlenecks. Environmental Science: Water Research & Technology, 6(4), 877-910.
[19] Cimprich, A., Young, S. B., Schrijvers, D., Ku, A. Y., Hagelüken, C., Christmann, P., ... & Hool, A. (2023). The role of industrial actors in the circular economy for critical raw materials: a framework with case studies across a range of industries. Mineral Economics, 36(2), 301-319.
[20] Palm, J., & Bocken, N. (Eds.). (2021). Achieving the Circular Economy: Exploring the Role of Local Governments, Business and Civic Society in an Urban Context. MDPI.

3.3 CE & eScience/digital innovation/computational techniques (machine learning, maintenance analytics, predictive repair) Circular Economy and Digitalisation

Main Keywords (20 Keyword)	NL #
1. Digit*	63
2. Digital	54
3. Smart	46
4. Quantitative	41
5. Artificial Intelligence OR AI	14
6. Sensor*	13
7. Big Data	13
8. Internet of Things	11
9. Machine Learning	8
10. Industry 4.0	7
11. Robot*	6
12. Blockchain	5
13. Analytics	5
14. Predictive	5
15. Nanotechnology	4
16. Information technology	4
17. App	3
18. Digital Twin	3
19. Predictive Maintenance	2
20. Digital Product Passport	1

Source: Web of Science

3.4 Link between the CE transition and the climate / energy transition: CE & scope 3 emissions with references

Link between the CE Transition and the Climate/Energy Transition: CE & Scope 3 Emissions

Circular Economy (CE) Transition and Climate Transition: The transition to a circular economy (CE) is increasingly seen as a pivotal strategy for reducing greenhouse gas (GHG) emissions. Integrating CE principles, such as recycling, reusing, and reducing waste, can significantly mitigate environmental impacts and contribute to climate goals. This is particularly evident in sectors like plastics, where CE policies relate to reducing GHG emissions. Scope 3 Emissions: Scope 3 emissions include all indirect emissions that occur in the value chain of the reporting company, including both upstream and downstream emissions. The integration of CE practices can lead to substantial reductions in these emissions by promoting sustainable production and consumption patterns. In this domain Institute of Environmental Sciences (CML), Leiden University, Leiden, The Netherlands and TNO Strategic Analysis and Policy, The Hague, The Netherlands are active organisations, examples:

1. **GHG Emissions Reduction through CE:**

"With the necessity of greenhouse gas (GHG) emissions reduction as a backdrop, the circular economy (CE) is increasingly being considered an effective response to this issue. Currently, China is facing a considerable challenge as it tries to respond to Paris Agreement targets; however, in many respects, China is ahead of other nations as it relates to the implementation of such innovative strategies such as the circular economy policies. For over ten years, China has been investigating how the circular economy policies could be used to respond to GHG emission issues. In particular, the effects of such economic development patterns need to be identified as well as the specific influence on GHG emissions reduction." [21]

[21] Liu, Z., Adams, M., Cote, R. P., Chen, Q., Wu, R., Wen, Z., ... & Dong, L. (2018). How does circular economy respond to greenhouse gas emissions reduction: An analysis of Chinese plastic recycling industries. Renewable and Sustainable Energy Reviews, 91, 1162-1169.

2. Impact of CE on Plastic Recycling Industries:

"This study presents an analysis of the Chinese plastic recycling industries (CPRI) through this lens. Plastics were specifically targeted, as such waste generation represents one of the highest fractions of global waste by mass, as well as the increasing public concerns of the environmental impacts of post-consumer plastics waste. Integrating the concepts of circular economy in this industry could be deemed an effective strategy, one which not only reduces post-consumer waste pollution but also mitigates GHG emissions. The results show that the contribution of the CPRI to CO2 emissions reduction increased from 7.67 million tons (MT) in 2007 to 14.57 MT in 2016; the scale factor and structure factor had significant impacts on GHG emissions reduction changes." (ibid)

3. Role of Cities and Innovation in GHG Emission Reductions:

"The Paris Agreement and SDG13 on Climate Action require a global drop in Green House Gases (GHG) emissions to stay within a 'well below 2 degrees' climate change trajectory. Cities will play a key role in achieving this, being responsible for 60 to 80% of the global GHG emissions depending on the estimate. This paper describes how Research and Innovation (R&I) can play a key role in decarbonizing European cities, and the role that research and education institutions can play in that regard. The paper highlights critical R&I actions in cities based on three pillars: (1) innovative technology and integration, (2) governance innovation, and (3) social innovation." [22]

These references above illustrate the crucial links between circular economy practices and their impact on reducing GHG emissions, particularly Scope 3 emissions, by **transforming production and consumption systems towards sustainability**, via **policy and governance innovations, technological innovations and industrial-level system transitions, and social innovation**.

[22] Fuso Nerini, F., Slob, A., Ericsdotter Engström, R., & Trutnevyte, E. (2019). A research and innovation agenda for zero-emission European cities. Sustainability, 11(6), 1692.

SECTION 4

Product Categories

In the **National CE Program,** the focus has been shifted from CE and raw materials in general to a product category approach.

The ICER focusses on CE &3 product categories:

1) Plastic packaging and beverage cartons (brik),
2) Buildings (more particular houses /dwellings) and
3) Renewable energy techniques (PV, Windmills, Batteries, and infrastructure)

The National CE Program focusses on CE & 15 product categories:

- **Plastics**
  - **1) plastic packaging,**
  - **2) plastics in construction,**
  - **3) plastics in agriculture,**
- **Consumption goods**
  - **4) electric and electronic devices,**
  - **5) textile,**
  - **6) furniture,**
  - **7) packaging and disposables**
- **Construction**
  - **8) engineering structures, concrete viaducts, and bridges**
  - **9) roads, road surfaces**
  - **10) dwellings/houses,**
  - **11) utility buildings (offices commercial- and industrial buildings),**
- **Manufacturing:**
  - **12) Capital Equipment**
  - **13) Solar PV systems,**
  - **14) Wind farms/Windmills,**
  - **15) Climate control systems à in buildings**

With respect to ICER and National CE Program product categories, the Netherlands has a leading position in circular economy and housing domain, yet there is room for circularity improvements for plastic in construction, plastic in agriculture, textile, disposables, PV, and batteries.

Table 4.1 Summary of the Results

Main Keywords	Total #	Line Up	NL	Share in Total	Position
ICER PC 1 Plastic packaging and beverage cartons (brik) / NCEP PC 1-3 Plastics (plastic packaging, plastics in construction, plastics in agriculture),					
Plastic Packaging	175	ENGLAND 30; GERMANY 26; ITALY 23; AUSTRIA 15; BELGIUM 12; NETHERLANDS 12…	12	6.86%	Above Average
Beverage Cartons	8	AUSTRIA 2; GERMANY 2; BELGIUM 1; BULGARIA 1; ITALY 1; NETHERLANDS 1…	1	12.50%	Above Average
Plastics in construction	155	ITALY 20; INDIA 16; PEOPLES R CHINA 16; AUSTRALIA 12; GERMANY 12; SPAIN 12; ENGLAND 8; MALAYSIA 8; PORTUGAL 8; NIGERIA 7; USA 7; BRAZIL 6; SAUDI ARABIA 6; CANADA 5; FRANCE 5; PAKISTAN 5; POLAND 5; FINLAND 4; NETHERLANDS 4	4	2.58%	Below Average
Plastics in agriculture	203	ITALY 32; SPAIN 25; USA 24; PEOPLES R CHINA 22; ENGLAND 16; INDIA 15; FRANCE 14; PORTUGAL 14; GERMANY 13; SOUTH KOREA 11; CANADA 10; GREECE 9; MALAYSIA 9; NETHERLANDS 7	7	3.45%	Below Average
NCEP PC 4-7 Consumption goods (electric and electronic devices, textile, furniture, disposables),					
Electric and electronic devices	335	ITALY 50; PEOPLES R CHINA 36; GERMANY 31; ENGLAND 30; BRAZIL 22; NETHERLANDS 19; …	19	5.67%	Above Average
Textile	615	PEOPLES R CHINA 70; ENGLAND 64; ITALY 57; INDIA 49; PORTUGAL 47; BRAZIL 37; SPAIN 36; ROMANIA 34; USA 34; BELGIUM 29; GERMANY 28; AUSTRALIA 24; FINLAND 24; SWEDEN 24; POLAND 21; TURKEY 18; NETHERLANDS 17…	17	2.76%	Below Average
Furniture	111	ITALY 13; POLAND 11; SPAIN 10; PEOPLES R CHINA 8; SLOVAKIA 7; AUSTRIA 6; ENGLAND 6; PORTUGAL 6; SWEDEN 6; BRAZIL 5; GERMANY 5; NETHERLANDS 5…	5	4.50%	Above Average
Disposables	83	ITALY 13; SPAIN 9; ENGLAND 8; PEOPLES R CHINA 6; USA 6; TAIWAN 5; AUSTRALIA 4; INDIA 4; SOUTH KOREA 4; SWEDEN 4; BRAZIL 3; FRANCE 3; GERMANY 3; GREECE 3; NETHERLANDS 3…	3	3.61%	Below Average
ICER PC 2 Buildings (more particular houses /dwellings) / NCEP PC 8-11 Construction (engineering structures, roads, dwellings/houses, utility buildings (offices commercial- and industrial buildings),					
Construction	2378	PEOPLES R CHINA 457; ITALY 252; SPAIN 242; ENGLAND206; AUSTRALIA 157; PORTUGAL 128; GERMANY 120; USA 119; NETHERLANDS 108	108	4.54%	Above Average

Demolition	625	PEOPLES R CHINA 99; SPAIN 74; ITALY 73; ENGLAND 64; AUSTRALIA 58; NETHERLANDS 41…	41	6.56%	Above Average
Housing	185	NETHERLANDS 24; PEOPLES R CHINA 20; ITALY 19; SPAIN 19; GERMANY 17…	24	12.97%	Above Average
Dwellings	25	ITALY 5; NETHERLANDS 4; SPAIN 4; AUSTRALIA 2; AUSTRIA 2; GERMANY 2; SCOTLAND 2; USA 2; CANADA 1; …	4	16.00%	Above Average
ICER PC 3 Renewable Energy Technologies (PV, Windmills, Batteries, and Infrastructure) / NCEP PC 12-15 Capital Equipment (PV, Windmills, Climate control systems à in buildings)					
PV	201	ITALY 31; USA 26; SPAIN 22; INDIA 19; GERMANY 17; AUSTRALIA 16; ENGLAND 14; PEOPLES R CHINA 14; BRAZIL 8; AUSTRIA 7, NETHERLANDS 7;…	7	3.48%	Below Average
Wind	215	USA 26; ENGLAND 22; PEOPLES R CHINA 20; DENMARK 17; ITALY 17; POLAND 17; SPAIN 17; AUSTRALIA 14; GERMANY 12; GREECE 10; NETHERLANDS 10;…	10	4.65%	Above Average
Battery	438	GERMANY 67; PEOPLES R CHINA 67; USA 50; SPAIN 46; ENGLAND 43; ITALY 40; AUSTRALIA 29; INDIA 23; SWEDEN 23; FINLAND 22; CANADA 16; FRANCE 15; BRAZIL 13; PORTUGAL 13; NETHERLANDS 11;…	11	2.51%	Below Average
Infrastructure	1005	ENGLAND 138; USA 110; PEOPLES R CHINA 104; INDIA 81; AUSTRALIA 68; GERMANY 64; ITALY 63; NETHERLANDS 60; …	60	5.97%	Above Average
Climate control systems: Not present in circular economy scientific literature as of 30 September 2024					
NL Share in World	4.30%				

Results:

ICER PC 1 Plastic packaging and beverage cartons (brik) / NCEP PC 1-3 Plastics (plastic packaging, plastics in construction, plastics in agriculture),

Main Keywords	Total	Line Up
Plastic Packaging ***"plastic packag*"***	**175**	ENGLAND 30; GERMANY 26; ITALY 23; AUSTRIA 15; BELGIUM 12; **NETHERLANDS 12…**

PLASTIC PACKAGING: PLASTIC PACKAGING WASTE; PLASTIC PACKAGING; RECYCLING TARGETS; MULTILAYER PACKAGING; RECYCLED CONTENT; RECYCLING RATE; PLASTIC WASTE MANAGEMENT; CLOSED-LOOP RECYCLING; PLASTIC RECYCLING; MECHANICAL RECYCLING

World (Research Areas): Environmental Sciences Ecology,107,61.143%; Engineering,77,44.000%; Science Technology Other Topics,65,37.143%; Chemistry,16,9.143%; Polymer Science,14, 8.000%; Energy Fuels,8,4.571%; Materials Science,6,3.429%; Computer Science,4,2.286%; Education Educational Research,4,2.286%; Food Science Technology,4,2.286%; Physics,4,2.286%; Agriculture,3,1.714%; Business Economics,3,1.714%; Biochemistry Molecular Biology,2,1.143%; Public Administration,2,1.143%; Area Studies,1,0.571%; Biotechnology Applied Microbiology,1,0.571%; Communication,1,0.571%; Construction Building Technology,1,0.571%; Dermatology,1,0.571%; Government Law,1,0.571%; Metallurgy Metallurgical Engineering,1,0.571%;

Oceanography,1,0.571%; Operations Research Management Science,1,0.571%; Optics,1,0.571%; Remote Sensing,1,0.571%; Social Sciences Other Topics,1,0.571%; Spectroscopy,1,0.571%; Thermodynamics,1,0.571%; Water Resources,1, 0.571%;

NL (Research Areas): Environmental Sciences Ecology, 10, 83.333%; Science Technology Other Topics, 7, 58.333%; Engineering, 4, 33.333%; Chemistry, 1, 8.333%; Physics, 1, 8.333%; Polymer Science, 1, 8.333%

World (Meso topics): 3.60 Herbicides, Pesticides & Ground Poisoning,73,41.714%; 6.115 Sustainability Science,56,32.000%; 2.39 Polymer Science,18,10.286%; 6.73 Social Psychology,6,3.429%; 3.85 Food Science & Technology, 3,1.714%; 7.300 Asphalt,3,1.714%; 2.244 Chemometrics,2,1.143%; 7.139 Energy & Fuels,2,1.143%; 2.59 Pigments, Sensors & Probes,1,0.571%; 3.171 Photoproductivity,1,0.571%; 3.45 Soil Science,1,0.571%; 3.51 Dairy & Animal Sciences,1,0.571%; 6.3 Management,1,0.571%; 7.121 Concrete Science,1,0.571%

NL (Meso topics): 3.60 Herbicides, Pesticides & Ground Poisoning, 5, 41.667%; 6.115 Sustainability Science, 4, 33.333%; 2.39 Polymer Science, 1, 8.333%; 6.73 Social Psychology, 1, 8.333%

World (Micro topics): 3.60.2078 Microplastics, 70,40.000%; 6.115.1244 Municipal Solid Waste, 26, 14.857%; 6.115.1554 E-waste,22,12.571%; 2.39.515 Ring-opening Polymerization, 13,7.429%; 6.115.1181 Life Cycle Assessment,7,4.000%; 6.73.1507 Environmental Concern,6,3.429%; 2.39.2197 Chemical Recycling,3,1.714%; 3.60.1654 Phthalates,3,1.714%; 3.85.741 Chitosan,3,1.714%; 7.300.908 Asphalt Mixture, 3,1.714%; 2.244.499 Chemometrics,2,1.143%; 7.139.89 Gasification,2,1.143%; 2.39.433 Isotactic Polypropylene,1,0.571%; 2.39.511 Polymer Melts,1,0.571%; 2.59.341 Chemosensor,1,0.571%; 3.171.477 Microalgae,1,0.571%; 3.45.397 Nitrous Oxide,1,0.571%; 3.51.206 Meat Quality,1,0.571%; 6.115.880 Renewable Energy,1,0.571%; 6.3.385 Corporate Social Responsibility,1,0.571%; 7.121.26 Compressive Strength,1,0.571%

NL (Micro topics): 3.60.2078 Microplastics, 5, 41.667%; 6.115.1554 E-waste, 2, 16.667%; 2.39.515 Ring-opening Polymerization, 1, 8.333%; 6.115.1181 Life Cycle Assessment, 1, 8.333%; 6.115.1244 Municipal Solid Waste, 1,8.333%; 6.73.1507 Environmental Concern, 1, 8.333%

Beverage Cartons ***"Beverage carton*"***	**8**	AUSTRIA 2; GERMANY 2; BELGIUM 1; BULGARIA 1; ITALY 1; **NETHERLANDS 1**…

PACKAGING WASTE; CIRCULAR ECONOMY; CIRCULAR BIOECONOMY; BEVERAGE; CIRCULARITY; WASTE VALORIZATION; PACKAGING; RECYCLING; BUSINESS MODELS; BIOREFINERY

World (Research Areas): Engineering,5,62.500%; Environmental Sciences Ecology,5,62.500%; Science Technology Other Topics,4,50.000%; Chemistry,1,12.500%; Materials Science,1,12.500%; Metallurgy Metallurgical Engineering,1,12.500%; Physics,1,12.500%
NL (Research Areas): Engineering,1,50%; Environmental Sciences Ecology,1,50%

World (Meso topics): 3.60 Herbicides, Pesticides & Ground Poisoning,3,37.500%; 6.115 Sustainability Science,3,37.500%; 3.87 Paper & Wood Materials Science,1,12.500%; 7.139 Energy & Fuels,1,12.500%

NL (Meso topics): 3.60 Herbicides, Pesticides & Ground Poisoning,1,100%.

World (Micro topics): 6.115.1244 Municipal Solid Waste, 3,37.500%; 3.60.2078 Microplastics,2,25.000%; 3.60.1654 Phthalates,1,12.500%; 3.87.527 Wood,1,12.500%; 7.139.1647 Fly Ash,1,12.500%

NL (Micro topics): 3.60.2078 Microplastics, 1, 100%

Plastics in construction

*Refine results for "*circular* *econom*" (Topic) OR "*circular* *econom*" (Title) and 2025 (Exclude – Final Publication Year) and 2024 (Exclude – Final Publication Year) and 2024 (Exclude – Publication Years) and Construction (Search within all fields) and Plastic* (Search within all fields)*

Related Keywords: CIRCULAR ECONOMY; PLASTIC WASTE; WASTE PLASTICS; MATERIAL FLOW ANALYSIS; PLASTIC WASTE RECYCLING; WASTE MANAGEMENT; RECYCLING HDPE; PLASTICS

Total number of publications: 155
ITALY 20; INDIA 16; PEOPLES R CHINA 16; AUSTRALIA 12; GERMANY 12; SPAIN 12; ENGLAND 8; MALAYSIA 8; PORTUGAL 8; NIGERIA 7; USA 7; BRAZIL 6; SAUDI ARABIA 6; CANADA 5; FRANCE 5; PAKISTAN 5; POLAND 5; FINLAND 4; **NETHERLANDS 4**

Plastics in agriculture

*Refine results for "*circular* *econom*" (Topic) OR "*circular* *econom*" (Title) and 2025 (Exclude – Final Publication Year) and 2024 (Exclude – Final Publication Year) and 2024 (Exclude – Publication Years) and Agri* (Search within all fields) and Plastic* (Search within all fields)*

Related keywords: NEW PLASTICS ECONOMY; EUROPEAN STRATEGY ON PLASTIC; PLASTIC WASTE STREAMS; AGRICULTURAL PLASTIC WASTE; BIO-BASED PLASTICS; PLASTIC WASTE MANAGEMENT; EXTENDED PRODUCER RESPONSIBILITY; CIRCULAR BIOECONOMY; BIODEGRADABLE PLASTICS

Total number of publications: 203
ITALY 32; SPAIN 25; USA 24; PEOPLES R CHINA 22; ENGLAND 16; INDIA 15; FRANCE 14 PORTUGAL 14; GERMANY 13; SOUTH KOREA 11; CANADA 10; GREECE 9; MALAYSIA 9; **NETHERLANDS 7**

ICER PC 2 Buildings (more particular houses /dwellings) / NCEP PC 8-11 Construction (engineering structures, roads, dwellings/houses, utility buildings (offices commercial- and industrial buildings),

Construction	**2378**	PEOPLES R CHINA 457; ITALY 252; SPAIN 242; ENGLAND 206; AUSTRALIA 157; PORTUGAL 128; GERMANY 120; USA 119; **NETHERLANDS 108**

Related Keywords (Construction): CIRCULAR ECONOMY; CIRCULAR CONSTRUCTION; CONSTRUCTION AND DEMOLITION WASTE; DEMOUNTABLE SHEAR CONNECTORS; CLOSED MATERIAL LOOPS; WASTE TRADING; GYPSUM WASTE; CONSTRUCTION AND DEMOLITION WASTE CDW; CIRCULAR ECONOMY CE; DESIGN FOR DECONSTRUCTION

Demolition	**625**	PEOPLES R CHINA 99; SPAIN 74; ITALY 73; ENGLAND 64; AUSTRALIA 58; **NETHERLANDS 41**…

Related Keywords (Demolition): CONSTRUCTION AND DEMOLITION WASTE; CONSTRUCTION AND DEMOLITION WASTE CDW; CONSTRUCTION AND DEMOLITION WASTE MANAGEMENT; CONSTRUCTION AND DEMOLITION; GYPSUM WASTE; CDW; DOWNCYCLING; WASTE TRADING; MEISAR

Housing	**185**	**NETHERLANDS 24;** PEOPLES R CHINA 20; ITALY 19; SPAIN 19; GERMANY 17…

Related Keywords (Housing): CIRCULAR DESIGN; BUILDING COMPONENTS; DESIGN FOR DISASSEMBLY; SUSTAINABLE HOUSING; PREFABRICATED CONSTRUCTION; URBAN METABOLISM; ADAPTIVE REUSE; SOCIAL HOUSING; RESOURCE EFFICIENCY

Dwellings	**25**	ITALY 5; NETHERLANDS 4; SPAIN 4; AUSTRALIA 2; AUSTRIA 2; GERMANY 2; SCOTLAND 2; USA 2; CANADA 1; …

Related Keywords (Dwellings): CIRCULAR ECONOMY, SUSTAINABILITY

ICER PC 3 Renewable Energy Technologies (PV, Windmills, Batteries, and Infrastructure) / NCEP PC 12-15 Capital Equipment (PV, Windmills, Climate control systems à in buildings)

PV	**201**	ITALY 31; USA 26; SPAIN 22; INDIA 19; GERMANY 17; AUSTRALIA 16; ENGLAND 14; PEOPLES R CHINA 14; BRAZIL 8; AUSTRIA 7, **NETHERLANDS 7;**…

Related Keywords (PV): PV WASTE; PV RECYCLING; EOL; PHOTOVOLTAIC PANELS; SOLAR PV; CIRCULAR BIOECONOMY; DUCKWEED; INDUSTRIAL SYMBIOSIS; ECONOMIC ASSESSMENT		
Wind	**215**	USA 26; ENGLAND 22; PEOPLES R CHINA 20; DENMARK 17; ITALY 17; POLAND 17; SPAIN 17; AUSTRALIA 14; GERMANY 12; GREECE 10; **NETHERLANDS 10;**…
Related Keywords (Wind): SUSTAINABLE ENERGY TRANSITION; END-OF-LIFE MANAGEMENT; WIND TURBINE BLADES; DESIGN STRATEGIES; OFFSHORE WIND; WIND TURBINE BLADE; MATERIAL FLOW ANALYSIS; END-OF-LIFE; WIND TURBINES		
Battery	**438**	GERMANY 67; PEOPLES R CHINA 67; USA 50; SPAIN 46; ENGLAND 43; ITALY 40; AUSTRALIA 29; INDIA 23; SWEDEN 23; FINLAND 22; CANADA 16; FRANCE 15; BRAZIL 13; PORTUGAL 13**; NETHERLANDS 11;…**
Related Keywords (Battery): BATTERY WASTE; METALLURGICAL RECYCLING; BATTERY RECYCLING; BATTERY REUSE; WASTE BATTERY TRANSPORTATION; ELECTRIC VEHICLE BATTERIES; BATTERY SECOND LIFE; SECOND LIFE; EV BATTERIES		
Infrastructure	**1005**	ENGLAND 138; USA 110; PEOPLES R CHINA 104; INDIA 81; AUSTRALIA 68; GERMANY 64; ITALY 63; **NETHERLANDS 60;** …
Related Keywords (Infrastructure): The electrodeposition–redox replacement (EDRR); GREEN VIRTUAL ENTERPRISES; METALS CIRCULAR ECONOMY; RESOLVE FRAMEWORK; MEISAR; BREEDING ENVIRONMENTS; CIRCULAR SUPPLY CHAIN MANAGEMENT; COLLABORATIVE NETWORKED ORGANISATIONS; SOCIO-ECONOMIC METABOLISM		
Climate control systems: *Not present in circular economy scientific literature as of 30 September 2024*		
NCEP PC 4-7 Consumption goods (electric and electronic devices, textile, furniture, disposables),		
Electric and electronic devices WEEE OR "Electrical and Electronic Equipment" OR "Electrical and Electronic Device*"	**335**	ITALY 50; PEOPLES R CHINA 36; GERMANY 31; ENGLAND 30; BRAZIL 22; **NETHERLANDS 19;** …
Related Keywords: WEEE; WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT; WASTE ELECTRICAL AND ELECTRONIC EQUIPMENT WEEE; DISTINCT URBAN MINE; WEEE MANAGEMENT; ELECTRICAL AND ELECTRONIC EQUIPMENT EEE; E-WASTE; ELECTRICAL AND ELECTRONIC WASTE; PREPARATION FOR REUSE; E-WASTE MANAGEMENT		
Textile	**615**	PEOPLES R CHINA 70; ENGLAND 64; ITALY 57; INDIA 49; PORTUGAL 47; BRAZIL 37; SPAIN 36; ROMANIA 34; USA 34; BELGIUM 29; GERMANY 28; AUSTRALIA 24; FINLAND 24; SWEDEN 24; POLAND 21; TURKEY 18; **NETHERLANDS 17…**
Related Keywords: TEXTILE RECYCLING, TEXTILE WASTE, CIRCULAR ECONOMY, CIRCULAR FASHION, CIRCULAR TEXTILE PRODUCTS, REGENERATED PROTEIN FIBRES, END-OF-LIFE TEXTILES, TEXTILE HISTORY, POST-CONSUMER WASTE, TEXTILE WASTE MANAGEMENT		
Furniture	**111**	ITALY 13; POLAND 11; SPAIN 10; PEOPLES R CHINA 8; SLOVAKIA 7; AUSTRIA 6; ENGLAND 6; PORTUGAL 6; SWEDEN 6; BRAZIL 5; GERMANY 5; **NETHERLANDS 5…**

Related Keywords: FURNITURE INDUSTRY; FURNITURE; CIRCULAR ECONOMY; WOOD WASTE; UPCYCLING; CLOSED-LOOP SUPPLY CHAIN; INDUSTRIAL ECOLOGY; PUBLIC PROCUREMENT; REMANUFACTURING; REUSE.

World (Micro topics): 6.115.1554 E-waste,42,37.838%; 6.115.1181 Life Cycle Assessment,8,7.207%; 3.87.527 Wood,7,6.306%; 3.87.269 Cellulose,6,5.405%; 6.3.385 Corporate Social Responsibility,5,4.505%; 2.165.679 Additive Manufacturing,3,2.703%; 3.40.1599 Forest Management,3,2.703%; 3.87.1003 Lignin,3,2.703%; 6.115.1244 Municipal Solid Waste,3,2.703%; 6.3.2135 Sharing Economy,3,2.703%; 4.84.260 Supply Chain,2,1.802%; 1.150.427 Cochlear Implant,1,0.901%; 1.158.1254 Alopecia Areata,1,0.901%; 2.39.2197 Chemical Recycling,1,0.901%; 2.39.515 Ring-opening Polymerization,1,0.901%; 2.67.1457 Carbon Dots,1,0.901%;3.16.28 Antioxidant Activity,1,0.901%;3.60.2078 Microplastics,1,0.901%; 3.83.1777 Biofiltration,1,0.901%; 3.87.946 Laccase,1,0.901%; 4.13.807 Internet Of Things,1,0.901%;4.224.1040 Industry 4.0,1,0.901%;4.237.911 Safety Climate,1,0.901%;4.84.1014 Minlp,1,0.901%;6.11.2298 Mixed Methods Research,1,0.901%

NL (Micro topics): 6.115.1554 E-waste,4,0.000%; 2.39.515 Ring-opening Polymerization,1,20.000%

Disposables *"Disposable*"*	**83**	ITALY 13; SPAIN 9; ENGLAND 8; PEOPLES R CHINA 6; USA 6; TAIWAN 5; AUSTRALIA 4; INDIA 4; SOUTH KOREA 4; SWEDEN 4; BRAZIL 3; FRANCE 3; GERMANY 3; GREECE 3; **NETHERLANDS 3…**

Related Keywords: CIRCULAR ECONOMY, CIRCULAR BIOECONOMY, WASTE VALORIZATION, PLASTIC WASTE, RESOURCE EFFICIENCY, PLASTIC POLLUTION, REUSE, Polylactic acid (PLA), WASTE MANAGEMENT, WASTE

World (Research Areas): Environmental Sciences Ecology,37,44.578%; Science Technology Other Topics,31,37.349%; Engineering 24, 28.916%; Chemistry,10,12.048%; Materials Science,10,12.048%; Energy Fuels,6,7.229%; Business Economics,5,6.024%; Polymer Science,4,4.819%; Computer Science,3,3.614%; Food Science Technology,3,3.614%; Physics,3,3.614%; Biochemistry Molecular Biology,2,2.410%; Government Law,2,2.410%; Health Care Sciences Services,2,2.410%; Metallurgy Metallurgical Engineering,2,2.410%; Social Sciences Other Topics,2,2.410%;Water Resources,2,2.410%; Agriculture,1,1.205%; Art,1,1.205%; Automation Control Systems,1,1.205%; Construction Building Technology,1,1.205%;Endocrinology Metabolism,1,1.205%; Geography,1,1.205%; Instruments Instrumentation,1,1.205%;Marine Freshwater Biology,1,1.205%; Oceanography,1,1.205%
NL (Research Areas) Science Technology Other Topics,3,100.000%; Environmental Sciences Ecology,1,33.333%

World (Meso topics): 6.115 Sustainability Science,23,27.711%; 3.60 Herbicides, Pesticides & Ground Poisoning,17,20.482%; 3.87 Paper & Wood Materials Science,9,10.843%; 8.124 Environmental Sciences,8,9.639%; 2.114 Organic Semiconductors,3,3.614%; 2.39 Polymer Science,2,2.410%; 3.45 Soil Science,2,2.410%; 3.83 Bioengineering,2,2.410%;7.121 Concrete Science,2,2.410%; 1.128 Fertility, Endometriosis & Hysterectomy,1,1.205%;2.53 Polymers & Macromolecules,1,1.205%; 2.62 Electrochemistry,1,1.205%;2.90 Water Treatment,1,1.205%; 3.85 Food Science & Technology,1,1.205%; 4.13 Telecommunications,1,1.205%; 4.61 Artificial Intelligence & Machine Learning,1,1.205%; 4.84 Supply Chain & Logistics,1,1.205%; 6.73 Social Psychology,1,1.205%; 7.139 Energy & Fuels,1,1.205%; 7.229 Mineral & Metal Processing,1,1.205%
NL (Meso Topics) 8.124 Environmental Sciences,2,66.667%; 6.115 Sustainability Science,1,33.333%

World (Micro topics): 3.60.2078 Microplastics,17,20.482%; 6.115.1554 E-waste,11,13.253%; 3.87.269 Cellulose,8,9.639%; 8.124.1648 Heat Waves,8,9.639%; 6.115.1244 Municipal Solid Waste,6,7.229%; 6.115.1181 Life Cycle Assessment,5,6.024%; 2.114.914 Stretchable Electronics,3,3.614%; 2.39.515 Ring-opening Polymerization,2,2.410%; 3.83.416 Anaerobic Digestion,2,2.410%; 7.121.26 Compressive Strength,2,2.410%; 1.128.2072 Premenstrual Syndrome,1,1.205%; 2.53.371 Hydrogels,1,1.205%; 2.62.52 Supercapacitor,1,1.205%; 2.90.27 Adsorption,1,1.205%; 3.45.1441 Composting,1,1.205%; 3.45.1903 Biochar,1,1.205%; 3.85.741 Chitosan,1,1.205%;3.87.1003 Lignin,1,1.205%; 4.13.807 Internet Of Things,1,1.205%; 4.61.56 Fuzzy Sets,1,1.205%;

4.84.260 Supply Chain,1,1.205%; 6.115.880 Renewable Energy,1,1.205%; 6.73.1507 Environmental Concern,1,1.205%; 7.139.89 Gasification,1; 1.205%;
7.229.774 Bioleaching,1,1.205%
NL (Micro topics): 8.124.1648 Heat Waves, 2,66.667%; 6.115.1554 E-waste,1,33.333%

REFERENCES

Merli, R., Preziosi, M., & Acampora, A. (2018). How do scholars approach the circular economy? A systematic literature review. *Journal of Cleaner Production*, *178*, 703-722.

National Circular Economy Programme 2023-2030, Accessible: National Circular Economy Programme - Rijksoverheid.nl

National Circular Economy Programme 2023-2030, Accessible: https://www.government.nl/binaries/government/documenten/reports/2023/09/27/national-circular-economy-programme-2023-2030/NPCE+Circulaire+Economie+rapport+Engels.pdf

PBL (2019). CIRCULAIRE ECONOMIE IN KAART. Accessible: https://www.pbl.nl/sites/default/files/downloads/pbl-2019-circulaire-economie-in-kaart-3401_0.pdf

PBL (2023) Integral Circular Economy Report 2023 Assessment for the Netherlands, Accessible: https://www.pbl.nl/en/publications/integral-circular-economy-report-2023-assessment-for-the-netherlands

Türkeli, S., Kemp, R., Huang, B., Bleischwitz, R., & McDowall, W. (2018). Circular economy scientific knowledge in the European Union and China: A bibliometric, network and survey analysis (2006–2016). *Journal of cleaner production*, *197*, 1244-1261.

Van Eck, N.J., Waltman, L. (2017). Citation-based clustering of publications using CitNetExplorer and VOSviewer. Scientometrics 111 (2), 1053e1070.

Appendix

Appendix A.1

Methodology

Query construction is one of the most important decisions in bibliometrics research. Researchers have three choices: the literal use of the concept (e.g. "circular economy" Geissdoerfer et al., 2017; Merli et al. (2017)), the use of wildcards to replace one or multiple characters in a query, (e.g. "e.g. circular econom*" Nobre and Tavares (2017)) or using an extended semantic set of keywords related to the research field which is expert-driven yet can be arbitrary. The query in this report "*circular* *econom*" can capture phrases such as circular economic, circularity, circular-economy, or "circular bio-economy". In this way, we capture scientific publications e.g., Tong and Tao (2016) on urban circular economic system, He et al. (2014) on circular economic development of the non-ferrous metal industry, Bocken et al. (2017) on taking the circularity to the next level, or Satpute et al. (2017) on innovative and smart technology in circular bioeconomy. The precision as such is often overlooked yet our query is a relevant improvement over Geissdoerfer et al., 2017 and Merli et al. (2017) which use "circular economy" as the keyword without wildcards.

Main Query:

Refine results for "*circular* *econom*" (Topic) OR "*circular* *econom*" (Title) and 2025 (Exclude – Final Publication Year) and 2024 (Exclude – Final Publication Year) and 2024 (Exclude – Publication Years) and NETHERLANDS (Countries/Regions)

WEB OF SCIENCE CORE COLLECTION

COVERAGE:

SCIENCE CITATION INDEX EXPANDED (SCI-EXPANDED) --1988-PRESENT

THE LARGER VERSION (SCIENCE CITATION INDEX EXPANDED) COVERS MORE THAN 8,500 NOTABLE AND SIGNIFICANT JOURNALS, ACROSS 150 DISCIPLINES, FROM 1900 TO THE PRESENT. THESE ARE ALTERNATIVELY DESCRIBED AS THE WORLD'S LEADING JOURNALS OF **SCIENCE AND TECHNOLOGY**, BECAUSE OF A RIGOROUS SELECTION PROCESS.

SOCIAL SCIENCES CITATION INDEX (SSCI) --1988-PRESENT

THE SSCI CITATION DATABASE COVERS SOME 3,000 OF THE WORLD'S LEADING ACADEMIC JOURNALS IN THE **SOCIAL SCIENCES** ACROSS MORE THAN 50 DISCIPLINES

ARTS & HUMANITIES CITATION INDEX (A&HCI) --1988-PRESENT

Subjects covered are the Arts, Humanities, Language (including Linguistics), Poetry, Music, Classical works, History, Oriental Studies, Philosophy, Archaeology, Architecture, Religion, Television, Theater, and Radio.

CONFERENCE PROCEEDINGS CITATION INDEX- SCIENCE (CPCI-S) --1990-PRESENT

CONFERENCE PROCEEDINGS CITATION INDEX- SOCIAL SCIENCE & HUMANITIES (CPCI-SSH) --1990-PRESENT

EMERGING SOURCES CITATION INDEX (ESCI) --2015-PRESENT

SOURCE: https://clarivate.com/webofsciencegroup/solutions/web-of-science/

TOPIC: (“*circular* *econom*”) OR TITLE: (“*circular* *econom*”)

Timespan: 1988-2023. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.

Topic and Title cover 1) Title of the scientific publications, 2) full abstract text, 3) author keywords, and 4) web of science keywords assigned for the article.

With respect to purpose of analysis, results are then refined by Web of Science built-in web functions.

e.g. Refined by:

COUNTRIES/REGIONS: (NETHERLANDS)

OR

e.g. Refined by

DOCUMENT TYPES: (ARTICLE)

OR

e.g. Refined by

SCIENCE CATEGORIES

OR

e.g Refined by

SOURCE TITLES: (RESOURCES CONSERVATION AND RECYCLING)

OR

e.g. Refined by

YEAR (2023) | For temporal analysis in each section

OR

e.g. Refined by

keywords of interest with wildcards, e.g. remanufactur*

Citation Topics are algorithmically derived citation clusters (using an algorithm developed by CWTS, Leiden). This is a three-level hierarchical document-level classification system. The three levels of the hierarchy and their content according the 2024 clustering are available to download.

Source: https://incites.zendesk.com/hc/en-gb/articles/22514077746961-Citation-Topics

Appendix A.2

Example QUERY List

Query #1 TOPIC: (“*circular* *econom*”) OR TITLE: (“*circular* *econom*”)
Refined by: TOPIC: (sharing) AND COUNTRIES/REGIONS: (NETHERLANDS)
Timespan: 1988-2023. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.

Query #2 TOPIC: (“*circular* *econom*”) OR TITLE: (“*circular* *econom*”)
Refined by: TOPIC: ("product as a service" OR "product-as-a-service" OR "product as service" OR "product-service-systems" OR PSS) AND COUNTRIES/REGIONS: (NETHERLANDS)
Timespan: 1988-2023. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.

Query #3 TOPIC: (“*circular* *econom*”) OR TITLE: (“*circular* *econom*”)
Refined by: TOPIC: (sufficiency) AND COUNTRIES/REGIONS: (NETHERLANDS)
Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=1988-2022

Query #4 TOPIC: (“*circular* *econom*”) OR TITLE: (“*circular* *econom*”)
Refined by: TOPIC: (reduce AND waste) AND COUNTRIES/REGIONS: (NETHERLANDS)
Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=1988-2023

Query #5 TOPIC: (“*circular* *econom*”) OR TITLE: (“*circular* *econom*”)
Refined by: TOPIC: (Reduce AND energy) AND COUNTRIES/REGIONS: (NETHERLANDS)
Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=1988-2023

Query #6 TOPIC: (“*circular* *econom*”) OR TITLE: (“*circular* *econom*”)
Refined by: TOPIC: (Reduce AND Waste AND energy) AND TOPIC: (waste)
AND COUNTRIES/REGIONS: (NETHERLANDS)
Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=1988-2023

Query #7 TOPIC: (“*circular* *econom*”) OR TITLE: (“*circular* *econom*”)
Refined by: TOPIC: (reuse) AND TOPIC: (material)
Timespan: 1988-2023. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.

Query #8 TOPIC: (“*circular* *econom*”) OR TITLE: (“*circular* *econom*”)
Refined by: TOPIC: (reuse) AND TOPIC: (second-hand OR "second hand" OR "Second use" OR "second-use") AND COUNTRIES/REGIONS: (NETHERLANDS)
Indexes=SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan=1988-2023

Query #9 TOPIC: ("Material reuse")
Refined by: COUNTRIES/REGIONS: (NETHERLANDS)
Indexes=SCI-EXPANDED, ESCI, A&HCI, SSCI, CPCI-SSH, CPCI-S Timespan=1998-2023

Cut-off date: *December 31st, 2023; e.g. Refined By: NOT Final Publication Year: 2025 AND.NOT Final Publication Year: 2024 AND NOT Publication Years: 2024

Backlog cut: 30/09/2024 not open to backlog record updates/amendments after this date.

Appendix A.3

Table A3.1 – PBL (2019) Circularity Strategy and Synonyms in Time (Earlier Data)

Keywords	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010
refuse	2	1										
rethink	3	2	2019 (1)		2017 (1)							
reduce	48	37	2019 (14)	2018 (5)		2016 (2)	2015 (2)				2011 (1)	
reuse	30	15	2019 (10)	2018 (6)	2017 (9)	2016 (2)	2015 (3)	2014 (1)				
remanufactur*	5	4	2019 (5)	2018 (2)	2017 (4)	2016 (3)		2014 (1)				
repair	8	7	2019 (11)	2018 (6)	2017 (2)	2016 (3)						
recycl*	51	50	2019 (29)	2018 (26)	2017 (13)	2016 (8)	2015 (2)	2014 (3)	2013 (1)			2010 (1)
recover*	34	33	2019 (15)	2018 (13)	2017 (10)	2016 (4)	2015 (2)		2013 (1)			2010 (1)
framework	48	45	2019 (30)	2018 (28)	2017 (15)	2016 (9)	2015 (1)	2014 (1)			2011 (2)	2010 (1)
policy	48	39	2019 (34)	2018 (20)	2017 (13)	2016 (8)	2015 (1)	2014 (3)	2013 (1)			2010 (1)
business model	37	24	2019 (15)	2018 (9)	2017 (10)	2016 (3)	2015 (1)					
manufactur*	27	13	2019 (13)	2018 (7)	2017 (9)	2016 (1)	2015 (1)		2013 (1)			
reuse NOT recycl*	16	9	2019 (4)	2018 (4)	2017 (7)		2015 (1)	2014 (1)				

*(x): number of publications

Query:

TOPIC: ("*circular* *econom*") OR TITLE: ("*circular* *econom*")

Refined by: TOPIC: (**"life extension" OR "life cycle extension" OR "product life cycle" OR "product life cycle extension"**)

Timespan: 1988-2022 May 23rd. Indexes: SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI.

Worldwide (127): 2022(13); 2021(36); 2020(21); 2019 (18); 2018 (20); 2017 (8); 2016 (3); 2015 (2); 2014 (1); 2013 (2); 2012 (1); 2010 (1); 2004 (1)

NL (10): 2022 (1); 2021(2); 2020 (3); 2019 (1); 2018 (1); 2017 (1); 2014 (1)

Table A3.2 R-Strategies in Time (Stable routine) (Earlier Data)

CE Core Domain			W. and NL	2021	2020	2019	2018	2017	2016	2015	2014	2013	2012	2011	2010	2009	2008 - 2004	Total - >2019	% of NL	T -> 2022	% of NL 2022
	Rethink																				
	Query #1	**Sharing**	W	113	80	2019 (91)	2018 (68)	2017 (34)	2016 (25)	2015 (2)	2014 (3)	2013 (1)	2012 (3)		2010 (1)	2009 (2)	2008 (1)	**231**		**362**	
			NL	9	6	2019 (8)	2018 (8)	2017 (5)	2016 (1)		2014 (1)							**23**	**0.10**	**32**	**0.09**
*	Query #2	**Product-as-a-service**	W	26	41	2019 (40)	2018 (21)	2017 (28)	2016 (10)	2015 (2)	2014 (2)							**103**		**208**	
			NL	3	4	2019 (3)	2018 (2)	2017 (3)	2016 (2)	2015 (1)								**11**	**0.11**	**20**	**0.10**
	Refuse																				
	Query #3	**Sufficiency**	W	23	12	2019 (6)	2018 (3)	2017 (3)	2016 (1)		2014 (1)	2013 (1)	2012 (1)					**16**		**61**	
			NL	2	2	2019 (1)	2018 (2)	2017 (1)			2014 (1)							**5**	**0.31**	**10**	**0.16**
	Reduce																				
Rank1	Query #4	**Reduce AND Waste**	W	333	221	2019 (211)	2018 (132)	2017 (78)	2016 (33)	2015 (12)	2014 (7)	2013 (8)	2012 (4)	2011 (7)	2010 (8)	2009 (1)	2008 - 2004 (8)	**510**		**961**	
			NL	8	7	2019 (7)	2018 (4)	2017 (2)	2016 (2)									**15**	**0.03**	**23**	**0.02**
Rank2	Query #5	**Reduce AND Energy**	W	132	99	2019 (132)	2018 (75)	2017 (60)	2016 (21)	2015 (9)	2014 (7)	2013 (6)	2012 (8)	2011 (8)	2010 (6)	2009 (5)	2008 - 2004 (6)	**343**		**674**	
			NL	2	6	2019 (3)	2018 (4)											**7**	**0.02**	**15**	**0.02**
Rank3	Query #6	**Reduce AND Energy AND Waste**	W	145	84	2019 (85)	2018 (52)	2017 (40)	2016 (13)	2015 (6)	2014 (3)	2013 (3)	2012 (2)	2011 (4)	2010 (3)		2008 - 2004 (5)	**216**		**422**	
			NL	1	3	2019 (1)	2018 (4)											**5**	**0.02**	**9**	**0.02**
	Reuse																				
	Query #7	**Reuse AND Material**	W	220	140	2019 (136)	2018 (94)	2017 (57)	2016 (22)	2015 (8)	2014 (9)	2013 (4)		2011 (3)	2010 (2)	2009 (1)	2007 (1)	**337**		**634**	
			NL	11	6	2019 (6)	2018 (4)	2017 (6)	2016 (2)	2015 (2)	2014 (1)							**21**	**0.06**	**28**	**0.04**
*	Query #8	**Reuse AND second-hand**	W	10	4	2019 (6)	2018 (4)	2017 (1)	2016 (1)	2015 (1)								**13**		**29**	
			NL	1	-		2018 (1)		2016 (1)									**2**	**0.15**	**3**	**0.10**
*	Query #9	**Material Reuse**	W	220	140	2019 (17)	2018 (21)	2017 (11)	2016 (6)	2015 (12)	2014 (6)	2013 (9)	2012 (9)	2011 (13)	2010 (9)	2009 (13)	2008 - 2000 (27)	**160**		**634**	
			NL	11	6	2019 (1)	2018 (1)	2017 (1)					2012 (1)	2011 (1)			2008-1999 (2)	**7**	**0.04**	**28**	**0.04**

*See Appendix A.2 for queries in detail.