Energy Transition in Central Asia: A Systematic Literature Review

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Abstract While there is abundant research on the expansion of renewable energy in developed countries, little attention has been paid to the decarbonisation of energy systems in Central Asia, despite the region's vulnerability to climate change, its rapidly growing domestic energy demand and the abundance of natural resources essential for the energy transition. Based on a systematic review of the literature, this chapter provides a comprehensive overview of the profile and trajectory of research on energy in Central Asia between 1991 and 2022. It finds that there was a shift from focusing on fossil fuels to clean energy around 2019–2020. However, despite recent growth, research on renewables and their significance in Central Asia is still sparse. This review indicates that while American and European researchers took the lead in this field in 2012, China, Japan, Kazakhstan and Russia have emerged as the leading contributors since 2016.

Keywords Central Asia · Clean energy transition · Renewable energy · Systematic literature review · Research networks · Bibliometric visualisation

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1 Introduction

While there has been abundant research on renewable energy in developed countries, less attention has been paid to energy system decarbonisation in less developed regions, though the latter are more vulnerable to the adverse effects of climate change, show rapid growth in domestic energy demand, and are rich in natural resources critical for energy transition (Apfel et al. 2021; Vakulchuk et al. 2020; Overland et al. 2019). One such region is Central Asia, which makes a particularly interesting case study owing to its strategic location and resources (Vakulchuk and Overland 2021). After the collapse of the Soviet Union in 1991, Central Asia came to play an important role in the global economy as a source of fossil fuels, primarily oil and gas. This is also reflected in the literature (Vakulchuk 2016; Vakulchuk et al. 2022). However, given the growing global demand for clean energy and materials critical for the energy transition, the countries of Central Asia may be of increasing interest to researchers of clean energy (Vakulchuk and Overland 2021; Eshchanov et al. 2019a, b, c, d).

The aim of this chapter is to provide a comprehensive overview of the profile and trajectory of energy research in Central Asia, with a particular focus on the social sciences. The existing review articles on Central Asia have tended to focus on specific topics in the scenario and sectoral analysis (Mehta et al. 2021; Kaiser and Pulsipher 2007; Karatayev et al. 2021). None has systematically reviewed the literature on energy transition or renewable energy.

This study presents a systematic review of the energy transition literature published between 1991 and 2022 based on data extracted from the Web of Science (WoS) Core Collection database. Using a combination of descriptive statistical analysis and bibliometric visualisation techniques, we address the following research questions: (1) What sub-topics are covered in research on energy issues in the countries of Central Asia? (2) Can a shift from research on fossil fuels to clean energy be identified? (3) What are the most influential articles and research organisations in the field of energy research in Central Asia?

In the next section, we present our strategy for selecting publications, the data extraction and screening processes and visualisation methods. This is followed by our results section, which addresses our research questions, illustrating the empirical results with data visualisations. In the final section, we present our conclusions.

2 Methodology

We based our identification and extraction of publications for review on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (Page et al. 2021). Our search covered social science publications written in English and listed in the Web of Science (WoS) Social Science Research indexes (SSCI, CPCI-SSH, BKCI-SSH) for the period from 1991 to 2022. Relevant publications

were first identified through the WoS Core Collection database by applying the following Boolean search string to the title, abstract and keyword fields:

((TS=((‘renewable energy’ OR ‘solar energy’ OR ‘solar power’ OR ‘wind energy’ OR ‘wind power’ OR ‘hydropower’ OR ‘hydroelectric energy’ OR ‘biofuel’ OR ‘geothermal energy’ OR ‘geothermal power’ OR ‘power plant’ OR ‘agrofuel’ OR ‘bioenergy’ OR ‘green energy’ OR ‘clean energy’ OR ‘energy efficiency’ OR ‘energy consumption’ OR ‘energy transition’ OR ‘nuclear energy’ OR ‘fossil fuel’ OR ‘coal’ OR ‘decarbonisation’ OR ‘low carbon’ OR ‘petrol*’ OR ‘gasoline’ OR ‘oil’ OR ‘fuel’ OR ‘electricity’ OR ‘natural gas’) AND (‘Central Asia’ OR ‘Kazakh*’ OR ‘Kyrgyz*’ OR ‘Tajik*’ OR ‘Turkmen*’ OR ‘Uzbek*’))) AND PY=(1991-2022)) AND LA=(English)

A total of 542 publications were initially retrieved. This was subsequently narrowed down to 305 publications following a screening process including manual relevance checks and the limiting of articles to those published in peer-reviewed journals. The extracted WoS data included the article title, author(s), year of publication, name/country of the research organisation, keywords, citation information and list of references.

The final sample of 305 articles was exported in tab-delimited format to the VOSviewer software. VOSviewer is an application for creating maps and visualisations based on network data (Van Eck and Waltman 2022). It can identify networks among scientific publications, journals, authors, research organisations, countries and/or keywords. Objects of interest (e.g. articles) can be linked, for instance, by co-authorship, citations and bibliographic links. VOSviewer provides three different visualisation modalities: network, overlay and density. In this study, we use overlay figures. An overlay figure represents items with labels and bubbles (Van Eck and Waltman 2022). The greater the weight of the object, the larger the label and the bubble. The colour of an item is determined by its grade, in our case, the grade is the year of publication. By default, the colours range from blue (earliest years) through green to yellow (latest years) (Van Eck and Waltman 2022). See Fig. 1 for an example of an overlay figure.

One of the main limitations of this study is that it is empirically limited to the WoS database. In future research, it would be possible to cover a wider range of databases, though we do not expect that the results would differ substantially. Another limitation is that our dataset includes only papers published in English, while Russian has remained an important language for academic articles on Central Asia and there is also a growing number of publications on the region in Chinese.

3 Results

3.1 Key Trends in Energy Research in Central Asia (Research Questions 1 and 2)

We analysed the co-occurrence of keywords to assess the attention given to different topics and how priorities have evolved. The visualisation in Fig. 1 is based on the

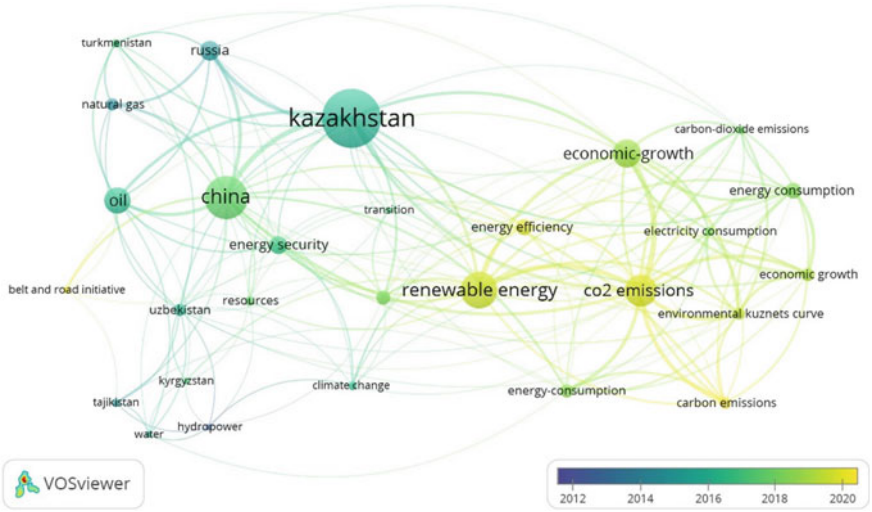

Fig. 1 Main topics in research on energy-related issues in the Central Asian countries (Overlay visualisation of co-occurrence of keywords using VOSviewer)

number of articles in which the same keywords occur. The rationale for this is that the topics that these words represent should be closely related and can illustrate research trends and patterns (Maier et al. 2020) in the popularity of topics over time. Figure 1 uses an overlay visualisation to represent 28 keywords that appear at least 6 times in our 305 articles (out of a total of 1296 keywords used in our analysis). The size of the circles indicates the total number of occurrences of a keyword, while the colour indicates the period when most of the occurrences were noted. VOSviewer automatically assigns a range of years to the period during which most articles were published. The colour of keywords of articles published before 2012 or after 2020 are converted to the 2012 or 2020 colour value, respectively. The distance between the words also indicates their co-occurrence within articles.

The colour coding in Fig. 1 indicates that there has been a shift from fossil fuel-related research to research on the clean energy transition. Thus, keywords such as 'renewable energy' occurred in 32 articles, 'CO_2 emissions' in 28 articles, 'environmental Kuznets curve' in 11. All appear as yellow-green circles, indicating that they have been used more frequently in recent years. By contrast, the keywords 'natural gas' (11) and 'oil' (23) were used more often around 2014–2016, as indicated by the blue/green colours. Analysing the proximity of keywords to one another, we find that the more recent research on clean energy relates more to 'energy efficiency' (14 times), 'energy consumption' (14 times) and 'economic growth' (12 times), as indicated by their size and proximity to each other. By contrast, the keyword 'hydropower' is located far from these other keywords and is coloured purple, indicating that the more recent clean energy research focuses less on hydropower than

on other topics. The figure also indicates a lack of publications on 'solar', 'wind energy' and 'bioenergy', as these do not feature in the figure.

Figure 1 indicates that Kazakhstan is the most studied country in the region from an energy perspective. Analysing the distance between the keywords, we can see that the word 'Kazakhstan' is located closer to the clean energy keywords than the other countries. This indicates that Kazakhstan is also the country in which renewable energy topics have been covered most in recent years. By contrast, other Central Asian countries are located at a greater distance from the 'recently occurring' keywords related to clean energy. The distance between keywords indicates that the main topics researched in relation to 'Kyrgyzstan' (6) and 'Tajikistan' (8) are 'hydropower' (6) and 'water' (6), while the colour indicates that these were published in the earlier period. For 'Turkmenistan' (8), the most commonly occurring keywords are 'natural gas' and 'oil', while for 'Uzbekistan' (11) it is 'oil', with colour also indicating earlier publication dates.

To identify key research clusters and hot topics, we analysed bibliographic links between articles with at least 20 citations. This resulted in 6 thematic clusters involving 60 articles (Table 1). Two articles are bibliographically coupled when they link to a common third work in their bibliography. The identified clusters are (A) Energy research from a macroeconomic perspective; (B) Energy security in Central Asia; (C) Natural resources of Kazakhstan; (D) Renewable energy and energy efficiency; (E) Energy geopolitics; and (F) Energy policy (Table 1).

According to the cluster analysis, energy research in Central Asia is most actively researched from the perspective of macroeconomics (Cluster A) and energy security (Cluster B). Cluster A covers the impact of natural resources, energy consumption and carbon dioxide on economic growth and trade (twelve articles in total); the energy-financial development nexus (three articles); and the environment (four articles, including Ansari et al. [2020], which revisit the environmental Kuznets curve). Most of these studies use the statistical method of panel data analysis and focus on multiple countries, both within and outside Central Asia. In Cluster B (energy security), the authors analyse political perspectives on energy corridors, natural gas resources, gas production and pipelines (six articles), and electricity reforms and energy security (eight articles).

3.2 Influential Articles, Authors and Research Organisations (Research Question 3)

Following Maier et al. (2020), we identified the most influential articles from our selection based on the number of citations (Table 2). Among the most cited articles, the three main research topics were the macroeconomic impacts of energy use; energy geopolitics; and climate change mitigation. The most cited article (Sorg et al. 2012) focuses on the impact of climate change on glaciation, the impact of runoff on water availability, and the implications for irrigation, industry and hydropower.

Table 1 Central Asian energy research clusters

Cluster A	*Energy from a macroeconomic perspective*	*Cluster C*	*Natural resources of Kazakhstan*
	Al-Mulali et al. (2012), Ansari et al. (2020), Bildirici and Kayıkçı (2013), Billmeier and Massa (2009), Buehn and Farzanegan (2013), Hafeez et al. (2019), Hasanov et al. (2017), Hasanov et al. (2019), Khan et al. (2014), Mukhtarov et al. (2020), Murshed (2020), Omri et al (2014), Qureshi et al. (2016); Rasoulinezhad and Saboori (2018), Sarkodie et al. (2019), Sun et al. (2019), Wang et al. (2020), Yildirim et al. (2020), and Zhang (2019)		Atakhanova and Howie (2007), Domjan and Stone (2010), Egert and Leonard (2008), Franke et al. (2009), Ipek (2007), Kaiser and Pulsipher (2007), Kalyuzhnova and Nygaard (2008), Lai (2007), Lee (2005), Pomfret (2005), and Zhao (2008)
Cluster B	*Energy security in Central Asia*	*Cluster D*	*Renewable energy and energy efficiency*
	Bilgin (2007), Bilgin (2009), Ericson (2009), Esen and Oral (2016), Knox-Hayes et al. (2013), Le et al (2019), Li et al. (2019), Mohsin et al. (2021), Sarbassov et al. (2013), Sovacool et al. (2012), Sovacool (2016), Taghizadeh-Hesary et al. (2019), Tavana et al. (2012), Wegerich et al. (2007), and Zhang et al. (2019)		Ahmad et al. (2017), Akhanova et al. (2020), Duan et al. (2018), Karatayev et al. (2016), Mahmood and Orazalin (2017), Przychodzen and Przychodzen (2020), Zhang and Bai (2020), and Zhao et al. (2018)
Cluster F	*Energy policy*	*Cluster E*	*Energy geopolitics*
	Koch and Perreault (2019) and Ngoasong (2014)		Chung (2004), Collins and Kearins (2010), Granit et al. (2012), Xunpeng et al. (2017), and Weinthal and Luong (2001)

Figure 2 shows a significant increase in the number of peer-reviewed journal articles and citations between 1991 and 2021. The annual number of citations grew rapidly, reaching 1598 in 2021. The first article in our selection was published in 1992, and until 2007 only a few articles were published annually. The number of peer-reviewed journal articles has been steadily increasing since 2007, accelerating after 2017 and peaking at 41 per year in 2020.

Figure 3 illustrates the number of researchers from their respective countries who have produced energy-related research on Central Asia. The size of a sphere is determined by the number of published articles from that country. The colour of a sphere is determined by the period that most articles were published (blue/purple represents the earlier period, and green/yellow is more recent). Figure 3 depicts 33 countries whose researchers have produced at least three energy articles (of the total of 63

Table 2 The 10 most cited articles

	Article	Author (year)	Journal	Total citations
1	Climate change impacts on glaciers and runoff in Tien Shan (Central Asia)	Sorg et al. (2012)	Nature Climate Change	524
2	Causal interactions between CO_2 emissions, FDI, and economic growth: Evidence from dynamic simultaneous-equation models	Omri et al. (2014)	Economic Modelling	267
3	Exploring the bi-directional long-run relationship between urbanisation, energy consumption, and carbon dioxide emission	Al-Mulali et al. (2012)	Energy	161
4	Energy investment risk assessment for nations along China's Belt & Road Initiative	Duan et al. (2018)	Journal of cleaner production	119
5	Geopolitics of European natural gas demand: Supplies from Russia, Caspian and the Middle East	Bilgin (2009)	Energy Policy	102
6	Global estimates of energy consumption and greenhouse gas emissions	Khan et al. (2014)	Renewable and Sustainable Energy Reviews	88
7	Nexus between energy efficiency and electricity reforms: A DEA-Based way forward for clean power development	Mohsin et al. (2021)	Energy Policy	86
8	Energy crisis, greenhouse gas emissions and sectoral growth reforms: Repairing the fabricated mosaic	Qureshi et al. (2016)	Journal of Cleaner Production	82

(continued)

Table 2 (continued)

	Article	Author (year)	Journal	Total citations
9	Panel estimation for renewable and non-renewable energy consumption, economic growth, CO_2 emissions, the composite trade intensity, and financial openness of the commonwealth of independent states	Rasoulinezhad and Saboori (2018)	Environmental Science and Pollution Research	76
10	Kazakhstan and Azerbaijan as Post-Soviet Rentier States: Resource Incomes and Autocracy as a Double 'Curse' in Post-Soviet Regimes	Franke et al. (2009)	Europe-Asia Studies	68

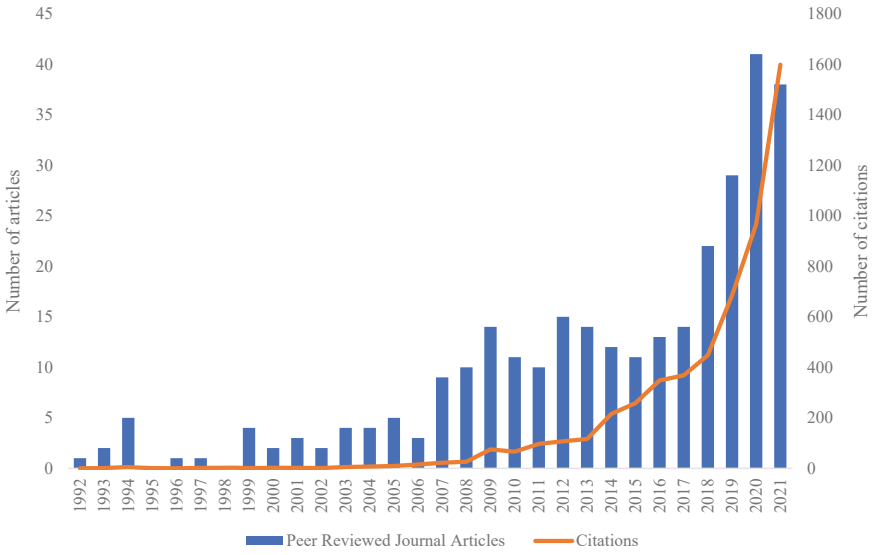

Fig. 2 Publications and the number of citations by year over the 1991–2021 period

countries whose researchers produced our 305 articles). The top contributors are from the US (79 articles), China (57), the UK (37) and Kazakhstan (34). However, there has been a clear dominance in recent years of China, Japan, Kazakhstan and Russia, while researchers from the USA, UK, The Netherlands, Germany and Turkey

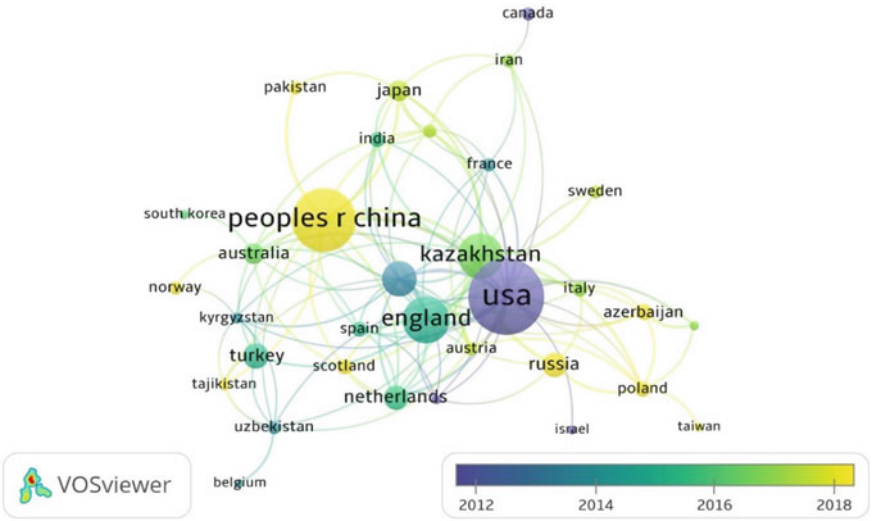

Fig. 3 Countries whose researchers publish the most research on energy in Central Asia (Overlay visualisation of co-authorship link between countries)

were more active between 2012 and 2016 (Fig. 3). This reflects a decline in international scholarly interest in the topic of petroleum resources in Central Asia from 2010 onwards.

The data also showed collaboration between the 33 research organisations that published at least three articles included in our selection (out of the 487 organisations that were involved in the 305 articles). The colour of the circles is determined by the year the articles were published (the most recent being yellow), with proximity indicating tighter collaboration. The greater the number of articles published by an organisation with a collaborating institution, the larger the circle. Thus, greater collaboration in recent years had been seen between Kazakhstan's Nazarbayev University (10 articles and 143 citations), the Asian Development Bank Institute (Japan) (3 articles and 31 citations), the CAREC Institute (China) (3 articles and 7 citations), and Al-Farabi Kazakh National University (6 articles and 31 citations).

4 Discussion and Conclusions

The main objective of our study was to provide a comprehensive overview of trends in energy research in Central Asia. We carried out a systematic literature review and examined 305 articles published between 1991 and 2022 in journals indexed in the Social Science Research indexes, namely SSCI, CPCI-SSH and BKCI-SSH, of the Web of Science Core Collection.

Our bibliometric analysis revealed a trend in research publication topics moving away from fossil fuels towards clean energy in Central Asia between 1991 and 2022. Despite recent growth in the number of articles published on renewable energy in these countries, there is a lack of articles on solar, wind and bioenergy. The top contributors to the literature in recent years are from China, Japan, Kazakhstan and Russia, while researchers from the USA, UK, The Netherlands, Germany and Turkey were more active in the 2012–2016 period. The strongest collaboration between research organisations is observed between Kazakhstan's Nazarbayev University, the Asian Development Bank Institute, the CAREC Institute and Al-Farabi Kazakh National University.

This data provides us with a picture of the academic research networks currently operating in the field of energy transition in Central Asia. Such analysis can help those who are seeking research partners or a research base, those who might want to fund productive collaboration, and those wishing to better understand the dynamics of current research. This study contributes to understanding the clean energy transition in Central Asia; however, for deeper analysis, we recommend exploring more databases and including Russian-language publications.

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