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Energy, Sustainability and Society (2023) 13:47
https://doi.org/10.1186/s13705-023-00426-z

Energy, Sustainability
and Society

RESEARCH

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Analyzing development finance flows in the Western Balkans' energy sector: a 2008–2020 perspective

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Abstract

Background Development finance is vital for low- and middle-income countries to enhance their sustainability agendas, as it provides essential funding necessary to close domestic financing gaps, including in the energy sector. Coal is still a vital power source for the energy sectors in the Western Balkans (i.e., Bosnia and Herzegovina, Kosovo, Montenegro, North Macedonia, and Serbia). The energy sector is a critical component in the five countries' pursuit to decarbonize (i.e., follow the net zero pathways) due to its central role as a primary contributor to greenhouse gas emissions and a critical enabler of sustainability transition. This article presents a mapping exercise of development finance for five Western Balkan countries' energy sectors. The study conducted a scoping literature review and detailed analysis of the five countries' energy sector-related development finance flows from 2008 to 2020. This aimed to provide insights into the development finance flows for renewable and non-renewable energy sources in five Western Balkan countries.

Results The scoping literature review indicated a significant gap in knowledge about the effects and effectiveness of development finance in the Western Balkans. Data analysis identified US$3.2 billion in energy development finance in the examined countries. The disbursement ratios were above the global average of 63%. Serbia received the highest proportion of the total funding, while Montenegro obtained the highest funding per capita. The data analysis did not establish a connection between adopting the Paris Agreement in 2016 and increasing development finance flows for renewable energy projects. Around one-third of the disbursed development finance was invested in projects for energy supply using non-renewable sources. Official Development Aid loans represented 37% (US$1.2 billion) of the total funding, contributing to the increase in indebtedness in the five countries. European-based bilateral and multilateral development finance providers were the most important actors in the five examined countries.

Conclusions The amount of the disbursed development finance was insufficient to cover a significant percentage of the needs of the surveyed countries. Although carbon-intensive energy infrastructure received considerable funding, the total amount of disbursed energy development finance ranged between 0.15 and 0.62% of the average gross domestic product for the analyzed countries during the study period. Based on the research findings, we recommend that development finance providers and recipient countries pay greater attention to planning for strategic funding disbursement.

Keywords Development aid, Energy transition, Renewable energy, Non-renewable energy, Electric power system, Carbon intensity

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Background

Keeping the planet within a safe operating space requires a societal transition and sizeable investment [1–3]. A pledge to reduce greenhouse gas emissions (GHG) and shift societies towards low-carbon development pathways was one of the main components of the Paris Agreement [1]. However, the path to realizing the pledge into concrete changes on the ground differs from country to country. This challenge is easier to accomplish for high-income countries because they possess enough domestic financial resources to fund the transition, unlike middle- and low-income countries [2–4]. To aid in closing the funding gap across low- and middle- to high-income countries, in 2010 high-income countries pledged US$100 billion annually [5–8]. Western Balkan countries are transition economies (i.e., middle-income countries) undertaking fundamental adjustments to create market-based institutions. Development finance is critical for Western Balkan countries since it provides the funds to invest in new low-carbon infrastructure. However, the exact distribution of the provided financial flows remained unstudied until now.

The Western Balkan countries, comprising Bosnia and Herzegovina, Kosovo[1], Montenegro, North Macedonia, and Serbia, were territorial units of the Socialist Federal Republic of Yugoslavia (SFRY) until the early 1990s. The violent disintegration of the SFRY was manifested through wars[2] characterized by, among other issues, the destruction of the energy sector infrastructure [9–11]. Destructive events in the 1990s shaped the current socio-economic and political conditions in all Western Balkan countries [12, 13].

Alongside limited national budgets, development finance has been essential in fostering post-war development efforts and supporting the region's economic and social advancement [14, 15]. Development finance is crucial for countries undergoing economic transition where large-scale private sector funding is limited [16, 17].

Furthermore, development finance is crucial for supporting the energy transition and decarbonization in the Western Balkans [5]. This transition will require significant investments in new infrastructure, technologies, policy, and regulation changes to support clean energy development [17, 18]. Additionally, compared to fossil fuel-based power systems, where fuel consumption is the main cost and is spread over the asset's operating life, renewable energy sources present a different financing challenge as most costs involve significant upfront capital investment [17, 19].

Historically, the European Union (EU) and its member states have been a crucial provider of development finance to the Western Balkan countries [15]. Today, the EU provides financial assistance to Western Balkan countries through the Instrument for Pre-accession Assistance and has funded various renewable energy and energy efficiency projects. Furthermore, the EU has established the Western Balkans Investment Framework, which provides financial support for energy infrastructure and promotes a just transition to a low-carbon economy in the region [20].

The significance of coal in the Western Balkans

The Western Balkans region is rich in reserves of low-quality lignite coal deposits [21]. Coal, known for its affordability and ease of extraction, is crucial to national energy security in five Western Balkans countries, where coal mining and thermal power generation provide governments with direct and indirect employment opportunities and tax revenues [22, 23]. Given the limited financial resources available in all five Western Balkan countries, the low price of coal makes it an attractive option to provide a reliable but highly polluting energy supply [21, 24].

Bosnia and Herzegovina has an installed thermal power capacity of 2081 megawatts (MW), contributing between 60 and 70% of electricity generation, depending on the year [25]. Hydropower is the second most important electricity generation source in Bosnia and Herzegovina, covering the remaining annual power needs [25]. Kosovo's electricity generation almost entirely depends on two thermal power plants with a combined installed capacity of 1478 MW, which gives 97% of the power generation [26]. Montenegro meets around 46% of its electricity needs through thermal power plants with an installed capacity of 532 MW. The remaining electricity generation is predominantly supplied by hydropower [27].

North Macedonia has a total thermal power installed capacity of 824 MW, contributing between 50 and 60% of electricity generation, depending on the year [28]. Hydropower accounts for approximately 30% and natural gas for the remaining 20% of the total electricity production in North Macedonia [28]. Serbia has an installed thermal power capacity of 4390 MW, contributing between 60 and 75% of electricity generation, depending on the year [29]. Hydropower is the second most important electricity generation source, accounting for the remaining power generation [29]. It is essential to mention that Bosnia and Herzegovina is currently the only net exporter of electricity in the Western Balkans, while North Macedonia is dependent on electricity imports [25, 28]. On

[1] This designation is without prejudice to positions on status and is in line with UN Security Council resolution 1244/1999 and the International Court of Justice opinion on the Kosovo declaration of independence.

[2] Four wars and three insurgencies spanning from 1991 to 2001.

an annual basis, the remaining three countries are net export–import neutral [26, 27, 29].

While using coal for power generation may have certain short-term advantages in the Western Balkans, there are also several significant disadvantages. Coal mining and combustion processes cause an increase in the emission of GHG, particulate matter, sulfur dioxide, and nitrogen oxides. The increase in these emissions negatively impacts human health, causing respiratory and cardiovascular illnesses and some types of cancer, as well as environmental impacts, such as air pollution, acid rain, and climate change [30–32].

Coal is non-renewable, with finite reserves that will eventually run out. An over-dependence on coal for energy production can leave a nation vulnerable to energy shortages and changes in the price of coal on the global market [23, 33]. As many countries shift towards using cleaner and more sustainable energy sources, investing in coal-related energy infrastructure may become riskier, resulting in stranded assets and financial losses for governments and investors [34, 35].

The Paris Agreement and net zero transition

The continued reliance of the Western Balkan countries on coal jeopardizes the achievement of global climate commitments, such as the Paris Agreement. Bosnia and Herzegovina, Montenegro, North Macedonia, and Serbia have signed and ratified the Paris Agreement. Although not a party to the Paris Agreement, Kosovo is committed to following the United Nations (UN) climate agenda [36]. Therefore, meeting Paris Agreement pledges will require the Western Balkan countries to decarbonize by 2050, which will be hard without a coal phase-out [4, 24, 37, 38].

According to the Paris Agreement, countries must provide recurring reports on their GHG emissions and progress toward national climate objectives with net zero targets [39]. The latest Nationally Determined Contributions (NDCs) of Bosnia and Herzegovina, Montenegro, North Macedonia, and Serbia for the period 2020–2030 state that these countries plan to submit their national inventory reports, biennial transparency reports, and other relevant information to the United Nations Framework Convention on Climate Change (UNFCCC) Secretariat every two years, starting from 2024 [40]. Kosovo is not a party to the UNFCCC. Hence, the country does not have its NDC document. This requires increasing carbon dioxide (CO_2) removal while decreasing emissions and supporting initiatives like reforestation, renewable energy infrastructure development, and carbon capture technologies [41, 42]. Thus, it is crucial to shift away from coal as a fuel to reach net zero targets.

According to an analysis from 2021 by the International Energy Agency, the International Group of Seven[3] countries will need to phase out coal-related electricity by 2035 [43]. All five Western Balkan countries considered here must substantially change their power generation [21, 24, 44]. Therefore, switching to a clean energy supply becomes imperative to reaching net zero targets and achieving a low-carbon energy future. This goal requires significant investments, well-balanced and long-term strategies, and implementation of new technologies and policies, and it can only be achieved with bilateral, multilateral, and private sector funding and local dedication [45, 46].

The implications of the 2022 Russo-Ukrainian War on the decarbonization efforts across Europe

The 2022 Russo-Ukrainian War has impacted energy security globally, including in the Western Balkans. With the onset of the war, the EU imposed sanctions against Russia, which led to cutting Russian natural gas supplies to Poland, Bulgaria, Finland, Netherlands, and Denmark and reducing supplies to Germany and Italy [47, 48]. The 2022 Russo-Ukrainian War catalyzed the transition to net zero in several EU member states by accelerating different national programs to reduce dependency on imported Russian natural gas and oil, while in other member states, the use of coal increased [47–49].

Given its location and historical ties, the EU has long seen the Western Balkans as a critically strategic region. The EU's enlargement strategy is eventually admitting all Western Balkan countries to the EU while promoting stability and democratic ideals [50]. All countries from the Western Balkans have shown aspirations to join the EU [50]. Kosovo is a potential EU candidate, while the remaining four countries already have candidate status with different levels of progress in the accession negotiations [50]. Foreign political pressure, particularly from the EU, may push the Western Balkans countries to phase out coal [51]. North Macedonia and Montenegro have committed to phase out coal by 2027 and 2035, respectively [24]. Kosovo has abandoned plans to build new thermal power stations, while Bosnia and Herzegovina and Serbia have scaled down their ambitions to expand thermal power facilities [21, 24].

In 2020, the EU launched the Green Agenda for the Western Balkans, which aims to drive the region's economic recovery, adherence to EU standards, and climate neutrality by 2050 [51]. The EU has committed to funding the Green Agenda with US$9.5 billion in grants

[3] Consisting of seven major high-income countries: Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States.

Table 1 Search terms for the topic search on Web of Science Core Collections; the full search string is combined as follows: A AND B AND C

A. Setting terms (location)	
	(Bosnia* OR Herzegovin* OR BiH OR Bosn* OR Hercegovin* OR "Western Balkan*" OR Kosov* OR Serbia* OR Macedonia* OR Montenegr* OR "Crna Gora" OR "South East Europe")
B. Intervention terms (finance)	
	(financ* OR donor* OR aid OR funds OR fund OR funding* OR invest OR investment* OR loan* OR grant* OR reconstruct* OR "World bank" OR EBRD "European Bank for Reconstruction and Development" OR ODA OR "Official development assistance" OR "Global Environmental Facility" OR GEF OR "European Commission" OR "European Union" OR USAID OR "US Agency for International Development" OR EIB OR "European Investment Bank" OR IFC OR "International Finance Corporation" OR UN OR "United Nations" OR UNDP OR "United Nations Development Programme" OR UNEP OR "United Nations Environmental Programme" OR WBIF OR "Western Balkans Investment Framework" OR GCPF OR "Global Climate Partnership Fund" OR ICI OR "International Climate Initiative" OR GCF OR "Green Climate Fund" OR GGF OR "Green for Growth Fund" OR "Austrian Development Agency" OR "German Federal Ministry of Economic Cooperation and Development" OR "Czech Development Agency" OR "French Global Environment Facility" OR "Netherlands Development Finance Company" OR GIZ OR "German Technical Cooperation" OR "Japan International Cooperation Agency" OR "German Development Bank" OR "KfW Development Bank" OR "Swiss Development Cooperation" OR "Slovenia* Development Cooperation" OR Sida OR "Swedish International Development Cooperation Agency" OR "Turkish Cooperation and Coordination Agency" OR Norway OR OPEC OR "Fund for International Development" OR"EU Institutions" OR Luxembourg OR Italy OR France OR Finland)
C. Outcome terms (energy)	
	(climat* OR energ* OR "net zero" OR net-zero OR *carbon* OR coal OR *renewable* OR "green industry" OR (transition NEAR/3 energy) OR electric* OR mitigation OR geothermal OR "power plant*" OR biofuel* OR "natural gas" OR "fossil fuel*" OR oil-fired OR "oil fired" OR oil-powered OR "oil powered" OR "heat plant*" OR heating OR cooling OR "retail gas" OR (hydro NEAR/2 energy) OR (hybrid NEAR/2 energy) OR "green deal" OR "green agenda" OR "just transition*")

and US$21 billion in investments between 2024 and 2030 [52]. The 2022 Russo-Ukrainian War revealed the risks of energy dependence on Russia and stimulated the EU to initiate a more aggressive stance towards decarbonization. Although the 2022 Russo-Ukrainian War has not explicitly been cited as a justification for accelerating EU enlargement in the Western Balkans, it has strengthened the EU's commitment to assist stability and security through the enlargement process [53].

Methods

This study explores the development finance flows for the energy sector in the Western Balkans and its implications for the following energy transition questions:

1. *What research evidence exists on (the effectiveness of) energy sector-focused development finance flows in the five Western Balkan countries?*
2. *What are the development finance flows for energy sector-related projects across the five Western Balkan countries between 2008 and 2020? What is the disbursement ratio?*
3. *Did the volumes of development finance for decarbonizing the energy sector increase following adopting the Paris Agreement in 2016? Is there an increase in development finance flows for renewable energy projects from 2016 to 2020?*
4. *What financial instruments have been used to disburse energy sector-related development finance from 2008 to 2020?*
5. *Who are the most significant bilateral and multilateral energy sector-related development finance providers?*

To answer these five questions, we conducted a scoping literature review [54] of the research on international financial flows in the Western Balkan energy sector and examined 2008–2020 financial flow data from the same region reported by countries, multilateral funds, and development banks to the Organization for Economic Cooperation and Development (OECD) Development Assistance Committee (DAC). The scoping literature review gave a necessary understanding of the existing evidence base on development finance flows for Western Balkan countries. Subsequently, we addressed knowledge gaps by analyzing the received financial flows for a given period.

Scoping literature review

The scoping literature review was chosen as a method to rapidly determine the coverage and volume of literature on our research topic [54]. We searched the Web of Science Core Collection (WoSCC) via Stockholm University Library subscription to gather available empirical research on international finance flows related to any energy sector in the five Western Balkan countries. The topic search (including keywords, titles, and abstract) in WoSCC was conducted using English search terms. The search string included a combination of setting, finance, and energy terms (Table 1). The string was developed through iterative testing. Search comprehensiveness was checked using three benchmark papers. The string was adjusted until it captured all benchmark papers. Additional file 1: Annex S1 contains a benchmark list and details about search string development.

Search records were uploaded to Eppi-Reviewer Web, review management software used for the screening stage of the review process [55]. The screening was done in two phases: the title and abstract, and the full text (following full-text retrieval).

To ensure title and abstract screening repeatability and clarify eligibility criteria, a consistency check exercise was conducted before commencing screening on a subset of randomly selected titles and abstracts. The exercise included two screening rounds and was performed until screening decisions reached an agreement level of 80%. In each round, three reviewers screened the same subset of 106 titles and abstracts (10% of the total number of records) to ensure consistency of screening decisions. We compared screening decisions, discussed disagreements, and clarified eligibility criteria accordingly. After the consistency check exercise, two reviewers independently screened the rest of the titles and abstracts. Full text screening was conducted by a single reviewer and all decisions were cross-checked by a second reviewer to ensure consistency. We applied the following eligibility criteria to both screening stages:

- Eligible settings: Energy sectors (including renewable and non-renewable sources) of Bosnia and Herzegovina, Kosovo, North Macedonia, Montenegro, and Serbia.
- Eligible interventions: Any type of financing from bilateral or multilateral sources at the portfolio level. Individual project-level financing is not eligible. Fiscal policy and tax articles, private investments and improving investment options, state budget planning, drafting and adoption, public revenue and spending, remittances, aid conditionality, and public debt were excluded. Scenarios for investments and feasibility studies are excluded.
- Eligible outcomes: Any outcomes related to (a change in) the energy sector, including energy generation, energy efficiency, and similar.
- Eligible publication period: Studies published after 2008.
- Eligible languages: English.
- Eligible study types: Any type of empirical studies, reviews, and modeling studies.
- Theoretical or commentary papers, including conference proceedings, were excluded.

Studies judged as relevant in the full text were coded and narratively summarized after that. Coding was done by one reviewer and cross-checked by a second reviewer for consistency. Coding included information about study type, years of analysis, targeted countries, financial information (including funder, funding source and type, and financial data source), targeted energy sectors, and insights into potential or actual outcomes. Additional file 1: Annex S1 contains a list of excluded studies based on title and abstract and full text with reasons for exclusion, coding tree definitions, as well as the evidence base, i.e., a dataset of included relevant articles and their metadata.

Analysis of energy sector development finance flows

This second part of the analysis examines development finance for the energy sector in the Western Balkans region from 2008 to 2020, focusing on the periods before and after adopting the Paris Agreement in 2016. The analysis examined energy sector-related development finance data from Bosnia and Herzegovina, Kosovo, North Macedonia, Montenegro, and Serbia. Data from Albania were not included since coal does not play an essential role in the country's energy sector, as it depends entirely on hydropower [56]. We consider Kosovo within its geographical limits starting from 2008.

Although the OECD DAC Creditor Reporting System (CRS) [57] development finance for energy sector-related data is available from 2002, we chose 2008 as a starting year since Kosovo declared unilateral independence from Serbia that year, which led to the registration of development finance flows to support energy sector-related projects by the development finance providers that recognized Kosovo as separate from Serbia (e.g., the United States, Germany, Japan, Switzerland, and Norway). The OECD DAC CRS database did not provide data for the most recent years when this research was conducted (i.e., 2021, 2022, and 2023); hence, 2020 was chosen as the last analysis year.

Dataset

The data are extracted from the OECD DAC CRS database, which contains the most comprehensive compilation of development finance flows to low- and middle-income countries. Specifically, the CRS database includes detailed information on development finance reported by DAC members, multilateral providers, global funds, non-DAC providers, and private development finance providers. It incorporates Official Development Assistance (ODA), which encompasses concessional contributions (i.e., grants and low-interest loans) to promote the development, and other official flows (OOF) that support development finance provider exports, including grants for commercial objectives, money for private investment in low- and middle-income countries, and funding that does not fit the conditions of ODA. OOF are mixed instruments encompassing different types of official assistance and financial instruments provided by governments and official agencies of one country to another. The CRS database also covers private development finance and equity investments. Private development finance refers to financing provided by civil society organizations. Equity refers to investments made with the intention of a successful return and taking the form of an ownership share in a resource or activity.

Every transaction logged in the OECD DAC CRS database is labeled with sector (e.g., "Energy"), sub-sector (e.g., "Energy distribution"), and purpose codes (e.g., "District heating and cooling"). Because the CRS database does not discriminate between energy-related interventions and other transport sector operations, these are not included in the analysis.

All transactions coded within the energy sector (DAC sector codes 231 to 236) encompass the following sub-sectors included in the analysis:

1. "Energy policy" (energy policy);
2. "Energy generation, renewable sources" (renewable sources);
3. "Energy generation, non-renewable sources" (non-renewable sources);
4. "Hybrid energy plants" (hybrid plants);
5. "Nuclear energy plants" (nuclear plants); and
6. "Energy distribution" (energy distribution infrastructure).

Purpose codes provide a more detailed classification of the sub-sector level data into different activities within the respective sub-sector (see Table S1 in Additional file 2: Annex S2 for more details). Furthermore, while examining the dataset, the "Energy generation, non-renewable sources, unspecified" and "Energy generation, renewable sources—multiple technologies" purpose codes caused confusion due to their wording. While the language of most of the purpose codes was straightforward (e.g., "Wind energy"), the phrases "unspecified" and "multiple technologies" sounded broad and all-encompassing. We carefully examined data and listed all projects classified under two purpose codes to gain better insight into the structure of these codes. The purpose code "Energy generation, renewable sources—multiple technologies" refers to projects that cannot be attributed to one technology (e.g., combining wind and solar), while "Energy generation, non-renewable sources—multiple technologies" is a purpose code for thermal power-related projects utilizing multiple energy sources (e.g., combined natural gas–coal power plants).

The analysis focused on disbursed development finance since this is the funding five Western Balkan countries received instead of promised commitments. The commitments were used only to calculate the disbursement ratio (defined as the share of commitments that materialize into disbursements).

Since the analysis focused on examining the OECD DAC CRS dataset for energy sector-related development finance flows spanning thirteen years across five countries, the consistency of information needed to be constantly checked to avoid errors. The values in Figures S1, S2, and S3 in Additional file 2: Annex S2 were compared with those in Fig. 3. A consistent match was achieved for all five countries.

To simplify the data analysis, we clustered funders that provided below US$10 million for the five considered countries between 2008 and 2020 into one group titled "Cumulative amount for other providers (< US$10 million individually)." We also labeled development finance flows by the International Development Association (IDA), the International Bank for Reconstruction and Development (IBRD), and the International Finance Corporation (IFC) as the World Bank, as these entities are international organizations owned by the World Bank.

Besides the OECD DAC CRS dataset, we used data from multiple sources to contextualize analysis and understand socio-economic implications as follows:

1. data from the UN Data Portal on the average population sizes and Human Development Index (HDI) scores for five countries between 2008 and 2020 [58];
2. the World Bank data on average gross domestic product (GDP) per capita (current US$) between 2008 and 2020 [59]; and
3. the University of Oxford's Our World in Data on carbon intensity of electricity between 2008 and 2020 [60].

The information on population size and HDI scores was essential for performing calculations that helped the study gain better contextualization. HDI assesses a country's population's overall development and well-being. It is widely used as a comparative tool to scale progress in human development across different countries. Including HDI scores was essential to assess development progress beyond purely economic indicators comprehensively. While GDP focuses on material wealth, HDI is an index that measures the country's prosperity based on life expectancy, education, and gross national income.

Utilizing per capita analysis (of GDP and funding disbursement) enabled a nuanced understanding of how development finance influences individual prosperity within the broader context of human development.

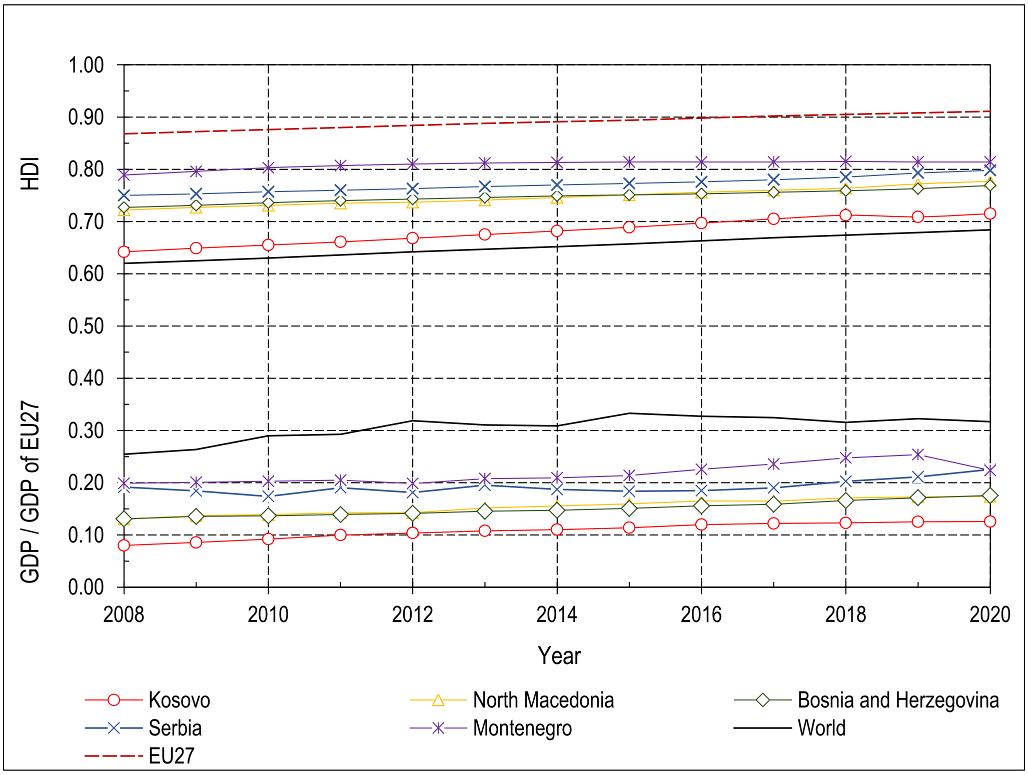

Fig. 1 Average values for relative Gross Domestic Product (lower lines) and Human Development Index (upper lines) [58, 59]

Despite the criticism of the World Bank GDP-related data, the organization's diligent data collection and stringent methodologies ensure precision and comparability across countries and periods [61–63]. We used GDP per capita (current US$) value instead of GDP based on Purchasing Power Parity (PPP) because it directly measures the domestic economic activity and individual purchasing power within a country without the potential distortions introduced by adjusting for price levels and exchange rates [64].

Results

Scoping literature review

The WoSCC search yielded 1058 results imported into EPPI-Reviewer Web and screened at title and abstract. During the title and abstract screening process, 1016 records were excluded. Records mainly were excluded for their subject area (i.e., they were not at all related to financing and energy sectors) (872; 85.8% of excluded records), a lack of finance information (107; 10.5%), a study location outside of Western Balkan region (26; 2.6%), their study type (8; 0.8%), or a lack of energy focus (3; 0.3%). Forty-two records were included for full-text screening (4% of all records), of which eight could not be retrieved. Out of 34 screened full texts, 30 studies were excluded. Specifically, 20 excluded studies analyzed the energy sector without clarifying international public funding flows, they did not provide portfolio-level financial information, or they analyzed potential and future financial needs. Five studies did not include relevant energy-related outcomes, four were off-topic, and one was a commentary paper without relevant empirical data.

The evidence base included only four relevant research articles. A ROSES flow diagram [65] with an overview of information throughout the scoping review process is in Additional file 3: Annex S3. Moreover, Additional file 1: Annex S1 includes an overview of all included studies with their metadata. One of the four included studies had a portfolio-level analysis of development finance flows but focused on a single country (i.e., Bosnia and Herzegovina) [66]. That study was published by the same lead author as this study. The other three studies had a broader geographical scope. Still, they focused on a specific multilateral funding source [67], the Clean Development Mechanism [68], or an overview of Chinese investment [69]. Overall, the scoping literature review results confirmed a knowledge gap or lack of research on (the effectiveness of) development finance in the energy sector of the Western Balkans.

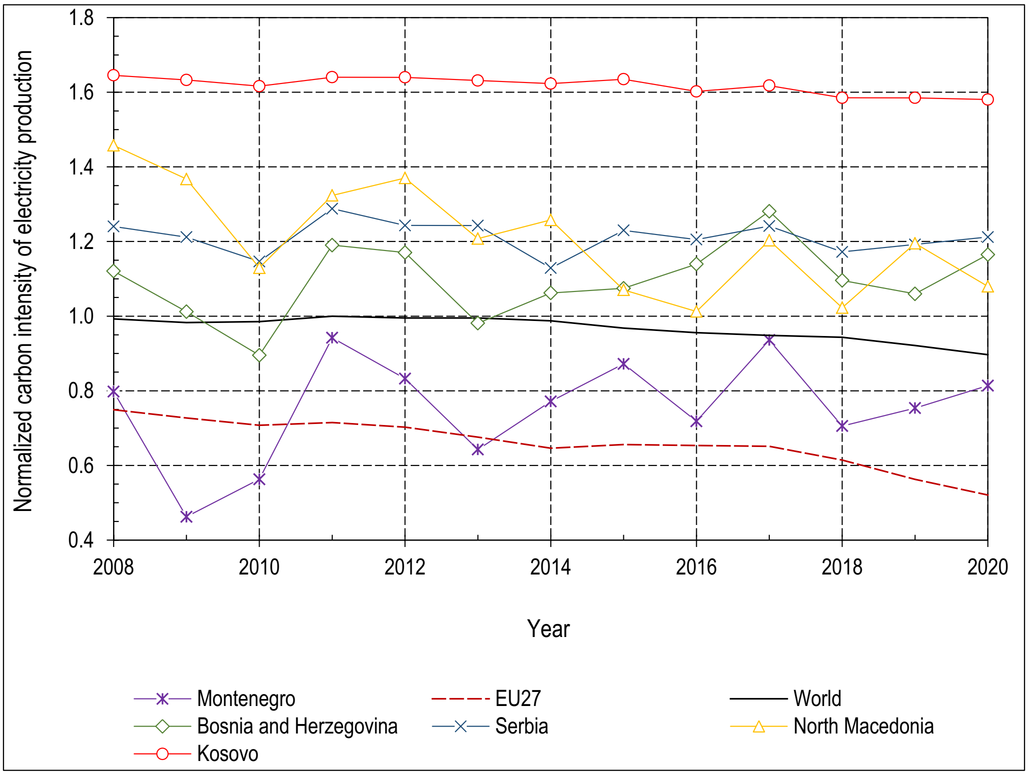

Fig. 2 Normalized annual carbon intensity of electricity in Western Balkan countries, the European Union, and the world [60]

The interplay of electricity's carbon intensity, Gross Domestic Product, and Human Development Index

All five Western Balkan countries rank lower on GDP (lower lines) [59] compared to the world and the EU (with 27 member states, i.e., the EU 27) averages (Fig. 1). Specifically, the Western Balkan countries' GDP was only up to 25% of most of the EU 27's GDP for the analyzed period. In the case of HDI (upper lines) [58] Western Balkan countries rank higher compared to the world average but lower compared to the EU 27 average (Fig. 1). The HDI values of all five countries are higher than the world average (ranging from about 0.6 to 0.8 from a maximum value of 1) but are below the EU's value (which was above 0.9 in 2020).

All five countries had, on average, a higher carbon intensity[4] than the world and the EU 27 averages between 2008 and 2020 (see Fig. 2) [60]. Kosovo had, on average, about a 60% higher intensity than the world average and 80% higher than the EU 27 average. In the same period, Serbia and North Macedonia emitted CO_2 emissions that were approximately 20% higher per generated kilowatt-hour (kWh) of electricity than the world average, 40% higher than the EU 27 average. Bosnia and Herzegovina's values were somewhat lower than those of Serbia and North Macedonia. Although the values for Montenegro oscillated between the EU 27 and world averages, the country's electricity generation carbon intensity increased during the analyzed time. More precisely, it had an average annual increase of approximately 1.3% from 2008 to 2021.

Commitments versus disbursements

Financial commitments for energy sector-related development finance amounted to US$4.7 billion for the five study countries between 2008 and 2020. For the same period, of a total of US$3.2 billion, US$1.6 billion was disbursed to Serbia (50%), US$680 million to Bosnia and Herzegovina (21%), and US$370 million to Montenegro (12%), which received the highest amounts of total funding per capita, followed by Kosovo (US$354 million or 11%) and North Macedonia (US$212 million or 6%).

The disbursement ratio for energy sector-related development finance between 2008 and 2020 varied between countries (Fig. 3). Kosovo had the highest disbursement ratio of 74%, followed by Bosnia and Herzegovina (73%), Montenegro (68%), Serbia (68%), and North Macedonia (64%). Comparatively, the disbursement ratio for all

[4] In this paper, carbon intensity is the amount of CO_2 (in grams) released to produce one unit (kWh) of electricity [60].

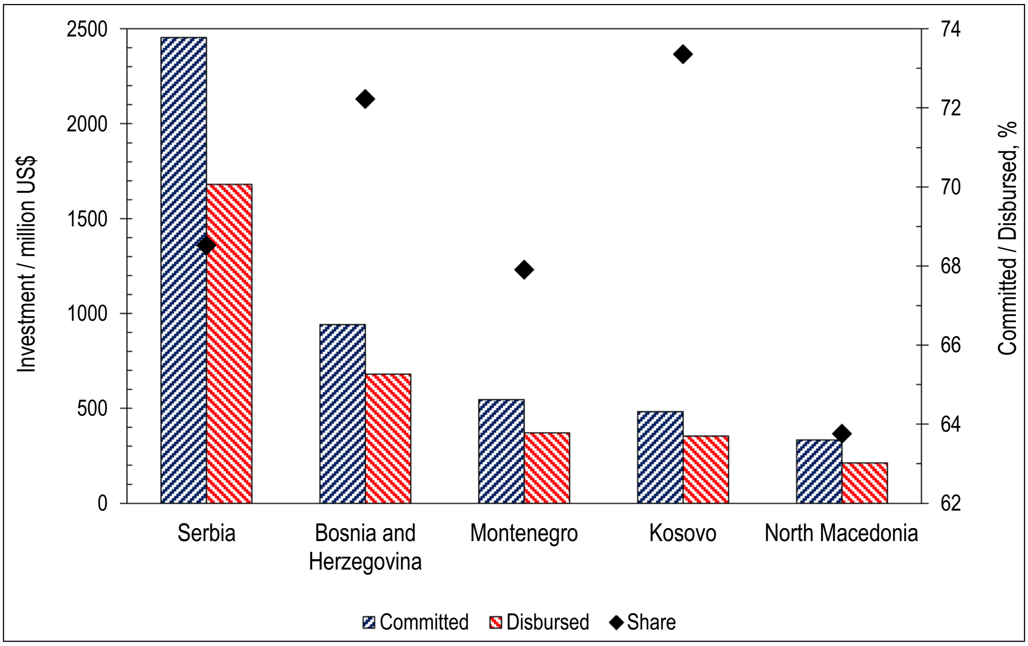

Fig. 3 Total energy sector development finance commitments versus disbursements in examined countries with corresponding relative shares (diamonds) between 2008 and 2020

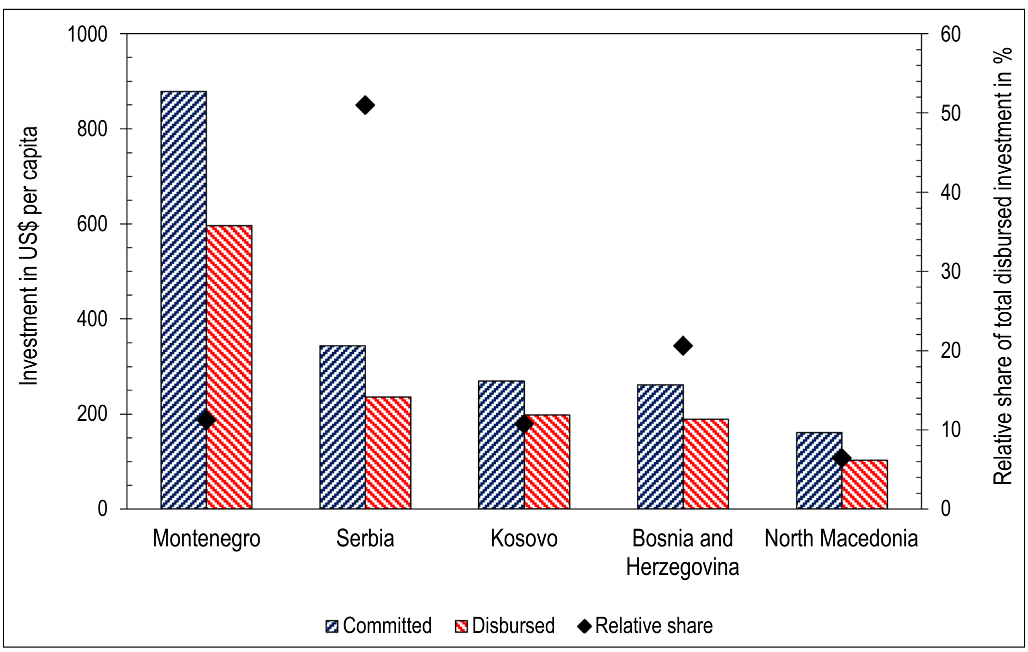

Fig. 4 Total committed versus disbursed energy sector development finance per capita with corresponding relative shares (diamonds) between 2008 and 2020

development finance worldwide over the same period was 63% [15].

However, the results are significantly different when observing the disbursed amounts per capita (Fig. 4) [58]. Montenegro received the highest funding per capita (US$596), and Bosnia and Herzegovina, Serbia, and Kosovo followed, with amounts ranging between US$189 and US$236 per capita. The lowest per capita disbursed

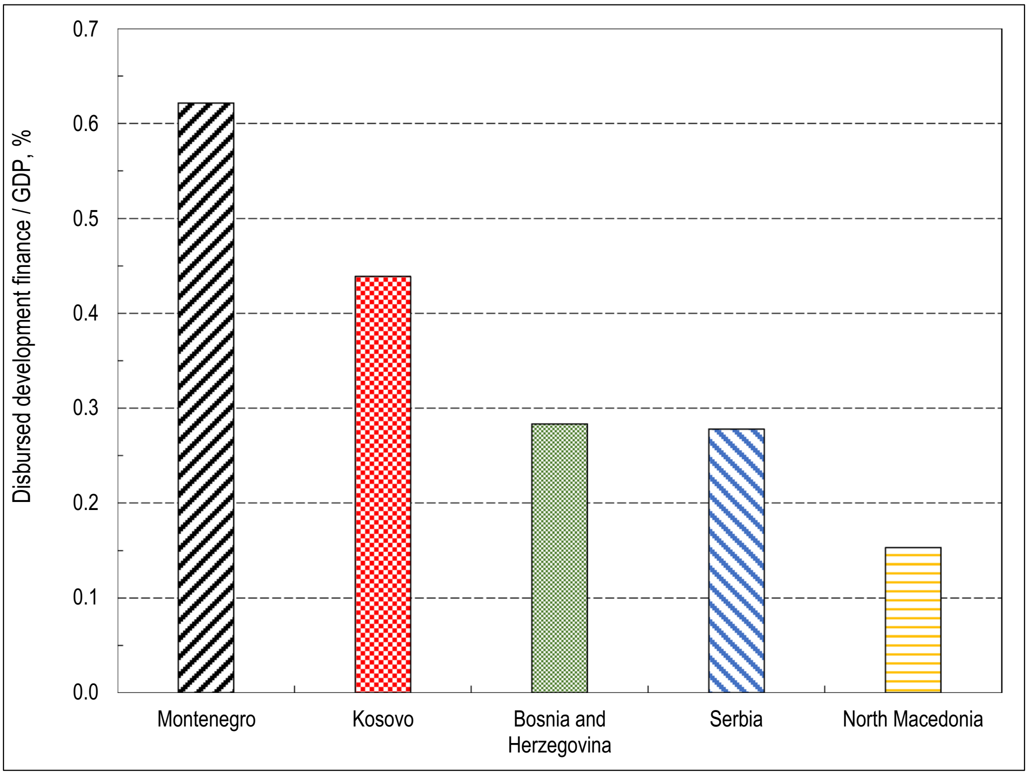

Fig. 5 Average values of disbursed energy development finance as a percentage of the gross domestic product between 2008 and 2020

funding was US$103 for North Macedonia. Nevertheless, diamond-shaped markings in Fig. 4 show that Serbia had the highest value (51%) of the total disbursed funding for all countries when observed in relative terms. Again, North Macedonia (6%) had the smallest share.

When the energy development finance received by the five countries between 2008 and 2020 is observed alongside the average GDP of each country during the examined time, the findings revealed a concerning trend (Fig. 5). Namely, the development finance received represented a minor fraction of each country's average GDP. Montenegro received the highest proportion at 0.62%, followed by Kosovo with 0.44%. Bosnia and Herzegovina and Serbia received 0.28% each. North Macedonia obtained the lowest proportion of 0.15%.

Funding distribution per sub-sector (total and per capita) and purpose code

Based on results obtained in Figure S1 in Additional file 2: Annex S2, three sub-sectors emerge as most relevant in all countries. Those are energy distribution infrastructure, non-renewable sources, and renewable sources.

In Bosnia and Herzegovina, disbursed amounts of energy-related development finance had peaks in 2009, 2012, and 2017, with different sub-sectors driving the peaks (i.e., energy distribution infrastructure, non-renewable sources, and renewable sources). The funding distribution dynamic differed in Kosovo, where energy distribution infrastructure funding peaked in 2015, while renewable sources peaked in 2017. Montenegro experienced stable growth in finance for energy distribution infrastructure between 2012 and 2016. The most significant funding peaks for energy sub-sector-related development finance in North Macedonia were in 2010, 2014, and 2019, all related to the distribution infrastructure sub-sector. In Serbia, the funding peak in 2010 for the energy distribution infrastructure sub-sector was followed by a sharp decline in energy sector-related development finance from 2011 to 2015. Serbia experienced funding peaks in 2016 for non-renewable and renewable sources and recorded a significant rise in 2018.

Altogether, the funding for renewable sources experienced an increase in Bosnia and Herzegovina, Kosovo, and Serbia after 2016, the year marking the international adoption of the Paris Agreement (Figure S1 in Additional file 2: Annex S2). This trend was not seen in Montenegro and North Macedonia. On the contrary, brief peaks for this sub-sector were followed by a continuous decline in funding. Additionally, substantial funding flows for non-renewable sources were most evident in Bosnia and Herzegovina and Serbia (Figure S1 in Additional file 2: Annex

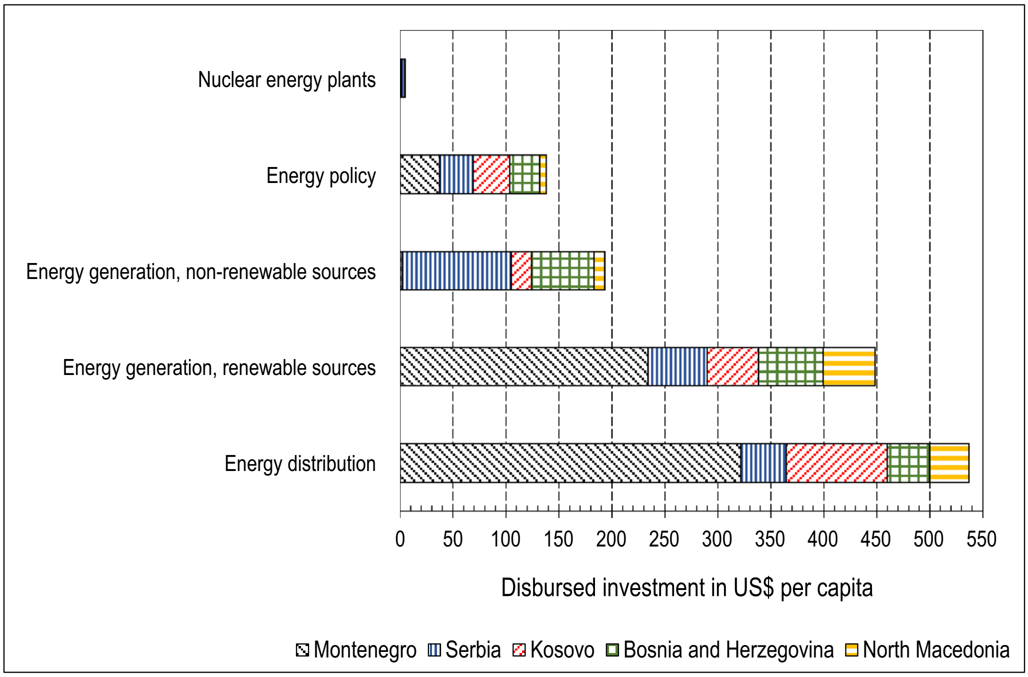

Fig. 6 Average disbursed energy development finance per sub-sector by five countries in per capita terms between 2008 and 2020

S2). Data available for Montenegro and Kosovo demonstrate that energy distribution infrastructure received continuous funding in these countries from 2012 to 2019.

The nuclear energy sub-sector received US$23 million in funding. Bosnia and Herzegovina and Serbia were the only countries that received funding for the nuclear energy sub-sector (see Fig. 6). The development finance for the nuclear energy sector in these two countries, which do not have nuclear power generation, is mainly related to other aspects of nuclear science and technology (e.g., radiation protection, environmental monitoring, radioactive waste management, and nuclear safety and security) [15, 57]. The hybrid plants sub-sector was the only energy-related sub-sector listed in the OECD DAC CRS database without development finance.

Montenegro had the highest funding per capita compared to other countries per sub-sector (see Fig. 6), with the energy distribution infrastructure sub-sector acquiring the highest share of funding. Serbia received the highest per capita amounts for non-renewable sources. Bosnia and Herzegovina received the second largest per capita amounts for non-renewable and renewable sources. Kosovo received the second largest per capita funding in the energy distribution infrastructure sub-sector. North Macedonia received the lowest funding per capita in all sub-sectors.

The analysis focused on examining financing for purpose codes within each sub-sector to gain a more granular understanding of the funding flows (see Figure S2 in Additional file 2: Annex S2). Five sub-sectors (i.e., energy policy, renewable sources, non-renewable sources, nuclear energy, and energy distribution infrastructure) comprise 16 different purpose codes (more information about sub-sector-specific purpose codes is available in Table S1 in Additional file 2: Annex S2). When purpose codes were analyzed, the following results were obtained. In Bosnia and Herzegovina, the three most funded purpose codes were transmission and distribution ("Electric power transmission and distribution (centralized grids)") with US$140 million, "Coal-fired electric power plants" with US$116, and renewable sources—multiple technologies ("Energy generation, renewable sources—multiple technologies") with US$102 million. In Kosovo, the transmission and distribution purpose code accounted for slightly below half of the total funding, specifically US$154 million of the total US$354 million. Like Kosovo, Montenegro's energy distribution infrastructure sub-sector and transmission and distribution purpose code received US$200 million of the country's total US$370 million. In North Macedonia, the renewable sources—multiple technologies purpose code obtained US$80 million. This purpose code was closely followed by the energy distribution sub-sector's transmission and distribution purpose code with US$76 million. The "Energy generation, non-renewable sources, unspecified" and renewable sources—multiple technologies purpose codes

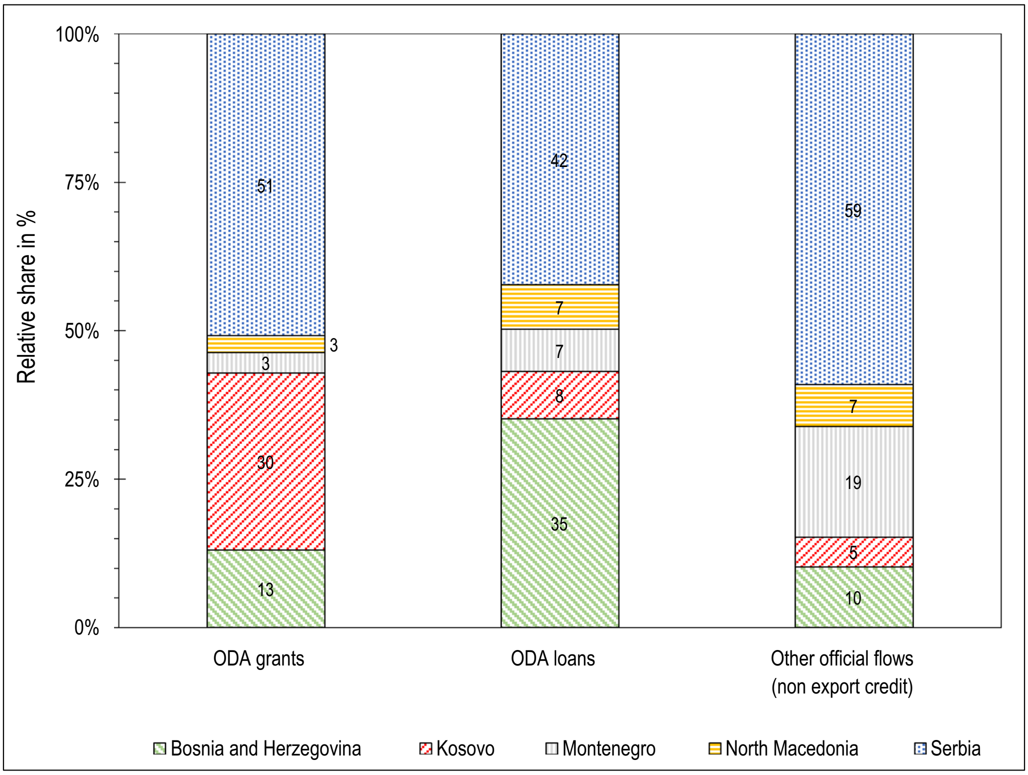

Fig. 7 Relative share of disbursed energy sector development finance per financial instrument per country between 2008 and 2020

received US$806 million in Serbia (equivalent to 50% of the country's total funding).

Financial instruments

From 2008 to 2020, multiple financial instruments were deployed in the Western Balkan countries (see Fig. 7). Specifically, US$1.3 billion was disbursed as OOF, US$1.2 billion in ODA loans, US$608 million in ODA grants, and US$18.4 million in equity investments (Figure S3 in Additional file 2: Annex S2, and Fig. 7). We found no private development finance in the data. The funding received by the study countries did not include any projects funded by this instrument.

In Bosnia and Herzegovina, ODA loans were the most significant financial instrument, with US$457 million, followed by OOF with US$140 million and ODA grants with US$79 million. ODA loans were a principal financing instrument for non-renewable and renewable sources sub-sectors, while OOF-led energy distribution financing. ODA grants comprised slightly less than half of the funding for energy distribution and the entire financing of nuclear energy. The US$3.6 million in equity investments was used as a funding source for renewables.

In Kosovo, ODA grants encompassed US$182 million, ODA loans US$103 million, and OOF US$70 million. ODA grants were the main funding instrument for the energy policy and non-renewable sources sub-sectors. Also, ODA grants comprised slightly less than half of the funding for renewable sources. ODA loans were the principal financial instrument in the energy distribution sub-sector.

For Montenegro, almost two-thirds of funding (US$255 million) was provided in OOF. In comparison, ODA loans comprised a quarter of funding (US$92 million), and ODA grants ranked third, covering the remaining amount (US$21 million). The OOF financial instrument was the primary funding source for renewable sources and energy distribution sub-sectors. ODA grants and ODA loans provided equivalent funding for the non-renewable sources sub-sector, whereas ODA grants and OOF equally funded the energy policy sub-sector. Around US$2 million was allocated as an equity investment for the renewable sources sub-sector.

The funding distribution per financial instrument in North Macedonia was unique because OOF and ODA loans obtained around US$97 million each. The funding amount for ODA grants was US$17 million. ODA grants entirely funded the energy policy sub-sector. Non-renewable sources and energy distribution sub-sectors were almost entirely funded through OOF. Besides negligible funding for equity investment and ODA grants, ODA loans almost entirely financed the renewable sources sub-sector. Approximately US$0.8 million of equity investment appeared while examining the data for the renewable sources sub-sector.

In Serbia, funding distribution per financial instrument consisted of US$811 million in OOF, US$549 million in ODA loans, US$309 in ODA grants, and US$12 million in equity investment. The OOF financial instrument was the most prevalent type of funding for energy policy, non-renewable sources, renewable sources, and energy distribution sub-sectors. ODA loans are the second largest funding source for non-renewable sources, renewable sources, and energy distribution sub-sectors. ODA grants comprised the total funding for the nuclear energy sub-sector and were the second most crucial funding instrument for the energy policy sub-sector. A small share of equity investments was present in the sub-sectors of non-renewable sources (US$3.1 million) and renewable sources (US$9.1 million).

Serbia acquired the highest percentage of all financial instruments. Serbia got the most significant funding for OOF, ODA loans, and ODA grants. However, Kosovo received the most ODA grants per capita, while Bosnia and Herzegovina received the biggest absolute ODA loans. It is essential to mention that equity investments represented a small amount (US$18.6 million), and this value was not included in Fig. 7.

Development finance providers (funders)

Between 2008 and 2020, bilateral and multilateral development finance providers disbursed US$3.2 billion in energy sector-related development finance in the examined Western Balkan countries. With funding of just above US$1 billion, the European Bank for Reconstruction and Development (EBRD) was the most significant provider of energy sector-related development aid. Germany was ranked second with US$902 million, followed by the EU institutions, excluding the European Investment Bank (EIB) contributions, with US$456 million. The World Bank (US$380 million) and Japan (US$236 million) were important energy sector-related development finance providers. According to the OECD DAC CRS classification, the EBRD and the World Bank are multilateral, and Germany, the EU institutions, and Japan are bilateral development finance providers.

In Bosnia and Herzegovina, Germany (US$197 million), the EBRD (US$120 million), Japan (US$118 million), the EU institutions (US$111 million), and the World Bank (US$75 million) provided almost all energy sector-related development finance. In Kosovo, the most significant providers were Germany (US$117 million), the EU institutions (US$94 million), and the EBRD (US$69 million), allocating more than two-thirds of all the funding. In Montenegro, the EBRD (US$221 million), Germany (US$89 million), and the World Bank (US$26 million) were the most important energy sector-related development finance providers.

North Macedonia was the only country in the studied sample that received less than US$100 million in individual development finance provider contributions, with Germany (US$98 million), the World Bank (US$51 million), and the EBRD (US$46 million) being the primary providers. In Serbia, the EBRD (US$599 million) and Germany (US$401 million) provided over half of the US$1.6 billion funding for the energy sector. The contributions from the EU institutions (US$238 million), the World Bank (US$211 million), and Japan (US$118 million) are also significant. Figure S4 in Additional file 2: Annex S2 includes a detailed overview of development finance providers and disbursement amounts.

About 33% of the disbursed development finance (see Fig. 3) in Bosnia and Herzegovina was invested in energy supply projects using non-renewable sources. The corresponding percentage was 44% for Serbia. Close to 94% of the funding to non-renewable sources in the analyzed dataset was given to these two countries. Regarding Bosnia and Herzegovina, Fig. 8 illustrates a breakdown of shares of renewable sources that received slightly more funding than non-renewable sources. The primary development finance provider for renewable sources was ultimately Germany. Regarding non-renewable sources, Japan and the EU institutions represented the leading providers. In Serbia (see Fig. 8), the distribution of development finance to non-renewable sources dominated over renewable sources, almost twice as high. The EBRD, Germany, and Japan were this sub-sector's most significant development finance providers. Germany and the EBRD disbursed the majority of funding in the renewable sources sub-sector.

Discussion

This research collated the existing research evidence base on Western Balkans development finance and analyzed the financial flows between 2008 and 2020. Our scoping literature review found only four relevant studies addressing financial flows in the Western Balkans [66] or all funding sources [67–69]. These findings indicate an urgent need to gain an in-depth understanding of the development finance flows in the region and justify our financial data analysis.

The analysis of development finance flows for the analyzed Western Balkan countries showed higher-than-average disbursement ratios when compared to other low- and middle-income countries that received energy sector-related development finance in the examined period [15]. This suggests the study countries might have a relatively efficient and better-organized system

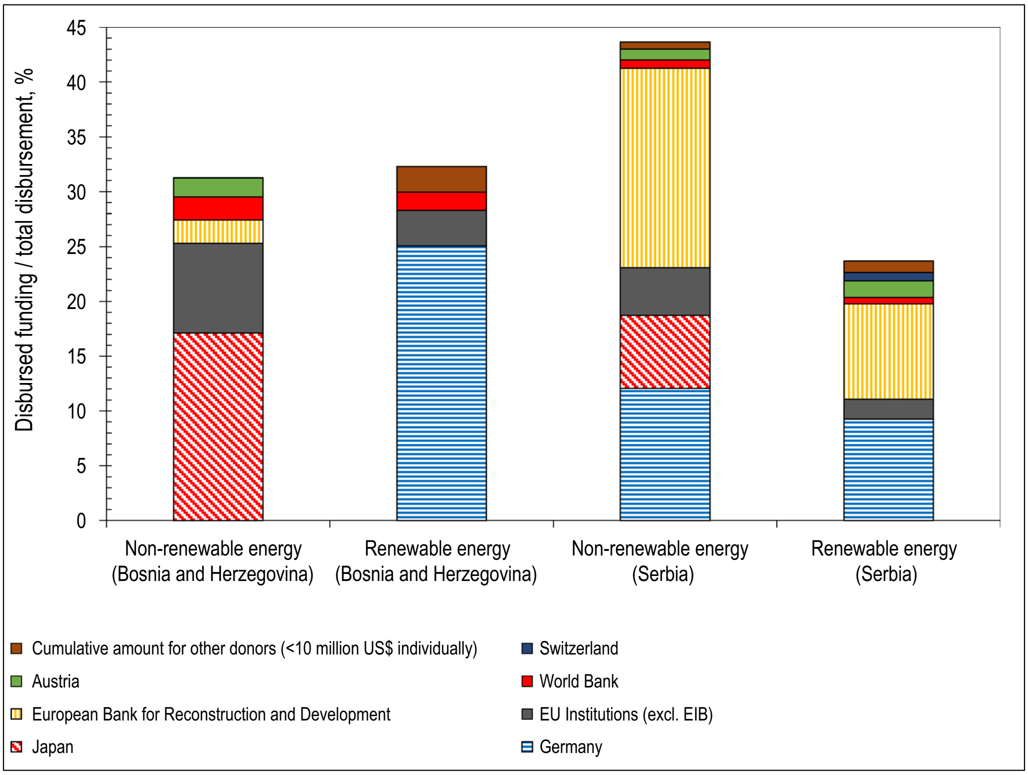

Fig. 8 Distribution of funding per provider for renewable and non-renewable sub-sectors in Bosnia and Herzegovina and Serbia between 2008 and 2020

for applying for and receiving development finance compared to other low- and middle-income countries from the OECD DAC CRS database, potentially indicating good partnerships with bilateral and multilateral development finance providers [70]. Furthermore, a higher-than-average disbursement ratio could further show the recipient countries' ability to satisfy bilateral and multilateral conditions, reporting, and accountability obligations associated with the funding [71].

The analysis indicates that energy development finance (including renewable and non-renewable sources funding) represents a small fraction (from 0.15 to 0.62%) of the average annual GDP of the Western Balkan countries in the examined period. Therefore, these funding amounts might not cover the necessary sustainable transition efforts in Western Balkan countries [72]. Specifically, four of the five countries stated that a much higher amount of funding than is currently disbursed is required to support a net zero transition of their energy systems between 2020 and 2030 in their energy strategies or NDC. Specifically, Bosnia and Herzegovina stated that it needs US$9.3 billion to finance a certain level of energy sector decarbonization from 2020 to 2030 [73], in contrast to the US$680 million (Fig. 3) disbursed from 2008 to 2020, which is almost 14 times less. Kosovo's energy sector planned for US$3.3 billion [74] to execute necessary energy transition changes between 2022 and 2031, but the country has received US$354 million in the examined period. From 2015 to 2030, the Montenegrin government estimated that US$4.4 billion is needed to significantly decarbonize the country's energy sector [75]. However, Montenegro received US$370 million from 2008 to 2020. The North Macedonian government stated that US$7.5 billion is required to cover energy transition costs until 2030 [76], but the country received US$212 million. Serbia received US$1.6 billion in the examined period, but the country's estimate for energy sector decarbonization until 2030 is US$22.7 billion [77]. If the situation with inadequate disbursements continues, it is evident that the five Western Balkan countries cannot depend on development finance alone to serve as a substantial and reliable source of funding for their decarbonization endeavors.

The analysis demonstrated that energy sector-related development finance disbursements were characterized by unsustained funding peaks, periodically followed by downturns (see Figure S1 in Additional file 2: Annex S2). Based on the data, the analysis could not clearly explain these trends. Nevertheless, in general, development finance oscillations can be influenced by various factors such as challenges of development finance delivery, the willingness of bilateral and multilateral providers to supply finance, economic difficulties, political upheavals, or changes in government leadership, which lower the amount of money available for development finance with a bilateral or multilateral provider [78]. The fluctuation in development finance flows can also be connected to the socio-economic and political realities in the recipient country. Weak governance and corruption (e.g., mismanagement of funds), lack of policy reforms and commitment (e.g., failure to implement agreed-upon reforms), and conflict and instability (e.g., ongoing armed conflict) can quickly decrease or block development finance [2]. Various administrative delays can also cause fluctuations in development finance disbursements. For example, specific projects can be negotiated and approved for funding in a particular year. Still, administrative processes and procedures (e.g., legal and contractual agreements, project planning, and procurement processes) with both the development finance provider and the receiving country can cause delays in the disbursement of funds [70, 79]. Situations like these can lead to a scenario where a project approved in a particular year receives funding several years later.

Our analysis cannot establish a clear link between adopting the Paris Agreement in 2016 and increasing development finance flows for renewable energy projects. For some countries in our sample, the results showed increased funding after 2016, but there was a decline for others. Furthermore, US$1 billion (or 31% of the total disbursed funding) was invested in projects for energy supply using non-renewable sources across all countries and periods, even after adopting the Paris Agreement. Bosnia and Herzegovina and Serbia were the two countries with the highest shares of such investments. Japan, Germany, and the EU institutions were the three most significant providers of these funding streams. Our data cannot show motivations behind such investments, but they could be due to funders' interests and/or recipient country's preferences and priorities [70, 80–82]. Although the percentages of investments in non-renewable energy sources were relatively high (33% for Bosnia and Herzegovina and 44% for Serbia), the total amount of development finance flows to Bosnia and Herzegovina and Serbia was below 0.3% of the two countries' average annual GDPs. Therefore, on a macroeconomic scale, funding for non-renewable energy sources was relatively insignificant.

Interestingly, most energy sector-related development finance flows went to projects that simultaneously employed several types of renewable energy. This pattern is most probably a reflection of a global trend to increase the use of renewable energy sources and diversify energy production to provide efficient and sustainable energy [83, 84].

In all five countries, 24% of all development finance disbursed for energy distribution infrastructure was concentrated in energy transmission and distribution infrastructure improvements (totaling US$798 million). These results might show the high demand for the modernization of centralized grid systems in the five countries and the potential need for effective transmission and distribution networks to guarantee a dependable and accessible electrical supply (and to satisfy the rising demands of the residential, commercial, and industrial sectors) [75, 76].

The overall dominance of the OOF financial instrument in the Western Balkans implies that bilateral development finance providers preferred financial instruments with export-enabling objectives [70, 71]. OOF consolidate the provider country's private sector (i.e., firms and industries) export capacities within the recipient country. This indicates that development finance may not simply focus on development but can also include business interests and commercial benefits as goals [80, 81, 85].

ODA loans ranked as the second most dominant financial instrument, with Serbia and Bosnia and Herzegovina having the highest shares of such flows. Bosnia and Herzegovina had the highest per capita ODA loan indebtedness. Incurring further debt through ODA loans can only hamper Western Balkan countries' future economic development.

The study countries' low share of equity investments signals high investment risks [16, 86]. Globally, low- and middle-income countries face the challenge of mobilizing the funds necessary to achieve net zero status in the energy sector [87–91]. To transition to net zero in the energy sector, some countries (e.g., Barbados, Costa Rica, and Rwanda) are expanding their funding sources towards private or blended[5] finance [92, 93]. Nevertheless, this kind of finance might sometimes come with the burden of the private sector's vested interests and should provide careful consideration [87–91].

Germany, the EBRD, and the EU institutions (excluding the EIB) were the most important providers of energy development finance to the study countries. This finding signals the determination of the EU and its member states to continue supporting Western Balkan countries in their aspirations to join the EU [94, 95].

Limitations

Limitations of this study originate from two sources: the literature review scope and the data reporting quality.

[5] The strategic combination of public, private, and philanthropic capital to mobilize additional investment for sustainable development projects.

Namely, the scoping review relied only on one search source (i.e., WoSCC), used only English-language search terms, and included only English-language literature. Nevertheless, this review was meant to provide a general indication of the amount of empirical evidence on the topic. Similar future reviews should expand search sources as well as include local languages.

The financial flow dataset had three reporting issues. First, the sector was not always correctly classified. For instance, specific donations for energy-related development finance may have been classified by providers as "General Environment Protection". If so, these transactions were not included in the study, as only transactions labeled "Energy" were part of the analysis. Second, the fact that the information is reported by organizations without recipients' verification can introduce bias or inaccuracies in the data. Finally, the database excludes several development finance providers outside the OECD, such as China. China became a significant player in the development financing sector in the last decade with its specific style and goals [96, 97]. Specifically, China has been investing in coal-associated infrastructure projects in Bosnia and Herzegovina, Montenegro, and Serbia, providing Bosnia and Herzegovina with US$1.2 billion and Serbia with US$578 million in loans between 2010 and 2020 for upgrading its thermal energy generation infrastructures [98, 99]. Neglecting China's finance for the Western Balkans' energy sector is a significant gap and limits our assessment of development finance flows and their effectiveness.

Additionally, this study did not investigate the development of a finance-related funding flow control system, the reporting responsibilities, or the accuracy of reports in the recipient countries. However, these interesting questions should be researched since they provide more insights into the effectiveness and accountability of development finance flows.

Conclusions

This study aimed to gain better insights into energy sector-related development finance flows by executing a scoping literature review and financial flow data analysis. The study came to the following conclusion.

There is a significant gap in scientific evidence about the effects and effectiveness of development finance in the Western Balkans. Also, the amount of the disbursed development finance was insufficient to cover the financial needs for the green transition of the analyzed Western Balkan countries. In addition, a substantial share of development finance disbursed to the study countries was in loans, increasing countries' indebtedness and distorting the principle of climate justice.

The study did not find evidence that signing the Paris Agreement in 2016 increased development finance funding flows for renewable energy infrastructure in the study countries. Lastly, the European Union and its member states were the most relevant development finance providers to study countries. This can be interpreted as a signal that the European Union considers Western Balkan countries potential future member states and is committed to supporting their development.

One of the main implications of this study is that development finance providers and recipient countries need to pay greater attention to planning for strategic funding disbursement. They should align their funding decisions with the long-term goals of decarbonizing the energy sector and achieving net zero emissions by 2050. They should also consider the social and economic impacts of the green energy transition, such as creating green jobs, reducing energy poverty, and improving public health. Furthermore, they should coordinate their efforts with other stakeholders, such as the private sector, civil society, and regional organizations, to ensure a coherent and effective approach to financing the energy transition. These efforts can maximize the benefits and minimize the risks of development finance for the energy sector in the examined Western Balkan countries. Also, the issues of energy sector-related development finance flow control, reporting responsibilities, and accuracy of reports in the five studied Western Balkan could be used to design future research delivering more insights into the effectiveness and accountability of development finance.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s13705-023-00426-z.

Additional file 1: Annex S1. It includes an overview of the scoping literature review process, including searching and screening outputs asfollows—Sheet 1: Search string. Sheet 2: Benchmark list. Sheet 3: Excluded searches based on the title and abstract. Sheet 4: List of unretrievable articles. Sheet 5: Excluded results based on title and abstract screening with reason. Sheet 6: Coding definitions used in the scoping review. Sheet 7: List of the final results.

Additional file 2: Annex S2. It includes table and figures generated from the OECD DAC CRS data—**Table S1.** Distribution of purpose codes per the sub-sector in examined countries. **Fig. S1.** Total disbursed energy sector development finance flows per country and sub-sector. **Fig. S2.** Total disbursed energy sector development finance per country and purpose code. **Fig. S3.** Total disbursed energy sector development finance per country and financial instrument. **Fig. S4.** Bilateral and multilateral disbursed energy sector development finance providers per country.

Additional file 3: Annex S3. It includes the ROSES Flow Diagram for Systematic Maps. Version 1.0.

Author contributions

AC conceptualized the study, developed the methodology, supported the literature review, and wrote and edited the manuscript. AP validated the data, developed all the figures in text and supplementary materials, contributed to the writing, and developed the methodology. BM designed and executed the literature review, developed the methodology, and contributed to the writing. NH collected that data and contributed to the development of the methodology. SS conducted a literature review.

Funding
AC and AP did not receive any funding for this work. This work was partially supported (i.e., the language editing services and open-access publication were paid for) by the Swedish Embassy in Bosnia and Herzegovina and the Swedish International Development Cooperation Agency (Sida) as a part of the Stockholm Environment Institute's BiH SuTra project [Sida Contribution No. 15273]. The funder had no role in the study design, data collection, data analysis, decision to publish, or manuscript preparation.

Availability of data and materials
All data from this analysis is publicly available from the OECD DAC CRS, World Bank, UN Population Division, and Our World in Data. See https://stats.oecd.org/Index.aspx?DataSetCode=crs1
https://data.worldbank.org/
https://population.un.org/dataportal/home/
https://ourworldindata.org/co2-emissions

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper. AC is affiliated with Morningstar Sustainalytics, a company providing analytical environmental, social, and governance (ESG) research, ratings, and data to institutional investors and companies. This study was done independently and was not funded by the AC's employer. The opinions and views reflected herein pertain to its author, do not represent the official position of Morningstar Sustainalytics and may deviate from it. The information and data contained herein are not proprietary of, and are in no way connected to, or derived from Morningstar Sustainalytics or any of its products/services. Morningstar Sustainalytics assumes no responsibility for the reliability, completeness or accuracy of any opinion provided herein and makes no representation or warranty with regards to any information contained herein. Neither Morningstar Sustainalytics nor its content providers are responsible for any damages or losses arising from any use of this information, as it solely reflects the opinions/views of its author only.

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Received: 20 September 2023 Accepted: 25 November 2023
Published online: 15 December 2023

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