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Economic Analysis of Measures for GHG Emission Reduction

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Abstract: The European Union, as a signatory to the Paris Agreement, has approached the action against greenhouse gas (GHG) emissions and climate change quite ambitiously, striving to achieve climate neutrality by 2050. Extension of the European Green Deal policy implementation to the Western Balkans can only increase the chances of the climate neutral agenda. Expectations from Montenegro in the coming period are transposable to other Western Balkans countries as they are urged to start implementing the Paris Agreement by establishing appropriate policies and measures. In this regard, this paper presents the analysis of the financial and economic analysis results of measures to reduce GHG emissions in Montenegro. With this respect, least cost analysis—cost effectiveness analysis and cost–benefit analysis were conducted. The analysis results indicated that due to the thermal power plant reconstruction, increased use of renewable energy sources and measures to increase energy efficiency, the largest reduction in GHG emissions in Montenegro in the next 10 years is expected in the energy sector.

Keywords: GHG emission; economic analysis; least cost analysis; cost-benefit analysis

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1. Introduction

One of the most important challenges currently facing the global international community is the combat against climate change. It is expected that all international actors will indeed gather around the goal of keeping global temperature rise well below 2 °C and continue efforts to maintain it at 1.5 °C, meaning that the emission trajectory would have to ensure that global temperature rise remains within safe limits. In the context of global greenhouse gas (GHG) emissions, the share of fossil carbon dioxide, CO_2, dominates, and it has been continuously increasing throughout the period 1990–2015, from 32.8 to 49.1 Gt of CO_2 equivalent per year, with a total increase in total GHG emissions of about 50%. The world's largest CO_2 emitters are China, the United States, India, the EU28, Russia, and Japan, which together accounted for 51% of the population in 2018, 65% of global gross domestic production, 80% of total global consumption of fossil fuels, and emitted 67.5% of total global fossil CO_2 [1]. In the future, more intensive and closer international cooperation will be needed, both in advanced and developing economies. Through a higher level of commitment, countries would be willing to establish explicit carbon prices and gradually reduce fossil fuel subsidies, encouraging a more robust economy, but also creating conditions for climate change improvement. Introducing taxes on carbon or trade systems restraint creates an environment for consumption choice, targeting low-carbon activities, increasing investment in more environmentally friendly technologies.

In terms of reducing GHG emissions, the European Union (EU), which is a signatory to the Paris Agreement, has set ambitious goals, which it seeks to achieve climate neutrality by 2050 [2]. In order to get closer to the EU's goal of producing net zero CO_2 equivalent emissions by 2050, the current target is a 40% reduction by 2030, with a commitment from the European Commission (EC) to explore opportunities to increase to at least 50% by 2030, and whether with additional engagements the figure of 55% can be approached. Given that the implementation of climate change mitigation policies is a global challenge and requires the cooperation of all international partners, launching its flagship economic policy European Green Deal, 2019 [3], the EU will seek to reverse the transition to climate neutrality in favor of modernizing European industry.

Theorists and empiricists in economics are increasingly analyzing the interrelationships between economic growth and global warming. According to the European Environment Agency (EEA), the share of the transport sector was 27% of total GHG emissions in the EU-28 [4] caused by global warming and climate change. It is worrying that despite significant reductions in emissions of air pollutants [5], even the countries that are the seven top carbon emitter economies have failed to significantly reduce carbon emissions [6] because the transport sector (especially road) is dominant and still dependent on fossil fuels. The situation is not better with countries outside Europe either. The transport sector in China has joined the power generation, as well as the steel and iron, industries as one of the major CO_2 emission sectors [7]. Transportation contributed to around 13% of India's energy-related CO_2 emissions in 2010, and the dominance of fossil fuels now, and in the future, will pose unique sustainability challenges besides climate change—for GHG emissions, energy security, and air pollution [8]. The transportation sector is one of the largest contributors to air emissions in the USA, both in terms of GHG and air pollutants, and it represents 26% of the total GHG emissions [9].

However, in order to limit the global temperature rise, CO_2 and GHG emissions have been the focus of numerous transport studies. Road transport is the largest fuel consumer in the transport sector, while the share of fuel consumption in air transport is growing rapidly. Recent economic and current health crisis consequences and the expansion of global environmental concerns also have a major impact on changes in the air transport system [10]. However, some papers have proven that diesel cars and air transport have the largest contribution in the total cost of GHG emissions (about 98%) [11]. On the other hand, a positive experience is the example of the Netherlands, who managed to take first place on the list of European countries with the lowest average CO_2 emissions of new cars [12]. Also, Norway and Sweden, which are known for extremely high taxes on cars and their constant innovation in their calculation, had similar experiences with CO_2 reduction [13,14]. France, Austria, and Belgium have introduced the so-called bonus-malus system, which uses CO_2 emissions as a reference value for granting bonuses to cleaner vehicles, or additional penalties to cars that emit larger amounts of CO_2 [15], while Sweden fosters linear system of annual taxes on CO_2 emissions [16]. In parallel, some studies, as a result, have offered methodologies for predicting the cost of GHG emissions in road and air transport [17].

According to the EU's Six Environment Action Program (2002–2012) [18], waste reduction has been suggested as an urgent priority, with an emphasis on sanitary landfills and waste recovery. Waste management measures are being developed in countries with a pronounced rural population in order to reduce the impact on the environment [19]. The importance of sustainable waste management at the municipal level is emphasized by the impact of the latest pandemic [20]. Some of the latest research has concluded that reducing costs and increasing the efficiency of leading waste treatment policies, reducing waste generation, and focusing on changing agents' behavior and companies' decisions at the level of waste production [21] are crucial factors. At the same time, one recent study suggested that GHG emissions can be mitigated reducing waste by the way it is generated [22,23]. A recent study in China has shown that under different municipal solid waste (MSW) management strategies, it is possible to achieve 70.82% emission reductions [24]. In order to affirm sustainable development, it is obvious that the extractive industry must adapt its business to changing demand patterns for oil, natural gas, and coal [25]. Progress is expected along low-carbon pathways in energy, transportation, and construction to combat climate change. It is certain that the share of fossil energy should be reduced in favor of renewable energy sources (RES) in all EU countries [26]. In this regard, the 2030 EU energy strategy set out three key objectives for 2030: to reduce GHG emissions by at least 40% (compared to 1990), to provide at least 27% of final energy from RES, and to achieve a 27% increase in energy efficiency. However, although a long-term increase in the use of environmentally friendly RES is suggested [27], it is to be expected that fossil fuels (especially natural gas as a substitute for coal) will be used for decades. In this regard, the extractive industries are at the center of the climate change challenge. These technologies must support national and international efforts to combat GHG emissions and climate change issues. According to some forecasts, RES could by 2022 provide 30% of total electricity production [28]. On the other hand, subsidies for fossil fuels are significantly higher than subsidies for RES [29]. In the electricity production of China and India, coal still accounts for more than 50% of total production [30] and the construction of about 2400 new coal-fired power plants is planned by 2030 [29]. However, China has reduced its own coal production and limited its exports and is increasingly oriented towards RES, i.e., it is responsible for around half of the global take up of solar PV [31]. Carbon pricing is shifting incentives in electricity production towards natural gas (which is a smaller emitter than coal) and RES. However, according to some considerations, although the EU's emissions trading scheme (ETS) was the first and most comprehensive in the world, the price for its carbon credits is now too low, so natural gas has not replaced coal to the extent expected [32]. However, the results of certain research, according to which energy technology innovation leads to the transition to a lower-carbon economy, stimulate the development of energy users' markets [33].

Aldieri et al. gave a valuable econometric analysis of the climate change impact on firms' productivity considering a sector-based panel dataset for the USA, Japan, and a certain number of European countries over the time span 2002–2014 [34]. Bai et al. showed that at the scale of Kentucky (USA), climate change has a greater impact than land use on water retention, while land-use change has a greater impact on soil retention, nitrogen export, and phosphorus export [35].

Recent research has suggested that stock markets could enhance their role in achieving greener growth, stimulating innovation leading to cleaner manufacturing processes within industries and improve environmental performance with greater lending to forms that are part of the low-carbon economy. On the other hand, acts according to the sustainable economic growth and climate principles should contribute to a greening of bank lending [36]. Economic complexity can be used as an explanatory variable when examining the environmental Kuznets curve. In this regard, one study found that the level of economic complexity, which is related to income inequality [37], is one of the indicators of reducing the level of carbon emissions [38].

The application of cost–benefit analysis (CBA), as an extension of conventional financial analysis, has found its place in externalities that are not easy to calculate, such as environmental quality and human health. However, some studies have addressed the issue of excessive uncertainty regarding climate change, on the one hand, and the application of CBA on the other, where in case of infinitely large uncertainties on the GHG emission reduction side, the use of other techniques is recommended and climate policy analyses need to be interpreted very carefully [39]. Regarding the specific use of CBA, some research has indicated certain uncertainties in the application of this analysis in projects in the transport sector. Among other things, issues are related to the problem of defining unit value of CO_2 emissions as well as the estimation of the physical CO_2 quantities [40]. Also, one of the studies based on cost-effectiveness (CE) and co-benefit analysis developed an alternative scenario of measures to reduce emissions, in which the optimization (minimization) of costs together affects both air quality and GHG emissions [41]. Additionally, a combined CBA on local air pollution, global climate change, and energy security pointed to the importance of integrating these policies that should simultaneously address these three related issues [42]. Some research has observed that certain long-term climate change strategies affect air quality improvement [43].

CBA in relevant research in the field of climate change has come to the fore, to examine the relationship between social costs and social benefits from potential projects in different sectors, which reduce GHG emissions. Some studies, based on CBA, have focused on evaluation of global mortality as a consequence of climate change. Thus, in a study conducted for over 40 countries using future climate simulations, the median willingness-to-pay of USD 20 (in the case of a moderate CO_2 scenario) to USD 39 (in the case of a high CO_2 scenario) was calculated to avoid excess risk of mortality caused by a 1-ton increase in CO_2 [44]. The same study showed that an additional 35 °C day (−5 °C day), relative to a day at 20 °C, increases the annual all-age mortality rate by 0.4 (0.3) deaths per 100,000. Moreover, there is a significant heterogeneity in the ratio of mortality and temperature depending on the country's degree of economic development. Some previous research has tried to determine the exact figure of the social cost of carbon, noting that overstated prices could have negative implications for energy policy and for policies on afforestation [45]. Some research has looked at the health implications of policies aimed at combating climate change, proving that measures to reduce GHG emissions often (though not always) imply significant net health benefits [46]. Thus, for example, considering the costs and benefits of walking and cycling programs, one of the studies showed that such programs simultaneously provide the net health benefits and reductions in transport-related carbon emissions. Using a discount rate of 3.5%, the estimated B/C ratio was 11:1 [47]. Furthermore, a systematic review of available studies indicated significant economic savings in health terms from healthy transport interventions, and that in cycling networks, we have a median B/C ratio of 5:1 from infrastructure investments when health benefits are included in the total benefits [48]. However, back in 2011, the WHO pointed out that existing CBA methods often unjustifiably ignore the critical indirect effects of transport projects to health [49]. To limit the temperature rise to 2 °C, the International Energy Agency estimates that about 21% of emission reductions should be provided by transport, and various vehicle trilogies are emerging, whose justification for use is being assessed by applying CBA [50].

Furthermore, the results of research based on the CBA application and assessment of the co-benefits of a sustainable energy policy showed that YOLL (years of life lost) totaling 0.11–0.21 years (41–78 days) per capita or premature deaths totaling 126,507–251,169 will be avoided during 2010–2030 under the RE (renewable energy) plus EEI (energy efficiency improvements) scenario. Due to higher investment B/C ratio ranges from 1.9–2.1 under the EEI scenario, while for the RE scenario it ranges from 7.2–7.9, which suggests that the RE scenario is socially beneficial. Determined net benefit under the RE scenario during the same period was estimated at approximately USD 5972–6893 per person or USD 170–190 per MWh, suggesting that the CBA results show that external benefits involving saved social costs (reduction of CO_2 emissions, averted morbidity, and averted mortality) significantly exceed the compliance or investment costs for the RE and EEI [51]. In terms of RE technologies, CBA was used in research to assess the suitability of biofuels policies at the national level. The results confirmed the positive impact of this policy on the quality of the environment, mainly due to the GHG emission reduction [52]. Research conducted for the Greek power generation sector, supported by CBA and multicriteria decision analysis, has confirmed that the highest penetration of RES is the best scenario that has been proven to ensure the best balance between economic, technical, and environmental considerations and the sustainable development power generation sector [53]. Until recently, economic research related to solid waste management analysis ignored the global warming potential (GWP) impacts. However, research that integrates GHG emissions with CBA, as a useful tool for making decisions about on waste to energy (WtE) technology is the best for a particular situation [54]. Other research has indicated the need for the use of electricity and heat from combined heat and power plants from WtE to achieve the full potential of WtE [55].

The CBA conducted in our paper aimed to assess the justification for the implementation of a set of measures to reduce GHG emissions in Montenegro. The analysis was based only on the envisaged measures climate effects, while other effects have not been considered. Thus, final conclusion on the justification, i.e., the rank of individual measures, should be observed only through the prism of effects on climate change, which was the primary goal of our paper. We emphasize that this type of research has never been done in Montenegro, and its importance is unquestionable in terms of filling theoretical and empirical gaps. We believe that the results of this research can have useful implications in the process of defining and differentiating policies and prioritization of measures for reducing GHG emissions in Montenegro.

2. The Status of GHG Emissions in Montenegro

In October 2006, Montenegro became a party included in the UN Framework Convention on Climate Change. The country joined to the Kyoto Protocol on 27 June 2007 as a non-Annex I party and later ratified the Paris Agreement on 20 December 2017. Under the Paris Agreement, Montenegro committed itself to reducing GHG emissions by 30% by 2030 compared to the 1990s, in accordance with the Montenegro Background Report for preparation of updated National Determined Contribution (NDC 2020) [56].

In addition, the Law on Protection against Negative Impacts of Climate Change was adopted in December 2019. The law sets the basis for the establishment of the National System for Monitoring, Reporting, and Verification of GHGs. The law stipulates obligation for development a low-carbon development strategy with an accompanying action plan(s), a definition and elaboration of a measures and projections required for successful functioning of entire implementation of the monitoring mechanism. An update of the greenhouse gas (GHG) emissions inventory for the 2016–2017 period was prepared, applying the new 2006 Intergovernmental Panel on Climate Change (IPPC) methodology, with significantly improved data in the waste and forestry sectors within the 3rd National Communication on Climate Change under auspices of the United Nations Framework Convention on Climate Change (UNFCCC). In October 2019, Montenegro began work on its third Biennial Update Report on Climate Change.

The EU welcomed the initiative of Montenegro in 2020 to introduce legislation to limit the emission of greenhouse gases (GHG), as well as an emission trading scheme for large industrial emitters. According to the Montenegro Background Report for preparation of updated NDC in 2020, total national GHG emissions in 1990 amounted to 5289 kt CO_2 eq., which decreased to 1956 kt CO_2 eq. in 1995 due to the temporary closure of the thermal power plant in Pljevlja and the economic recession after the dissolution of Yugoslavia. In 2018, total national GHG emissions amounted to 3767 kt CO_2 eq., which is 30% below the 1990 emission level [56]. Detailed data on total GHG emissions in Montenegro for the period 1990–2018 are shown in Figure 1.

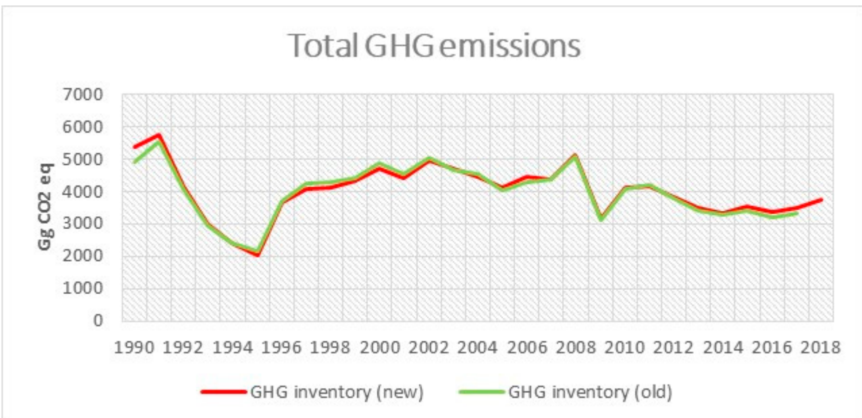

Figure 1. Total greenhouse gas (GHG) emissions in Montenegro for period 1990–2018.

After the global financial crisis, GHG emissions showed a steady and increasing trend, particularly in the energy and industry sector. According to these data, it is clear that sectors of energy and industry are key to achieve the needed GHG reductions in Montenegro.

Regarding the energy sector, estimates of energy consumption lie between 33 PJ and 36 PJ, while there are forecasts of an increase up to 40 PJ in the five-year period [56]. The transport and residential sectors consume almost 70% of the total final energy. Even though coal occupies the most dominant place in the primary energy balance structure, renewable energy is expected to play the most important role in the further development of the energy mix in Montenegro, as there are plans for expansion of wind and solar energy use.

Emissions in the transport sector accounted for 21.9% emissions of the total national emissions in 2018 [56]. Due to increasing overall mobility trends, the transport emissions have more than doubled in the last three-decade period. Electric vehicles functioning with conventional internal combustion vehicles (with a reduced number of diesel cars) are among solutions to address the issue, with a precondition of a set of elements for electric mobility. Transport sector goals to be achieved are to cause less impact on the environment—GHG emissions and local pollutants, as well as higher employment—and the creation of new (green) jobs.

According to NDC [56], the industrial processes and product use (IPPU) sector accounted for 10% of Montenegro's total gas emission in 2018, with the metal industry contributing the most compared to other industries. New technology in the aluminum industry's newly installed plants is characterized by limited emissions, with new investments in this industry having reduced GHG emissions. Also, the disruption of obsolete lines has led to a PFC emission reduction, and further technological improvements are being considered.

Further gas emission reductions can be expected through accurate treatment and disposal of solid waste and waste water treatment. The waste sector contributes the least to gas emission of all sectors in Montenegro. In the last 30 years, waste sector emissions have increased by 39%, while the amount of waste deposited increased only by 16% [56]. In order to reduce waste gas emission, additional efforts are expected to contribute to separate collection of waste, including avoiding the landfilling of waste fractions and the installation of landfill gas recovery systems. The Law on Waste Management is a key legal instrument in the waste sector, as a five-year national waste management plan. The measures applied are aimed at achieving certain target values from the EU negotiation Chapter 27 on the share of biodegradable municipal waste. However, some measures related to wastewater reduction management have little impact on total GHG emissions.

In the future, Montenegro will continue to strive for the establishment of a complete system required to reduce GHG, protect the ozone layer, and adapt to climate change.

In order to apply the model of sustainable economic growth in the Western Balkans, it is necessary to balance economic, social, and environmental aspects of economic growth, by implementing more effective policies and development strategies [57] and cooperation at the international level that includes great responsibility of public institutions for innovation. Significant benefits are expected from financial market regulation favoring low carbon portfolios [58].

Extending the implementation of the European Green Deal policy to the Western Balkans and directing the region towards the goals of climate neutrality in 2030 and 2050, with the EU support, can lead to an acceleration of the region's transition. As part of the presentation of the Economic and Investment Plan for the Western Balkans (2020) worth EUR 9 billion, adopted by the European Commission, in parallel, the presentation and guidelines for the implementation of the Green Agenda for the Western Balkans entail actions grouped around five pillars: (I) climate action, including decarbonization, energy and mobility; (II) the circular economy, in particular dealing with waste, recycling, sustainable production and resource efficiency; (III) biodiversity, with the aim of protecting and restoring the natural wealth of the region; (IV) combating air, water and soil pollution; and (V) sustainable food systems and rural areas [59].

The Green Agenda, as a paved path that will be jointly adopted by both the EU and the Western Balkans, can only increase the chances of success of the climate-neutral agenda, and identify more economically viable scenarios for rapid reduction of GHG emissions in short period of time. It is of utmost importance that neighboring countries also take effective action for the ecological transition, only in that way will the Green Deal for Europe be fully effective.

The first concrete steps that will follow the signing the Sofia Declaration on a Green Agenda for the Western Balkans on November, 2020 by the Western Balkan Six leaders, will be to stimulate the carbon tax and develop market models for the use of renewable energy sources, as well as the phasing out of coal subsidies [60]. Alignment with the EU Emissions Trading Scheme (EU ETS) will continue and also, in order to steer up promotion of a decarbonization in the Western Balkans region, climate plans with clear measures to reduce GHG emissions are expected to be set up.

Taking into consideration expected membership of Montenegro in the EU in 2025, fulfilling the goals that match with ones proclaimed by the EU Member States towards a low carbon economy will be necessary. Namely, Montenegro, which has not yet become an EU member has to align with EU legislation and strategies in the negotiations Chapter 27—Environment and Climate Change.

Cooperation with the European Environment Agency (EEA), which began more than 20 years ago, is important for the Western Balkans region and all countries have also become an integral part of the European Environment Information and Observation Network (Eionet). From a broader context view, 39 EIONET countries face a common set of environmental challenges, generated from altered/distorted patterns of consumption and production. Through this mechanism, the Western Balkan countries have the opportunity to share environmental information with wider Europe, with the aim of achieving improvement in our common environment.

The Western Balkans region produced almost 100 Mt of CO_2 emissions from combustion and fossil fuel processes in 2018 [61], which is almost 3% of EU CO_2 emissions in that year (3457 Mt CO_2). This total amount is close to that of 1990, although major changes took place during those years, and energy demand varied due to political changes in the countries of the region. Emissions of CO_2 in the region during 2018 were 8.7% below 1990 levels.

Montenegro and Serbia produced almost 60% of CO_2 emissions in the Western Balkans region in 2018. This contribution is slightly below the contributions of these two countries in 1990. In the same period, the contribution of Bosnia and Herzegovina increased from almost 23% in 1990, to almost 28% in 2018, while Albania with 4.8% and North Macedonia with 8.1% in 2018 reduced contributions compared to their 1990 contributions [61].

What is expected from Montenegro in the coming period, and can be transposed to other Western Balkan countries, is the urgent need to start implementing the Paris Agreement by establishing policies and measures, updating and adapting to climate change, implementing a low-emission development strategy, and starting development of integrated national energy and climate plan.

3. Materials and Methods

In the following part of this paper, the analysis results will be presented, i.e., the assessment of the financial and economic impact of measures to reduce GHG emissions in Montenegro. This analysis was one of the results of expert work on the document Montenegro Background Report for the preparation of updated NDC in 2020 (The updated NDC to be submitted to the Secretariat of United Nations Framework Convention on Climate Change under the Paris Agreement is a rather short document presenting the political commitment to reduce GHG emissions by a certain amount, together with information on national circumstances, the planning process, assumptions, and methodological approaches. The NDC target is based on already existing domestic measures, which have a realistic chance of being implemented and deliver on the expected impacts).

3.1. Methodology and Data

Analysis of the financial and economic impact of measures assessment to reduce GHG emissions in Montenegro was conducted in accordance with the general principles of the reference European methodology ("Guide to Cost-Benefit Analysis of Investment Projects", European Commission, 2014–2020), using different study documentation, as well as previous authors' experiences in similar analyzes in different sectors.

In the first part, we performed the analysis and an estimate of the measures' implementation costs to reduce GHG emissions in Montenegro was made. For this purpose, various relevant sources (laws, strategies, reports, action plans, contracts) were used, as well as relevant national statistics, relevant market data, data obtained directly from the parties involved in individual projects, as well as on the basis of expert author's assessment.

In second part of the analysis, we performed least cost analysis (LCA), a simpler form of economic analysis, which assesses the proposed measures' cost-effectiveness by determining the calculation of required investments for reduction of one ton of GHG emissions in Montenegro, for each of the proposed measures. In this regard, LCA—cost-effectiveness analysis implies costs determination of individual GHG emission reduction measures' implementation (presented in the previous part of this document), as well as the nominal emission reduction projection, estimated in tons, for each measure separately. Based on these values, the cost-effectiveness of investments was calculated, i.e., it is determined the relationship between investments in the individual measures' implementation and emission reduction amount, which was the result of these measures implementation.

Since the LCAs in this measure's structure could not provide a complete answer to their individual acceptability, in the third part of the analysis, we opted for cost–benefit analysis which allowed us to quantify the projected GHG emission reductions, put them in relation to the estimated costs of measures implementation, and discount at the beginning of realization.

In general, the main advantage of CBA is that it is easy to understand, as well as the wide possibility of application for various projects, locations, and scales [62]. It is aimed at making decisions on the allocation of scarce resources, when there are more requests for resources and when each use of resources implies opportunity costs, because the same resources cannot be used for other purposes. Although inefficient resource allocation goals may be more policy-relevant in some areas and technical constraints may prevent quantification and monetization of key direct benefits and direct costs of a particular project. CBA is a decision-aiding tool to provide useful information to policy makers [63].

In the CBA part of this paper, the appropriate methodology defined the way of considering the costs and benefits in the process of evaluation of the envisaged measures and it implies the comparison of costs and benefits for each identified measure. After determining the required investments for each measure, as well as the estimated reduction of GHG emissions by measures, it was necessary to determine the benefits per ton of reduced emissions and make appropriate projections of the effects. Finally, in order to estimate the total benefit of each individual measure, the discounting of net effects and benefits–cost ratio were performed. This was followed by cost-effectiveness conclusion on investing in certain measures to reduce GHG emissions in Montenegro, which determined the assessment of their relationship, i.e., the priority.

The economic analysis was done by determining the following dynamic efficiency indicators:

- Net present value, NPV;
- Benefit–cost ratio, B/CR.

Net present value (NPV) is an indicator that takes into account time preferences and represents the sum of net effects in the economic life of the project reduced by discounting to the present moment, i.e., at the beginning of the investment.

Benefit–cost ratio (B/CR) indicates how much net benefit can be achieved per unit of cost. It is calculated as the ratio of the discounted sum of all future benefits and the discounted sum of all costs.

Both indicators are based on the assumption of discounting all future benefits and costs at the beginning of the project implementation, at a predetermined discount rate of 5%.

It is important to emphasize that this analysis considered only the benefits of GHG emission reduction in relation to total investments, and it did not consider all other benefits coming from the individual measures' application. Therefore, this analysis' results in no way reflect the profitability of individual measures investments, but only show their contribution and mutual relationship in terms of effects, exclusively, from the reduction of GHG emissions. The advantage of this approach is that it allows the selection of measures that bring the greatest economic benefits, while the disadvantage is that the benefits of individual measures include only part of the positive effects that individual measures cause.

In order to better understand, the process of work is displayed in Figure 2.

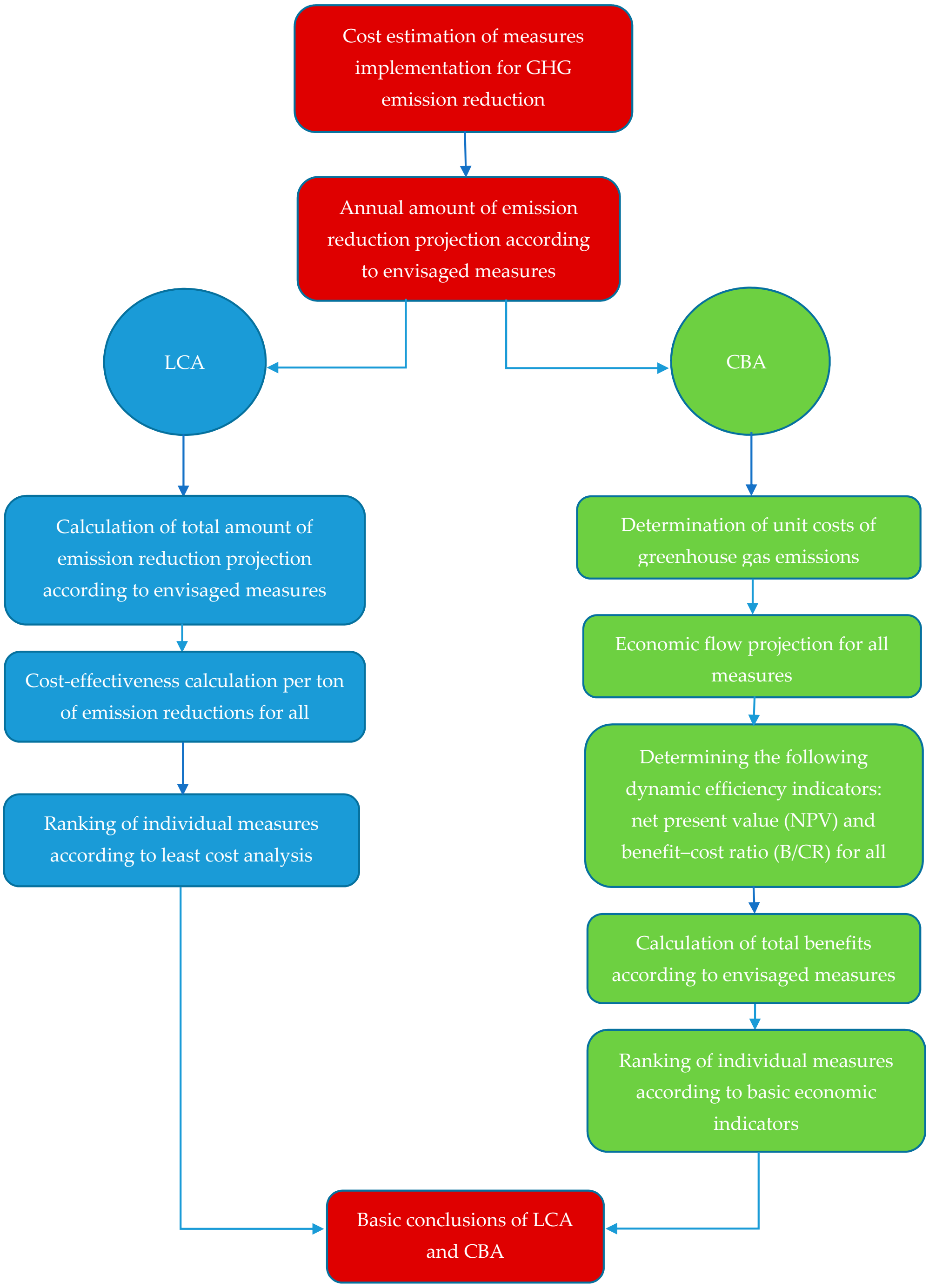

Figure 2. Flow chart with the steps of the applied methodologies.

3.2. Estimation of Implementation Costs and Review of Financing Sources of Envisaged Measures for GHG Emission Reduction

In this part of the paper, we present the cost estimation of emission reduction measures' implementation for GHG emission reduction in Montenegro. Cost estimation was done individually for each measure, and for this purpose, all available official documentation (laws, strategies, reports, action plans, contracts), relevant market data, and data obtained directly from experts involved in individual projects, as well as on the basis of consultant expert assessments, were taken into consideration.

Concurrently, an analysis of funding sources was performed individually according to each of the proposed measures. Funding sources were identified for those measures for which funds have been provided, while for the identified missing funds, a proposal of an appropriate funding model and method is given for a certain measure. Envisaged sources of financing for the implementation of planned measures to reduce GHG emissions in Montenegro were budgets (from central and local governments and potential environmental funds), EU and other donors grants, private/commercial sector investments, and loans from international financial institutions and commercial banks.

Measures envisaged for the reduction of GHG emissions in Montenegro have been divided into 3 areas: energy—label for measure "E", IPPU (industrial processes and product use) —label for measure "I", and waste—label for measure "W".

Tables 1–3 show a recapitulation of the required financial investments and sources of financing for all areas in which GHG emission reduction measures in Montenegro were envisaged.

Table 1. Recapitulation of estimated investments and financing sources for the energy sector.

Measure	Amount (mil. EUR)	Secured Funds and Financing Sources	Unsecured Funds and Potential Financing Sources
1E Ecological refurbishment of the thermal power plant in Pljevlja	54.45	Secured funds 100% (of which commercial sector 100%) Signed contract on the project realization of the ecological reconstruction of Pljevlja TPP Block I in June 2020 with deadline for the completion in 2023. Contractor: DEC International—Bemax—BB Solar—Permonte consortium.	/
2E New renewable power plants	899.6	Secured funds 56% (of which commercial sector contributes 88.86% and credit funds contribute 11.14%	Unsecured funds 44% (Potentially: EPCG, EBRD, public–private partnership, loans, citizens, donations)
Reconstruction and modernization of Perućica HPP		Elektroprivreda Crne Gore (EPCG) and the German development bank KfW signed a loan agreement of EUR 33 mil.	
Reconstruction and modernization of Piva HPP		Funding provided from the German development bank KfW loan, with the total value of EUR 12.1 mil.	
Construction of small HPPs		Based on signed concession agreements, 55 sHPP are planned, of which 13 have been completed. Total value EUR 160 mil.	
Construction of Gvozd WPP			In 2019, an agreement on the joint Gvozd WPP development signed between EPCG and IVICOM, worth EUR 60 mil.
Construction of Brajići WPP		In 2020, signed contract with the German consortium WPD Brajići, worth EUR 101.3 mil.	

Table 1. *Cont.*

Measure	Amount (mil. EUR)	Secured Funds and Financing Sources	Unsecured Funds and Potential Financing Sources
Construction of Briska Gora SPP Construction Komarnica HPP Construction of Velje Brdo SPP Production of solar energy by prosumer		In 2018, signed contract between EPCG, Fortum, and Sterling & Wilson for SPP construction, capacity of over 250 MW, worth EUR 200 mil.	Set preliminary design, Komarnica HPP, worth EUR 246.5 mil. Tender dossier prepared, worth EUR 75 mil. The government of Montenegro announced that subsidies will be allocated to interested individuals for this purpose, worth EUR 11.7 mil.
3E District Heating in Pljevlja	23	Secured funds 14% (of which EPCG contribute 100%) This project is only a first step in constructing a complete district heating system. Further extension is needed. There only exist estimates on the investments. Secured funds amounted at EUR 3.2 mil.	Unsecured funds 86% (potentially: budget of Montenegro, local budget, citizens, donations) Unsecured funds amounted at EUR 19.8 mil.
4E Development and implementation of energy efficiency regulatory framework in buildings	No investments planned	/	/
5E Increased energy efficiency in public buildings	55.8	Secured funds 100% (of which credit funds contribute 91.40% and donations contribute 8.60%) At the end of 2019, a loan agreement was signed with representatives of the German development bank KfW for the “Energy Efficiency Program in Public Buildings—Phase III” (EEPPB III), in the amount of EUR 45 mil. A grant agreement was signed for the same program in the amount of EUR 4.8 mil.	Unsecured funds 0%
6E Financial incentives for citizens/private households (for energy efficiency investments)	1.3	Secured funds 100% (of which donations contribute 76.92% and budget funds contribute 23.08%) Budget funds amounting to EUR 300 thousand have been anticipated, covering the implementation and the subsidies to interest rate with commercial banks. The second activity is planned to support the household sector for the implementation of energy efficiency measures through the Western Balkans Residential Green Economy Financing Facility (GEFF) project, which is implemented by the EBRD worth EUR 1 mil.	Unsecured funds 0%

Table 1. *Cont.*

Measure	Amount (mil. EUR)	Secured Funds and Financing Sources	Unsecured Funds and Potential Financing Sources
7E Energy labeling and ecodesign requirements for energy related products	138.9	Secured funds 0%	Unsecured funds 100% (potentially: budget funds) For the purpose of implementing this measure, a market study was conducted, which included an analysis of devices that will be replaced by certain dynamics in households in Montenegro.
8E Establishment and implementation of EE criteria in public tendering	No investments planned	/	/
9E Implementation of energy efficiency measures in public municipal companies	5.12	Secured funds 2% (of which budget funds contribute 8.33% and donations contribute 91.67%) Donation in the amount EUR 110 thousand from the UNDP and EUR 10 thousand from the budget of Montenegro.	Unsecured funds 98% (potentially: local budgets, private investors) This measure implies the improvement of monitoring and maintenance conditions, as well as investments aimed at improving EE in public enterprises of local government with regard to: public lighting, water supply, and sewerage and other utility services. Total estimated value amounted at EUR 5 mil.
10E Development of transmission and distribution power network (decrease of losses)	640	Secured funds 100% (of which the commercial sector contributes 100%) CEDIS continuously monitors the level of losses through measurements and analyses. The goal of reducing losses is set by the Energy Development Strategy until 2030, and that is to reduce total losses to the level of 10%, in relation to the electricity consumed by 2025 [1].	Unsecured funds 0%
11E Refurbishment of small hydro power plants (increased EE)	3.26	Secured funds 100% (of which the commercial sector contributes 100%) The group of sHPP covered by this measure has been in operation for many years without serious investments that would accompany technological innovations. These are power plants with a total installed capacity of 2.8 MW, as follows: - sHPP Podgor—250 kW—in operation since 1937; - sHPP Rijeka Mušovića—1.36 MW—in operation since 1950; - sHPP Rijeka Crnojevića—754 kW—in operation since 1952; - sHPP Šavnik—386 kW—1946 - sHPP Lijeva Rijeka—50 kW—1947.	Unsecured funds 0%

Table 1. *Cont.*

Measure	Amount (mil. EUR)	Secured Funds and Financing Sources	Unsecured Funds and Potential Financing Sources
1T Electric cars	379.2	Secured funds 0%	Unsecured funds 100% (potentially: citizens, companies, budget funds) UNECE financed "Program of Measures for Air Pollution Control", September 2019, which will be the main input for preparation of the Air Quality Management Strategy 2021–2029, under preparation. Projections of electric and hybrid cars' participation are given based on studies conducted by the Hrvoje Požar Institute on the development of e-mobility in Montenegro, 2019.
TOTAL	2200.63		

[1] Transmission Network Development Plan 2020–2029, Distribution Network Development Plan 2020–2029.

Table 2. Recapitulation of estimated investments and financing sources in the field of industrial processes and product use (IPPU) [1].

Measure	Amount (mil. EUR)	Secured Funds and Financing Sources	Unsecured Funds and Potential Financing Sources
1l Uniprom KAP: electrolysis cells replacement and overhauling (2020–2024) and ETS (2025–2030)	26.00	Secured funds 100% (of which the commercial sector contributes 100%) This is the only measure in the field of IPPU from the Uniporm KAP company.	Unsecured funds 0%
2l Decrease of HFC (hydrofluorocarbons) in accordance with the Law on Recognition of Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer	No investments planned	/	/
TOTAL	26.00		

[1] IPPU—Industrial Processes and Product Use.

Table 3. Recapitulation of estimated investments and financing sources in the field of waste.

Measure	Amount (mil. EUR)	Secured Funds and Financing Sources	Unsecured Funds and Potential Financing Sources
W1 Reduction of bio-waste in municipal waste	33.8	Secured funds 0%	Unsecured funds 100% Based on data from the National Strategy for Transposition, implementation and enforcement of the EU acquis on environment and climate change, and the study on assessing the need for revision of the strategic master plan for waste management in Montenegro and recommendations for organizing waste management until 2030.
W2 Increase of connection rate to sewage system (target 93% by 2035)	553.9	Secured funds 0%	Unsecured funds 100% Cost estimation was made on the basis of information on the settlement's surface, population density, as well as available data on the current situation and the coverage percentage.
TOTAL	587.7		

Recapitulation of estimated total investments for all sectors is shown in Table 4, based on which the total amount of necessary investments required for the implementation of measures to reduce GHG emissions in Montenegro in all sectors was estimated at EUR 2814.33 million.

Table 4. The recapitulation of estimated total investments required for the implementation of measures in all sectors.

Sectors	Amount (mil. EUR)
Energy	2200.63
IPPU	26.00
Waste	587.7
TOTAL	2814.33

4. Results

Economic analysis results of the GHG emission reduction measures in Montenegro follow. However, it should be borne in mind that the implementation of these projects achieves a number of positive effects that are not the subject of this analysis (they do not relate to GHG emission reduction), and therefore this analysis is not an analysis of the feasibility of these projects, but it only serves as a mean of adequately comparing the effects of climate change alone with the level of investment.

In order to assess the economic impact of measures to reduce GHG emissions in Montenegro, as already mentioned, LCA—cost effectiveness analysis and CBA were conducted.

4.1. LCA Results—Cost Effectiveness Analysis

A projection of annual amount of emission reductions (Table 5) was prepared for the purpose of LCA, and later the corresponding CBA in order to determine the total amounts of emission reductions for the entire projected period. The total amount of emission reductions according to the envisaged measures in kilo tons (kt), is shown in Figure 3.

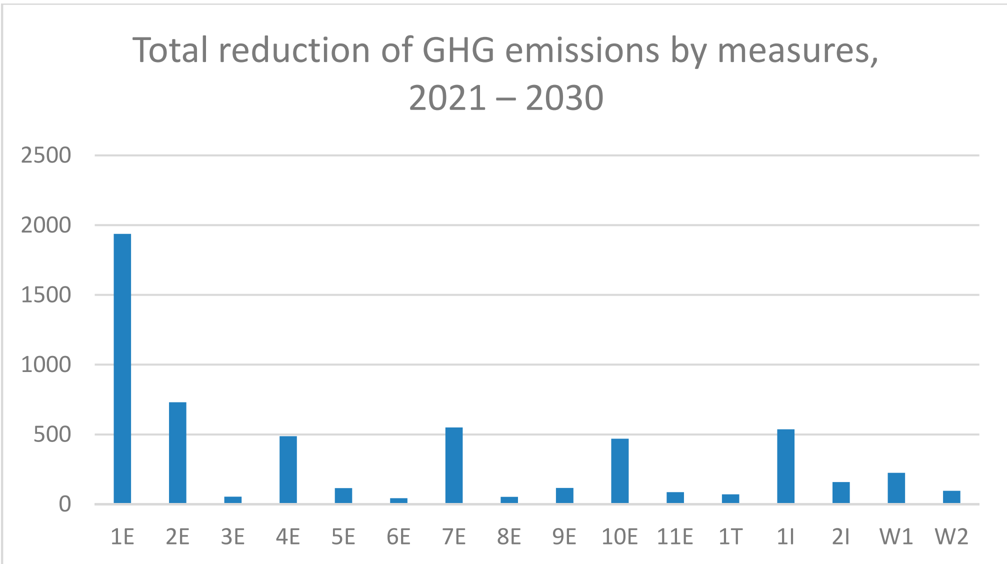

Figure 3. Total amount of emission reductions according to envisaged measures for period 2021–2030 (in kt).

Table 5. Projection of annual quantities of GHG emission reductions according to the planned measures for the period 2021–2030 (in kt) [1].

Measure	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	Total
1E Ecological refurbishment of the thermal power plant in Pljevlja	511	511	0	33	66	99	133	166	199	221	1938
2E New renewable power plants	0	0	0	31	40	100	149	137	144	130	731
3E District heating in Pljevlja	0	0	2	3	5	6	8	9	11	12	54
4E Development and implementation of energy efficiency regulatory framework in buildings	19	26	32	39	45	52	58	65	71	78	487
5E Increased energy efficiency in public buildings	4	5	6	8	9	11	14	16	19	23	115
6E Financial incentives for citizens/private households (for energy efficiency investments)	4	4	4	4	4	4	4	4	4	4	43
7E Energy labeling and ecodesign requirements for energy related products	21	32	40	47	54	61	67	72	76	81	550
8E Establishment and implementation of EE criteria in public tendering	2	3	4	4	5	6	6	7	8	9	53
9E Implementation of energy efficiency measures in public municipal companies	7	10	12	12	12	12	12	12	12	12	116
10E Development of transmission and distribution power network (decrease of losses)	27	41	47	48	49	50	51	52	53	54	469
11E Refurbishment of small hydro power plants (increased EE)		5	10	10	10	10	10	10	10	10	86
1T Electric cars	1	1	2	2	3	4	7	11	16	23	70
1I Uniprom KAP: electrolysis cells replacement and overhauling (2020–2024) and ETS (2025–2030)	25	32	37	43	54	59	65	70	76	76	537
2I Decrease of HFC (hydrofluorocarbons) in accordance with the Law on Recognition of Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer	0	0	0	0	9	16	23	30	37	43	158
W1 Reduction of bio-waste in municipal waste	4	7	10	14	17	21	27	33	41	50	225
W2 Increase of connection rate to sewage system (target 93% by 2035)	4	5	6	7	9	10	12	13	14	16	96

[1] All projections are contained in the Montenegro Background Report for the preparation of the updated National Determined Contribution (NDC) in 2020.

Based on the previous table data, it is obvious that the application of measure of ecological refurbishment of the thermal power plant in Pljevlja contributes to the largest quantitative reduction of GHG emissions, followed by these measures: new renewable power plants, energy labeling and ecodesign requirements for energy-related products, and Uniprom KAP: electrolysis cell replacement and overhauling (2020–2024) and ETS (2025–2030). The smallest amounts of GHG emission reductions are provided by the implementation of these measures: financial incentives for citizens/private households (for energy efficiency investments) and establishment and implementation of EE criteria in public tendering.

Establishing the relationships between the measures' costs of implementation and total GHG emission reductions' amount and the cost-effectiveness calculation per ton of emission reductions was the next step, which is shown in Table 6 and Figure 4 for greater visibility.

Table 6. Cost-effectiveness calculation of the planned measures' implementation to reduce GHG emissions in Montenegro—LCA.

Measure	Total 2021–2030 (in kt)	Investment Cost Estimation (in mil. EUR)	Cost-Effectiveness (EUR/t)
1E Ecological refurbishment of the thermal power plant in Pljevlja	1938	54.45	28.09
2E New renewable power plants	731	899.60	1230.44
3E District heating in Pljevlja	54	23.00	422.59
4E Development and implementation of energy efficiency regulatory framework in buildings	487	0.00	0.00
5E Increased energy efficiency in public buildings	115	55.80	486.06
6E Financial incentives for citizens/private households (for energy efficiency investments)	43	1.30	30.41
7E Energy labeling and ecodesign requirements for energy related products	550	138.90	252.62
8E Establishment and implementation of EE criteria in public tendering	53	0.00	0.00
9E Implementation of energy efficiency measures in public municipal companies	116	5.12	44.17
10E Development of transmission and distribution power network (decrease of losses)	469	640.00	1363.97
11E Refurbishment of small hydro power plants (increased EE)	86	3.26	38.12
1T Electric cars	70	379.20	5404.33
1I Uniprom KAP: electrolysis cells replacement and overhauling (2020–2024) and ETS (2025–2030)	537	26.00	48.39
2I Decrease of HFC (hydrofluorocarbons) in accordance with the Law on Recognition of Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer	158	0.00	0.00
W1 Reduction of bio-waste in municipal waste	225	33.80	150.20
W2 Increase of connection rate to sewage system (target 93% by 2035)	96	553.90	5798.94

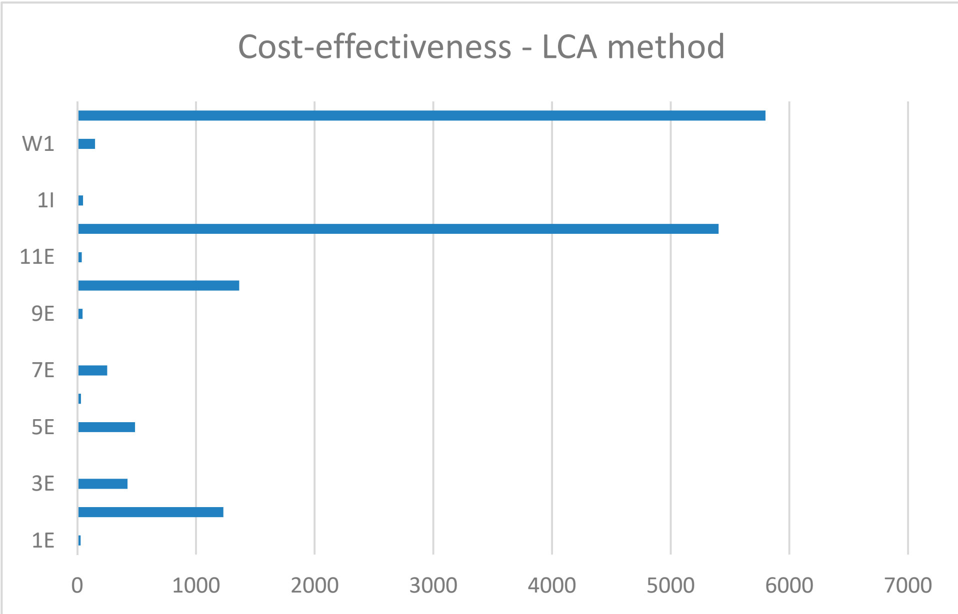

Figure 4. Cost-effectiveness level—amount of investment per ton of reduction of GHG emissions for envisaged measures.

Based on the conducted LCA, it is clear that, except for two regulatory measures, for which no investments are planned and the application of which leads to a reduction of GHG emissions, application of the ecological refurbishment of the thermal power plant in Pljevlja measure achieves the best effects from the aspect of investment efficiency in relation to the total amount of GHG emission reductions. The analysis shows that the GHG emission reduction of 1 ton is based on the investment of about EUR 28 in this measure implementation.

From the further sequence of measures and investment efficiency point of view, measures of financial incentives for citizens/private households (for energy efficiency investment), refurbishment of small hydro power plants (increased EE), and implementation of energy efficiency measures in public municipal companies follow.

Weakest results according to the LCA criteria are achieved by the implementation of measures related to electric cars and increased connection rate to sewage system (target 93% by 2035), primarily due to the large amount of required investments, where the effects are not predominantly climatic.

Established indicators confirm that the LCA is the best method of considering investment's cost-effectiveness in the case of measures with extremely large differences in the amount of investment.

However, as aforementioned, in addition to certain LCA advantages in certain situations and its simplified application, CBA, i.e., analysis of the ratio of investments and monetized effects of GHG emission reductions allows better understanding of cost-effectiveness investments in measures, and their comparison as it also takes into account the time distribution of costs and benefits.

4.2. CBA Results Per Certain Measure for GHG Emission Reduction

What is common for project implementation in the fields discussed in this document, or for the effects their implementation should lead, is the GHG emissions that lead to climate change. Climate change caused by GHG emissions causes huge long-term risks to human health and life. These detrimental effects cause large cash outflows, and therefore investing in reducing their emissions results in these costs savings. In this way, the economic savings of these investments can be quantified.

The most acceptable method for the economic analysis of these investments is to determine the "damage" that emissions cause by not realizing the project, in emission units, usually in tons. This is not an easy task, because it is necessary to clearly determine the correlation between GHG emissions, as well as the detrimental effects they cause.

In Montenegro, as well as in most of the developed EU countries, no individual research of these values has been done, but there are certain relevant studies and methodologies, which adequately investigated this issue at the EU level, drew certain conclusions and determined GHG values based on the adverse effects they cause. In the past period, numerous studies have been done, as well as studies that have dealt with the analysis of the greenhouse gas emissions costs. Within these documents, an assessment of global damage and social costs from their emission was performed. Global damage potentials were compared with the GWP, which is a key metric used to determine these values.

Climate change is affected by the emissions of many GHGs, but carbon dioxide (CO_2) is the primary GHG and most research in this area has been focused on CO_2. Within these studies, very detailed analyses were performed, which led to the determination of unit costs of greenhouse gas emissions. These results are presented in Table 7 and will be used in further analysis, noting that their value will not be adjusted for the level of Montenegro. Since these gases emission are a global problem, which affect the entire planet, the recommendation is to use this principle in further evaluations.

Table 7. Unit value of CO_2 emission costs (EUR/t).

Gas Type	World Bank (2017) [1]	Economics, The Open Access (2014) [2]	European Commission (2014) [3]	NCEE (2012) [4]	Average Unit Value
CO_2	36–72	23	10–40	30	33

[1] “Guidance note on shadow price of carbon and economic analysis”, World Bank, November 2017. [2] “The marginal damage costs of different greenhouse gases”, Stephanie Waldhoff, Economics—The Open Access, October 2014. [3] “Guide to Cost-Benefit analysis of investment projects”; Economic Appraisal Tool for Cohesion Policy 2014–2020, European Commission, December 2014. [4] “Estimating the social costs of non CO_2 GHG emissions: CH4 N20”, National Centre for Environmental Economics, February 2012.

According to previously presented data, and taking into account certain variations in the determined levels of these costs, depending on the processor and methodology, their average values were calculated and the average unit value of CO_2 emissions of 33 EUR/t was determined, which will be used in the future analysis.

Based on the determined investment costs for the application of individual measures, the projected reductions of gas emissions by measures and the above-mentioned unit values of CO_2 emission costs, analyses were performed for each of the analyzed measures. Economic effects of the developed measures were considered annually, for the period of 10 years, from 2021–2030 and discounted using the selected discount rate (in our case 5%) and reduced to a common denominator (expressed in the present value of monetary units). The economic analysis was done by determining the dynamic efficiency indicators —NPV and B/CR (for a measure to be considered economically viable, the following criteria should be met: NPV greater than EUR 0.00; B/C greater than 1).

Based on the performed analyzes, individually, for all proposed measures, a comparative overview of the established economic indicators implementation follows. According to these indicators, certain conclusions can be drawn about the comparative cost-effectiveness of investment implementation of individual measures and the possible priority, i.e., the order of their implementation.

Table 8 provides comparative overview of economic indicators, total benefits, NPV, and B/CR.

Table 9 shows the ranking of each individual measure, according to the established economic indicators of justification of measures to reduce GHG emissions—NPV and B/CR.

Table 8. Comparative overview of economic indicators by measures for GHG emission reduction in Montenegro.

Measure	Estimated Investment Cost (in mil. EUR)	Total Benefits (in mil. EUR) [1]	NPV (in mil. EUR)	B/CR
1E Ecological refurbishment of the thermal power plant in Pljevlja	54.45	63.96	2.48	1.05
2E New renewable power plants	899.6	24.12	−800.02	0.02
3E District heating in Pljevlja	23	1.79	−20.14	0.06
4E Development and implementation of energy efficiency regulatory framework in buildings	/	16.08	11.75	N/A
5E Increased energy efficiency in public buildings	55.8	3.79	−47.94	0.05
6E Financial incentives for citizens/private households (for energy efficiency investments)	1.3	1.41	−0.12	0.9
7E Energy labeling and ecodesign requirements for energy related products	138.9	18.14	−93.21	0.13
8E Establishment and implementation of EE criteria in public tendering	/	1.75	1.28	N/A
9E Implementation of energy efficiency measures in public municipal companies	5.12	3.83	−1.85	0.61
10E Development of transmission and distribution power network (decrease of losses)	640	15.48	−482.46	0.02
11E Refurbishment of small hydro power plants (increased EE)	3.26	2.82	−0.93	0.69
1T Electric cars	379.2	2.05	−324.28	0.004
1I Uniprom KAP: electrolysis cells replacement and overhauling (2020–2024) and ETS (2025–2030)	26	17.73	−7.01	0.65
2I Decrease of HFC (hydrofluorocarbons) in accordance with the Law on Recognition of Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer	/	5.21	3.49	N/A
W1 Reduction of bio-waste in municipal waste	33.8	7.43	−22.07	0.19
W2 Increase of connection rate to sewage system (target 93% by 2035)	553.9	3.15	−433.54	0.01

[1] Undiscounted total climate benefits for the period 2021–2030 according to the envisaged measures for reduction of GHG emissions in Montenegro.

Table 9. Determined rank of individual measures for GHG emission reduction according to basic economic indicators.

Measure	Total Benefits (mil. EUR)	NPV (in mil. EUR)	B/CR
1E Ecological refurbishment of the thermal power plant in Pljevlja	1	3	4
2E New renewable power plants	2	16	13
3E District heating in Pljevlja	14	9	11
4E Development and implementation of energy efficiency regulatory framework in buildings	5	1	1
5E Increased energy efficiency in public buildings	10	11	12
6E Financial incentives for citizens/private households (for energy efficiency investments)	16	5	5

Table 9. *Cont.*

Measure	Total Benefits (mil. EUR)	NPV (in mil. EUR)	B/CR
7E Energy labeling and ecodesign requirements for energy related products	3	12	10
8E Establishment and implementation of EE criteria in public tendering	15	4	1
9E Implementation of energy efficiency measures in public municipal companies	9	7	8
10E Development of transmission and distribution power network (decrease of losses)	6	15	13
11E Refurbishment of small hydro power plants (increased EE)	12	6	6
1T Electric cars	13	13	16
1I Uniprom KAP: electrolysis cells replacement and overhauling (2020–2024) and ETS (2025–2030)	4	8	7
2I Decrease of HFC (hydrofluorocarbons) in accordance with the Law on Recognition of Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer	8	2	1
W1 Reduction of bio-waste in municipal waste	7	10	9
W2 Increase of connection rate to sewage system (target 93% by 2035)	11	14	15

5. Conclusions

Energy is a strategic resource for Montenegro as the country is a net importer of liquid and gaseous fossil fuels for energy needs. The energy sector is the largest source of emissions in the country and fossil fuel combustion for heat production and heating is the most significant source of emissions. Major investments from the past few years will continue, especially in the field of renewable energy sources. Some investments will reduce energy consumption and accompanying CO_2 emissions, support the reduction of energy costs, etc. Energy development strategies (action plan) have been developed with measures targeted at energy and heating, and increasing energy efficiency. Additional mitigation options have been specified in order to reduce GHG emissions from the energy sector.

Our results suggest that the measure of ecological refurbishment of the thermal power plant Pljevlja has the best economic indicators. This investment realization with the amount which is not high in relative terms compared to other measures, significantly reduces GHG emissions, so the economic effects of this measure are the greatest. In this regard, with this measure the highest individual economic benefits are realized, as well as the net present value of investments but also individual ratio of benefits and costs.

Certain regulatory character measures—development and implementation of energy efficiency regulatory framework in buildings and HFCs in accordance with the Law on Recognition of Amendments to the Montreal Protocol on Substances that Deplete the Ozone Layer have highly ranked indicators of net present value and benefit-cost ratio, for for the simple reason that their implementation does not require special additional investments and certainly their application achieves a certain reduction in GHG emissions. For this reason, these two measures should also have priority in implementation.

In the past few years, major investments have been made in Montenegro in the field of RES, with a tendency to continue (wind farms, small hydro power plant—sHPP, together with the planned investments in SPP). Measures related to new renewable power plants were observed in their entirety during economic analyses, because the data on emission reductions also referred to all projects together that are being implemented within it. For that reason, the obtained indicators cannot reflect the individual significance of each of the projects separately. The overall benefits of applying this measure are highly ranked compared to other measures, although NPV and B/CR are low.

The aforementioned findings also apply to other measures, such as measures related to the development of transmission and distribution power network (decrease of losses) and electric cars, as well as the measure of increasing the connection to the sewage network (target 93% by 2035). These measures also have an extremely high investment value, but effects of their implementation are much more complex. Also, other observed and analyzed measures, to a greater or lesser extent, indicate that their implementation achieves significant environmental and economic effects and that further steps towards their implementation should be continued.

Regarding the transport sector in Montenegro, it can be concluded that currently it is characterized by an increase in the total number of registered vehicles (over 235 thousand in 2018, average age of 16 years), dominant share of road traffic, and a small share of public transport. Acceptance of electro-mobility as a comprehensive socio-technical system implies comprehensive preparation of the country for electric mobility (standards, regulatory frameworks, policies in the energy and environmental sector, established practices, charging infrastructure). Interestingly, our analysis showed a poor ranking for the measure electric cars, as a consequence of the high cost compared to the estimated benefits.

Finally, analyzing absolute changes in GHG emissions in Montenegro in the past, it can be concluded that the main reductions in GHG emissions have been achieved as a result of economic and structural changes in the metal industry. However, due to the reconstruction of the thermal power plant, increased use of renewable energy sources and measures to increase energy efficiency, the largest reduction in the next 10 years is expected in the energy sector. At the same time, the peak of emissions is expected in 2023, after which a downward trend in emissions is expected.

It is certain that achieving the final goal of a carbon neutral economy, which is targeted for 2050, requires further emission reductions. It is still unclear how the increased EU ambition of 50% (or maybe 55%) in 2030 will be divided among EU member states. In that sense, in the forthcoming period, stronger efforts of Montenegro will be needed in supporting the joint efforts of the EU member states.

This research, as well as many others, has certain limitations, some of which can be undoubtedly overcome in the future. One of the limitations having an impact on the analysis results and their comparability concerns the different degrees of data reliability regarding the required investment amount for certain measures to reduce GHG emissions. For some measures, the investment value was determined quite precisely (on the basis of a contract or project), while for others, the investment value was determined on the basis of certain estimates, previous experiences, etc. Thus, for example, it is very possible that the actual investment value for the second measure could deviate from the stated valuation, which could to some extent (though not significantly) affect the analysis results. This is one of the limitations that can be overcome in the future, when the conditions for more precise input determination are met. The second limitation, which is of a methodological nature, concerns the circumstance that the performed CBA was simplified, based only on climatic effects, while all other measures effects have not been considered. Final conclusions on cost-effectiveness, i.e., the rank of individual measures, should be viewed only in the climatic context and not in the context of the overall effects of individual measures, which was the primary goal of this paper. Certainly, difficulties regarding some costs valuation, as well as the discount rate determination issue especially for environmental projects, remain typical methodological CBA limitations, which are intended to be minimized in the case of specific analyses. Although these limitations can hardly be completely eliminated. However, despite aforementioned constraints, the CBA has its place in environmental impact assessment as a useful methodology for multiple alternatives. It may be possible in future to overcome some of these limitations many associate with expected changes in anthropocentric ethics and aggressive economics in favor of the ecocentric ethics paradigms and sustainable economic development.

Our paper creates space for further action in several directions, both in practical implementation of activities/measures for GHG emission reduction, and in further research ambitions on a given topic. As presented in the paper, out of the total planned EUR 2.81 billion, which needs to be allocated for the implementation of all proposed measures, slightly more than half of the necessary funds have been provided so far, i.e., over EUR 1.5 billion. Through the outcomes of the conducted least cost and CBA analyses, the rank of individual measures according to the basic economic indicators of justification was determined.

Further activities should take place in the direction of measures prioritization, their observance in the context of project implementation dynamics and positive short-term results, followed by short- and medium-term results correlation. This could contribute even more concretely to the more efficient measures implementation leading to the GHG emission reduction, and the expected efforts of Montenegro in the coming period, particularly in relation to the EU targets for 2030 and 2050.

Some efforts should be especially focused on measures for which funds have not yet been provided, in order to intensify activities on the appropriate project documentation preparation for obtaining the necessary funds. Key parts of this documentation would certainly be appropriate economic and financial analyses representing continuation and upgrades of the conducted analyses within this paper. Particularly significant activities are to be undertaken in the group of measures, for which funds have not been secured, and which should be financed mostly by the population (electric cars, efficient household appliances, prosumers). An adequate way of educating and informing the population about the advantages and personal interest in these measures implementation is forthcoming, followed by defining an appropriate financing scheme through subsidies and favorable loans.

Further theoretical research can be carried out in the direction of conducting a cluster analysis (using some of the suitable methods) in order to intensify combining of the proposed measures into groups of homogeneous measures that would differ according to the GHG emission total level and emission per capita. The aforementioned is in order to focus on the measures that contribute to the emission most, which could be a good basis for establishing differentiated policies to reduce GHG emissions in relation to certain clusters of measures. A higher level of actions operationalization would require targeting of the individual measures characteristic features included in individual clusters.

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References

1. Crippa, M.; Oreggioni, G.; Guizzardi, D.; Muntean, M.; Schaaf, E.; Lo Vullo, E.; Solazzo, E.; Monforti-Ferrario, F.; Olivier, J.; Vignati, E. *Fossil CO_2 and GHG Emissions of all World Countries*; Publications Office of the European Union: Luxembourg, 2019. Available online: https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/fossil-co2-emissions-all-world-countries-2020-report (accessed on 12 December 2020).

2. UNFCCC Paris Agreement. Conference. Parties Its Twenty-First Session. 2015. Available online: http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf (accessed on 20 December 2020).
3. European Commission. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of Regions. European Green Deal. 2019. COM(2019) 640. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2019:640:FIN (accessed on 28 January 2020).
4. European Environment Agency. *Greenhouse Gas Emissions from Transport (TERM 002)*; European Environment Agency: Copenhagen, Denmark, 2018. Available online: https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-greenhouse-gases-7/assessment (accessed on 22 December 2020).
5. European Environment Agency. *Emissions of Air Pollutants from Transport (TERM 003)*; European Environment Agency: Copenhagen, Denmark, 2018. Available online: https://www.eea.europa.eu/data-and-maps/indicators/transport-emissions-of-air-pollutants-8/transport-emissions-of-air-pollutants-8 (accessed on 22 December 2020).
6. Solaymani, S. CO_2 emissions patterns in 7 top carbon emitter economies: The case of transport sector. *Energy* **2019**, *168*, 989–1001. [CrossRef]
7. Mao, X.; Yang, S.; Liu, Q.; Tu, J.; Jaccard, M. Achieving CO_2 emission reduction and the co-benefits of local air pollution abatement in the transportation sector of China. *Envon. Sci. Polcy* **2012**, *21*, 1–13. [CrossRef]
8. Dhar, S.; Pathak, M.; Shukla, P.R. Transformation of India's transport sector under global warming of 2 °C and 1.5 °C scenario. *J. Clean Prod.* **2018**, *172*, 417–427. [CrossRef]
9. Van Fan, Y.; Perry, S.; Klemeš, J.J.; Lee, C.T. A review on air emissions assessment: Transportation. *J. Clean Prod.* **2018**, *194*, 673–684. [CrossRef]
10. Mirosavljević, P.; Gvozdenović, S.; Čokorilo, O. The transport aircraft pollution cost reduction strategy. *FME Trans.* **2010**, *38*, 157–166.
11. Ivković, I.; Čokorilo, O.; Kaplanović, S. The estimation of GHG emission costs in road and air transport sector: Case study of Serbia. *Transport* **2018**, *33*, 260–267. [CrossRef]
12. Transport and Environment. *CO_2 Emissions from New Cars in Europe: Country ranking: How National Car Tax Systems Helped Boost Sales of Lower-Carbon Cars across Europe in 2013*; European Federation for Transport and Environment: Brussels, Belgium, 2014. Available online: https://www.transportenvironment.org/publications/co2-emissions-new-cars-europe-country-ranking-2013 (accessed on 12 November 2020).
13. Fridstrøm, L.; Alfsen, K. Norway's path to sustainable transport. *Inst. Transp. Econ. Nor. Cent. Transp. Res. TOI Rep. Oslo.* **2014**, *1321*, 284.
14. Ciccone, A. Environmental effects of a vehicle tax reform: Empirical evidence from Norway. *Trans. Policy* **2018**, *69*, 141–157. [CrossRef]
15. Sprei, F.; Karlsson, S. Energy efficiency versus gains in consumer amenities—An example from new cars sold in Sweden. *Energy Policy* **2013**, *53*, 490–499. [CrossRef]
16. D'Haultfoeuille, X.; Givord, P.; Boutin, X. The environmental effect of green taxation: The case of the French bonus/malus. *Econ. J.* **2014**, *124*, F444–F480. [CrossRef]
17. Čokorilo, O.; Ivković, I.; Kaplanović, S. Prediction of Exhaust Emission Costs in Air and Road Transportation. *Sustainability* **2019**, *11*, 4688. [CrossRef]
18. European Commission. EU's Six Environment Action Program (2002–2012). EC: Environment, 2002. Available online: https://ec.europa.eu/environment/archives/action-programme/intro.htm (accessed on 15 November 2020).
19. Tun, M.M.; Juchelková, D. Estimation of greenhouse gas emissions: An alternative approach to waste management for reducing the environmental impacts in Myanmar. *Environ. Eng. Res.* **2019**, *24*, 618–629. [CrossRef]
20. Sarkodie, S.A.; Owusu, P.A. Impact of meteorological factors on COVID-19 pandemic: Evidence from top 20 countries with confirmed cases. *Envon. Res.* **2020**, *191*, 110101. [CrossRef]
21. Magazzino, C.; Mele, M.; Schneider, N.; Sarkodie, S.A. Waste generation, wealth and GHG emissions from the waste sector: Is Denmark on the path towards circular economy? *Sci. Total Envon.* **2020**, *755*, 142510. [CrossRef]
22. Karimipour, H.; Tam, V.W.; Burnie, H.; Le, K.N. Quantifying the effects of general waste reduction on greenhouse-gas emissions at public facilities. *J. Air Waste Manag. Assoc.* **2019**, *69*, 1247–1257. [CrossRef]
23. Zhang, C.; Xu, T.; Feng, H.; Chen, S. Greenhouse gas emissions from landfills: A review and bibliometric analysis. *Sustainability* **2019**, *11*, 2282. [CrossRef]
24. Xin, C.; Zhang, T.; Tsai, S.B.; Zhai, Y.M.; Wang, J. An Empirical Study on Greenhouse Gas Emission Calculations under Different Municipal Solid Waste Management Strategies. *Appl. Sci.* **2020**, *10*, 1673. [CrossRef]
25. Neagu, O.; Teodoru, M.C. The relationship between economic complexity, energy consumption structure and greenhouse gas emission: Heterogeneous panel evidence from the EU countries. *Sustainability* **2019**, *11*, 497. [CrossRef]
26. Kim, J.; Park, S. A contingent approach to energy mix policy. *Energy Policy* **2018**, *123*, 749–758. [CrossRef]
27. International Energy Agency. *Renewables 2019: Analysis and Forecasts to 2024*; International Energy Agency: Paris, France, 2019.
28. Shirai, T.; Adam, Z. *Fossil Fuel Subsidies Are Down, But Not Out*; International Energy Agency: Paris, France, 2017.
29. International Energy Agency. *Coal Falls as Gas Rises: World Energy Balances in 2016*; International Energy Agency: Paris, France, 2017.

30. Van Breevoort, P.; Blok, K.; Hagemann, M.; Fekete, H.; Höhne, N.; Hare, B.; Schaeffer, M.; Rocha, M.; Jeffery, L. *The Coal Gap: Planned Coal-Fired Power Plants Inconsistent with 2 °C and Threaten Achievement of INDCs*; Climate Action Tracker: Berlin, Germany, 2015. Available online: https://www.actu-environnement.com/media/pdf/news-25763-coal-gap-cop21.pdf (accessed on 7 November 2020).
31. Stern, N. *The Economics of Climate Change: The Stern Review*, 1st ed.; Cambridge University Press: Cambridge, MA, USA, 2007; ISBN 978-0-521-700801.
32. Dalton, G.; Gallachóir, B.Ó. Building a wave energy policy focusing on innovation, manufacturing and deployment. *Renew. Sustain. Energy Rev.* **2010**, *14*, 2339–2358. [CrossRef]
33. Guo, P.; Wang, T.; Li, D.; Zhou, X. How energy technology innovation affects transition of coal resource-based economy in China. *Energy Policy* **2016**, *92*, 1–6. [CrossRef]
34. Aldieri, L.; Vinci, C.P. Climate Change and Knowledge Spillovers for Cleaner Production: New Insights. *J. Clean Prod.* **2020**. [CrossRef]
35. Bai, Y.; Ochuodho, T.O.; Yang, J. Impact of land use and climate change on water-related ecosystem services in Kentucky, USA. *Ecol. Indic.* **2019**, *102*, 51–64. [CrossRef]
36. Hartmann, D.; Guevara, M.R.; Jara-Figueroa, C.; Aristarán, M.; Hidalgo, C.A. Linking economic complexity, institutions, and income inequality. *World Dev.* **2017**, *93*, 75–93. [CrossRef]
37. Can, M.; Gozgor, G. The impact of economic complexity on carbon emissions: Evidence from France. *Envon. Sci. Pollut. Res.* **2017**, *24*, 16364–16370. [CrossRef] [PubMed]
38. Addison, T. *Extractive Industries: The Management of Resources as a Driver of Sustainable Development*; Oxford University Press: Oxford, UK, 2018; Chapter: Climate Change and the Extractives Sector. [CrossRef]
39. Tol, R.S. Is the uncertainty about climate change too large for expected cost-benefit analysis? *Clim. Chang.* **2003**, *56*, 265–289. [CrossRef]
40. Meunier, D.; Quinet, E. Valuing Greenhouse Gases Emissions and Uncertainty in Transport Cost Benefit Analysis. *Transp. Res. Procedia* **2015**, *8*, 80–88. [CrossRef]
41. Chae, Y. Co-benefit analysis of an air quality management plan and greenhouse gas reduction strategies in the Seoul metropolitan area. *Envon. Sci. Policy* **2010**, *13*, 205–216. [CrossRef]
42. Bollen, J.; Hers, S.; Van der Zwaan, B. An integrated assessment of climate change, air pollution, and energy security policy. *Energy Policy* **2010**, *38*, 4021–4030. [CrossRef]
43. Bollen, J.; Van der Zwaan, B.; Brink, C.; Eerens, H. Local air pollution and global climate change: A combined cost-benefit analysis. *Resour. Energy Econ.* **2009**, *31*, 161–181. [CrossRef]
44. Carleton, T.A.; Jina, A.; Delgado, M.T.; Greenstone, M.; Houser, T.; Hsiang, S.M.; Hultgren, A.; Kopp, R.E.; McCusker, K.E.; Nath, I.B.; et al. Valuing the global mortality consequences of climate change accounting for adaptation costs and benefits (No. w27599). *Natl. Bur. Econ. Res.* **2020**. [CrossRef]
45. Pearce, D. The Social Cost of Carbon and its Policy Implications. *Oxf. Rev. Econ. Policy* **2003**, *9*, 362–384. [CrossRef]
46. Haines, A.; McMichael, A.J.; Smith, K.R.; Roberts, I.; Woodcock, J.; Markandya, A.; Armstrong, B.G.; Campbell-Lendrum, D.; Dangour, A.D.; Davies, M.; et al. Public health benefits of strategies to reduce greenhouse-gas emissions: Overview and implications for policy makers. *Lancet* **2009**, *374*, 2104–2114. [CrossRef]
47. Chapman, R.; Keall, M.; Howden-Chapman, P.; Grams, M.; Witten, K.; Randal, E.; Woodward, A. A cost benefit analysis of an active travel intervention with health and carbon emission reduction benefits. *Int. J. Environ. Res. Public Health* **2018**, *15*, 962. [CrossRef] [PubMed]
48. Cavill, N.; Kahlmeier, S.; Rutter, H.; Racioppi, F.; Oja, P. Economic analyses of transport infrastructure and policies including health effects related to cycling and walking: A systematic review. *Transp. Policy* **2008**, *15*, 291–304. [CrossRef]
49. World Health Organization. *Health in Green Economy: Health Co-Benefits of Climate Change Mitigation-Transport Sector*; World Health Organization: Geneva, Switzerland, 2012.
50. Lopez, N.S.; Soliman, J.; Biona, J.B.M. Life Cycle Cost and Benefit Analysis of Low Carbon Vehicle Technologies. In *Sustainable Energy Technology and Policies. Green Energy and Technology*; De, S., Bandyopadhyay, S., Assadi, M., Mukherjee, D., Eds.; Springer: Singapore, 2018; ISBN 978-981-10-8392-1. [CrossRef]
51. Yi-Hsuan, S.; Chao-Heng, T. Cost-benefit analysis of sustainable energy development using life-cycle co-benefits assessment and the system dynamics approach. *Appl. Energy* **2014**, *119*, 57–66. [CrossRef]
52. Santamaría, M.; Azqueta, D. Promoting biofuels use in Spain: A cost-benefit analysis. *Renew. Sustain. Energy Rev.* **2015**, *50*, 1415–1424. [CrossRef]
53. Diakoulaki, D.; Karangelis, F. Multi-criteria decision analysis and cost-benefit analysis of alternative scenarios for the power generation sector in Greece. *Renew. Sustain. Energy Rev.* **2007**, *11*, 716–727. [CrossRef]
54. Wang, Y.; Geng, S.; Zhao, P.; Du, H.; He, Y.; Crittenden, J. Cost–benefit analysis of GHG emission reduction in waste to energy projects of China under clean development mechanism. *Resour. Conserv. Recycl.* **2016**, *109*, 90–95. [CrossRef]
55. Jamasb, T.; Nepal, R. Issues and options in waste management: A social cost–benefit analysis of waste-to-energy in the UK. *Res. Conserv. Recycl.* **2010**, *54*, 1341–1352. [CrossRef]
56. Ćetković, J.; Elezović, S.; Ivanov, M.; Jablan, N.; Kampel, E.; Rincón Cristóbal, J.J.; Tadić, I. Montenegro Background Report for the preparation of updated NDC in 2020 (second draft). December; 2020.

57. Uvalić, M.; Cvijanović, V. Towards A Sustainable Economic Growth and Development in the Western Balkans. *New Econ. Agenda Southeast Eur.* **2018**, *13*, 1–22.
58. Campiglio, E.; Dafermos, Y.; Monnin, P.; Ryan-Collins, J.; Schotten, G.; Tanaka, M. Climate change challenges for central banks and financial regulators. *Nat. Clim. Chang.* **2018**, *8*, 462–468. [CrossRef]
59. European Commission. Guidelines for the Implementation of the Green Agenda for the Western Balkans accompanying the Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. An Economic and Investment Plan for the Western Balkans. 2020. SWD(2020). Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52020SC0223 (accessed on 12 November 2020).
60. Regional Cooperation Council. Sofia Declaration on the Green Agenda for the Western Balkans. 2020. Available online: https://www.rcc.int/docs/546/sofia-declaration-on-the-green-agenda-for-the-western-balkans-rn#:~{}:text=During%20the%20Western%20Balkans%20Sofia,aligns%20with%20EU%20Green%20Deal (accessed on 28 January 2020).
61. Banja, M.; Đukanović, G.; Belis, C.A. *Status of Air Pollutants and Greenhouse Gases in the Western Balkans: Benchmarking the Accession Process Progress on Environment, EUR 30113 EN*; Publications Office of the European Union: Luxembourg, 2020; ISBN 978-92-76-16860-7. [CrossRef]
62. Boardman, A.E.; Greenberg, D.H.; Vining, A.R.; Weimer, D.L. *Cost-Benefit Analysis: Concepts and Practice*; Cambridge University Press: Cambridge, UK, 2017; ISBN 978-1-108-44828-4.
63. Hanley, N.; Barbier, E.B.; Barbier, E. *Pricing Nature: Cost-Benefit Analysis and Environmental Policy*; Edward Elgar Publishing: Cheltenham, UK, 2009; ISBN 978-1-84542-789-4.