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Review

Energy Efficiency and Economic Policy: Comprehensive Theoretical, Empirical, and Policy Review

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Abstract: In this paper, we analyze the role of economic policy in prompting energy efficiency. This study reviews three aspects, theoretical, empirical, and existing policies to evaluate the relationship of energy efficiency and economic policy. This study furthermore identifies the existing issues from a policy perspective in energy efficiency. Although not all public policies may be justified, it suggests that these types of financial incentives, particularly those based on economic instruments, can play a crucial role in advancing energy efficiency. Additionally, this study identifies existing issues in energy efficiency target achievement and proposes solutions based on the literature review. Finally, it provides possible future research pathways from the aspect of economic policy tools in energy efficiency.

Keywords: energy efficiency; economic policy; incentives; review

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1. Introduction

Reduced energy consumption and emissions of greenhouse gases are the results of increased energy efficiency [1,2]. Additionally, energy efficiency measures can also promote energy equity by improving the accessibility and affordability of energy services for low-income and marginalized communities, leading to positive economic outcomes [3,4]. The growing knowledge of the effects of energy use and greenhouse gas emissions on the environment and human health has elevated the significance of these issues in recent years [2]. Increasing energy efficiency can be accomplished in several ways, for instance, through the adoption of more effective technology, the modification of existing building designs, and individual behavioral shifts. Energy efficiency is crucial since it has been shown to cut costs, decrease emissions of greenhouse gases, and improve environmental conditions [5,6]. Energy efficiency lessens demands for fossil fuels and the emissions that come with them by cutting energy consumption. It also aids in the preservation of finite and more expensive to extract natural resources such as coal, oil, and natural gas [7,8]. Energy efficiency can also lead to lower energy bills; boosting people's disposable pay in this way can boost the economy and lead to more job opportunities. Public health can also benefit from energy efficiency since it lessens the need for energy infrastructure such as power plants and transmission lines, which in turn reduces air pollution.

Incentives for and impediments to energy-efficient behavior and investment are provided by economic policy, which plays a crucial role in encouraging energy efficiency [9,10]. Energy-efficient technology, building designs, and lifestyles can all be pushed forward with the help of government policy. Tax breaks for energy-efficient products and subsidies for renewable energy sources are two examples of the kinds of economic policies that can be used to discourage the adoption of inefficient technologies [11].

Consumers are encouraged to buy energy-efficient products due to tax credits which reduce the price of these products [12]. Greater output and decreased pricing result from increased demand for energy-efficient goods [13]. The resulting increased demand further drives the price down, creating a self-sustaining cycle. Subsidies for renewable energy sources such as wind, solar, and hydropower are another example of a policy that helps to improve energy efficiency [14]. These subsidies lower the price of renewable energy technology by helping to fund its research, development, and eventual commercialization. By decreasing the reliance on fossil fuels, cutting down on harmful emissions leads to improved energy security [15–17].

Policy initiatives aimed at improving energy efficiency may also contribute to a more prosperous economy [18,19]. Production and installation of energy-efficient items are two examples of how energy efficiency regulations can generate employment opportunities [20]. Reducing energy expenses and increasing the allure of a company to potential investors are two ways in which energy efficiency can boost competitiveness [21,22]. Furthermore, energy efficiency policies can inspire innovation by supporting the study and development of cutting-edge energy-saving devices. Economic policy has a significant influence on fostering energy efficiency. Energy consumption and greenhouse gas emissions can be lowered with the support of economic policies that incentivize or discourage actions and investments to promote efficient use of energy. Energy efficiency regulations not only help save resources, but they also have the potential to deliver economic benefits such as reduced energy prices, enhanced competitiveness, and new employment opportunities [23–25].

The relationship between a prosperous economy and low energy consumption goes both ways. Energy efficiency is pushed by economic policies, and in turn, energy efficiency can help economic growth and development in a number of ways [26]. Improving energy efficiency has the potential to cut costs, boost competitiveness, and create new jobs. Gains in gross domestic product (GDP), energy intensity, and worker productivity are a few measures of the economic growth that would result from these measures' implementation as presented in Figure 1.

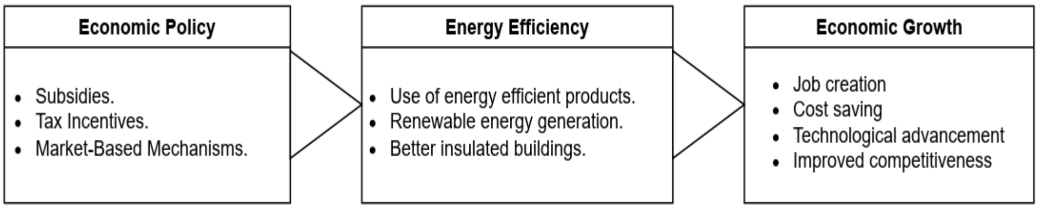

Figure 1. Theoretical framework of energy efficiency and economy. Source: Own elaboration.

First, a rise in GDP is just one potential outcome of improved energy efficiency. Bringing down energy prices is one way to make firms more competitive, which in turn can boost investment and economic activity. That can boost the economy and help more people find jobs. Second, improved energy efficiency can lessen energy intensity, or the amount of energy consumed per dollar of GDP. Lower energy costs for firms and people can boost competitiveness and economic activity if energy intensity is reduced. As a result, this may lead to expanded job opportunities and a healthier economy. Third, a boost in energy efficiency can improve productivity in the workplace. The reason for this is because by using energy-efficient technologies and practices, manufacturing efficiency can be increased, hence decreasing the amount of energy needed to create a given quantity of output. As a result, the economy may become more competitive, see decreased prices, and experience a surge in activity.

By providing incentives for energy-efficient behavior and investment, economic policies play a substantial role in increasing energy efficiency. Numerous economic measures, including subsidies, tax incentives, and market-based processes, are widely employed to encourage energy efficiency. With the increased need for energy efficiency, the previous literature reviews have only focused on the tools or economic outcomes of energy efficiency [27–29]. Therefore, the novelty of this paper lies with the aspect that it evaluates the literature from the point of view of driving economic factors. The objective and methodological novelties of this paper overlay each other as it explores the theoretical, empirical, and policy research available on the aspects of subsidies, tax incentives, and market-based mechanisms, and the contribution of the study is establishing the state of the art and proposing directions for future research.

Figure 2 further elaborates the contribution of the study and explains path of this study. This study evaluates the existing issues in the energy efficiency implementation in the following section; then, Sections 3–5 evaluate the conceptual, empirical, and policy work in the literature of policy instrument subsidies, tax incentives, and market-based mechanisms. Part 6 concludes the article with policy solutions for increasing energy efficiency based on the policy instruments discussed in Sections 3–5. Section 7 discusses all possible research avenues on the specific aspects of discussed policy instruments and energy efficiency and new broader research avenues for energy efficiency and economics.

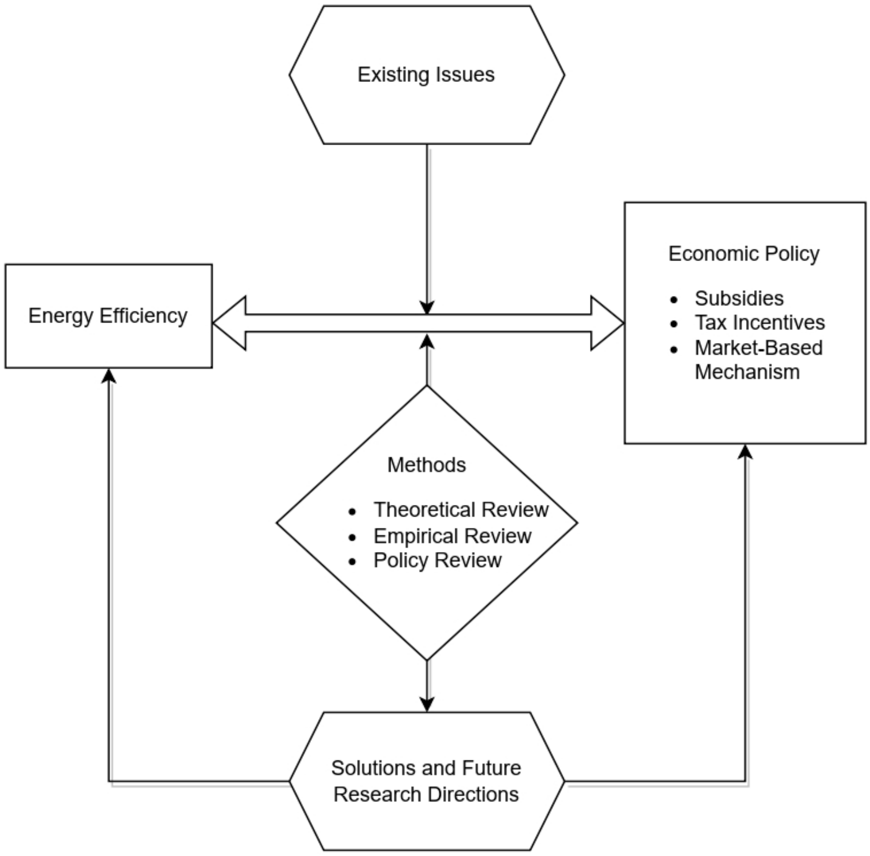

Figure 2. Framework of the study. Source: Own elaboration.

2. Energy Efficiency; State-of-the-Art, Issues, and Case of EU-27 2030

In the realm of energy management, the terms energy efficiency and energy conservation are closely intertwined yet conceptually distinct. Energy efficiency pertains to the optimal utilization of energy to achieve the same level of output while consuming lesser energy [30,31]. This goal can be achieved by implementing improved technologies, refining processes, and enhancing building or product designs. The primary objective of energy efficiency is to decrease energy usage while maintaining the same level of output. On the other hand, energy conservation aims to reduce energy consumption by altering daily habits and behaviors [32,33]. The purpose of energy conservation is to decrease overall energy consumption, which preserves natural resources and reduces carbon emissions.

According to the Paris Climate Agreement, the European Union has committed to increasing energy efficiency by at least 32.5% by the year 2030 [34–37]. Countries throughout the world joined the Paris Agreement in 2015 to work toward keeping global warming well below 2 degrees Celsius above pre-industrial levels [38,39]. Greenhouse gas emissions from energy consumption are one of the main sources of emissions worldwide; therefore, increasing energy efficiency is viewed as essential to reach these goals. In addition to lowering emissions and saving money, increasing energy efficiency may also strengthen energy security [40,41]. As the energy efficiency sector continues to expand, it may help reduce reliance on fossil fuels, boost business competitiveness, and generate new employment opportunities [42]. However, there are still issues existing in increasing energy efficiency, as elaborated in Table 1, and economic policy plays a vital role in the solution of these issues.

Table 1. Issues in energy efficiency.

Issues	Details
Lack of financing	Energy-saving measures often require a lot of financing up front, which businesses, governments, and households may not have easy access to. This can make it more challenging for individuals to use energy-saving technologies and methods, and it could mean missed chances to save energy and cut down on pollution [43,44].
Barriers to the adoption of energy efficiency technologies	Adoption of energy-efficient solutions is hampered by factors such as a lack of knowledge about available technology, restricted access to necessary resources, and reluctance to change. For instance, individuals can be unaware of the options for increasing energy efficiency or the value of doing so. Additionally, there may be inadequate incentives for organizations and individuals to adopt energy-efficient technology [45–47].
Resistance to policy and regulatory measures	There is opposition to policies and rules that are meant to make energy use more efficient, such as building codes, minimum energy performance standards, and requirements for energy labels. Policies that mandate the use of energy-efficient technology, for instance, may be met with resistance from businesses and individuals who view such mandates as an unnecessary burden or an unnecessary expense. Policies that prohibit the use of particular energy-intensive technologies or impose penalties for noncompliance may also meet opposition [48,49].
Limited technical capacity	Some governments lack the necessary technical competence to fully adopt energy efficiency measures, and this is particularly true for developing nations. Some of these barriers include a scarcity of readily available data and knowledge about energy efficiency, as well as a shortage of trained people capable of designing, installing, and maintaining such technology. In addition, research and development funding for energy efficiency may be inadequate, slowing the introduction of cutting-edge efficiency measures [50–52].
Rebound Effect	The phenomenon of the rebound effect is multifaceted and poses a significant challenge to the achievement of energy efficiency improvements and reduced energy consumption. The rebound effect can be defined as the situation in which energy savings achieved through efficiency improvements are offset by an increase in energy consumption. The rebound effect manifests in two primary forms: direct and indirect [53]. Direct rebound occurs when the efficiency gains in using a particular technology translate into lower costs, which, in turn, incentivizes users to increase their consumption of the technology, thereby offsetting some or all of the energy savings [54]. In contrast, indirect rebound arises when the efficiency improvements lead to reductions in the cost of goods and services, and consumers, as a result, increase their spending, thereby offsetting the gains from energy efficiency improvements by increasing energy consumption [55].

Source: Own elaboration based on the literature.

One of the major aims of improving energy efficiency is to reduce energy consumption. Lower energy expenditures, fewer emissions, and better sustainability are the results of switching to a more energy-efficient system or equipment [56]. Examples given in Figures 3 and 4 show the primary and final energy consumption with regards to the target set for 2030, respectively; based on the example, it is evident that the enhancement of energy efficiency constitutes a potent lever to achieve the energy consumption targets that contemporary societies face.

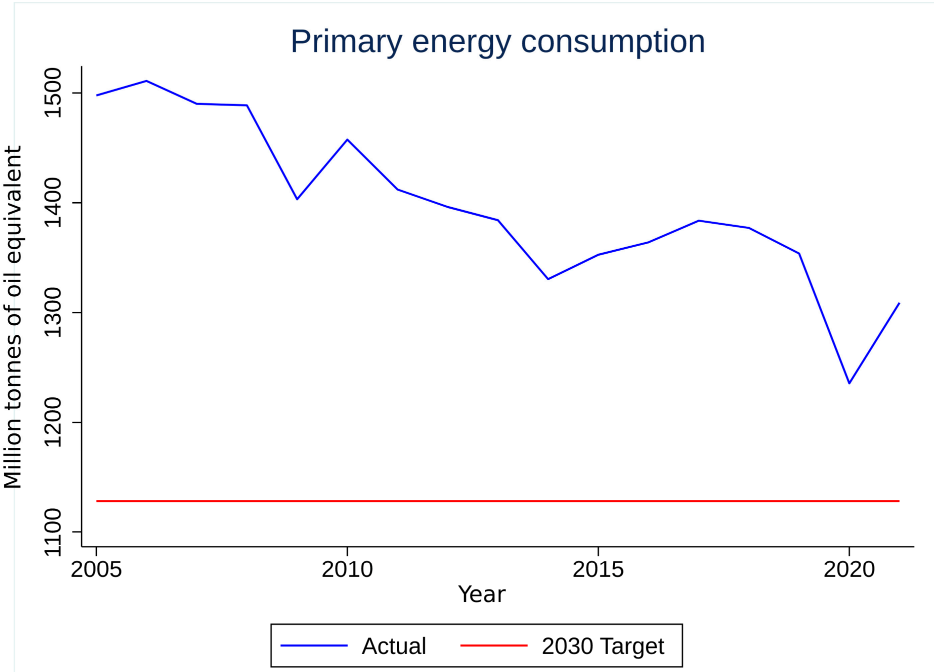

Figure 3. European Union's primary energy consumption with regard to 2030 goals. Source: Own elaboration based on public data available at EuroStat. The data were accessed on 4 February 2022 from https://ec.europa.eu/eurostat/web/main/data/database.

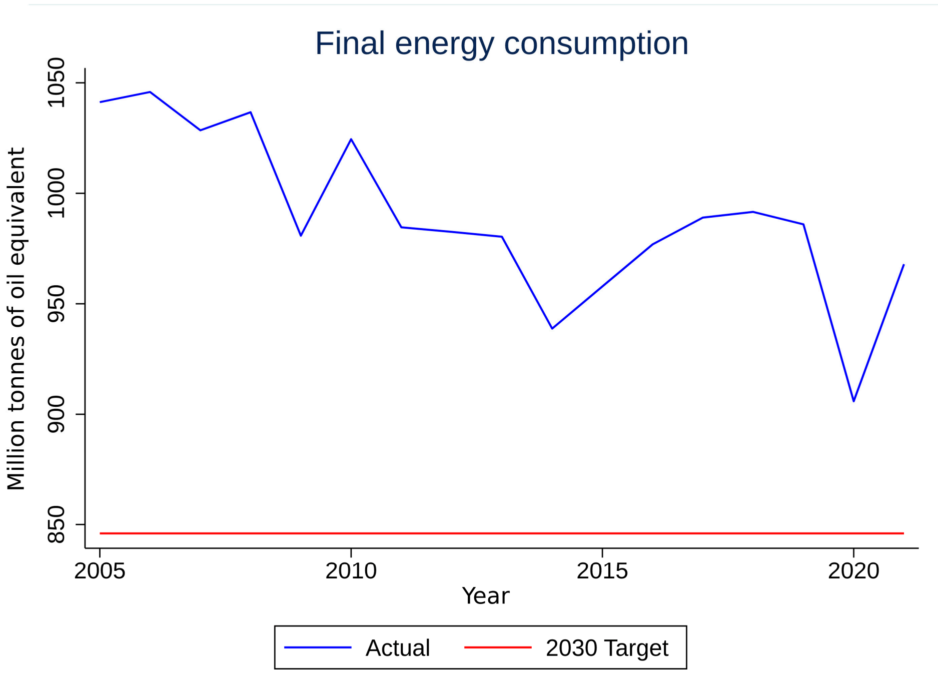

Figure 4. European Union's final energy consumption with regard to 2030 goals. Source: Own elaboration based on public data available at EuroStat. The data were accessed on 4 February 2022 from https://ec.europa.eu/eurostat/web/main/data/database.

Energy efficiency and consumption reduction are two areas where economic policy makes a significant difference. The government can help businesses and individuals save money and reduce their carbon footprint by enacting policies such as tax credits, subsidies, and market-based mechanisms that support the use of more energy-efficient products and methods. This study examines each of these policy measures in depth in Sections 4–6.

3. Statistical Research Trends

Before exploring the policy instruments in the area of energy efficiency, this study explores the existing trends in the literature in regard to energy efficiency and economic policy. We did two searches on Scopus and Web of Science databases to first explain the general trend with search query {"Energy Efficiency" AND "Econom*"} and second for a specific trend {"Energy Efficiency" AND "Economic Policy"}. Web of Science and Scopus databases were accessed on 18 February 2023. The first search rendered 37,695 articles in Scopus and 23,842 articles in Web of Science and the second search resulted in 152 articles in Scopus and 91 articles in Web of Science. This paper presents three key trends: (1) number of articles published annually, (2) top 10 journals based on annual article count publishing related research, and (3) top 10 subject areas based on annual article count published. Exploring research trends allows researchers to gain insightful comprehension about the research landscape, pinpoint knowledge gaps, and prioritize their own research endeavors. Examining variables such as annual article counts, top-rated journals, and subject areas can facilitate a comprehensive understanding of the present state and future direction of research in a specific field [57]. Figures 5 and 6 show the publishing trend in both Scopus and Web of Science for the first and second search, respectively. A trend in general research on economy and energy efficiency started emerging in the mid-1990s and research on economic policy and energy efficiency started to emerge after 2010.

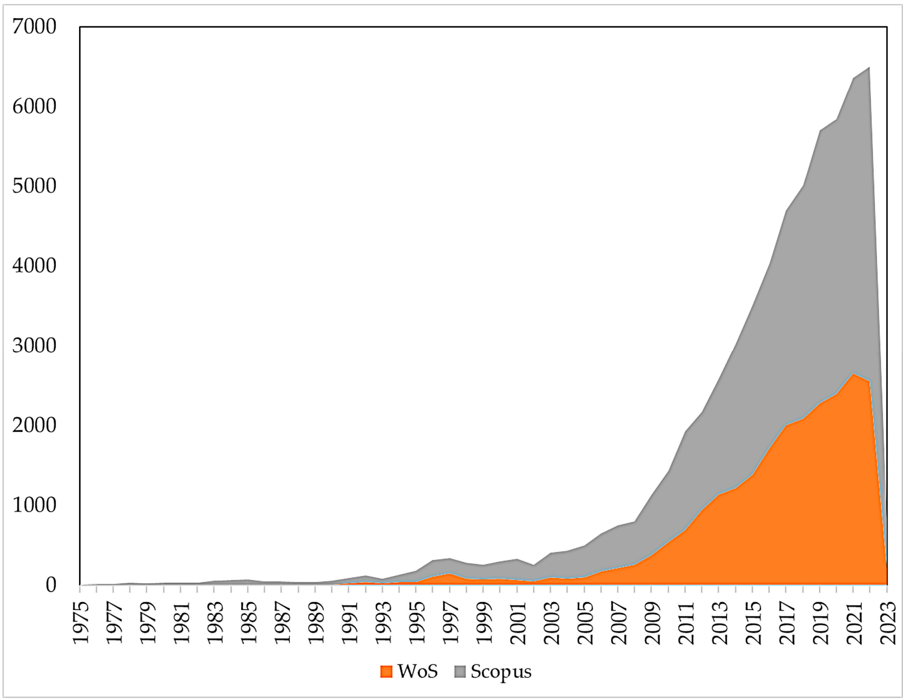

Figure 5. Number of articles published annually using first query. Source: Own elaboration.

Trends regarding journals based on article count are presented in Tables 2 and 3. The results show that for the first search, most of the articles according to Web of Science are published by "Energy Policy" with 931 articles indexed in Web of Science, and as per Scopus, it is "Energy" with 1724 articles indexed in Scopus. In Web of Science indexation, the lowest number of articles are published in "Energy Conversion and Management" with 364 articles. Scopus has 441 articles as the lowest number published in "Renewable and Sustainable Energy Reviews".

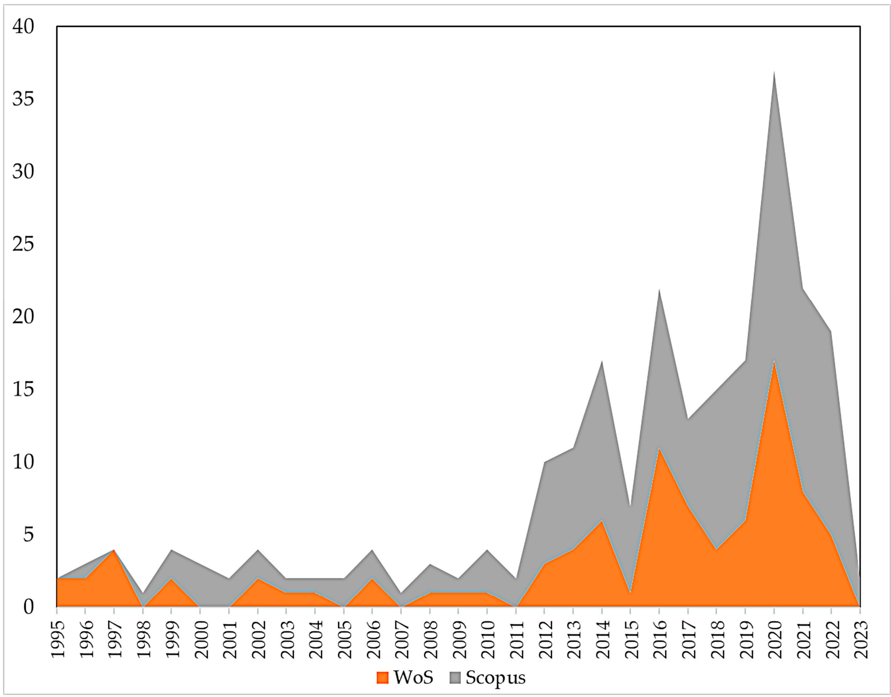

Figure 6. Number of articles published annually using second query. Source: Own elaboration.

Table 2. Top 10 Journals in Web of Science and Scopus for first query.

Journals in WoS	Articles	Journals in Scopus	Articles
Energy Policy	931	Energy	1724
Journal Of Cleaner Production	860	Energy Policy	1232
Energy	799	Applied Energy	1134
Energies	775	Energies	831
Applied Energy	550	Journal Of Cleaner Production	772
Sustainability	550	Sustainability	575
Renewable and Sustainable Energy Reviews	450	Renewable Energy	478
Energy and Buildings	430	Energy Conversion and Management	468
Energy Economics	388	Energy And Buildings	462
Energy Conversion and Management	364	Renewable and Sustainable Energy Reviews	441

Source: Own elaboration based on data from Web of Science and Scopus.

Table 3. Top 10 Journals in Web of Science and Scopus for second query.

Journals in WoS	Articles	Journals in Scopus	Articles
Contemporary Economic Policy	6	Energy Policy	13
Energy Policy	5	Applied Energy	6
American Economic Journal Economic Policy	3	Climate Policy	4
Energy	3	Energy	4
Oxford Review of Economic Policy	3	Energies	3
Asian Economic Policy Review	2	Energy Economics	3
Ecological Economics	2	Environmental Innovation and Societal Transitions	3
Energy Economics	2	International Journal of Energy Economics and Policy	3
Environmental Innovation and Societal Transitions	2	Renewable Energy	3
Equilibrium Quarterly Journal of Economics and Economic Policy	2	Energy and Environment	2

Source: Own elaboration based on data from Web of Science and Scopus.

One conclusion is that articles related to energy efficiency and the economy in general are published in journals related to energy and not in interdisciplinary or economy-related journals. The results for the second search are different, as in the second search the top journal publishing research on energy efficiency and economic policy is "Contemporary Economic Policy", which is a fairly economics-focused journal with six articles indexed in Web of Science.

As per Scopus indexation with 13 articles, "Energy Policy" is top journal. The 10th-ranked journals in Web of Science and Scopus are "Environmental Innovation and Societal Transitions" and "Energy and Environment", respectively. One of the major differences according to publishing research is that in the second search, prestigious journals in economic policy are included in top 10 journals as well, such as "American Economic Journal Economic Policy" and "Oxford Review of Economic Policy".

Figures 7–10 show the top 10 subject areas based on the article count for both the first and second searches in Web of Science and Scopus. For the first search, the top area of research in Web of Science is "Energy Fuels" with 28% of research in this area, and the 10th rank is "Construction Building Technology" with 5% of total research. In Scopus, the top area of research is "Engineering" with 26% of research in this area, and the 10th rank is "Economic, Econometric and Finance" with 3% of total research.

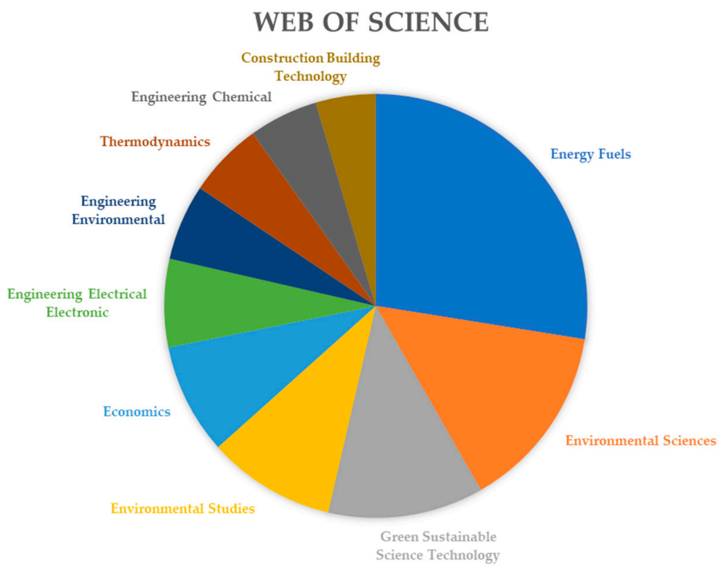

Figure 7. Top 10 subject areas in Web of Science based on articles published annually using first query. Source: Own elaboration.

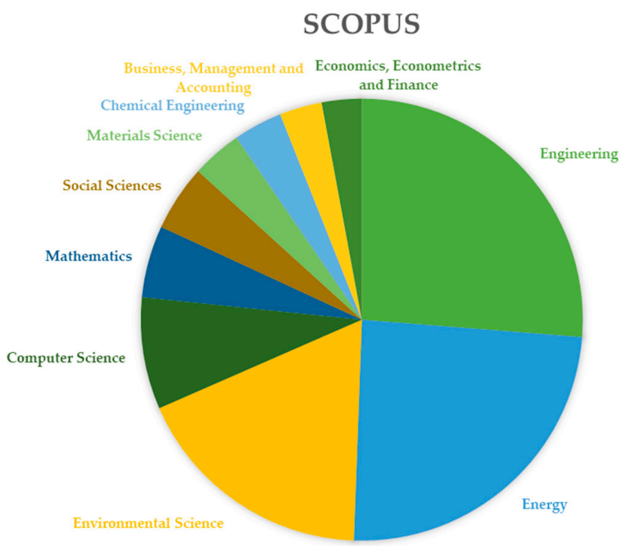

Figure 8. Top 10 subject areas in Scopus based on articles published annually using first query. Source: Own elaboration.

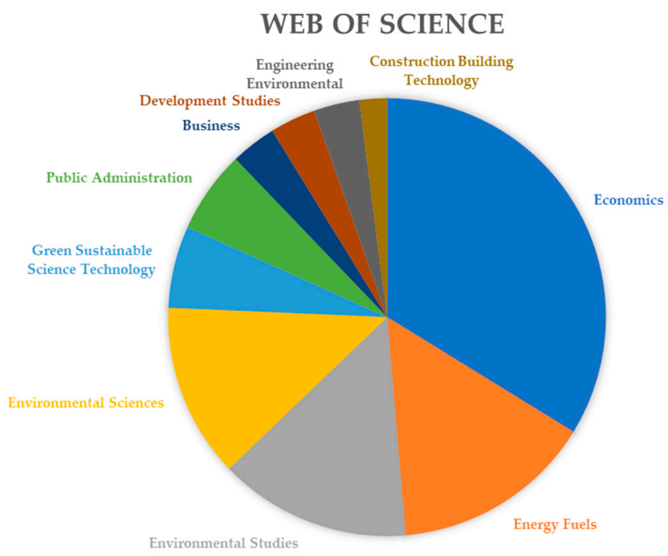

Figure 9. Top 10 subject areas in Web of Science based on articles published annually using second query. Source: Own elaboration.

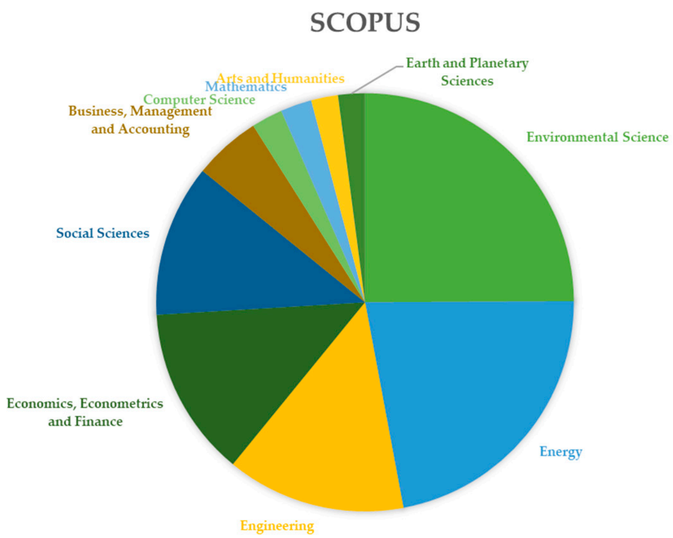

Figure 10. Top 10 subject areas in Scopus based on articles published annually using second query. Source: Own elaboration.

For the second search, the top area of research in Web of Science is "Economics" with 34% of research in this area, and the 10th rank is "Construction Building Technology" with 2% of total research. In Scopus, the top area of research is "Environmental Science" with 25% of research in this area, and the 10th rank is "Earth and Planetary Sciences" with 2% of total research. Confirming the trend from journals, this study found that the second search has a major part, i.e., 13% in "Economics, Econometrics and Finance".

4. Subsidies

Government subsidies are direct monetary payments made to energy-efficient individuals, organizations, and businesses. The fundamental purpose of subsidies is to decrease the cost of energy-efficient technologies, thus making them more accessible and affordable to consumers [58–60]. There are a variety of sorts of subsidies, such as grants, loans, tax benefits, etc. Frequently, subsidies are used to promote the development and implementation of renewable energy sources. Government subsidies may be available to companies that invest in renewable energy technology [61–63]. These subsidies can help reduce the cost of renewable energy systems and increase their competitiveness against conventional energy sources.

Subsidies can also be used to promote the adoption of energy-efficient appliances, cars, and structures. Individuals that purchase energy-efficient appliances or automobiles, as well as enterprises that invest in energy-efficient equipment, receive government incentives. These subsidies can assist in reducing the price of energy-efficient products, making them more accessible and affordable for customers. The United States is an example of a government that has offered incentives to consumers and companies purchasing energy-efficient equipment. The federal government provides a number of incentive schemes for energy-efficient behavior and investment. For instance, the Energy Star program offers tax incentives to people and businesses who invest in energy-efficient appliances and cars. Energy Star was established in 1992 and is administered by the United States Environmental Protection Agency (EPA) and the United States Department of Energy (DOE). The program gives tax credits for appliances, air conditioners, and light bulbs that satisfy specified energy-efficiency criteria. The tax credits are intended to reduce the price of energy-efficient goods and promote their widespread adoption [64–66].

Subsidies can help develop a market for energy-efficient products and services in addition to decreasing the price of energy-efficient technology. By providing financial incentives for energy-efficient behavior and investment, subsidies can encourage firms to develop and install energy-efficient technology and encourage consumers to adopt them [66–68]. Australia's Renewable Energy Target (RET) program serves as a real-world example of incentives that encourage energy-efficient behavior and investment. The RET is a market-based system that offers businesses and people financial incentives to invest in renewable energy technologies, such as solar panels, wind turbines, and hydropower. Under the RET, firms that create renewable energy are compensated for each unit of renewable energy they generate [69–72].

Some interesting findings are reached, and some social phenomena are explicated rationally by [73] while exploring the energy efficiency subsidies under market power. Initially, a rise in total subsidies increases the number of subsidized businesses. In addition, fiercer competition increases the number of enterprises requiring subsidies. Thus, the number of supported companies is contingent upon the level of competition in this field. Second, output subsidies result in a larger consumer surplus and a smaller producer surplus than fixed subsidies. Consequently, consumers prefer output subsidies, whereas companies prefer fixed subsidies. Finally, output subsidies have a more positive influence on the environment and subsidize more businesses than fixed subsidies. Thus, the effects of production subsidies on the environment outweigh those of fixed subsidies. The above-mentioned work supported production subsidies and demonstrated benefits based on the environmental and consumer surplus effects.

Many researchers have argued for housing and vehicular subsidies for energy efficiency. The paper [74] shows that subsidized properties are associated with higher energy consumption than comparable market-rate properties, and that, among subsidized housing schemes, public housing tends to be the most energy-intensive. Despite the potential for retrofitting multifamily homes and the associated cost, energy, and carbon emission reductions, regulatory restrictions limit investment and consumption decisions for subsidized properties. The authors of the paper [75] in their investigation uncovered strong relationships between the quantity of subsidies received per capita in districts and characteristics indicating territorial stability and social capital. There are considerable disparities in the rate of subsidy receipt between regions that are considered economically disadvantaged and where the danger of energy poverty is greater. While border communities in the eastern United States demonstrate an above-average usage of funding for the insulation of existing homes, persons in larger cities and their suburbs are more likely to use subsidies for a new home. The results imply that subsidies should be redistributed and targeted more precisely in accordance with the program's stated goals.

As presented in [76], if the subsidy is insufficient, a low-cost firm may manufacture an uncertified product while a high-cost firm produces a certified product. Additionally, the government's optimal endogenous subsidy scheme operates under three distinct objectives: minimizing total energy consumption, average energy consumption per product, and average energy consumption per unit of GDP. In order to minimize total energy consumption, it is sometimes ideal to induce the low-cost firm to make an uncertified product and the high-cost firm to produce a certified product.

From the perspective of vehicles, the author of [77] suggested that subsidies for electric cars should be reduced or eliminated, with a focus on rapid increases in the fuel efficiency of light-duty vehicles, which will have positive spillover effects on the final energy intensity of electric vehicles and mineral needs following a delayed market scale-up. The author of the paper [78] recommended, instead of subsidizing, mandating the early market uptake of plug-in hybrid electric vehicles (PHEVs) and hybrid electric vehicles (HEVs). Furthermore, it is added that a preferable plan would be to rapidly boost automotive fuel economy requirements to that which can be attained only with HEVs, with moderate support for PHEVs, followed by the support for energy-efficient PHEVs and/or battery electric vehicles (BEVs) if scientific advancements essential for century-scale sustainability are accomplished.

While exploring evidence from China, the authors of [79] discovered that government subsidies had a substantial crowding effect on the R&D intensity of new energy vehicle (NEV) companies. As government subsidies increase, the crowding impact progressively decreases. From the aspect of EU-27, the authors of [80] report that the results are very diverse, depending on the power mix of each nation analyzed, and they indicate that the proposed subsidies can create advantages for consumers in countries that employ the greatest renewable energy sources. Using recent experiences from Estonia, the authors of [81] evaluated the energy renovation subsidy program and found that the distribution of renovation subsidies is linked to geographic socio-economic metrics and that real estate value explains 40% of subsidy distribution differences across geographic areas.

The research of [82] examined how government subsidies for energy efficiency in residential buildings could be best distributed to achieve maximum cost savings. The case study of the Danish municipality of Lyngby-Taarbaek was discussed, revealing systemic bias in heat demand estimations, with the result that older homes were incorrectly assigned a higher heat need than they had. As a result of this bias, 39% of all CO_2 emissions are improperly allocated, and 40% of all subsidies are skewed.

It is essential to realize that subsidies might sometimes have significant disadvantages. Subsidies, for instance, might distort market signals, resulting in inefficient resource allocation. Subsidies can also foster reliance on government assistance, which can lead to market instability if government policies are altered. Subsidies are routinely utilized as a policy instrument to improve energy efficiency despite these potential downsides. Subsidies can aid in reducing energy consumption, cutting greenhouse gas emissions, and conserving natural resources by lowering the cost of energy-efficient technology and promoting their adoption.

5. Tax Incentives

Tax incentives are a type of economic policy that is used to encourage energy efficiency by making it cheaper to act and invest in ways that use less energy [83]. Tax incentives work by giving people or businesses who invest in energy-efficient products, technologies, or ways of doing business tax breaks or lower taxes. Tax incentives can come in the form of tax credits, tax deductions, tax exemptions, or other types of tax relief [84,85]. Tax breaks are a common way to encourage people to use less energy because they are easy to set up and can be tailored to specific actions or investments. For example, tax incentives can be used to get people to buy appliances or cars that use less energy, or to get businesses to invest in equipment that uses less energy. Tax breaks may be directed towards encouraging modifications to buildings that can result in significant energy savings and reduced emissions of greenhouse gases [86].

Tax incentives confer a financial advantage to individuals or organizations that alter their energy usage patterns or invest in energy-efficient technologies. This provides an impetus for such entities to undertake sustainable energy practices that can contribute to a reduction in greenhouse gas emissions and environmental conservation. By making these actions and investments cheaper, tax incentives can get more people to use energy-efficient products and practices, which can help cut energy use and greenhouse gas emissions [87,88]. For instance, The Energy Efficient Homes Tax Credit works by giving people who make changes to their homes that save energy a tax credit. The tax credit pays for a portion of the cost of the upgrades, which helps to lower the total cost of the improvements. So, people who use the tax credit are more likely to put money into energy-efficient home improvements, which can help them use less energy and release less greenhouse gases. Another benefit of tax incentives is that they are usually easy to change or adjust to keep up with changes in the energy market or in technology. Tax breaks can be changed to reflect changes in the prices of energy-efficient products or to encourage the use of new technologies that use less energy [89].

In the paper [90], findings imply that incentives to promote the use of energy-efficient appliances may be cost-effective, but whether they are or not depends on the specific nation and the alternatives being considered. In Denmark and Italy, tax credits on boilers appear to be a cost-effective choice, whereas in France and Poland, subsidies on compact fluorescent lamp (CFLi) bulbs are cost-effective in terms of €/ton of carbon dioxide (CO_2) abated. Comparing the subsidies to the energy tax choices, the authors discovered that most of the time, the energy tax is more cost-effective than the subsidies.

According to a study of the effectiveness of current and former energy efficiency tax incentives by [91], the 10% energy efficiency tax credits implemented in 1978 were ineffective at generating significant energy savings because they encouraged the same tried-and-true energy efficiency measures that many customers and companies were installing on their own, leading to high costs for "free riders" (consumers and businesses that would have installed the efficiency measures regardless of the tax credits). In addition, the tax incentive was insufficient to encourage new installations.

While exploring the role of tax incentives in encouraging energy efficiency, the research in [92] found that while tax incentives certainly play a part in decision making, other non-tax considerations affect South African enterprises' decisions to engage in energy efficiency and/or renewable energy projects, according to the findings. These firms did not consider the present tax incentives to be useful or sufficiently motivating for them to alter their environmental practices.

Tax incentives to modernize the energy efficiency of housing in Spain were explored in [93]; their findings showed that a monetary approach to encouraging residential energy efficiency is advantageous. In this regard, it suggests adding an incentive to the personal income tax tied to an increase in the energy efficiency rating of homes. In addition, it proposes changes to the present laws governing tax advantages for the real estate tax and the tax on building, installations, and infrastructure work.

From the perspective of China's value-added tax reform, the research in [94] indicated that the reform decreases enterprises' coal intensity by around nine percent. After the reform, coal intensity decreased more for large-scale enterprises, firms in energy-intensive industries, and private firms. This policy reduces energy consumption by encouraging businesses to invest in fixed assets and increase output. Nonetheless, tax benefits are not without restrictions. One difficulty with tax incentives is that they can be difficult to comprehend and implement, especially for small enterprises and individuals unfamiliar with the tax system. In addition, tax incentives may be costly to execute and have a major impact on government finances if they are not carefully targeted [95]. To be efficient and to have the least possible impact on government finances, tax incentives must be properly developed and administered.

6. Market-Based Mechanisms

Market-based methods are economic programs that employ market forces to increase energy efficiency [96,97]. These strategies are designed to generate a market-driven incentive for individuals and organizations to adopt energy-efficient behaviors and invest in energy-efficient technology. Market-based strategies include white certificate emissions trading systems (cap-and-trade schemes), and renewable energy regulations, among others. Emissions trading systems, commonly referred to as cap-and-trade programs, function by placing a limit on the total quantity of greenhouse gas emissions that may be produced in a certain region or industry. Companies that release greenhouse gases are thus obliged to possess emissions permits, with each permit reflecting the authority to emit a particular quantity of greenhouse gases [98,99]. Creating a market for emissions reductions, firms that pollute less than their allowances may sell their unused allowances to enterprises that emit more than their limits [100,101]. This market-driven incentive encourages businesses to cut their emissions and adopt energy-efficient practices and technology, as doing so reduces their emissions and the number of permits they must hold [102,103].

Market-based mechanisms have been proposed as a policy tool to promote energy efficiency, and one such mechanism is the use of white certificates. White certificates are a type of tradable instrument that serve as evidence of energy savings achieved by organizations, and they can be traded on a market that creates a competitive environment that incentivizes organizations to reduce their energy usage and encourage energy efficiency [104,105]. The use of white certificates can create a competitive market that drives down the cost of energy efficiency investments and encourages the development of new energy-saving technologies, thus facilitating the transition towards a sustainable economy [106,107]. This market can help overcome barriers to energy efficiency investment, such as the high upfront cost of energy-saving investments and the difficulty of measuring energy savings accurately. By promoting investment in energy efficiency, white certificates can help reduce energy consumption, greenhouse gas emissions, and promote sustainable development. Overall, white certificates can be an effective policy tool for promoting energy efficiency and contributing to climate change mitigation efforts [108–111].

The European Union Emissions Trading System (EU ETS) is a cap-and-trade system covering over 11,000 power plants and industrial units in 31 nations. It was established in 2005 and is the largest carbon market in the world. The system imposes a limit on the total amount of greenhouse gas emissions that may be generated by covered facilities and allocates a limited number of permits, each reflecting the right to release a particular quantity of greenhouse gases. The EU ETS has successfully reduced greenhouse gas emissions in the electricity and industrial sectors and offered a market-driven incentive for businesses to adopt energy-efficient practices and technology [112–114].

Renewable energy requirements, also known as renewable portfolio standards, are an additional market-based mechanism that encourages energy efficiency. Electricity suppliers are required under renewable energy standards to generate a particular amount of their electricity from renewable energy sources. The EU's Green Public Procurement (GPP) sets a criteria at 50 percent [115]. These criteria provide a market demand for renewable energy, which stimulates investment in renewable energy technologies and promotes the development and deployment of these technologies [116].

As a policy instrument for increasing energy efficiency, market-based methods provide several benefits. Individuals and corporations are incentivized by the market to adopt energy-efficient habits and invest in energy-efficient technologies. These strategies can be more successful and efficient than command-and-control rules since they rely on market forces to promote energy efficiency [117,118]. Second, market-based procedures are adaptable and simple to modify in response to changes in energy markets and technology [119,120]. For instance, emissions trading systems can be modified to reflect changes in the cost of emissions reductions or to adapt to alterations in the trend of greenhouse gas emissions. Lastly, market-based procedures can be cost-effective because they let people and enterprises select the most cost-effective means of reducing energy use and emissions.

Summarizing the research in market-based processes, these are essential and efficient instruments for increasing energy efficiency. These approaches can be more effective and efficient than classic command-and-control rules by generating a market-driven incentive for energy efficiency and employing market forces to promote energy efficiency. Moreover, market-based procedures are quickly adaptable to changes in energy markets and technology, making them an appropriate policy instrument for encouraging energy efficiency in a fast-changing energy landscape.

7. Conclusions

To ensure long-term prosperity, energy efficiency is essential. To conserve natural resources, lessen reliance on fossil fuels, and boost public health, its primary value is in lowering energy use and greenhouse gas emissions. Promoting energy efficiency through the introduction of economic policies that offer financial incentives to individuals and businesses has been shown to be an effective strategy. Table 4 presents the solution to existing issues in energy-efficiency adoptions based on the literature review.

Table 4. Solution of the problems faced in implementation of efficient energy consumption through economic policy.

Issues	Subsidies	Tax Incentives	Market-Based Mechanisms
Lack of financing	In order to combat the shortage of funding and make energy-efficient solutions more widely available and affordable, subsidies can provide direct financial assistance for their implementation.	Offering tax credits or deductions for investments in energy efficiency is one way that government programs may help bring down the price of energy-saving technology and practices. This has the potential to increase the demand for and adoption of energy-efficient solutions.	Market-based methods, such as cap-and-trade systems or carbon taxes, can place a price on carbon emissions, providing a financial incentive for firms and individuals to adopt energy-efficient technology and practices. As the price of carbon emissions rises, this might spur investment in efficient energy technologies.
Barriers to the adoption of energy efficiency technologies	By providing financial support for promotion, dissemination of information, installation and demonstration of these technologies, research and development, and the creation of stakeholder networks, subsidies can address the lack of awareness and access to information about energy-efficient technologies.	Increased public knowledge and the lower purchase prices made possible by tax incentives are two ways in which these kinds of technology might be made more widely available.	By providing a financial incentive for companies and individuals to adopt energy-efficient technology, market-based processes can aid in spreading energy efficiency knowledge. This can reduce the barriers to adopting energy-efficient solutions and help people adjust to the new normal.
Resistance to policy and regulatory measures	Subsidies provide monetary assistance for the adoption of energy-efficient technology and practices, which can help overcome resistance to policy and regulatory initiatives. With this backing, energy-efficient solutions may be made more easily accessible and inexpensive, which in turn can boost adoption and lessen resistance to change.	By making energy-efficient solutions more appealing and accessible and by lowering their cost, tax incentives can help diminish opposition to policy and regulatory actions.	In order to lessen opposition to policy and regulatory measures, market-based mechanisms might offer a financial incentive for firms and individuals to adopt energy-efficient technology and practices.
Limited technical capacity	Providing financing for energy efficiency research and development, as well as the training and development of trained professionals, is one way in which subsidies may help solve a shortage of technical competence.	Tax breaks can help alleviate a lack of technical expertise by stimulating investment in energy efficiency research and development and making professions in energy efficiency more appealing.	By providing a financial incentive for investment in energy efficiency R&D and the training of trained individuals, market-based methods can help alleviate the shortage of technical talent. To achieve this, market signals such as carbon pricing, emissions trading systems, and performance-based incentives are used to encourage people and companies to adopt more energy-efficient technologies and practices.

Table 4. *Cont.*

Issues	Subsidies	Tax Incentives	Market-Based Mechanisms
Rebound Effect	If the rebound effect proves to be considerable, it may be necessary to reevaluate the efficacy of subsidies for energy efficiency measures. In some instances, it may be necessary to curtail or terminate subsidies to prevent the rebound effect from nullifying potential energy savings. Nevertheless, it is crucial to consider the broader economic and social consequences of such a decision. Subsidies may be indispensable in promoting the adoption of energy-efficient technologies, particularly in low-income and disadvantaged communities, where the initial expenses associated with such technologies may represent a barrier to adoption.	Tax incentives can serve as an effective tool to discourage excessive energy consumption, and one way of achieving this is by implementing taxes on energy consumption. This mechanism motivates individuals and businesses to curb their energy usage to avoid paying higher taxes. As a result, such a measure encourages more efficient energy use, as individuals and businesses may be inclined to seek out more energy-efficient technologies or modify their energy consumption behavior.	Market-based mechanisms, including emissions trading or carbon taxes, can be employed as effective means of reducing the rebound effect. These mechanisms help internalize the negative externalities associated with energy use and incentivize energy-efficient behavior by raising the cost of energy consumption. This increased cost can motivate individuals and businesses to seek ways to reduce their energy consumption, thereby promoting more efficient energy use.

Source: Own elaboration based on literature.

Subsidies have been found to enhance the market for energy-efficient products and services, as well as stimulate energy-efficient behavior and investment. However, other research has indicated that energy efficiency incentives are not effectively targeted, with the majority of beneficiaries being higher-income homeowners. In addition, there are inequalities in the rate at which different regions get subsidies; low-income communities, which are more vulnerable to energy insecurity and the adverse effects of climate change, receive a smaller share of the total subsidies awarded. Energy subsidies can have the greatest impact if they are tailored to help the most disadvantaged members of society while also providing funding for low-carbon technologies that have broader social and economic advantages.

It has been determined that tax incentives play a substantial role in promoting energy efficiency, decreasing energy consumption, and lowering greenhouse gas emissions. These incentives provide financial benefits to individuals and organizations that invest in energy-efficient products, technology, or practices, therefore increasing their accessibility and desirability. The efficiency of tax incentives varies by country, policy option, and implementation procedure. It has been determined that certain tax incentives, such as the Energy Efficient Homes Tax Credit, are cost-effective and yield significant energy savings. However, the 1978 10% tax credits for energy efficiency were deemed inadequate due to their inability to motivate new installations and their high costs for “free riders”. Some studies have also indicated that non-tax factors, such as personal values and environmental responsibility, have a considerable effect on energy efficiency decisions.

Emissions trading systems, cap-and-trade schemes, and renewable energy regulations are all examples of market-based methods that have been shown to be effective economic programs for encouraging people and businesses to adopt energy-efficient behaviors and invest in energy-efficient technology by harnessing the power of market forces. Successful examples of cap-and-trade systems that have decreased greenhouse gas emissions in the power and industrial sectors include the EU ETS. Regulations mandating that power companies increase their use of renewable energy sources by a specific percentage are known as renewable portfolio standards. Because of their versatility, low cost, and reliance on market forces to promote energy efficiency, market-based solutions have shown to be an efficient policy instrument for doing just that.

Evaluation of Economic Policy

It is essential for governments to evaluate a policy as much as it is to introduce policies. This study discusses two major policy evaluation methods for energy efficiency (1) Evaluation, measurement, and verification (EM&V) and (2) Cost-effectiveness metrics.

Evaluation, measurement, and verification (EM&V) are critical components of any effective economic policy designed to promote energy efficiency and sustainability [121,122]. The main objective of EM&V is to assess the effectiveness of energy efficiency policies by measuring their impact on energy consumption and the environment. The evaluation process involves gathering data and analyzing it to determine the efficacy of energy policies, while measurement and verification involve quantifying the energy savings achieved through the implementation of these policies [123]. This information is then used to improve the policies and ensure that the goals of energy efficiency and sustainability are met [124].

From an economic policy perspective, EM&V is essential to ensure the success of energy efficiency policies. Without effective evaluation, it is impossible to determine the impact of policies or identify areas for improvement. EM&V can provide a systematic approach to assess the effectiveness of energy efficiency policies, including subsidies. This approach involves the collection, analysis, and interpretation of data to evaluate the impact of policies on energy savings and other relevant outcomes. By measuring the energy savings achieved by the technology or practice being incentivized by subsidies, taxation or market-based mechanisms, policymakers can determine if the policy instruments are achieving their intended goals and if they are cost-effective.

Secondly, cost-effectiveness metrics are crucial in assessing the economic viability of various policy options, including those related to energy efficiency [125,126]. Such metrics enable policymakers to measure the efficiency of policies by weighing their costs against their benefits [127,128]. Benefit–cost tests are a specific type of cost-effectiveness metric that aim to compare the net benefits of a policy to its costs while also considering its broader economic, social, and environmental impacts [129]. Policymakers can use benefit–cost tests to identify the most cost-effective policy options that maximize policy efficiency by allocating resources optimally. The use of such metrics can also ensure that policies do not impose undue burdens on businesses or individuals, which can undermine their effectiveness and lead to opposition [130]. Therefore, it is important to employ cost-effectiveness metrics in evaluating the economic impacts of policies such as subsidies, tax incentives, and market-based mechanisms, as they aid policymakers in identifying the most effective and efficient policy options.

8. Future Research Directions

More research is needed to find the best way to direct funding for energy efficiency programs to the people and places that may benefit the most. Future research directions are outlined in two aspects: (1) specific to the economic policy instruments discussed in this paper and (2) other possible areas of research. Incentives might be targeted to low-income neighborhoods or individuals by employing "tagging" or other technologies that identify regions with high rates of energy poverty. Researchers might look into the environmental consequences of various subsidy programs to find the ones that are best at boosting energy efficiency and cutting carbon emissions.

Studies might be undertaken to evaluate the effectiveness of subsidies in lowering energy usage in various settings, such as households, companies, and other public places. Having this data would be helpful for policymakers as they try to figure out how effective subsidies are in increasing energy efficiency. Studies might be done to assess how subsidies affect energy markets and the competitiveness of renewable energy sources. The effect of subsidies on energy costs and the spread of renewable energy sources might be examined as part of this process. The social and economic effects of subsidies, including their dispersion across regions and communities, might be the subject of future research.

Some possible research areas for research on tax initiatives and energy efficiency could be in the following areas: effectiveness of different types of tax incentives, cost-effectiveness of tax incentives, further analysis of the financial benefits of tax incentives for various energy-efficient products and practices across countries. The impact of tax incentives on government finances, the effectiveness of tax incentives in different industries, and companies' decisions to invest in energy efficiency and/or renewable energy projects can be explored by future research into the non-tax variables, beyond tax incentives, that influence such decisions. Moreover, studies can be conducted to explore how successful tax incentives are for small businesses and individuals who may not be familiar with the tax system and have trouble understanding and using the incentives. Value-added tax reforms may have an influence on energy usage; more research is needed to quantify this effect and establish how the reforms might be improved.

Some potential avenues for future study with regards to market-based mechanisms can be examining how various market-based approaches, such as carbon trading systems, cap-and-trade programs, and renewable energy standards, might best encourage energy efficiency and cut down on greenhouse gas emissions. The feasibility of adapting and improving market-based approaches in light of developments in energy markets and technologies is now being investigated. Examining how market-based approaches to improving energy efficiency stack up against other policy instruments in terms of cost-effectiveness can be useful. How organizations and individuals are affected by market-based approaches, as well as the incentives offered to encourage the adoption of energy-efficient practices and technologies, can be analyzed. Further work can also analyze the cultural, political, and economic aspects that may affect the success of using market-based approaches in various areas and sectors. These avenues for further study have the potential to expand upon the current body of knowledge and furnish policymakers with more solid information upon which to base their judgments about the usage of subsidies as a means of encouraging energy efficiency and lowering carbon emissions.

Generally, the convergence of energy efficiency and economic policy offers promising prospects for novel research initiatives. One potential research direction is the utilization of big data and machine learning methodologies to create more precise and effective assessment techniques for energy efficiency policies. To illustrate, data-driven approaches could be applied to gain deeper insights into the effects of different policy designs and implementation approaches on energy savings and economic ramifications.

Another potential area for research is the establishment of novel financial instruments that incentivize energy efficiency investments. For instance, the deployment of blockchain technology to create a decentralized platform for energy efficiency investments could surmount conventional financing barriers, including high transaction costs and a lack of transparency. Furthermore, future research could investigate the social equity and environmental justice implications of energy efficiency policies. By analyzing the distributional impacts of policies on low-income and marginalized communities, policymakers could gain a better understanding of the potential unintentional consequences of policy interventions and design more effective and equitable policies.

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