Energy Efficiency and Economic Policy

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Reduced energy consumption and emissions of greenhouse gases are the results of increased energy efficiency. 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. 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. 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. 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.

energy efficiency economic policy incentives

1. 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 [1][2][3]. 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 [4][5][6]. 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 [7][8][9].

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 [9][10][11]. 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 [12][13][14][15].

Some interesting findings are reached, and some social phenomena are explicated rationally by [16] 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 abovementioned 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 [17] 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 [18] 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 [19], 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 [20] 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 [21] 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 [22] 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 [23] 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 [24] 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 [25] 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.

2. 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 [26]. 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 [27][28]. 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 [29].

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 [30][31]. 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 [32].

In the paper [33], 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 [34], 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 [35] 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 [36]; 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 [37] 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 [38]. To be efficient and to have the least possible impact on government finances, tax incentives must be properly developed and administered.

3. Market-Based Mechanisms

Market-based methods are economic programs that employ market forces to increase energy efficiency [39][40]. 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 [41][42]. 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 [43][44]. 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 [45][46].

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 [47][48]. 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 [49][50]. 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 [51][52][53][54].

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 [55][56][57].

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 [58]. 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 [59].

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 [60][61]. Second, market-based procedures are adaptable and simple to modify in response to changes in energy markets and technology [62][63]. 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.

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