Cost-Benefit Analysis of a Policy that will Limit Carbon Dioxide Emissions of Diesel-Powered Generator.

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DOI: https://doi.org/10.56293/IJASR.2022.5543

IJASR 2023
VOLUME 6
ISSUE 4 JULY – AUGUST **ISSN: 2581-7876**

Abstract: This paper presents a detailed economic analysis of a proposed regulation to limit carbon dioxide emissions from diesel generators in the United States. The analysis is conducted through a cost-benefit framework, with the objective of determining whether the societal benefits of reduced carbon dioxide emissions would outweigh the economic costs of the regulation. The study draws from previous research on the application of cost-benefit analysis in the context of environmental policy, particularly climate change. It then estimates the potential benefits from avoided carbon dioxide emissions, and contrasts these with the costs that could arise from implementing carbon capture technologies, a reduction in the diesel generator sector's value, and a drop in diesel fuel demand. The results suggest that the economic costs of the proposed regulation outweigh the benefits, both in the short term and the long run. However, the paper concludes with a call for continued efforts in finding economically and environmentally balanced solutions to reduce carbon dioxide emissions, particularly in sectors with significant contributions like the electric power sector.

Keywords: Cost-Benefit Analysis, Carbon Dioxide Emissions, Diesel Generators, Environmental Regulation, Carbon Capture, Alternative Energy Sources, Diesel Fuel Demand, Economic Impact, Environmental Policy.

1.0 Paper Thesis

Cost-benefit analysis shows that a policy passed that will prevent diesel generators from emitting more than 0.3kg of carbon dioxide per kWh is an inefficient way to tackle climate change because the costs of bringing the regulation to fruition are higher than the benefits, even if we attach high values to reducing carbon emissions.

2.0 Environmental Issue and Policy

Carbon dioxide is an important heat-trapping gas, or greenhouse gas, that comes from the extraction and burning of fossil fuels, wildfires, and natural processes like volcanic eruptions. The largest source of carbon dioxide is the combustion of fossil fuels. This produces 87% of human carbon dioxide emissions. Burning these fuels releases energy, most commonly turned into heat, electricity, or power for transportation. Some examples of where they are used are in power plants, cars, planes, and industrial facilities. In 2011, fossil fuel use created 33.2 billion tons of carbon dioxide emissions worldwide. There are many fuels available today, and diesel is one of them; diesel is one of the fossil fuels that can be extracted from crude oil; diesel is a liquid fuel specifically designed for use in a diesel engine, a type of engine in which fuel ignition takes place without a spark as a result of compression of the inlet air and then injection of fuel. Therefore, diesel fuel needs good compression ignition characteristics. One of the major uses of diesel is to power a generator. Diesel-powered generators are built to provide significant amounts of power for a long time. Because of their efficient engine design and fuel consumption, the motors can run far longer than a standard gasoline engine.

Diesel-powered generators are much more efficient than others, and presently, owing to the growing instances of power outages and rising development of hotels, corporate offices, and homes, the United States diesel generator market is expected to reach $3,132.4 million by 2030 from $2,175.6 million in 2021, at a 4.1% compound annual growth rate from 2021 to 2030.

The burgeoning diesel generator market in the United States is a positive thing for the economy. Still, if we evaluate the situation meticulously, we recognize that there's a trade-off here between the economic benefits and the environmental harms to our planet. The growing market for diesel generators means carbon dioxide emissions would rise, which is very bad for our climate.

Greenhouse gases like carbon dioxide essentially trap heat on the planet. The more emissions increase, the more effect this has on the atmosphere, raising temperatures on our planet and leading to climate change; between 2000 and 2020, the Earth's emissions more than quadrupled from the previous decade.

At the current rate, this high carbon dioxide level doesn't directly affect humans. Still, the side effects it causes on nature could be detrimental in the longer term if major efforts are not made to slow carbon emissions down. Some of the major long-term effects are: heat waves, which is already the deadliest type of extreme weather, and an increase in carbon dioxide directly leads to increased temperatures; the hotter it gets, the more challenging it will be to survive; pollution, this currently kills nine million people worldwide per year, higher levels of carbon dioxide increase pollution levels worldwide, leading to more human deaths for every degree increased; insect plagues, warmer weather increases the arrival of mosquitos, ticks and other disease-carrying insects, these pests expand their territory and remain longer before the cold weather removes them, essentially increasing the potential victims of their diseases; hurricanes, fires and other natural disasters, as the Earth gets warmer, the ice melts, causing higher sea levels, this ultimately impacts our natural weather patterns, causing an increase in hurricanes and large storms; and increase in forest fires burning for a more extended period because the trees and vegetation are dryer and more flammable.

Also, increasing carbon dioxide emissions has a negative effect on our oceans. Almost a quarter of all carbon dioxide emissions are absorbed by ocean vegetation and become fixed in ocean plants. These plants absorb carbon dioxide much like land plants, except most end up dissolved in the oceans, causing ocean acidification. Ocean acidification's long-term impact includes dissolving our ocean's natural coral reefs. The increased acid levels also impact shellfish. We see the corrosive water deteriorate their shells before they mature, causing lasting damage.

In addition, plants use sunlight, carbon dioxide from the atmosphere, and water for photosynthesis to produce oxygen and carbohydrates that plants use for energy and growth. Rising levels of carbon dioxide in the atmosphere drive an increase in plant photosynthesis, known as the carbon fertilization effect. However, elevated carbon dioxide levels is not all good news for plants.

It's more complicated than that because climate change also impacts other factors critical to plants' growth, such as nutrients, temperature, and water. Researchers that studied hundreds of plant species between 1980 and 2017 found that most unfertilized terrestrial ecosystems are becoming deficient in nutrients, particularly nitrogen. They attributed this nutrient decrease to global changes, including rising temperatures and carbon dioxide levels. Higher temperatures and an increase in moisture also make crops more vulnerable. Weeds, many of which thrive in heat and elevated carbon dioxide, already cause about 34 percent of crop losses; insects cause 18 percent of losses and disease 16 percent. Climate change will likely magnify these losses.

2.1 Proposed Policy

Because of the importance of this issue, a policy to limit and reduce carbon dioxide emissions from diesel electric generators in the United States would mitigate the damages expected to occur. Since the Environmental Protection Agency (EPA) has regulatory jurisdiction over carbon dioxide emissions under the Clean Air Act. The Environmental Protection Agency (EPA) can publish an advance notice of proposed rulemaking to limit carbon dioxide emission from diesel- powered generators.

The proposed rule would specify limits on carbon dioxide emission rates for diesel-powered generators of various engine sizes and other engine characteristics on emissions, generator size, weight, and hazard patterns and the different challenges that may be faced in meeting emission rates expressed in kilogram per kilowatts hour. My research proposes a maximum of 50kg per kilowatt hour of carbon dioxide emission from diesel-powered generators and evaluates its efficiency.

The proposed regulation's purpose is not to dictate how generators would meet the carbon dioxide emission limits. Instead, under the proposed rule, firms and other end users would be flexible in determining the appropriate technology to meet the specified performance requirements. Firms and households that use diesel generators and diesel generator traders would be the regulated parties.

This proposed regulation will negatively affect firms and other diesel generators' end-users; they would have to limit their use of diesel generators or capture their carbon emissions which will increase production costs. This cost increment might lead to the closing of firms and businesses that cannot compete on a cost basis. Investment and exports of goods and services would be lower. Although captured carbon dioxide can be put to productive use in enhanced oil recovery and the manufacture of fuels, building materials, and more, most times, it's stored in underground geologic formations. In addition, some firms and households that don't need heavy-duty generators per se will turn to other unregulated fossil fuel-powered generators, manoeuvre the regulation, and keep polluting; with this, there will still be a drop in the demand for diesel-powered generators, which will have a negative effect on the burgeoning sector, consequently, creating a lose-lose situation.

3.0 Literature review

No research to date has explored the proposal of regulation that will limit the emission of carbon dioxide from diesel-powered generators using benefit-cost analysis. However, researchers have explored benefit-cost analysis when tackling other environmental issues related to carbon emissions. Alan S. Manne and Richard G. Richels (1990) used cost-benefit analysis to evaluate the reduction of carbon dioxide emission in the U.S.; the paper analyzed the result of carbon constraints and concluded that there's a need for more research and development on the topic. This led me to the method of carbon capture of fossil fuels emissions; several studies have explored the method of carbon capture of fossil fuels to mitigate carbon dioxide emissions that's going out of hand (Özge İşlegen and Stefan Reichel stein; 2011); they used benefit-cost analysis and found out that emissions cost $30 and $60 per tonne of carbon dioxide would be break-even value for coal fire plant and natural gas plant respectively.

Some research systematically reviewed the limits of cost-benefit analysis when applied to climate change, as not all climate issues have data readily available; Jonathan S. Masur & Eric A. Posner (2011) assessed the limit of benefit-cost analysis and concluded that the framework does not work well with political questions involving contested normative issues, which is not data intensive. Still, some assumptions were made to be able to come up with numbers used for the research.

Also, Anthony R. Raduazo (2018) evaluated the disparate treatment of greenhouse gas emissions in the regulatory cost-benefit analysis and the National Environmental Protection Act review contexts; he concluded firmly without much data that the social cost of carbon integration into the National Environmental Protection Act review process is both normatively desirable and legally feasible.

To conclude, Dagobert L. Brito and Robert F. Curl (2011) estimated the cost of carbon dioxide restrictions in the production of electricity; after deciphering the cost, they concluded that using other energy sources can help reduce carbon dioxide emissions without much cost. This Paper uses Dagobert L. Brito and Robert F. Curl research as a starting point for regulating carbon dioxide emissions from diesel-powered generators but narrow the research down to the burgeoning diesel generator market in the U.S. using cost-benefit analysis.

4.0 Economic Analysis

I will be using cost-benefit analysis to evaluate the proposed policy and see if the benefits of the policy will outweigh the cost that would be incurred. Cost-benefit analysis (CBA), sometimes also called benefit-cost analysis, is a systematic approach to estimating the strengths and weaknesses of alternatives. It is used to determine options which provide the best method to achieving benefits while preserving savings in, for example, transactions, activities, and functional business requirements. In Environmental Economics, CBA may be used to compare completed or potential courses of action and to estimate or evaluate the value against the cost of a decision, project, or policy.

I adopted the cost-benefit analysis methodology for this research because it will help me delineate how society would fare under the range of the proposed policy options, as this is the case for developing environmental policy. Cost-benefit analysis is central to designing and implementing environmental policies in many countries.

4.1 Benefits

Diesel fuel is a mixture of hydrocarbons that produce only carbon dioxide (CO_2) and water vapor (H_2O) during an ideal combustion process. Indeed, diesel exhaust gases are primarily composed of CO_2, H_2O, and the unused portion of engine charge air, and we know carbon dioxide is not healthy for our environment. This will lead me to the estimation of the numbers associated with these damages caused by carbon dioxide.

The monetary value of damages to society caused by 1000kg of carbon dioxide emissions is $185. Also, it has been stated that, on average, a diesel generator emits 10kg of carbon dioxide per gallon, and we know diesel generators' size ranges between 20kw to 2250kw in the U.S. (Average size of 550kw); if this is running at an average of its efficiency(275kwh), it would consume 21 gallons of diesel per hour. This means, on average, across varying kilowatts sizes, diesel generators in the United States emit 210kg of carbon dioxide per hour (0.763kg CO_2/kWh). Today there are 7.68 million units of diesel generators in the United States; this means after the policy has been passed (0.3kg CO_2/kWh), after each user exhausts 82.5kg of carbon dioxide emission per hour limit, there would be 979.2 million kg of excess carbon dioxide emission per hour. This would result in an excess social cost of $181 million per hour.

On average, many industrial facilities, large buildings, institutional facilities, hospitals, households, and electric utilities have diesel generators for backup and emergency power supply. This means they don't run it 24/7; let's assume it's used during a power outage. According to EIA, Interruptions in electricity service vary in frequency and duration across the nearly 3,000 electric distribution systems in the United States. Many factors, including weather, vegetation patterns, and utility practices, cause power interruptions. In 2018, the latest data available, power outage durations for U.S. electricity customers averaged 5.8 hours per customer. Multiplying the excess social cost estimated above by 5.8 hours will result in an average of $1.05 billion in social cost per year. Using the social cost as the only proxy for benefits, I've estimated a little bit above a billion dollars that the U.S. as a country would lose to diesel generators' carbon dioxide emissions per year if the regulation proposed in my paper is not adopted.

4.2 Costs

Everything in Economics comes at a price; in this section, I will look at how this regulation will impact the regulated parties' cost-wise and how it would transfer to society.

4.2.2 Carbon Capture

Several studies have explored the method of carbon capture of fossil fuels to mitigate carbon dioxide emissions going out of hand. Using benefit-cost analysis, researchers found that it will cost $30 and $60(breakeven value) to capture 907kg of carbon dioxide, for coal and natural gas, respectively. Diesel fuel is produced from various sources, the most common being petroleum. Other sources include biomass, animal fat, biogas, natural gas, and coal liquefaction; this means the estimated cost value applies to diesel fuel. However, carbon capture is more expensive than the break-even values; it will, on average, cost about $425 per 907kg of carbon dioxide capture, from a recent estimate.

We know from the Benefits estimation that after the policy has been passed, there will be 979.2 million kg of excess carbon dioxide emission per hour from the diesel generators' end users, which would amount to 5.7 billion kg of excess carbon dioxide per year ceteris paribus, i.e., multiplying the per hour emissions by 5.8 hours of power outages the EIA said an average customer experiences per year. It has been stated that 69% of Americans prioritize developing alternative energy sources, such as wind and solar, over expanding the production of oil, coal, and natural gas; let's assume this percentage applies to the diesel generator market end users in the U.S. Under this assumption, let's say 31% of diesel generator users would go above and beyond to meet the new diesel generators' carbon dioxide emissions standard; let's assume they do this using carbon capture, as it will be hard to cutback from 210kg of carbon dioxide emissions per hour to 82.5kg of carbon dioxide emissions per hour. This means diesel generators' end users would capture 1.8 billion kg of excess carbon dioxide annually, assuming there's the capacity to capture that much, this will amount to $843.4 million annually. These diesel generator users would want to factor this into their productions, and it will be passed on to their market; if it's being used for non-profit, it will reduce purchasing power.

4.2.3 Diesel Generator Sector Shrinkage

Under the earlier assumption, 69% of Americans using diesel generators prioritize developing alternative energy sources, such as wind and solar, over expanding the production of oil, coal, and natural gas. Let's assume that out of the 69%, those who can afford the other sources will switch their energy source, and those who can't afford it will shut down or turn to other unrestricted fossil fuels. It might be hard to estimate the cost here, but one cost is sure, the diesel generator market would lose 69% of its value, amounting to $1.5 billion in loss.

4.2.4 Loss in the Demand for Diesel

After the policy has been passed, following our earlier assumption that each user in the diesel generator sector would on average exhaust 82.5kg of carbon dioxide emission per hour, there will be 979.2 million kg of excess carbon dioxide emission per hour. This will accrue to 5.7 billion kg of excess carbon dioxide annually. If 69% of the market stops using a diesel generator by switching energy sources or shutting down, there will be a 3.9 billion kg of carbon dioxide cutback; it has been stated that, on average, a diesel generator emits 10kg of carbon dioxide per gallon. This will be 390 million gallons of diesel cutback per year; one gallon of diesel costs an average of $5.21 in the United States this year, which will amount to a $2 billion yearly cutback on diesel demand if the diesel rate stays the same.

4.3 Cost Benefit Analysis

During the delineation of the benefits, I estimated a $1.05 billion minimum for the first year after the policy has been passed. For the costs, across all the different analysis, I estimated a $4.3 billion minimum for the first year after the policy has been passed. This will amount to a net benefit of - $3.25 billion for the first year, and also, in the long run, the loss will persist since the carbon capture and drop in the demand for diesel costs are yearly variables in my analysis.

5.0 Conclusion

Cost-benefit analysis shows that if the regulation I proposed that will prevent diesel generators from emitting more than 0.3kg of carbon dioxide per kWh is passed, the country will be worse off.

This is because the cost of the regulation will outweigh the benefits in the short and long run. If the regulation is passed, there will be a cutback of 5.7 billion kg of excess carbon dioxide per year in the U.S. However, this will force end users who would like to continue using diesel generators to pay a considerable price to meet the new standard; in this paper, we use carbon capture as the proxy, and this will result in a much more expensive product and services for firms and reduction in purchasing power for households. Also, there will be a significant drop in the demand for diesel fuel, and the diesel generator sector will lose more than half its present value overnight.

In conclusion, the regulation can't be adopted, which means the diesel generator sector will keep polluting the environment without restriction. However, as the inhabitant of earth, humans need to keep striving to reduce carbon dioxide emissions as this has been proven to result in all negative things associated with climate change. Perhaps, future research can explore if the benefit of restricting the carbon dioxide emissions coming from the electricity sector would outweigh its cost. As of 2021, carbon dioxide emissions by the U.S. electric power sector were 1,552 million metric tons (MMmt), or about 32% of total U.S.

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