IMPROVING ENVIRONMENTAL POLICY EFFICACY THROUGH PERSONAL AND PUBLIC ACCOUNTABILITY

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By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Global awareness of climate change issues and the necessity of pollution mitigation procedures has led to increased regulation since the Conference on Human Environment in Stockholm in 1972 (Chauhan & Chauhan, p. 209). However, despite increased legislation, many areas still have rising pollution levels. Nitrogen oxides (NO_x) specifically have risen due mainly to vehicular emissions in some urban areas (EPA 2018, p. 2; Duncan et al. 2016). Environmental policies targeted in this area are needed, but in order to direct those policies, more focused emission data and statistics are necessary. The technical capstone project addresses the need for data through the design of a nitrogen dioxide monitoring CubeSat. The STS research paper investigates the potential policy changes that may be enacted with such data through Actor-Network Theory (Callon, 1986), specifically focusing on improvements in developing countries such as India.

THE STATE OF NITROGEN OXIDE EMISSIONS AROUND THE WORLD

A United States Congressional study published in 1975 found that 51% of the total 53 million tons of nitrogen dioxide emissions around the world came from various coal burning processes, and another 41% from petroleum (p. 719). The United States Environmental Protection Agency (EPA) reported findings from the National Emissions Inventory that the US national average concentration of NO_x had decreased from 25.2 million tons in 1990 to 12.3 million tons in 2014 (2018, p. 2). On-road vehicles were the greatest contributor to the total emission, but the quantitative evidence was only an estimate based on years of modeling (EPA 2018, p. 2). In contrast, industrial boiler emissions can be directly measured by on-site monitoring devices regularly reporting to the agency. To truly verify the statistics, there should be some way of monitoring the actual nitrogen output of vehicles on the roads, but implementing individual trackers on each car would be impractical. The lack of clear and comprehensive

information on concentrations of nitrogen oxides makes it difficult to determine their source and thus how to proceed with mitigation efforts.

The lack of adequate information is especially clear in developing countries. Nation-wide accounting of pollution statistics is greatly hindered by the limited availability and use of air quality monitoring stations. These stations have limited application as they can only characterize the air in their immediate surroundings. Gurjar, Ravindra, and Nagpare (2016) reported a contrasting trend of decreased ambient nitrogen oxide but increased vehicle presence and nitrogen oxide emissions in the air of Mumbai, India. The authors stated that the contrast may be "partly due to an insufficient number of monitoring stations not representing the complete Mumbai region," (p. 482). Gurjar et al. also noted that the nitrogen oxide concentration in Delhi steadily increased by 164% from 1991 to 2012 as both the human and vehicle populations increased (p. 482). This data supports the claim of Duncan et al. (2016) that countries such as India and Pakistan with rapidly growing populations and economies must necessarily see rises in pollution levels (p. 982). Rapid industrialization coupled with greatly increased demand in the energy and transportation sectors leads to mass production of anthropogenic emissions. In order to accurately determine which sectors need more focus and guidance in terms of regulations, more information is needed about their relative contributions, especially for vehicular emissions.

Satellite imaging is perhaps the most effective way to measure pollutant concentrations around the world. Since the instruments are able to sweep out large areas of the globe in relatively little time, they provide frequent updates to the global picture of pollutants in the atmosphere. Data from space-borne observatories provide global comparisons for which cities or regions have the highest nitrogen oxide concentrations as well as the trends in each region. From these data scientists can tell if a locality has effectively reduced pollution long-term and be

alerted if there are any sudden peaks or uncharacteristic drops in concentrations compared to previous trends. For example, scientists at the European Space Agency were able to identify a significant decrease in air pollution in both China and Italy in February, 2020, compared to data from previous years. These decreases are attributed to the shutdown of industrial processes and travel in both countries due to containment efforts for the novel coronavirus outbreak (Gohd, 2020). New satellite instruments and CubeSats, such as the one being developed in the Spacecraft Design course at the University of Virginia, may provide even greater insight into the causes of emissions trends. With greater resolution, these instruments will be able to pinpoint the locations of pollution hotspots to within one kilometer and separate out industrial processes from vehicle exhaust even within crowded urban areas. This can lead to greater accountability when the public knows who is responsible. In 2018, scientists used satellite data to characterize a massive methane leak in Ohio that proved far worse than Exxon had originally reported based on their ground tests (Tabuchi, 2019). When asked about this incident, Dr. Steven Hamburg, a collaborator on the satellite project, said that satellites are an important part of understanding and preventing methane leaks because "you can't manage what you don't measure," (Tabuchi, para. 13). Access to comprehensive information is the key to effectively mitigating pollution around the world, and satellites are able to provide a vast majority of that data.

EFFICIENCY OF CURRENT ENVIRONMENTAL POLICY

There is copious evidence to show that air pollutant levels have steadily declined in countries such as the United States. Some European countries have seen even greater successes with the implementation of their strict environmental regulations. However, many countries outside Europe continue to see pollution increases despite similar efforts to curb emissions. The outcome of certain legal decisions can be drastically different given the socio-economic power

distribution of the area and even with those same conditions, different decisions will be made given different cultural values. It is important to understand not only the natural but also the political and social environment of the region in order to affect change.

Multiple studies have shown that the greatest contributor to urban CO and NO_x emissions in India and around the world are motor vehicles. The Indian government has adopted the Bharat fuel standards, a series of regulations on the sulfur content of petroleum and diesel fuels modeled after European policies. The timeline of the implementation of these regulations has sped up as the pollution situation becomes more dire, forcing the fuel and automobile industries to comply. Without new automobiles built to take this low-sulfur fuel, consumers and motorists are forced to feed their incompatible engines, which can decrease fuel efficiency (Dutta, 2018). A set of unfortunate consequences arises. Namely, the consumer is unhappy with the performance of their car and the governmental pressure to buy a new one. The auto industry is also unhappy with the government for increasing pressure for more efficient engines when they do not have the capability to produce them. Finally, the gas and oil companies are shifting the blame for the delay in rollout on the auto industry (Karunakaren). The issue here is the lack of consideration for other stakeholders. Decisions about the future of environmental policy and the industries related to it should be made with all actors in mind.

Similar cases can be found in all areas of energy and environmental policy-making. Jolivet and Heiskanan (2010) described the problems arising from a proposed wind farm in France. While the original idea was well-framed and accepted by those closest to the issue, the creative team faced resistance from citizens of the towns surrounding the intended site who claimed the turbines would compromise the aesthetic that appealed to tourists. Since those planning the project did not consult all the affected parties before the proposal period, they were

blocked at a critical stage in the process leading to an indefinite halt of the development of the wind farm. In the United States, President Obama's commitment to reducing carbon emissions was taken as a war on coal since the proposed regulations disproportionately affected the coal industry. Coal supporters argued that the cuts would force coal workers out of business completely due to the severe economic impact and this would cost Americans thousands of jobs in coal mining states. Again, lack of consideration and input from all actors thwarts even the noblest intentions. Figure 1 shows the current, one-way technology transfer model demonstrated by this situation.

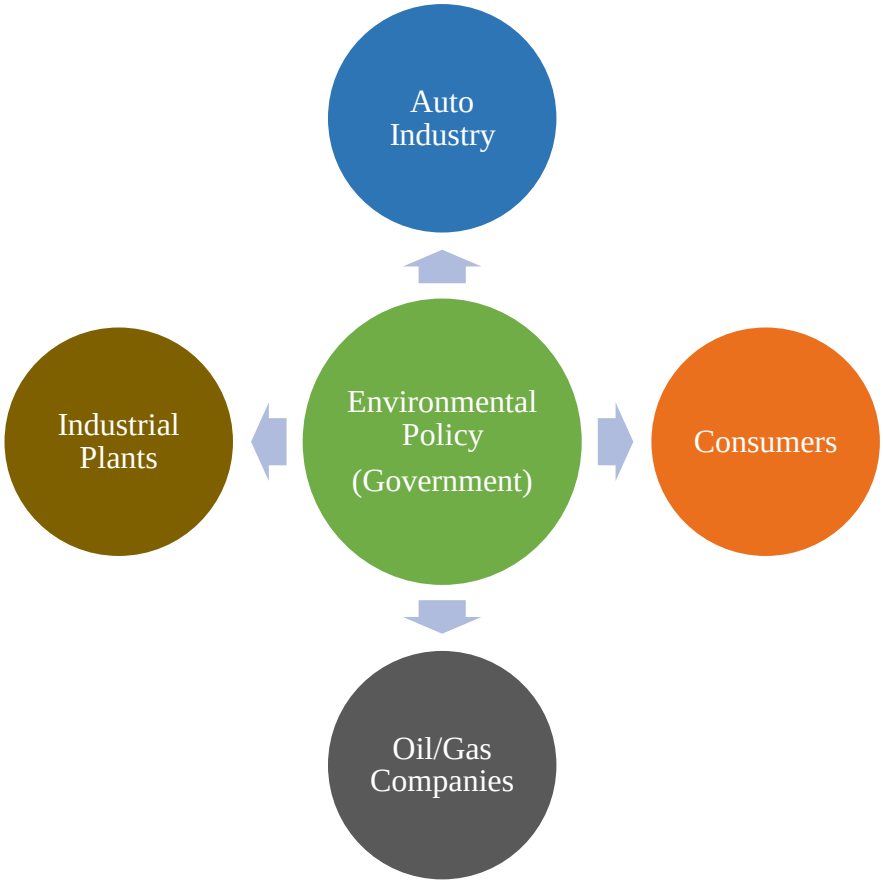

Figure 1. Transfer of Environmental Policy. The current model of environmental policy decisions (Adapted by Genesis Brockett, 2019, from B. Carlson, 2009).

The figure is an adaptation of the transfer of technology model originally pictured by WB Carlson as an interpretation of the Social Construction of Technology developed by Pinch and

Bijker. It represents the environmental policy created by the government (center) that is forced onto all other associated parties. This transfer is shown by unidirectional arrows to signify the actors having no control or input to the central issue. Notice that there is also no connection or communication between the actors. The lack of communication severely hinders the efficiency of the proposed policy. Other issues stem from lack of enforcement of the current policies and inability by the affected parties to comply. Dr. Bhaskar Vira (2001) noted that the recognition by the Indian supreme court of the people's right to clean air and water has not prevented companies from polluting since they know the government does not have the power to stop them (p. 647). The multitude of factors at play require careful reconsideration.

Support for the use of an actor network in environmental applications comes not only from the wind-farm example given by Jolivet and Heiskanan (2010), but also a predictive modeling exercise published by Loughlin et al. (2015). They conducted a sensitivity study where, in addition to the maximum use of currently available emission reduction technologies, they input different combinations of increased renewable energy, increased energy efficiency, and greater prevalence of electric vehicles to predict trends in air pollution levels in the United States. The modeling framework evaluated the tradeoffs associated with the chosen parameters and the affected industries and groups. Through these tradeoffs with often unexpected consequences, Loughlin et al. clearly exposed an actor network at play in the determination of the most effective emissions mitigation processes. In one instance, the authors noted that while replacing more cars with electric vehicles decreased mobile emissions, "the resulting fuel price pressures led to an increase in industrial emissions," and that "in some regions, overall NO_x emissions increased" despite reduced vehicular contributions (p. 1090). This hypothetical scenario shows the often-overlooked connections between industries that must be considered

when making regulation decisions. Similarly, observed statistics reported by Gurjar et al. (2016) showed that while the Bharat standards for sulfur content in Indian fuel did decrease ambient sulfur dioxide in the atmospheres of major cities, the nitrogen oxide levels increased due to the fuel's alternative. Understanding the consequences of a policy in areas it was not directly targeted at is one of the pivotal issues the current policy model does not address.

RESTRUCTURING POLICY-MAKING PROCESSES FROM THE BOTTOM UP

The supreme court in India, much like in the U.S., has used interpretations of the constitution to protect the environment, providing guidance for the people as well as the government. However, words and ideas alone cannot stop the rise in pollution. The real solution requires personal initiative; every actor needs to take it upon themselves to do their part. There are many existing technologies meant to stop or reduce NO_x emissions before they reach the atmosphere, but people must implement them. There are alternative modes of public transportation that would produce less exhaust overall, but commuters have to choose to use them instead of personal vehicles. Numerous alternatives to coal-powered generation have been introduced and proven effective, but still the industry does not switch to renewable energy. All of these options exist, but if the technology is not being used, it cannot have its intended effect.

The proposed model consists of a system where each group has input in the implementation of environmental policy so that everyone benefits, as long as they adopt the technologies that allow them to comply. This is similar to the cap and trade system established in the U.S. currently. In this system, combustion facilities are given certain allowances for emissions that are less than their baseline. They may purchase or trade allowances with other companies to cover their emissions, or they may reduce emissions in whatever way they deem

most cost effective in order to avoid federally imposed fines and penalties if they fail to meet the allowance caps (EPA, 2009). However, this still relies on government agencies regulating and checking in on those affected by the policies. There needs to be some kind of personal accountability that makes people want to cut back on emissions on their own. Each group needs to have a stake in the outcome, and be personally invested in how their performance impacts others and the Earth as a whole. A graphic of these ideas can be seen in Figure 2, where personal accountability surrounds and pressures all the actors within the network.

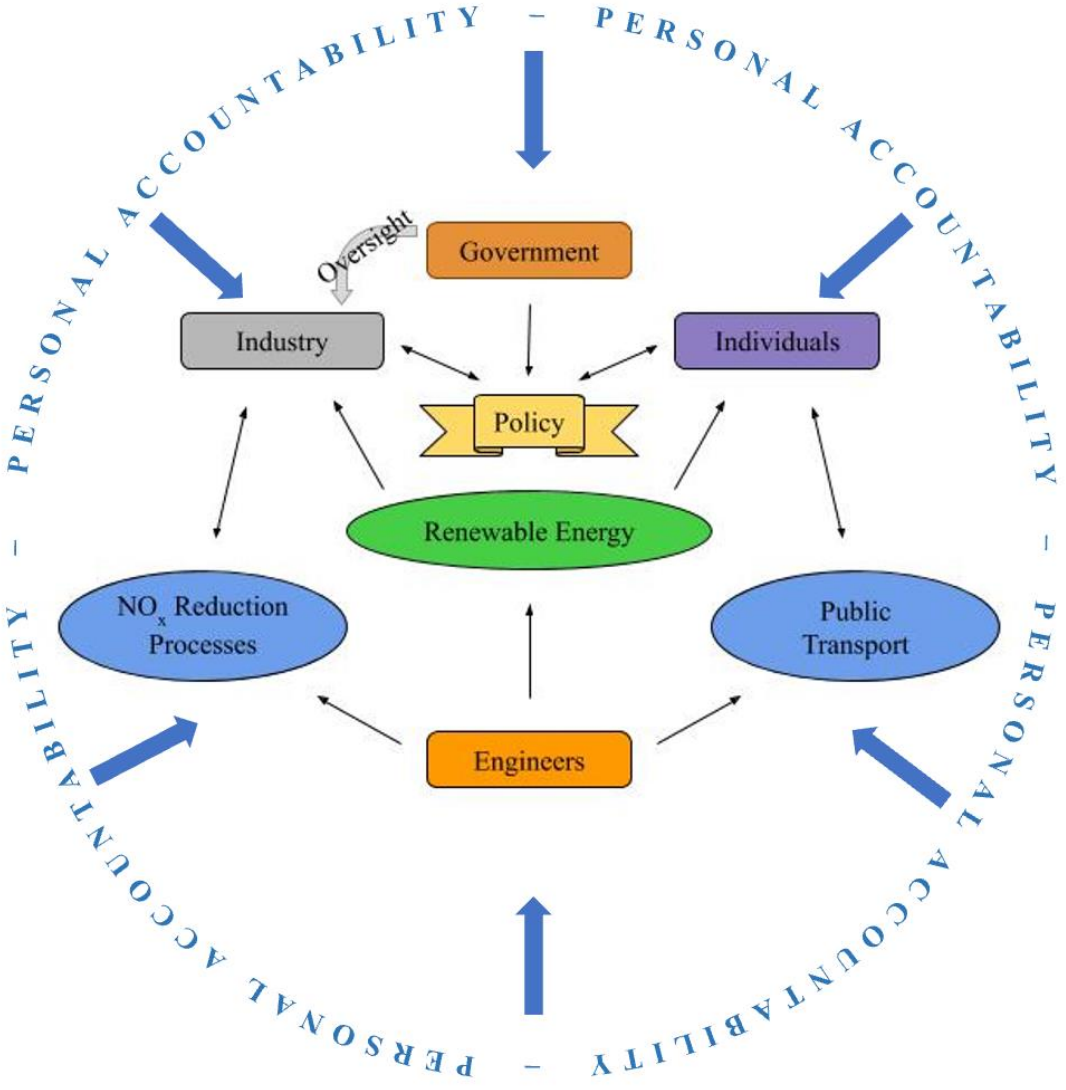

Figure 2. Proposed Network. Concept map shows the relationships different groups have with the environmental policy and the technologies that help adhere to it (Created by Brockett, 2019).

In this model based on Actor-Network Theory (ANT), the actors communicate with each other and all have input in the new environmental policy. The actors also interact with the environmentally responsible technology created by the engineers, who feel that same sense of duty to protect the natural resources of the world they live in. The environmental policy, and government oversight that comes with it, is still central to the process so that individuals and groups are held accountable; some governments may lack the power necessary to enforce the policy, so that influence may have to come from other sources.

Acceptable methods of enforcement depend heavily on governmental structure and its moral backbone. Dr. Vira (2001) outlined the various ways moral arguments can be used to support opposing views on the limitations of government influence in the environment. He especially focused on the contrast between individual rights ethics, which would support no government interference, and utilitarian ethics, which requires the government to interfere on behalf of public welfare. Finding a balance between the two can often be challenging, and we look to current examples of both sides to inform us. For example, the Chinese government was able to take unprecedented measures to control the population to prevent pollution spread before the Beijing Olympics. Their massive effort to reduce traffic, stop industrial plants, and other extreme measures allowed an incredible reduction in pollution around the city, avoiding global outrage at the air quality for the visitors to the games (Jing, 2013). However, the measures could only be held for the duration of the Olympics, and the government had no plans for lasting control measures. Now, with many countries ordering residents to self-quarantine due to COVID-19, we are seeing similar short-term effects. It may take another of these kinds of global crises, or at least scandals, to spur people into action. Without such drastic measures, governments with less formal powers must make use of what they do have. Thus, there is a

strong connection between the moral, legal, and financial aspects of the problem, since economic sanctions are among the most effective ways to corral errant companies or organizations regardless of governmental restrictions. But the government is not alone in the ability to hold industries accountable; consumers also hold great economic power over industries, and public opinion can cripple a company as the monetary support dries up. The public is often swayed by the media, so it is increasingly important for environmental news to be published and accessible. With available high-resolution satellite data to locate the sources of pollution leaks, spikes, and long-term contributors, consumers may be poised to use their buying power to influence industry-wide change.

Another important factor in the network is community and individual support guided by the internal desire of each individual to protect the environment. This provides internal desire to contribute something positive in addition to the external pressure to comply with the policy in order to avoid negative consequences. Active communication between the actors seems like an obvious and easily achievable solution. While there are doubtless some obstacles to overcome, there is at the very least a clear goal. The main issue to tackle to achieve this ideal model is the more abstract sense of personal accountability. One pathway to instilling this responsibility is education. People must have all the facts in order to make an informed decision, which is why public availability of pollution data is so important. Even so, availability of information does not guarantee that people will see it, since they would likely have to already be interested in the topic in order to seek out the data. Public education systems should make more of an effort to teach environmental awareness at a young age, and mandatory training workshops and refresher courses should be provided for adults. Catered appeals to different sets of moral and ethical mindsets may be effective in awakening individuals' conscience to the issues. Dr. Noor

Mohammad (2011), an environmental policy researcher in Malaysia, makes bold claims about the role of religion in regulating the environment, stating that the State needs the help of organized religion to aid conservation efforts because they are "an act of worship" (p. 1249). His idea that "without evaluating the shariah law, the world cannot be healthy" is a little extreme, but he has a point that the duty ethics outlined by shariah law and other religious doctrines may influence people's inherent sense of rightness when it comes to their impact on the environment (p. 1249). The most important and most daunting task is inspiring people to take action for the good of the planet. Without this, the actor network would crumble.

The last, important aspect of the proposed policy model is its context. In the predictive models run by Loughlin et al. (2015), while one set of variables may work best for the country as a whole, the detailed results vary by region, indicating that the most effective changes would be implemented by state or local governments and tailored to the specific area (p. 1090). An example of this consideration being taken into effect can be found in the Netherlands. There, the national government gives power to local governments to develop specific policies based on their local environmental needs and budgets (Gupta, 2008). Joyeeta Gupta, an environment and sustainability professor at the University of Amsterdam in the Netherlands, remarked that "policies are likely to have a higher compliance pull when they build on local initiative, knowledge and circumstances" (p. 181). The Netherlands have seen great compliance with national and European environment goals through their bottom-up approach to policy.

Other successful policy examples can be found in Sweden and the United States. Both countries regulate industrial emissions through taxes to different degrees. While the U.S. allows companies to trade or sell allowances for certain quantities of emissions, Sweden is not so lenient. The Swedish government imposes the same fee per kilogram of nitrogen oxide produced

on all companies producing over a certain amount per year. The government then invests the collected taxes in those same companies, redistributed by the average amount of emissions per unit of energy, so that more efficient companies see greater returns (OECD, 2013). This fosters competition without letting big companies who can afford to trade allowances off the hook. It is this kind of thinking, not necessarily these specific policies, that should be implemented in countries like India to further progress toward cleaner air.

ENVIRONMENTAL IMPLICATIONS

To reduce nitrogen oxide emissions in India and around the world, it would be prudent for more countries to adopt measures such as those enacted in the Netherlands and Sweden for curbing emissions. However, while these measures have worked well in those countries, each situation is different and may call for changes to the proposal. Different cultures and governmental structures require different approaches to implementation and enforcement of environmental regulations. New measures can have observable effects thanks to satellite data so scientists and legislators can keep track of their efficiency and readjust policy as necessary. Public record will also keep governments and companies accountable to the people they serve. A system of updated regulations and current scientific data available to the public will bring the changes necessary to curb global climate change and improve air quality.

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