GRO Summer Internship Final Report

External Environmental Impacts of Renewable Energy Technologies

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This summer has been one of the most extraordinary experiences I have had so far in my 21 years of life. I have greatly enjoyed working at the EPA Region 8 Headquarters in Denver, CO. While working under Mr. Craig Greenwell, Facilities Supervisor, I was given a great deal of latitude in designing and creating my project for my independent research during my internship. It was quite a change from my past experiences where I was typically aiding the research projects of my professors or of my employers with past internships. I selected my topic, the external environmental impacts of renewable energy technologies, because of two concerns that I have had with any sort of new technology. The first concern is a resource allocation issue: is the technology able to be used on a large scale without straining supplies and market prices, how long can the resource be made to last, and what are the strategic implications of the resource in terms of global supply and geologic distribution? The second concern was focused upon the impact to the environment: where does degradation occur, why does it occur, can it be mitigated, are there alternatives, and can the materials be recycled or recovered? These two complex questions have to be addressed in order to ensure that any renewable energy technology actually lives up to its “green” ideals.

The Environmental Protection Agency has begun to promote renewable energy technologies through a number of initiatives, especially in Superfund sites. These sorts of brownfield sites typically have at best limited economic development prospects after remediation unless the original contamination was fully contained. But, given the site’s already degraded state, it makes it a prime candidate for the integration of renewable energy. There are few concerns about despoiling virgin country and it provides an economic function to land that would otherwise have little use. Administrator Jackson has also made renewable energy promotion part of the proposed strategic plan for the EPA between 2011 and 2015. This has given further impetus for researching and integrating these technologies into the broader work of the EPA.

Given my interest in renewable energy, I was fortunate to work under Mr. Timothy Rehder on a project examining the cost benefits of installing a photovoltaic system. This gave me practical experience in learning how the technologies I was studying are actually used today. Colorado is interesting in that a number of regulations have been implemented by the legislature creating a positive climate for promoting the use of renewable energy technologies. Most of these technologies are still not cost-competitive with traditional fossil fuel-based technologies. However, using various tax incentives and rebates, Colorado has created opportunities for early adopters of renewable energy technologies to gain substantial benefits. This applies not only to corporate interests but also to home and property owners. Part of my work revolved around the integration of renewable energy projects in a forthcoming commercial development in downtown Denver. I was tasked with researching the various advantages that a building owner could gain by installing photovoltaic (PV) systems on his/her buildings. It allowed me to learn how to read various tax codes and regulations while also learning about the logistics of photovoltaic systems. Over a 30-year period, a building owner who installed a PV system would see significant savings, given that the cost of electricity will only increase. It just requires the desire on the part of the developers to make the upfront capital investments in the building to install a

solar energy system and think about the long term benefits financially, aesthetically, and environmentally.

I also did some work with alternative fuel vehicles; specifically, I worked under the direction of Mr. Bill Daniels to research forthcoming electrical vehicles. My investigations revolved around American manufactured vehicles, such as the debuted Chevrolet Volt, the Tesla Motors S (due out in 2012), and the Ford Focus electric (due out in 2011). Part of the research involved examining the current infrastructure installed in the Region 8 parking garage for charging an electrical vehicle. I found that the current system installed in the garage was an outmoded induction charging paddle developed for the General Motors EV1. The Society of Automotive Engineers recently adopted a new standard, the SAE J1772 that specifies a new standard conductive charging connector. Thus, I had to determine if the current electrical system would still accommodate the new charging stations that would have to be installed to charge a new electric vehicle. Under Mr. Greenwell's supervision, I learned to read building plans for the electrical system and later for all of the Region 8 office systems in general.

These two applications, electric vehicles and renewable energy projects, were valuable in guiding the way in which I went about my central research project of learning about the external environmental impacts of renewable energy technologies. I traced the supply chain of the technologies based upon previous research that had been conducted to analyze the net power that renewables generate after the energy of manufacturing is taken into account, and the greenhouse gas emissions that evolve from the production of the devices. Thankfully, both wind and solar have an energy payback period of around one year, after which they generate more energy than it took to produce the devices. The devices also achieve carbon neutrality and become greenhouse gas emission reducing technologies after about a year. Typically, a wind turbine or PV array will produce power for 30 years without producing greenhouse gas emissions, thus reducing the overall emissions from electricity generation.

However, renewable energy technologies are not without environmental risks. For example, thin film photovoltaic systems that employ cadmium-telluride (CdTe) substrates pose a serious environmental risk if not disposed of properly after the end of their useful lives. Both cadmium and tellurium are toxic metals and when alloyed together have a synergistic toxicity that is greater than either metal alone. Because almost all of the panels produced are still in operation, it will not be for another 30 years that the full impact of the technology can be appreciated with real world data. This forces people using the technology to take great care to ensure that the toxic components do not end up in the broader environment.

My study of CdTe panels also lead to another discovery, using data from the United States Geological Survey, I found that there are in fact no mines in the world that produce cadmium or tellurium as a single product. Both metals are found in such low concentrations that it is only through the mining of lead and zinc that enough is collected as a byproduct to be of any commercial importance. This raised an alarming question for me: supposing that CdTe became an important photovoltaic technology in the future, what would happen if something occurred that made lead and zinc less desirable to mine? It would ripple through the market and affect all of the technologies that are dependent upon those metals to function. Thus, there are broad strategic implications for the future of the technology as it is so dependent upon totally unrelated factors as the price and supplies of lead and zinc. Thinking about the strategic importance of metals in manufacturing many of the technologies that make contemporary life possible led me to the Achilles' heel of wind turbines: neodymium.

Neodymium is a rare earth metal. While the elemental nomenclature is a bit of a misnomer (the metals are not “rare” in quantity but were “rare” to the scientists in the eighteenth and nineteenth centuries who first isolated them), rare earth metals are of vital importance to the future of advanced technologies as disparate as high-efficiency light-weight turbines for generators and the guidance systems of precision munitions. The rare earth elements are found on the lanthanide series of the periodic table and have unique chemical and physical properties that make them very important to producing magnets and other devices and for which there are no other suitable replacements. This would not be a problem if it were not for the fact that the People’s Republic of China produces around 90 percent of all rare earth metals. Thus, while we may complain about our dependency upon oppressive petrol funded regimes and OPEC for our oil supplies, the United States is equally dependent upon China for rare earth metals. The Communist government has also made attempts to further strengthen its control of the market by creating state-owned companies that are aggressively buying rights to mines abroad and purchasing foreign companies that produce devices that use rare earth metals. This has allowed China to move further up the supply chain and consolidate its control not only of the raw material but also of the means of production through refinement and finished products. While it is beneficial to China, it leaves the rest of the world dependent on the Chinese. It also made conducting research on the environmental impact of rare earth mining quite difficult to carry out, as the Chinese researchers and corporate entities responsible for producing rare earth metals are quite guarded in what information they will release.

I was quite thankful to find some of the research conducted by Lieutenant Commander Cindy Hurst, United States Navy Reserve. Lt. Commander Hurst has written a number of papers that were invaluable to understanding what was going on within the People’s Republic of China and the broader world of rare earth metals. While her focus was primarily upon the strategic concerns for the United States, she did outline the reason why the Chinese were able to dominate the market. The country has virtually no environmental regulations and virtually no labor safety regulations. This grave disregard for human health and the environment has allowed the Chinese producers to undersell all other nations. In the United States the rare earth mine at Mountain Pass, California was closed because of dropping prices from Chinese competition and rising environmental concerns.

Like any mining venture, rare earth metal mining produces a great deal of waste in the form of tailings. Typically tailings are just waste rocks that pose, at worst, moderate risks. However, with rare earth mining, the tailings have elevated levels of thorium, a radioactive element that can contaminate ground water and river systems if not properly stored. To further complicate matters, thorium is not used in many commercial applications. One of the most common uses is in the mantles of gas lanterns and vacuum tubes; however, these uses do not consume as much thorium as is present in the tailings. Without much use, the thorium-rich tailings simply accumulate in repository sites. There are possible future uses for thorium, not the least of which is new nuclear reactor designs that are ideal for developing nations because they do not pose an extreme threat of proliferating nuclear weapons manufacturing like conventional nuclear reactors. However, this proliferation-resistant technology is still many years away from commercial development and generally underfunded in the West because of the perceived dangers of nuclear reactors. Historically, the technology was not funded for the very reason that it does not produce good bomb-grade nuclear material. Thus, until uses are developed for the thorium, the tailings will continue to grow and cause problems in areas where they are not properly contained.

Thus, as we proceed to adopt more renewable energy technologies, the external environmental supply chains must be properly managed if these are to truly be “green” technologies. Mining is not going to stop, ever, and if anything, its importance may grow as we turn away from other extracted resources such as petroleum and start to use other methods to deliver the energy and services we have come to expect as a society. If any conclusion can be drawn from my research, it is that prudent regulating of entire supply chains will be necessary if we want to ensure that new technologies live up to their “green” claims. Also, issues of environmental justice extend not just to this country but to the whole world. The degradation in China raises the serious question of how appropriate it is for one nation to “green” itself at the expense of the indigenous populations of other nations.

I have greatly enjoyed working within the Environmental Protection Agency because it has given me the freedom to do a lot of different things. I have also been exposed to topics and ideas that are very different, interdisciplinary, and stimulating. Overall, I was quite impressed with the Agency, although it was a bit different from what I had expected. I had worked in very structured and rigid office settings before. I had expected to find a similar situation in Denver but I was pleasantly surprised to find that the office culture was quite different. While there is a very clear hierarchy, collaboration and synergy are strongly encouraged. The Regional Administrator, Jim Martin, was very much committed to the idea of “One EPA” in that all of the employees were part of a larger organization with a set mission. Mr. Martin held a number of meetings to discuss what was going on within the Agency and always invited comments. I really enjoyed working with everyone at the Denver office. All of the employees were very professional and very much committed to the mission of the Agency.

I was also fortunate to have the chance to attend the Aspen Institute Environmental Forum. It was held in the summer this year and I went because I was so close to Aspen. This gave me a chance to meet some of the most brilliant minds in the environmental movement, who I would not have been able to meet anywhere else. I was also exposed to a lot of different ideas about environmental issues and how to approach them. It is a very innovative forum that provides huge networking opportunities. I got to network with a lot of people who were either attending or had graduated from many of the graduate programs I am looking into.

To next year’s fellows, I would say that it is imperative that you meet as many people as possible and not be intimidated. The staff will respect you because of your interest in the environment and interacting with them in a professional manner will only help to advance your cause further. Overall, my experience with EPA and the Greater Research Opportunities fellowship program has been wonderful and has helped me find a greater purpose to my career and education goals.