The Public Land Renewable Energy Act of 2013 (S.279)
Workshop in Applied Earth Systems Management

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Executive Summary

The Public Land Renewable Energy Development Act of 2013 (S.279) promotes a competitive leasing program for renewable energy projects on public lands held by the Bureau of Land Management, National Forest Service, and the military. It proposes to assess suitable lands for renewable energy development and establish two wind and two solar energy pilot programs with the goal of reaching a permanent leasing program within two years. The intent of this bill is to generate more renewable energy sources and reduce fossil fuel consumption. By promoting this development, the Public Land Renewable Energy Development Act represents an indirect solution to mitigate the global impacts of greenhouse gas emissions (GHGs) from fossil fuels combustion and the local impacts of fossil fuel extraction.

Mining fossil fuels has significant local environmental impacts including habitat destruction, wildlife disruption, erosion, loss of biodiversity, water waste, and water contamination. Additionally, burning fossil fuels significantly contribute to climate change, causing sea levels to rise, oceans to warm, and weather patterns to change. These impacts will affect humans and ecosystems all over the world.

While the bill presents a potential solution to these issues, it presents issues that must be addressed, such as the cost of renewable energy production, the efficiency of transmission and storage of power, . If passed, the bill will be successful if it increases the amount of responsible renewable energy production on public lands thus reducing the local impacts of fossil fuels extraction and the global impacts of fossil fuels combustion.

1. Introduction

The Public Land Renewable Energy Development Act of 2013 (S.279) encourages wind and solar energy development on Bureau of Land Management (BLM), United States Forest Service (USFS), and military lands. Public lands represent a significant amount of territory in the United States (US) and have three main uses (77). First, they are used for commercial activities such as oil and gas extraction, renewable energy development and forage for livestock. Second, they are used for recreation, including hunting, fishing and other outdoor activities. And third, they are used for natural resource conservation. The public lands have 21 million acres available that are capable of generating wind power and 29 million acres available that can produce solar energy (26).

The purpose of the act is to establish a pilot competitive leasing program on these lands for two wind power and two solar utility scale projects (90). The bill proposes Programmatic Environmental Impact Studies (PEIS) assess project feasibility and projects' environmental impacts are mitigated in accordance with relevant laws (90). The bill also directs the Agriculture and Interior Secretaries to not only segregate lands suitable for renewable energy development from mining claims but also study the feasibility of using conservation banks by establishing the Renewable Energy Resource Conservation Fund for federal and state to further mitigate the environmental impacts of solar and wind energy development.

This paper outlines the environmental problems associated with fossil fuel extraction and combustion, how the Public Land Renewable Energy Development Act of 2013 proposes an indirect solution to these problems, issues and controversies associated with increased renewable energy development on public land, as well as how to measure success of the legislation.

2. The Environmental Problem

The Public Land Renewable Energy Development Act aims to address two distinct environmental problems. First, the land-use shift from traditional fossil fuel extraction to renewable energy would decrease the environmental degradation, wastewater production, and water contamination of public lands. Second, by encouraging the production of renewable energy on public lands, the bill will reduce fossil fuel consumption and its contribution of greenhouse gases (GHG) to the atmosphere.

2.1 Fossil Fuel Formation and Local Impacts of Extraction on Public Land

Coal, natural gas, oil, and tar sands all formed through the decomposition of living organisms combined with extreme heat and pressure for hundreds of millions of years. Coal is formed between layers of sediment on land, while oil and natural gas are formed by the decomposition of marine organisms by anaerobic bacteria under layers of ocean sediment. There are two hypotheses of how tar or oil sands are formed either as a result of an old crude oil microbiologically deteriorating or extreme amounts of pressure caused the tar to seep into the surrounding sediments (4).

Coal and tar sands are extracted by removing the surface layers of rock and sediment above the resource. It is then shipped to power plants or further refined in the case of the tar sands. Oil and gas are extracted by drilling vertical wells and relying on the natural pressure of the gas or of the water, chemicals, and steam to flush it out of the deposit. Recently, new forms of hydraulic fracturing have added new methods of extraction. This process adds horizontal drilling into the surrounding rock at the bottom of the well. The rocks containing the secured deposits are fractured and water and sand flushed the natural gas out of its location.

In order to set up a mining location, there must be appropriate roads constructed for the heavy equipment that is used in both the drilling and transportation of the resource. These roads can cause habitat fragmentation by disrupting the local wildlife and their patterns of movement across the landscape. For example, in the removal of tar sands from the mining site, trucks with a capacity of up to 320 tons per load are used to transport the sands for refining (1). The trucks are powered by fossil fuels that emit carbon dioxide and produce noise that disturbs wildlife (93). While the Bureau of Land Management (BLM) sets guidelines for best practices, even simple dirt two-rut roads increase erosion. After mining is complete, major reclamation is needed. It can take up to 15 years for an ecosystem to recover, but sometimes the mixing of soil types, compaction, and loss of topsoil degrade soil quality so much that the species that repopulate the area are weedy and less diverse than the original ecosystem (93).

Additionally, the extraction process is extremely water intensive. Most of the deposits on public lands have limited water resources. Tar sand extraction and processing require several barrels of water for each barrel of oil that is produced (59). In other situations, groundwater is extracted along with the resource and then injected into the ground to flush more of the oil or gas out of the ground. This contaminated water is one of the largest wastes associated with all of the mining processes. The contaminated water can be stored in large pits on the surface, but can leak into the groundwater, aquifers, or natural surface water, which are the sources of drinking water for both humans and wildlife. It is estimated that up to 42% of these waste pits are unlined, providing no barrier to protect natural water sources (59). Coal mining specifically introduces sulfur and nitrogen compounds into nearby water that then has similar effects as the acid rain. (59). Natural gas production through hydraulic fracturing adds more methane to the atmosphere, which is a more powerful but a short term GHG, through leakage and venting during gas extraction and carbon dioxide release during combustion (10).

The BLM has outlined best management practices to mitigate the damage caused by each extraction method. They range from suggested paint colors for equipment to better camouflage into the surroundings, the creation of the smallest roads possible, and guidelines for reclamation of roads and the remaining footprint of the drilling activities (29). In addition to negatively impacting local lands, the combustion of fossil fuels contributes to climate change.

2.2 Climate Change Impacts

The extraction of fossil fuels for energy production is responsible for the emissions of major pollutants (including NOx, SO_2, particulate matter, and other traceable pollutants) drastically changing the composition of the atmosphere and causing climate change.

Climate change is a broad term that refers to the change in the historical patterns of climate factors such as temperature, wind, humidity, and precipitation that have been observed in the past 150 years. These long-term patterns influence environmental and human systems alike and even slight changes are proving to have drastic repercussions (Professor Jason Smerdon). Climate change is the result of GHG emissions from the combustion of fossil fuels such as coal, oil, and natural gas. These fuels have been used to power transportation, industry, and domestic comforts since the mid-nineteenth century. Despite significant advancements in technology, the combustion of these fuels still produces high levels of emissions, which disturb the natural balance of the environment.

GHGs trap some heat that should radiate away from Earth into the solar system. These insulating gases create Earth's moderate temperature in which liquid water and life can exist. Solar radiation reaches the planet in the form of short-wave radiation which can travel through the atmosphere and is absorbed as heat. Earth reradiates this heat as longwave radiation which is absorbed by GHGs and rather than escaping the atmosphere, it warms the surrounding atmosphere and surface of the Earth.

Carbon dioxide is the most abundant GHG emission. This compound occurs naturally in the atmosphere, but human activities, mainly fossil fuels combustion, disrupt the balance of the carbon cycle by removing the carbon that is stored underground and putting it into the atmosphere in the form of carbon dioxide faster than the Earth can reabsorb it. Currently, the concentration is above any naturally occurring concentration in the past 400 thousand years based on air samples from ice cores (6).

In the U.S., the main production of carbon dioxide is from electricity (33%), transportation (28%), and industry (20%) (23). Of all electricity produced, 70% is generated using fossil fuels. In 2011 alone, the U.S. produced 6,702 million metric tons of carbon dioxide. Climate change is an issue facing the entire world but the U.S. still produces roughly 20% of global carbon emissions, second in production only to China (23).

Over the past 100 years, a very short time period on the geologic scale, the average temperature of the planet has increased by 1.4°F (63). If emissions of heat trapping carbon are not reduced, the average surface temperature is projected to rise another 2 to 11.5°F over the next 100 years (25). To date, GHG emissions have already caused glacier and ice cap melt, sea level rise, and an increase in extreme weather patterns.

1. Oceans and Climate

Studies on the Agassiz Ice Cap in the Canadian Arctic show that the melt rate of the past 25 years is greater than any period seen in the past 4,200 years (31). This shrinkage of ice causes a natural feedback loop, which increases the warming effects because incoming radiation is absorbed by the oceans instead of reflected back into the atmosphere. This in turn increases ocean temperatures and rate of ice melt. The graph below demonstrates that September 2012 was the lowest record of sea ice extent in the history of satellite monitoring at 1.3 million square miles-- 49% lower than the 1979-2000 average (63).

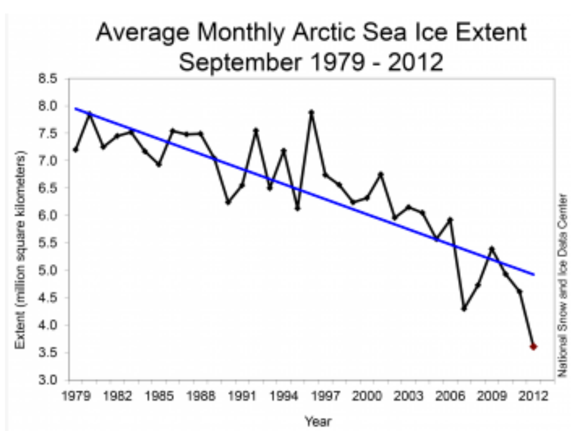

Figure 1. Minimum sea ice extent for each year.
The linear rate of decline per decade is 13.0% (45)

The melt of the sea ice has contributed to a rise in sea levels, estimated at 0.12 inches per year, a rate almost twice as much as the historic increase from 1880 (94). This could have detrimental impacts on both biological and human welfare. For example, sea turtle nesting beaches could be lost. It could also cause many coastal communities to be destroyed, which would displace a large portion of the U.S. population.

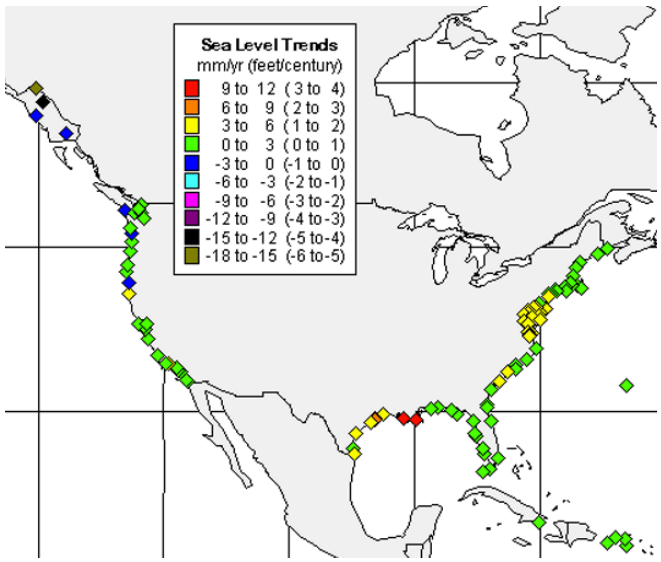

Figure 2. Average change in sea level around the continental U.S. (58)

Other indicators of climate change include shifting ranges in climatic patterns, and an increase in severe weather events such as hurricanes and droughts. In 2012, almost 75% of the continental U.S. experienced drier than normal conditions and the Department of Agriculture has declared many heavily drought-stricken wheat-growing areas to be in a state of natural disaster (29). Globally, there has been an increase in precipitation and temperature fueling larger and more destructive storms. In November 2012, Hurricane Sandy spent a significant amount of time over ocean water 5° F warmer than normal average temperature, which increased the amount of water that it carried to shore (23). The occurrence of extreme precipitation events, where one location received a great deal more precipitation than normal in a single day, was relatively constant from 1910 to 1980 until it began to increase. Eight of the top 10 years of extreme one-day events have occurred within the past 20 years (94).

2. Changes in Landscape and Wildlife Patterns

As the patterns of rain and snow are changing, plants and animals that depend on these weather functions are forced to move toward polar regions and alpine environments. For example, the National Audubon Society collects annual data on the movement of migratory birds in North America, and in the past 40 years, 58% of the species showed a pattern of shifting wintering ranges. This pattern was observed in a variety of species, as the average range shift for all species was 35 miles north (6). The International Union for the Conservation of Nature has roughly estimated that 23% of mammals and 12% of bird species are threatened with extinction due climate change and the factors contributing to it (45,101). Species and ecological communities may be left with little remaining viable habitat thus, changing the ecosystems and natural wildlife around the world (65).

3. Human Issues

Different models predict human and societal struggles under different climate change scenarios. There could be an increase in extreme weather related deaths, and an increase in air pollution related diseases. Changing weather patterns may increase the number of violent storms, including flooding, which could lead to more water borne illness and disease. For example, extreme weather events (e.g. droughts, floods, etc.) will likely affect agricultural yield production. This could compromise the availability of fresh food and water threatening human health through malnutrition and the spread of disease (26). It has been documented that an increase in temperature increases disease rates and food poisoning. Traditional economies, such as skiing in the Northeast, are already suffering due to shorter winter seasons (94). Further, although only 2% of the world's land lies at or below 10 meters of elevation, these areas contain 10 percent of the world's human population. This means about 634 million people would be directly threatened by sea level rise (6).

Because the local impacts of fossil fuel extraction and the global impacts of climate change are significant. Senator Jon Tester, introduced the Public Land Renewable Energy Development Act in February 2013. Legislative proponents include Dean Heller (R-NV), Mark Udall (D-CO), Tom Udall (D-NM), James Risch (R- ID), Martin Heinrich (D-NM), Max Baucus (D-MT), Michael Bennet (D-CO) (68, 19, 41, 47, 48, 53, 57, 80, 86).

3. Environmental Solutions in the Public Land Renewable Energy Development Act

Government action is needed to encourage the development of commercial size renewable energy projects to keep up with increasing energy demand and reduce the impacts of fossil fuel use. Additional benefits of these projects include: lowering air pollutants from non-renewable resources (coal, natural gas and oil); energy diversification; as well as improving human health, water resources, and ecosystems (76).

As mentioned above, climate change will significantly impact the U.S.'s air quality, water resources and landscape. However to date, there is minimal legislative direction on how to increase wind, geothermal and solar energy projects on public lands. Government action is needed to encourage renewable energy development and infrastructure, as well as standardize and streamline competitive bidding processes. Additionally, the government must ensure that commercial wind and energy projects are developed with minimal and mitigated environmental impacts (76).

To ensure that the Public Land Renewable Energy Development Act does not encourage further local environmental degradation through the development of commercial scale wind and solar farms, the bill proposes the segregation of lands suitable for renewable energy projects and the development a Programmatic Environmental

Impact Statement (PEIS) as well as the Renewable Energy Resource Conservation Fund. For background, this section also describes how wind and solar energy are produced.

3.1 Segregating Suitable Lands and Assessing Environmental Impacts

According to BLM data, as of 2010, 41,000,000 acres of federal public lands were leased for oil and gas development (89). The promotion of renewable energy on public lands would segregate lands suitable for solar and wind energy development from mining claims, thereby preventing the negative impacts of future fossil fuel extraction, such as loss of biodiversity, degradation of landscapes, water and air contamination, and the associated human health risks.

3.2 Renewable Energy Resource Conservation Fund

From 2003 through 2012, the government has explicitly earmarked only about 7.6% of revenues from natural resource leases to conservation efforts, through disbursements to the Land and Water Conservation Fund. The federal government distributes this money as matching grants to state and local agencies to secure or improve parks and recreational areas, across the country.

The Public Land Renewable Energy Development Act of 2013, however, establishes a different disbursement scheme for revenues generated by solar and wind energy development by setting up the Renewable Energy Resource Conservation Fund, which would use the leasing program's revenues to conserve fish and wildlife habitats and corridors by restoring and protecting lands impacted by solar and wind energy development. This money can also be used to secure recreational access to Federal public lands that are inaccessible or restricted (26).

During the first 15 years of the leasing program, the Treasury Secretary will disburse revenues in the following way:

Conservation Fund	35%
County	25%
State	25%
U.S. Treasury	15%

After 15 years, the percentage of revenues allotted to the U.S. Treasury will be diverted to the Conservation Fund. Moreover, throughout the life of the leasing program, the States must use 33% of their allotted revenues for purposes in line with the Conservation Fund. Effectively, this means that during the first 15 years of the leasing program, about 43% of renewable energy development revenues will be used for conservation purposes and 58% thereafter.

3.3 Renewable Energy Technology

Since the Public Lands Renewable Energy Development Act addresses wind and solar energy, it is pertinent to describe how these technologies work. Current technologies for both wind and solar energy include:

1. Wind Power

To harness wind energy, a turbine that is a minimum of 100 feet tall with 2 to 3 blades turns when the wind blows between 7 and 22 miles per hour (60). The blades spin a rotor, which in turn rotates a conventional generator. Energy from the generator is then converted into a voltage that can be transferred into the utility grid and distributed for use. Wind energy is currently not stored but used as produced. Wind turbines produce alternating current, which is what is need for electrical utility grids, and then is converted to direct current to be sent long distances and converted back before distribution (99).

2. Concentrated Solar Power (Thermal)

The reflection of the sun's energy to heat a single source is the primary component of concentrated solar power. Both the power tower system and the parabolic trough system apply this concept in different ways but achieve the same result.

Power Tower

Through the focusing of heliostats or sun tracking mirrors, the power tower system reflects the sun's radiation to a central fixed point. Generally, at the top of a tower this concentrated thermal energy heats up a conductor fluid that in turn heats water to power a steam powered generator. The generator then spins, starting the multiple step process of creating electricity for the utility grid (32). There are currently no utility scale applications of this system in the United States. In Spain, there is extensive implementation of the Power Tower system. An example of this would be the Gemasolar system in Seville. This produces 110 MW per year and is built on 85 hectares of land and uses 2650 concentrated mirrors. This power usage is equivalent to 25,000 homes and reduction atmospheric CO_2 emissions by more than 30,000 tons a year (82).

Parabolic Trough System

Similar to a power tower, this system uses mirrors to reflect solar energy to a tube that is attached to the long network of mirrors. The tube contains a conductor fluid, such as oil, that heats water to form steam and power a steam generator (7). The solar energy systems three sites in Kramer junction and Harper Lake California are the largest application of the parabolic trough system in the world and they combine to produce over 350 MW in capacity over 1,600 acres of land (73).

Photovoltaic

This is the most common form of solar power, which converts light from the sun into electricity through a series of steps. The arrays are lined with a semi conductor material such as silicon, which excites electrons which is energy being transferred. Like wind turbines the voltage must first be changed before it enters the utility grid (32). Nellis Air Force Base in Nevada developed a photovoltaic field of 70,000 panels, which has a 14 MW capacity and spans 140 acres (61).

3.4 Controversies

The solution to the environmental problems is not free of concern. There exist several controversies related to renewable energy production on public lands that could impact the future development of these projects. These controversies include the opponents, ecological impacts, reliability of energy production, energy transmission and storage and the cost of these productions.

1. Opponents of the Bill

As with any new bill or regulation for new development, there are stakeholders in opposition. Naturally, non-renewable energy companies, are potentially threatened by a shift to renewable energy development, and are opposed to the definition of the problem. Through lobbying efforts that include pushing for the introduction of disinformation into classrooms, and lowering the regulation for GHG emitters; these opponents base their arguments in favor of jobs and energy independence (49). Sympathetic to this group are those who either deny the existence of anthropogenic climate change, or consider the costs of renewable energy endeavors to outweigh the costs (e.g. Solyndra) (54). A less likely opponent to how the problem is addressed a certain environmental groups who are concerned that the activities to mitigate greenhouse gasses will cause greater harm on the environment. One such group, the Western Lands Project has cited evidence showing that further greenhouse gasses will be released through soil use, and certain species on public lands may face extinction (37).

2. Ecological Impacts

Commercial scale wind and solar production on public lands may disturb wildlife by habitat alteration, avian deaths, and habitat loss. Local ecosystems are likely disturbed during the installation of solar photovoltaic fields. Additionally, shading created by equipment could potentially disrupt fragile ecosystems by changing vegetation distribution and type (25). One of the largest concerns is disruption from concentrated solar power installations. The Ivanpah Solar Plant in California's Mojave Desert, for example, has been subject to criticism from environmental organizations for its potential negative impacts on native plant and animal species, especially the endangered desert tortoise (96). The National Parks Conservation Association (NPCA) reports that the plant will directly impact vegetation communities by mowing which keeps plant biomass from interfering with solar mirror movement and can also contribute to the spreading of non-native invasive plants. The NPCA also points out that the number of desert tortoises living in the project area may have been underestimated in the initial assessment by the U.S. Fish and Wildlife Service. Thus, concerns remain about the efficacy of the project's plans to mitigate impacts on the tortoise (66).

For solar energy, there is the potential for disturbance by changing the distribution or type of plant life due to shading created by the field. The ramifications of concentrated solar power are primarily concerned with the disturbance of fragile desert ecosystem, due to their practical application in area with the most solar radiation. The shadows caused from the application of the mirrors and the disturbance of land to place infrastructure for energy production could potentially disrupt the fragile ecosystems (25).

Wind energy production may also negatively impact bird and bat populations. Research conducted in the U.S. and Europe over the past 20 years indicates that bird collisions with wind turbines could be as much as 30 collisions per turbine per year (42). Such fatality numbers are, however, extremely variable due to experiment design and data collection; other studies reported collision rates of less than one bird per turbine per year (42). The fatality rates are also influenced by a variety of geographic, biological, and technical factors, such as location, arrangement and distribution of turbines; bird species; time of year; and other factors (42). For example, more fatalities were reported when turbines were located within a migratory corridor, arranged in a linear fashion, and equipped with long blades and slower tip speeds, than when turbines were not in a migratory corridor, arranged in clusters, with shorter towers and blades (42). There has not yet been extensive study of the effects of wind turbines on bats, but early studies indicate that impacts may be even more severe than on bird populations. The highest fatality numbers have come from sites in West Virginia and Tennessee, with an estimated 47.53 bats mortalities per turbine per 8-months and 28.5 bats per turbine per year, respectively (42). Other sites, however, have reported much lower bat moralities of 1.3-3.02 bats per turbine per year (42).

In addition to collision fatalities, habitat loss associated with wind farm development can also impact wildlife. Studies report that the construction of wind farms makes habitats unsuitable for birds; Leddy et al. (1999) found that grassland bird species densities were higher in areas without wind turbines and on grasslands in areas that were at least 80 meters from turbines (42). A study of the Buffalo Ridge Resource Area in Minnesota found "that densities of 7 of 22 grassland bird species were lower in the vicinity of wind turbines" (42). Additionally, roads constructed to service wind farms can also alter habitat and harm other wildlife. Wind farms in the American Southwest report population declines in bighorn sheep, ocelots, desert tortoises, and several species of snakes and lizards in close proximity to wind farms (42).

3. Reliability of Energy Production

Solar and wind energy both have inherent intermittency problems including non-controllable variability, partial unpredictability, and location dependency. For example, hourly wind power output on 29 different days in April 2005 at California's Tehachapi wind plant showed huge variability each day and hour (38). This creates several challenges when integrating solar and wind generated energy into the grid. Non-controllable variability of solar and wind energy requires other more reliable energy sources to balance supply and demand in the grid on an instantaneous basis, as well as ancillary services such as frequency regulation and voltage support (38). Partial unpredictability is an issue because weather predictions are not always accurate, even when multiple forecast scenarios are considered (38).

Renewable energy production is dependent on specific locations, which are usually distant from population centers where power is needed. For example, the southwest is endowed with a vast solar resource and at least 640,000 km^2 (250,000 square miles) of land suitable for solar production (33). The available land area receives over 4,500 Q-Btu of usable solar radiation per year (6.4 kWh/m^2 day); just 2.5% of this solar radiation is enough to generate more than the current level of annual energy consumption in the U.S. (33). The most favorable wind sites are in the Midwest, where wind energy resources at a 50 meters elevation (typical operating hub height of turbines) are rich (97). This location dependence is closely tied to another issue, transmission capacity (38).

4. Energy Transmission

Unlike fossil fuel power plants, renewable energy development is restricted to where the sun shines and the wind blows. In order to utilize the energy produced in remote areas, an expansion of the current transmission network is required. Additionally, bottlenecks occur within the current grid network. For example, there's long been a transmission bottleneck along the California-Oregon Intertie that has limited the amount of power that can travel between the two states (24). California has a huge power demand and it usually purchases surplus energy from hydro power plants and wind farms in Oregon. As more wind energy comes online in the Northwest, the transmission system is filling up and limiting where wind power can go (24). The transmission bottleneck problem was exacerbated in 2011, due to a large amount of snowmelt. Oregon produced approximately 3,000 more MW of power (the equivalent of three nuclear plants) than there was space on the transmission line to carry (24). As a result, wind farms in Oregon and Washington State were shut down on a rolling basis (62).

According to a report by World Resources Institute, Renewable Portfolio Standard (RPS) mandates adopted by 31 states will add about 208 GW of renewable energy generation capacity by 2030. This will require at least 30,000 to 40,000 miles of new transmission lines by 2030 (72). The International Energy Agency estimates 300 GW of wind power projects are waiting on transmission in the U.S., though not all of these projects would be built even if transmission issues were resolved (72). Another report, jointly issued by wind industry, government, and the national laboratories (primarily the National Renewable Energy Laboratory and Lawrence Berkeley National Laboratory) stated that transmission investments of approximately $60 billion was needed in a scenario in which wind provides 20% of U.S. electricity by 2030 (97).

It is inevitable that the transmission network will expand with the development of renewable energy. However, this poses challenges because transmission planning is not coordinated by the federal government, but at the state and local government level. Because renewable energy production would likely take place far from where energy is needed, transmission lines that cross several states would be required to meet demand. Renewable energy developers must understand how siting decisions are made in each jurisdiction where the transmission lines will cross and each political boundary presents another regulatory review, increases the complexity of the siting process, and raises the risk of failure (72). Additionally, transmission on federal lands may further delay project development through required environmental reviews (72).

5. Energy Storage

While the energy storage can solve many of the transmission of renewable energy issues, many of the different types of energy storage technologies available are yet to be commercialized. These technologies include pumped hydro, compressed air energy storage (CAES), fly wheels, fuel batteries, and superconducting electricity storage (33). Currently, pumped hydro accounts for 99% (127,000 MW) of installed energy storage in the world (22). CAES installations are the next largest (440 MW), followed by sodium-sulfur batteries (316 MW) (22). Since installed storage capacities of flywheels and superconducting electricity storages are minimal, the three technologies more readily available in the market will be examined.

Most energy storage systems are expensive because of capital outlays or energy losses incurred while storing and retrieving energy (33). Pumped storage is one of the least expensive ways to store energy, but it is still a large investment (50). The Department of Energy estimates that the cost of building pumped storage is between $1 and 2 billion for a typical 1,000 MW facility (46). This storage works by moving water between two reservoirs located at different elevations (i.e., an upper and lower reservoir) (30). Generally, when electricity demand is low (e.g., at night), excess electric generation capacity is used to pump water from the lower reservoir to the upper reservoir (30). When electricity demand is high, the stored water is released from the upper reservoir to the lower reservoir through a turbine to generate electricity (30). The primary advantage of pumped hydro is that very large amounts of power can be stored for long periods of time, but accessed quickly (66). The disadvantages are that initial capital costs are high, and the technology is limited by geography to locations that can host a large reservoir at a significantly higher elevation than the power station (66). Additionally, there are regulatory barriers. For example, pumped hydro projects take five years to permit and another five years to build (46).

The second largest category of utility-scale energy storage is compressed air energy storage (CAES). Excess energy is used to run air compressors to pump air into underground caverns, where the air is stored under pressure (28). The compressed air is traditionally used with natural gas for increased efficiency (28). CAES can store a large amount of energy and the cost is half that of lead-acid batteries but like pumped hydro, it is also limited by geography because it requires an underground cavern with reservoir. The two most readily available energy storage options have their own geographical limitations, which do not necessarily overlap with favorable solar and wind sites. For example, pumped hydro requires two reservoirs at different elevations whereas most solar energy is located in deserts.

Portable energy storage options, such as batteries, are free from geographic limitations but they are seldom used for back up energy because they have low storage capacity, are expensive, and have a limited lifespan (66). The most widely used batteries are lead-acid batteries. Lead-acid batteries are a relatively mature technology with a reasonably low cost. However, lead-acid batteries are heavy, sensitive to temperature (low capacity at low temperature), have low storage capacity, high maintenance requirements, and hazards associated with lead and sulfuric acid during production and disposal (28). Other batteries include sodium-sulfur batteries, flow batteries, nickel cadmium batteries, lithium ion batteries, and fuel cells. Each technology has its own strengths and weaknesses but most commonly these batteries are expensive and have low storage capacity. However, there is much research underway on advanced batteries projected to reach GW levels of utility-scale storage over the next 10 years (66). This is favorable both for wind and solar energy.

It is suggested that a combination of several different storage technologies be used to provide smooth and uninterrupted electricity supplies, especially from utility scale renewable energy sites. In this way, both short and longer term power interruptions can be compensated from stored energy (28). However, preference of one storage method over another is site specific and must account for local conditions (28). Energy transmission issues can be partly addressed by developing energy storage for solar and wind energy.

6. Cost of Renewable Energy

Compared to conventional energy, renewable energy development has been costly. According to Environmental Law Institute's report on U.S. Government subsidies to energy sources, between 2002 and 2008, fossil fuels were subsidized by $72 billion while renewable energy more specifically corn ethanol received $29 billion in subsidies (24). A large portion of fossil fuel subsidies was derived from just a few provisions in the U.S. Tax Code, including a provision (the Foreign Tax Credit) whose operation does not appear to be widely understood by policymakers or the public (24). Looking at such data, it is evident that clean renewable energy providers such as solar and wind producers were not the beneficiaries of government subsidy over the past decade. However, with the Obama Administration's active commitment to diversifying energy sources and increasing renewable sources is likely to act as catalyst for cost reduction of renewable technologies.

The article by Jacobson and Delucchi in Scientific American in 2009 presented more favorable prospects for renewable energy in terms of cost. The average cost in the U.S. in 2007 of conventional power generation and transmission was about 7 cents per kWh, and it is projected to increase to 8 cents per kWh in 2020 (40). It was found that the costs of wind, geothermal and hydroelectric are all less than 7 cents per kWh, expected to decrease to 4 cents per kWh or less by 2020. On the other hand, solar power (both photovoltaic and concentrated) is relatively expensive now but should be competitive with fossil fuels (10 cents per kWh), by 2020 (40). The cost of solar power is expected to decrease slower than wind energy because the study took into account the long-distance transmission and the cost of compressed air storage of power for use at night (40).

5. Evaluating Success

The optimal outcomes for using the public lands for renewable energy development are to preserve the environment and conserve resources, diversify the US energy supply and reduce US contribution to emissions and climate change.

Mitigate Environmental Impacts

Input
- Conduct Programmatic Environmental Impact Statements (PEIS)

Output
- Establish policies and management techniques to protect and restore environment

Outcome
- Mitigate impacts and maximize utility scale renewable energy projects

The environmental impact from energy production can be significant, even renewable energy. With the construction of Utility Scale Renewable Energy Development (USRED), there is potential for significant damage to natural habitats of native plants and for the displacement of wildlife. Accordingly, one must determine the indicators within the inputs and outputs to determine the extent to which we can enact the mitigation of ecological impacts. The optimal outcome is to responsibly balance USRED with the ecological footprint that it may cause. It is difficult to quantify the ecological impact until the project has been enacted. Thus, mitigation of environmental impacts is maximized by restricting USRED to the areas that will create the least amount of damage.

Diversify Energy Supply

Input
- Enact 4 pilot projects to test the feasibility of competitive leasing structure

Output
- Streamline process to cite, review, and build renewable energy projects

Outcome
- Expand competitive leasing structure to all BLM managed, Military, and Forest Service Lands

In its Annual Energy Outlook 2007, the U.S. Energy Information Administration (EIA) estimates that U.S. electricity demand will grow by 39% from 2005 to 2030 (88). Price fluctuations in fossil fuels and energy independence also favor USRED to bolster energy independence (88). It is important to note that 4,054 billion kilowatt hours of energy were consumed in the U.S., only 3% and 0.11% of which were created by wind and solar energy respectively. These factors place further impetus on diversifying the energy supply. In 2013, President Barack Obama set a goal for the U.S. to build an additional 10 GW of renewable energy on public lands (21), and in addition three GW of renewable energy on military lands (21). The inputs and outputs of the bill directly address this demand.

Reduce America's Carbon Footprint

Input
- Establish areas suitable for development

Output
- Maximize potential to displace fossil fuel use

Outcome
- Lower greenhouse gas emissions

Energy consumption is one of the largest driving factors in greenhouse gas (GHG) emissions, namely the release of carbon dioxide into the atmosphere. Roughly 84% of current anthropogenic carbon dioxide emissions in the U.S. are energy-related and about 65% of all GHGs can be attributed to energy supply and energy use (39). In 2013, President Obama set a goal to lower the U.S.' carbon footprint to below 17% of the 2005 levels (21). Since 2005, the U.S. has lowered the amount of carbon emitted by 8% to about 5,300 million tons of carbon dioxide. While the bill has the potential to lower GHGs, it is important to note that this is just one aspect of the goal of reducing by 17%. From 2007-2012, wind and solar only accounted for 13% of the decrease in carbon emissions (55). Reductions can also come from improved fuel efficiency, emissions standards, and switching from coal power plants to less polluting GHG sources such as natural gas (94).

Discussion of Outcomes:

It is important to note that while PEIS's have been conducted to determine site suitability and identify best management plans, the bill will conduct site specific PEIS for each pilot project. The success of diversifying the energy supply will depend on whether or not solar and wind can keep up with their current pace of development, which from 2007-2012 has increased by 300% to 600% respectively (95). The most desirable outcome would be to maximize the amount of energy produced on public lands from these sources, as they have essentially zero carbon emission intensity once they have been installed.

Conclusion

In conclusion, public lands are a significant resource for wind and solar development. The Public Land Renewable Energy Development Act of 2013 assesses suitable lands for renewable energy projects and establishes a pilot competitive leasing program on public lands managed by the Bureau of Land Management, National Forest Service and the U. S. military. The bill, if adopted, will likely be an indirect solution to mitigate habitat destruction, wildlife disturbances, and other local environmental issues from fossil fuels extraction. Additionally, the Public Land Renewable Energy Development Act may mitigate the global impacts of greenhouse gas emissions (GHGs) from fossil fuels combustion and the impacts of climate change, including sea level rise, ocean warming, and changes in weather patterns. In addition to reducing the U.S. contribution to climate change, the bill also guides responsible agencies to assess and mitigate the environmental impacts of renewable projects on public lands.

While the bill presents a potential solution to these environmental problems, there are issues that must be addressed including the cost of renewable energy production, transmission efficiency, and energy storage. If passed, the success of the Public Land Renewable Energy Development Act would be determined if responsible renewable energy projects increased on public lands and reducing the impacts of fossil fuels extraction and combustion.

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