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*Article*

# Exploring and Contextualizing Public Opposition to Renewable Electricity in the United States

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**Abstract:** This article explores public opposition to renewable power technologies in the United States. It begins by discussing the genesis of environmental ethics, or how some Americans have come to place importance on the protection of the environment and preservation of species, ecosystems, and the biosphere. As result, renewable power systems have become challenged on ethical and environmental grounds and are occasionally opposed by local communities and environmentalists. The article finds that, however, such concern may be misplaced. Renewable electricity resources have many environmental *benefits* compared to power stations fueled by coal, oil, natural gas, and uranium. Opposition towards renewable resources can at times obscure the true costs and risks associated with electricity use and entrench potential racial and class-based inequalities within the current energy system.

**Keywords:** renewable electricity; renewable power; public opposition

## 1. Introduction

The forester and philosopher Aldo Leopold [1] once wrote that promoting sustainable development was "a job not of building roads into lovely country, but of building receptivity into the still unlovely human mind". His comment underscores that the true challenge for any new technology or idea, conventional or alternative, is to win the "hearts and minds" of the people relying on it. Renewable electricity sources such as wind turbines, solar panels, bioelectric power stations, geothermal power plants, and even hydroelectric dams often generate electricity with minimal environmental damage compared to their fossil-fueled or nuclear counterparts. Yet some concerned farmers, property owners, environmental scientists, and activists have attacked such systems for harming the environment and ruining the aesthetic beauty of the land.

To frame the opposition towards renewable energy in the United States, the article begins by discussing the genesis of environmental ethics, or how some Americans have come to place importance on the protection of the environment and preservation of species, ecosystems, and the biosphere. American concern toward the environment peaked in the 1970s after environmental crises precipitated a growing social frustration with the perceived mounting challenges of industrial pollution, population growth, and resource scarcity. These challenges convinced voters and politicians to acquiesce to a social movement that had been arguing for legislative actions to protect the country's environment. As a direct consequence of such action, and perhaps incongruously, renewable power systems have become challenged on ethical and environmental grounds and are opposed by some local communities and environmentalists for aesthetic reasons. The article finds that, however, such concern may be misplaced. Renewable electricity resources have many environmental *benefits* compared to power stations fueled by coal, oil, natural gas, and uranium. Opposition towards renewable resources can at times obscure the true costs and risks associated with electricity use and entrench potential racial and class-based inequalities within the current energy system.

## 2. The Emergence of American Environmental Ethics

For most of the country's history, Americans have tended to place their own personal needs above that of the environment. Nearly two hundred years of cheap fuels, industrial growth, abundant natural resources, and an environment that could seemingly absorb pollution endlessly convinced many people that they were, in fact, entitled to dominate Nature. These classical ideas created a worldview that correlated energy consumption with economic growth and convinced many Americans that they are somehow entitled to consume as much energy as possible, and promoted the notion that technology can overcome all resource constraints.

Historically, such a worldview can be connected to New England Puritan ideals. The original pilgrims found their natural surroundings strange and threatening, and their writings often referred to nature as an "enemy to be subjugated" [2]. Forests were cleared, wilderness declared an obstacle to progress, and the advancing frontier was conceived only as a terrain to be conquered through manifest destiny. To assist them in their conquest over Nature, settlers placed their faith in technology, their trust in experts, and their confidence in the idea that American ingenuity could solve all problems. Mastery over Nature went hand-in-hand with other American ideals, including the right to own land and property, individualism, independence, and self-reliance. These ideals were threaded together into an overall belief in progress. Such progress was to be accomplished through technological development and more energy consumption [3].

However, in the late eighteenth and nineteenth centuries, the emergence of the Romantic Movement began to challenge this worldview. The works of William Blake, William Wordsworth, and Johann Wolfgang von Goethe (among others) argued that Nature should not be viewed as an impersonal machine, but an organic process with which humanity is united. Other writers associated wilderness with the sublime, wild, and untouched landscape. The transcendentalists in New England referred in similar terms to the sacred dimension of Nature. Henry Thoreau held that Nature was a source of inspiration, vitality, and spiritual renewal, writing that "in wildness is the preservation of the World" [4]. The works of Charles Darwin (1859) and George Perkins Marsh (1864) described how species of plants and animals are part of Nature in continuity with other forms of life, including humans, and during the 1870s John Muir circulated the philosophy of wilderness preservation. A few decades later, during the Great Depression and the Dust Bowl in the 1930s, many Americans witnessed perhaps the country's worst ecological disaster firsthand, further inspiring a conservation ethic. Congress created the Soil Conservation Service (the future Natural Resources Conservation Service), Grazing Service (future Bureau of Land Management), and Civilian Conservation Corps to educate Americans about the value of preserving natural resources, a trend later disrupted by World War II and industrial wartime production.

Romanticist, transcendentalist, and conservationist ideals still greatly influenced later twentieth-century work arguing in favor of protecting wilderness and the environment. In his introduction to *A Sand County Almanac*, Aldo Leopold [1] directly challenged American destruction of the natural world and likened society to a hypochondriac, so obsessed with its own "economic health" that its people have lost the "capacity to remain healthy, the whole so greedy for more bathtubs that it has lost the stability necessary to build them, or even turn off the tap." The fundamental flaw with such a strategy, Leopold argued, was that it transformed the landscape from something humbling and natural into an economic symbol degradable and exploitable; a land that entails privileges but not obligations. Likewise, Charles S. Elton argued in favor of an environmental ethic in the mid-1950s [5]. Elton suggested that protecting the environment could be justified from a very practical desire to preserve the land, crops, forests, water, and fisheries that are needed to sustain human life.

The nation's environmental consciousness transformed dramatically during the 1960s. Rachel Carson's *Silent Spring* documented the terrifying threat from uncontrolled use of pesticides, and concluded that the challenges posed by threats could only be addressed by a sustained, coordinated, and a thoroughly ecological worldview [6]. Around the time Carson's text was hitting bookshelves, American politics became more nationalized, a phenomenon encouraged by the growth of the national media. The Santa Barbara oil spill, Cuyahoga River fire, and other environmental events became national events broadcast at a national level. While numerous environmental disasters had occurred in the preceding decades, stories of such events were not distributed as widely nor in as visceral a manner. The 1960s thus witnessed the start of national environmental legislation. The 1960 Multiple-Use Sustained-Yield Act directed federal agencies to better manage national forests. The 1964 Wilderness Act established federal lands as wilderness areas. The 1966 National Historic Preservation Act created a network of protected parks and areas. The 1966 Department of Transportation Act called for more efficient automobiles. And the 1968 Wild and Scenic Rivers Act aimed to clean up some of the country's rivers and streams.

These early acts laid the foundation for modern environmental ethics, advocated in turn by an organic environmental social movement. Even though, as a whole, the idea of "environmental ethics" is much more variegated than presented here, it advanced four basic themes: humans are dependent on nonhuman forms of Nature; pollution of air, water, and land is clearly detrimental to human life; limits should be set on the exploitation and use of natural resources; and humans have a duty to preserve the biosphere for future generations. While certainly supported on strong spiritual and ethical grounds, the concept of an environmental ethic also has its connections to advances in ecology, conservation biology, and evolutionary biology. These sciences developed the idea that species exist as part of an ecosystem; that humans are interdependent with all members of a biotic community; that biological diversity is needed for ecological balance and stability; and that finite limits exist for population growth and the capacity of the environment to provide resources.

The force of the environmental movement on society and policy was most profound in the United States during the 1970s. The federal government implemented copious federal statutes, including the Clean Air Act of 1970; National Environmental Policy Act of 1970; Federal Insecticide, Fungicide, and Rodenticide Act of 1972; Coastal Zone Management Act of 1972; Federal Water Pollution Control Act of 1972; Endangered Species Act of 1973; Safe Drinking Water Act of 1974; Resource Conservation and Recovery Act of 1976; Toxic Substances Control Act of 1976; Clean Water Act Amendments of 1977; Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (commonly known as "Superfund"); and the Alaska National Interest Lands Conservation Act of 1980. According to historian Robert Nash [3], it was during this time that "environmentalism changed from a religion to a profession" and moved from a "blue-jean-and-granola style of conservation evident at the time of the first Earth Day" to a sophisticated and lasting social movement. While laws aimed at protecting the environment have certainly been passed since, it was during this period that the conceptual and political groundwork was laid to support the wider environmental movement, and environmentalists continue to exert influence on state and federal policy.

## 3. Exploring Public Opposition to Renewable Electricity

Given the importance that many Americans place on environmental protection, it may come as no surprise that some have come to believe that, as part of preserving Nature, renewable electricity systems should be opposed because they harm species and destroy ecosystems. Yet the social acceptance of renewable electricity, and indeed many other forms of energy supply, has different dimensions. Acceptance and rejection at the scale of local communities tends to revolve around issues related to local environmental quality, procedural justice, distributional justice, and trust, yet at larger scales involve broader socio-political and market dimensions related to public approval, electricity prices, profitability for investors, and the ability to improve energy security [7]. Thus, renewable energy technologies can be rejected or accepted by communities and local operators along with the general public, environmental groups, electric utilities, regulators and commissioners, investors, electricity customers, and other firms. At times it can even be approved or disapproved of *within* groups. Whereas many conflicts between development and land use tend to revolve around economic benefits versus environmental costs, the case of opposition to renewable energy is unique in the sense that it can split environmental advocates that approve of projects against those that oppose them because of their land use impacts, a sort of "green on green" conflict [8]. Some forms of opposition can cut across community, socio-political, and market dimensions simultaneously. Landowners may oppose a wind farm because they fear it will lower their property values and increase their electricity bills; environmentalists because they believe it could harm birds and require fossil-fueled power stations to "backup" intermittent wind generation; investors because they worry about delays in project implementation; politicians and regulators about job losses and public controversy. These forms of opposition fuse community, environmental, economic, and political concerns together.

Extensive surveys of public opinion related to renewable energy (and other power plants) have also revealed that attitudes and values change over time and by location. One review of the literature found that some Americans think of renewable energy as environmentally friendly where others see it as expensive, unreliable and dangerous; some view it as way to enhance the economy and improve long term energy security while others view it as a threat to their jobs and current energy markets [9]. One longitudinal study looked at U.S. public opinion relating to energy sources and priorities from 1974 to 2006 and noted that public attitudes as a whole have shifted [10]. The assessment identified a more pessimistic view held during the energy crises of the 1970s, a more optimistic view in the early 1980s when oil prices dropped, a pessimistic view again in the late 1980s and early 1990s after Chernobyl, the *Exxon Valdez* spill, and Persian Gulf War, and a recent resurgence of concern (related to energy shortages) from 2001 to 2006.

Such shifting views highlight that renewable electricity sources, while cleaner than alternatives, provoke very different reactions among different groups of people and at different times. Although opposition and support of renewable energy is varied, however, some farmers, environmental advocates, investors, regulators, and ordinary citizens truly believe that they have serious environmental consequences. Correspondingly, this section briefly summarizes their primary concerns about wind energy, hydro, biomass, geothermal, and solar sources of electricity, with the greatest emphasis placed on wind turbines due to an abundance of data associated with their environmental performance.

### *3.1. Wind*

Perhaps the most vociferous environmental concern associated with wind energy relates to the death of birds resulting from collisions with wind turbine blades, an issue termed “avian mortality.” Onshore and offshore wind turbines present direct and indirect hazards to birds and other avian species. Birds can directly smash into a turbine blade when they are fixated on perching or hunting and pass through its rotor plane; they can strike its support structure; they can hit part of its tower; or they can collide with its associated transmission lines. These risks are exacerbated when turbines are placed on ridges and upwind slopes, close to migration routes, and when there are periods of poor visibility such as fog, rain, and at night. Indirectly, wind farms can physically alter natural habitats, the quantity and quality of prey, and the availability of nesting sites [11-15].

Others find wind turbines visually unattractive, especially in significant tourist or recreational destinations where the human-built turbines impose obtrusively on the natural environment. The regions in the United States with the most offshore wind potential include areas along the eastern seaboard, coastlines highly valued for their fisheries, aesthetics, and recreational activities. One recent study noted that for many people, “fears of three hundred foot spinning turbines and blinking navigational lights blanketing the horizon have caused an uproar that threatens to drown out wind power’s loudest advocates” [16].

And onshore, older wind turbines from the 1970s sometimes created interference with radio, television, and other electromagnetic transmissions. While recent improvements in turbine technology have eliminated these problems, blade noise from 1970s prototypes, induced by low-frequency aerodynamic sounds generated by the interaction of turbine blades and the tower, could often be heard up to one kilometer away. Consequently, many citizens campaign aggressively against wind farms. One survey of 1,200 residents in Watauga County, North Carolina, found that 64 percent believed that wind turbines would "harm mountain views." The community even stated that they would pay as much as $724,000 per year to have wind farms sited somewhere else [17].

Some argue that effective and large wind farms are sometimes highly land intensive. The U.S. Department of Energy [18] notes that large-scale utility wind turbines usually require one acre of land per turbine. When these big machines are built in densely forested areas or ecosystems rich in flora and fauna, they can fragment large tracts of habitat. At the Mountaineer Wind Energy Center in West Virginia, more than 40 acres of forest were bulldozed and 150 acres of forest interior were lost to erect eight turbines [19]. Similarly, 350 acres of forest habitat were destroyed to construct 20 wind turbines at a Meyersdale, Pennsylvania, wind farm [19].

### *3.2. Hydroelectric Dams*

For hydroelectric dams, the most extensively debated and complex problems relate to habitat and ecosystem destruction, emissions from reservoirs, water quality, and sedimentation [20]. All these concerns arise because of a dam's role as a physical barrier interrupting water flows for lakes, rivers, and streams. Consequently, dams can drastically disrupt the movement of species and change upstream and downstream habitats. Such barriers also result in modified habitats with environments more conducive to invasive plant, fish, snail, insect, and animal species, all of which may overwhelm local ecosystems. To maintain an adequate supply of energy resources in reserve, most dams impound water in extensive reservoirs. However, these reservoirs can also emit greenhouse gases from rotting vegetation [21].

### *3.3. Biomass*

While biomass combustion has the advantage of not releasing any net $CO_2$ into the atmosphere (and thus contributes little to the global inventory of greenhouse gases), it releases measurable levels of a wide variety of pollutants to air land and water [22]. These air pollution issues parallel aesthetic concerns about land use, smell, and traffic congestion. The combustion of biomass has been noted to release foul odors near some plants, and they can contribute to traffic congestion when large amounts of fuel must be delivered by trucks [23]. The use of agricultural wastes, forest residues, and energy crops such as sugar, legumes, and vineyard grain to generate electricity, when harvested improperly, can strip local ecosystems of needed nutrients and minerals [22]. Widespread use of these crops can also contribute to habitat destruction and deforestation [24].

### *3.4. Geothermal*

For geothermal electricity, plants can emit small amounts of hydrogen sulfide and $CO_2$ along with toxic sludge containing sulfur, silica compounds, arsenic, and mercury (depending on the type of plant) [25]. Geothermal systems require water during drilling and fracturing processes, and are ill-suited for desert areas or regions with low levels of water [26]. Extra land may also be required for the disposal of waste salts from geothermal brines, and contamination of groundwater and freshwater can occur if plants are poorly designed [27].

### *3.5. Solar*

Lastly, for solar power, the lifecycle for solar photovoltaic systems requires the use of hazardous materials, such as silicon, which must be mined from the earth and can contaminate areas of land when such systems break down or are destroyed, such as during hurricanes and tornados [28-30]. Chemical pollution has also been noted to occur during the manufacturing phase of solar cells and modules [31].

## 4. Contextualizing Public Opposition to Renewable Electricity

While pointing out the costs of renewable electricity sources is important, such a call for balance and clarity is counterproductive if it obscures that they are much better for the environment than conventional sources. As Holdren and Budnitz [32] pointed out more than three decades ago, “no existing or proposed energy technology is so free of environmental liabilities as to resolve satisfactorily the central dilemma between energy’s role in creating and enhancing prosperity and its role in undermining it through environmental and social impacts”. In assessing the environmental benefits of alternative energy systems, it is important to remember that all sources of electricity supply have environmental damages. Once this admission is accepted, renewable electricity generators have clear advantages over conventional sources of electricity supply. Even legitimate concerns about avian mortality, land use, hydroelectric dams, bioelectricity, geothermal energy, and solar photovoltaics are not as bad as they may appear.

### *4.1. Wind*

While the avian mortality issue should certainly be taken seriously, several facts make bird deaths unique to older wind sites. Altamont Pass, a wind farm known for its negative impact on birds, is located near bird migration routes and has terrain, such as craggy landscapes and various canyons, making it ideal for birds of prey. It takes at least fifteen Altamont turbines to produce as much electricity as one modern turbine, and early turbines were mounted on towers at the same level as bird flight paths (60 to 80 feet in height). Modern wind turbines, by contrast, need fewer units to produce the same amount of electricity and are mounted on towers that typically avoid birds at a height of 200 to 260 feet. Death rates of birds have decreased in recent years as wind power entrepreneurs have installed larger turbine blades that turn more slowly, and have used advanced thermal monitoring and radar tracking to site turbines more carefully [11]. Developers commonly avoid placing wind farms in areas of high nesting or seasonal density of birds, remove potential perches on lattice towers, and utilize micrositing to position turbines in ways that minimize intersection with flight paths. Researchers have also noted that birds often become aware of operating wind turbines and take measures to avoid them after erected [11].

One initial study of the avian deaths associated from wind, fossil fuel, and nuclear power facilities found that wind turbines were responsible for the *least* amount of bird deaths, both in absolute terms and when compared per unit of electricity generated [11]. That study found that wind turbines were responsible for about 0.3 fatalities per gigawatt-hour (GWh) but that nuclear facilities were responsible for 0.4 fatalities and fossil-fueled power plants 5.2 fatalities per GWh. If correct the estimate meant that wind farms killed approximately seven thousand birds in the United States in 2006 but nuclear plants killed about 327,000 and fossil-fueled power plants 14.5 million.

To put the avian mortality issue in greater perspective, the absolute number of avian deaths from onshore and offshore turbines is incredibly low compared to other sources. Millions of birds die each year when they strike tall stationary communications towers, get run over by automobiles, or fall victim to stalking cats. After surveying wind development in California, Colorado, Iowa, Minnesota, New Mexico, Oklahoma, Oregon, Texas, Washington, and Wyoming (the 10 states with more than 90 percent of total installed wind power capacity), the U.S. Government Accountability Office [33] calculated that building windows are by far the largest source of bird mortality, accounting for 97 million to 976 million deaths per year. Attacks from domestic and feral cats accounted for 110 million deaths; poisoning from pesticides came next at 72 million; and collisions with communication towers were next, at 4 to 50 million [33].

In addition, the land occupied by wind turbines, unlike the property needed for a coal plant or nuclear facility, can still be used for farming, ranching, and foresting. When configured in large centralized plants and farms, wind technologies use around 10 to 78 square kilometers of land per installed GW per year, but traditional coal-fired plants can use more than 100 square kilometers of land per year to produce the same amount of electricity when using open cut coal mines [34-35]. In open and flat terrain, newer large-scale wind plants require about 60 acres per MW of installed capacity, but the amount drops to as little as 2 acres per MW for hilly terrain. While this may sound like a lot, however, only 5 percent or less of this area is actually occupied by turbines, access roads, and other equipment; 95 percent can remain free for other compatible uses [36]. Because almost all of the fuel cycle impacts for a wind farm are in one location (whereas the fuel cycle impacts of a coal plant are spread out over a number of different and unconnected locations), however, the apparent impact of wind turbines sources (misleadingly) seems larger.

### *4.2. Hydroelectric Dams*

All forms of hydroelectric generation combust no fuel, meaning they produce little to no air pollution in comparison with fossil fuel plants. Gagnon van de Vate [21] conducted a full life-cycle assessment of hydroelectric facilities, and focused on the activities related to the building of dams, dykes, and power stations; decaying biomass from flooded land (where plant decomposition produces methane and carbon dioxide); and the thermal backup power needed when seasonal changes cause hydroelectric plants to run at partial capacity. The study found that typical emissions of greenhouse gases for hydropower were still 30 to 60 times less than those from equally sized fossil-fueled stations.

### *4.3. Biomass*

Dedicated biomass electrical plants release no net carbon dioxide into the atmosphere (as long as they avoid combusting fossilized fuel) and produce fewer toxic gases. One study conducted by the Center for Energy Policy and Technology found that combined cycle biomass gasification plants produce much lower levels of atmospheric pollutants than those emitted by similarly sized coal-fired and natural gas-fired plants [37]. Landfill capture generators and anaerobic digesters harness methane and other noxious gases from landfills and transform them into electricity. This does not just produce useful energy, but also displaces greenhouse gases that would otherwise escape into the air-shed.

High-yield food crops leach nutrients from the soil, but the cultivation of biomass crops on degraded lands can help stabilize soil quality, improve fertility, reduce erosion, and improve ecosystem health. Perennial energy crops can improve land cover and enable plants to form an extensive root system, adding to the organic matter content of the soil [38,39]. Agricultural researchers in Iowa, for instance, discovered that planting grasses or poplar trees in buffers along waterways captured runoff from corn fields, making streams cleaner [40]. Prairie grasses, with their deep roots, build up topsoil and put nitrogen into the ground, and twigs and leaves decompose in the field after harvesting, enhancing soil nutrient composition [41]. Woody biomass plantations can reduce erosion by improving water infiltration and stabilizing soil through their roots and by creating leaf litter [42]. Switchgrass grows without irrigation and is harvested with a low-labor process similar to mowing the lawn; in some cases its cultivation can actually create filter strips that trap and purify pollutants [43]. Biomass crops can also create better wildlife habitats, since they frequently utilize native plants that attract a greater variety of birds and small animals [40].

### *4.4. Geothermal*

Geothermal plants have immense environmental benefits. A typical plant using hot water and steam to generate electricity emits about 1 percent of the sulfur dioxide, less than 1 percent of the nitrogen oxide, and 5 percent of the carbon dioxide emitted by a coal-fired power plant of equal size. Its airborne emissions are “essentially nonexistent” because geothermal gases are not released into the atmosphere during normal operation [27]. Another study calculated that the geothermal plants currently in operation throughout the United States avoid 32,000 tons of nitrogen oxide, 78,000 tons of sulfur dioxide, 17,000 tons of particulate matter, and 16 million tons of carbon dioxide emissions every single year [44].

### *4.5. Solar*

When integrated into building structures and facades, solar PV systems require no new land. The California Exposition Center in Sacramento, California, fully integrates 450 kW of solar panels into a parking lot. The Energy Policy Initiatives Center at the University of San Diego recently estimated that the city could construct 1,726 MW of solar PV relying only on available roof area downtown [45]. The Worldwatch Institute even believes that solar power plants that concentrate sunlight in desert areas require 2,540 acres per billion kWh. On a life-cycle basis, this is less land than a comparable coal or hydropower plant generating the same amount of electricity [46].

## 5. Putting It All Together

More than just an interesting insight about American society, the opposition to renewable electricity technologies has at least two important consequences. Firstly, it may obscure greater risks inherent with conventional forms of supply. Secondly, it can naturalize racism and classicism connected with current patterns of electricity consumption and use.

*5.1. Obscuring Greater Risks*

What happens when the costs and benefits of renewable electricity systems are added together, and compared to other existing alternatives, may surprise readers. The existing electricity rates and prices that customers see on their bills do not reflect many of the costs and benefits discussed above, nor do they reflect them for fossil-fueled and nuclear power stations. Economists refer to such items as "externalities", or costs and benefits resulting from an activity that do not accrue to the parties involved in the activity. Consider the classic example of unregulated pollution from a smokestack. A factory produces items that are priced by taking into account the demand for the products, labor, and capital, but the damages from the factory's pollution—deterioration of public health and degradation of the environment—are true costs borne by society that are unaccounted for in the price of the factory's widgets. These latter costs are commonly referred to as "externalities" because people tend to consume them as by-products of other activities that are "external" to market transactions, and therefore un-priced.

Not all externalities have to be negative. One survey of American electricity markets in 2006, for instance, found that renewable electricity technologies were not adequately valued for at least six of the positive externalities that they provided, including risk management, environmental performance, financial stability, reduced resource use, improved public image, and economic spillover effects [47]. Awerbuch [48], a financial economist, found that the "risk management" benefits of renewable electricity sources amounted to at least 0.5 ¢/kWh that were not reflected in traditional electricity markets.

While their list is incomplete, Sundqvist and Soderholm [49] and Sundqvist [50] analyzed 38 electricity externality studies and 132 estimates for individual generators to determine the extent that positive and negative externalities were not reflected in electricity prices. The authors found that these costs, when averaged across studies, represented an additional 0.29 to 14.87 ¢/kWh in 1998 dollars, with coal, oil, and nuclear power having the greatest net costs followed by biomass, natural gas, hydroelectric, solar, and wind technologies.

One important aspect of their analysis is that they did not weight or adjust the values given by the studies they surveyed and instead amalgamated them into a single class of estimates presented in Table 1. They caution that jumbling the numbers together does not account for significant discrepancies among estimates resulting from the differing methodologies those studies used, but they do conclude that "even if much of this knowledge cannot be transferred directly into a tax or a regulation, it should be able to impact upon the focus of the political debate and ultimately on policy decisions" [49]. In other words, comparing many studies with different foci and methodologies has its flaws, but in the end such comparisons should affect and influence policy.

Notwithstanding these caveats, when updated to $2007 and correlated with actual electricity generation in the United States, the extra costs associated with conventional sources identified by Sundqvist and Soderholm are monumental: $228 billion in damages per year for coal, $105 billion for oil and gas, $87 billion for nuclear power—an amount worth more than the industry's entire revenue for that same year [51].

**Table 1.** Negative Externalities Associated with Conventional, Nuclear, and Renewable Power Plants ($1998).

| | **Min** | **Max** | **Mean** | **SD** | **N** |
|---|---|---|---|---|---|
| **Coal** | 0.06 | 72.42 | 14.87 | 16.89 | 29 |
| **Oil** | 0.03 | 39.93 | 13.57 | 12.51 | 15 |
| **Gas** | 0.003 | 13.22 | 5.02 | 4.73 | 24 |
| **Nuclear** | 0.0003 | 64.45 | 8.63 | 18.62 | 16 |
| **Hydro** | 0.02 | 26.26 | 3.84 | 8.40 | 11 |
| **Wind** | 0 | 0.80 | 0.29 | 0.20 | 14 |
| **Solar** | 0 | 1.69 | 0.69 | 0.57 | 7 |
| **Biomass** | 0 | 22.09 | 5.20 | 6.11 | 16 |

Source: Sundqvist and Solderholm [49] and Sundqvist [50].

Some important points need to be made about these numbers as to why they may underestimate the damages from conventional resources. When surveying externalities, Sundqvist and Soderholm did not include any value for carbon dioxide and climate change. They explain that their meta-survey found a range of damages so large (from 1.4 ¢/kWh to 700 ¢/kWh) that they decided to exclude climate change externalities. Virtually none of the studies accounted for the risk of environmental damages—such as tipping points that are crossed as the earth's climate changes, unknown ecological thresholds that are passed, and species extinctions that are fundamentally irreversible—that entail impacts impossible to recover from once they begin. Most of the studies surveyed modeled damages associated with a single power plant, and not the combined or cumulative damages from a fleet of power plants or an entire utility system. Many studies assumed reference, rather than representative, technologies; that is, they assumed benchmark and state-of-the art technologies instead of those used by utilities in the real world where one-fifth of the nation's power plants are more than 50 years old.

Others have made similar estimates of the relative life-cycle costs of conventional and renewable fuels. In one recent study, traditional coal boiler generation technology appeared to produce relatively cheap power—under 5 ¢/kWh over the life of the equipment, which included capital, operating and maintenance costs, and fuel costs—while wind-turbine generators and biomass plants produced power that cost 7.4 ¢/kWh and 8.9 ¢/kWh, respectively. But when analysts factored in a host of externality costs, coal boiler technology costs rose to almost 17 ¢/kWh, while wind turbines and biomass plants yielded power costing about 10 ¢/kWh [52].

Researchers from the Alliance to Save Energy, a nonpartisan think tank, found that if damages to the environment in the form of noxious emissions and impacts on human health resulting from combustion of coal, oil, and natural gas were included in electricity prices, coal would cost 261.8 percent more than it does; oil, 13.4 percent; and natural gas, 0.5 percent. If priced to include the risks from greenhouse gas emissions and climate change, the costs of coal would rise 35 to 70 percent more; oil, 9 to 18 percent more; natural gas, 6 to 12 percent more [53]. The researchers also found that if electricity was priced this way, fossil fuel use would decrease 37.7 percent compared to projections; $CO_2$ emissions would decrease 44.1 percent; GDP would improve 7.7 percent; and household wealth would jump 5.5 percent (primarily as the result of improved health).

Kammen and Pacca [54] found that if they internalized the cost of mortality and asthma—just two externalities—into electricity rates, assuming the value of a life was $5 million, then the annual cost of operation for conventional coal power plants in Illinois, Massachusetts, and Washington was 50 ¢/kWh, almost eight times higher than the average 6.5 ¢/kWh then paid by consumers.

Simply put, pubic resistance towards renewable electricity in the name of environmentalism tacitly endorses more polluting systems that degrade the land, pollute the air, foul the country's water, and destroy the environment to a much greater extent.

### *5.2. Naturalizing Inequity*

Nor are the impacts and negative externalities from electricity supply distributed equally within the United States. Claims that renewable electricity sources should be rejected for aesthetic and even environmental reasons may naturalize the harms from the current power system and, in turn, promote what has been termed "environmental racism". Put another way, the "NIMBY" attitude emanating from some opponents to renewable electricity does not eliminate hazards completely, but instead redistributes them. Some have argued that the risk from dirty power is not reduced but instead shifted to less affluent populations. People of color (African, Hispanic, and Native Americans) must then bear "a disproportionate share of the nation's noxious risks and environmental hazards" as the consequences of energy production move "from white, affluent suburbs to neighborhoods of those without clout" [55]. Mohai and Bryant [56] conducted a meta-analysis of studies documenting the spatial distribution of pollution and found "clear and unequivocal evidence that income and racial biases in the distribution of environmental hazards exist". A similar assessment of environmental pollution across 2,083 counties found that "toxic releases increase as a function of [minorities in] the population" [57].

The existing configuration of the electricity industry could also reinforce environmental inequity since people living in poverty pay proportionally more for electricity, meaning they are less likely to accumulate the wealth needed to make investments to escape their poverty, and the deleterious health effects from power plant related pollution are more likely to impact household members. The United Nations [58] has warned that energy pollution has an often ignored class dimension: infant mortality rates are more than five times higher among the poor, the proportion of children below the age of five who are malnourished is eight times higher, and maternal mortality rates are 14 times higher.

Electricity use and pollution has racial, geographic, and age-based dimensions along with its class-based ones. African Americans consume more fish in larger portions than other Americans, meaning that they have a higher exposure to mercury poisoning from power plants [59]. More than two-thirds of all African Americans live within 30 miles of a coal-fired power plant. They are rushed to the emergency room for asthma attacks at more than four times the national average, and have children three times as likely to be hospitalized for treatment of asthma [60]. About half of African American children have unacceptable levels of mercury and lead in the bloodstream compared to 16 percent of the general population, and nationwide studies demonstrate that the air in communities of color contain higher levels of particulate matter, carbon monoxide, ozone, and sulfur dioxide [61].

Pollution is also concentrated among certain locations and age groups. Ohio has the most polluted air of any state in the nation, and the 1.4 million people living there in Cuyahoga County face a cancer risk more than 100 times the goal established by the Clean Air Act [60]. One of the most comprehensive studies ever undertaken on environmental externalities, a $3 million, three-year study by ORNL and Resources for the Future, found that power plant pollution was primarily responsible for increased mortality among the elderly, the very young, and individuals with preexisting respiratory disease [62-64]. It also found that the effects of airborne pollutants from power plants on human health were two orders of magnitude greater in the Southeast.

While these assessments do suggest the presence of environmental racism, their conclusions should be treated with care. One recent meta-survey of the environmental justice literature found that 96 out of 110 studies analyzed reported actual proof of environmental injustice [65]. This implies that a sort of adverse selection problem is occurring where the only ones writing about environmental racism are those with grievances. Furthermore, the meta-survey concluded that much of the literature on environmental inequity was value laden, meaning that the presence of injustice was strongly influenced by the judgments made by researchers and their methodological choices. Lastly, the meta-survey noted that the literature focused mostly on equitable outcomes but tended to ignore equitable processes, presenting a somewhat skewed picture of environmental racism and injustice.

### *5.3. The Symbolic Nature of Renewable Electricity*

Why, then, do some consumers and even environmentalists reject technologies that would bring them comparative benefits? The literature explaining public opposition to wind, biomass, and other renewable electricity technologies is vast and growing [66-73]. One explanation is that renewable electricity systems possess symbolic meaning. Opposition to the siting of new power plants can occur because such technologies inflame preexisting social conflicts that have little (and sometimes nothing) to do with electricity. Rural residents, for example, often resent urban developers who wish to build electricity projects in their midst. Others oppose new generators because they feel that they have been excluded from the policy making, permitting, or siting process. In other cases, rural residents want renewable electricity projects for their own use, as a vehicle for economic development, and resent what seems like meddling by urban residents intent on preserving the countryside for its scenic and recreational value. In this way, renewable electricity technologies become more than simply an electricity generator: they symbolize a method of organizing the landscape, a system of ownership and control, and a personal ethic or a reflection of attitudes [74]. One researcher even jokingly commented that energy projects can provoke controversy to such a degree that “not in my backyard,” or NIMBY, is rapidly turning into “build absolutely nothing anywhere near anything,” or BANANA [75].

Much of this conflict has to do with the immobility of renewable resources. Wind moves but windy locations do not. Wind and sunlight differ from coal and conventional fuels because they cannot be extracted and transported for use at a distant site. For wind farms to be successful, turbines can only be installed where sufficient wind resources exist. Thus, the site-specific nature of wind energy invites conflict with existing or planned land uses. The landscape itself can shape public attitudes toward renewables, as some landscapes are more valued than others. Place turbines in sensitive areas, perhaps along the coast or in a national park, and prepare for social uproar. Place them out of view or in low value areas such as sanitary landfills, and opposition diminishes [76].

Yet opposition to renewable electricity is hardly uniform—something that becomes more apparent when looking at the world and not just the United States. For example, various studies [7,66,77-79] surveying public attitudes towards wind energy from Canada, Denmark, Germany, Ireland, Netherlands, Sweden, United Kingdom, and the United States have found that:

- People with no specific experience with wind energy are more likely to oppose it, overestimate its costs, and underestimate its benefits;
- Middle aged people and risk-averse people are more likely to oppose projects than young or old respondents;
- Opponents tend to place a higher value on aesthetics than on other aspects such as climate change or employment effects;
- Acceptance is stronger when turbines are believed to work ("spinning" turbines are more favored than "idle" ones);
- The more expensive a group of people perceive a particular project the more they are likely to oppose it in their community;
- City dwellers are more likely to oppose projects than country dwellers (one explanation is that urban residents have a more romantic view of the countrywide whereas rural residents view it as a resource to be harnessed);
- The same person or group can simultaneously support the *idea* of wind power (holding a positive view) but oppose the construction of a *particular* wind farm (holding a negative view), creating a "gap" between public support and private behavior;
- Opposition to wind projects changes significantly before and after projects are completed, with projects contentious at the planning stage but generally accepted after they have been constructed. Put another way, local people become more favorable towards wind farms after their construction and the degree of acceptance tends to increase in proximity to the wind farm;
- Opposition to projects generally declines when respondents are given a rationale for building a new wind farm as opposed to asking them questions in the abstract;
- Providing incentives for local citizens to invest in or own part of a project, or inviting them to participate in planning and siting procedures, can strongly influence public acceptance;
- Residents of "stigmatized" or degraded landscapes are more likely to welcome facilities that they see as green or supportive of the local economy.

Interestingly, individual electricity consumption has been shown not to be a good predictor of attitudes for or against constructing new plants [80].

In essence, these studies challenge the notion that the NIMBY phenomenon adequately explains opposition to wind farms and other renewable energy projects. Warren *et al.* [79] surveyed public attitudes toward wind energy in Ireland and Scotland and found an "inverse NIMBY syndrome" where those with wind farms in their backyard vigorously praised and supported them. Ansolabehere and Konisky [80] documented that NIMBY reactions are highly variable and depend on demographic characteristics of the public, their perceptions of cost and environmental harm, individual attitudes concerning risk, and the types of facilities or technologies involved. Wolsink [7,81,82] found that a true “NIMBY attitude,” defined as a tendency for people to frame their objection to wind turbines in terms of individual utility or selfishness, accounted for only one-quarter of the stated reasons for opposition. Instead, Wolsink’s research found that wind turbines were primarily accepted or rejected based on broader factors relating to public interest and the interests of others as well as notions of fairness and equity. Wolsink proposes that these institutional factors play a greater role influencing wind power development than NIMBY attitudes. Breukers and Wolsink [83] found differing attitudes towards wind energy in the Netherlands (where public opposition was more about the prospect of volatile electricity prices and an exclusionary method of approving wind projects), the United Kingdom (where opponents were critical of the “neo-liberal” approach to wind development), and Germany (where the public was primarily concerned about protecting the environment).

Opposition to wind power projects may also appear more pronounced than it actually is due to the nature of wind power siting and the media. Unanimous consent is sometimes needed for wind projects to go forward, yet a single “devoted opponent” can delay or derail them [81,82]. The minority opposing wind turbines is often disproportionately vocal and more cantankerous than a contented and silent majority, making support less newsworthy and therefore underreported [83].

## 6. Conclusions

A gap between what lifecycle assessments and scholarship reveal about renewable and conventional power sources and what some people in industry, government, and society believe may be emerging. The existing electricity industry in the United States is at a curious state where some intelligent and sensitive environmentalists, consumers, regulators, and investors reject a collection of technologies that would most benefit them. The situation demonstrates that the most visible impacts from a given energy system—such as avian deaths from wind turbines or habitat destruction from large dams—are not always the most significant. Many renewable electricity technologies seem to present a significant threat to the environment because all of their negative externalities are concentrated in one place, while those from conventional and nuclear fuel cycles are spread across space and time. The evidence so far suggests that fossil fuels and nuclear power plants are more dangerous to the environment than renewable power plants, and reminds us that what can sometimes be considered the most obvious consequences of a given technology need not be the most salient.

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