RESPIRATORY HEALTH ASSOCIATION®

Issue Brief

The Electricity You Generate and the Air You Breathe:

The Lung Health Benefits of Investing in Clean, Renewable Electricity

I. Introduction

Our energy choices affect our quality of life. Reliable, affordable *access* to energy raises a community's quality of life, but so can the *source* of that energy. Production, distribution, and consumption of energy can all impact health.[1] This is especially true with use of fossil fuels. Emissions from burning fossil fuels can harm health directly and contribute to global warming, resulting in other indirect health risks.

Clean, renewable electricity has become increasingly commonplace and cost-effective and continues to grow and expand. With the clean, renewable technologies available today, we have the potential to decrease U.S. carbon emissions from electricity generation by more than 80 percent, and perhaps as much as 100 percent by 2050.[2] We also have an opportunity to drastically reduce the morbidity and mortality associated with burning fossil fuels.

Increased use of clean, renewable energy, such as wind and solar-generated power, when combined with increased energy efficiency, can improve health both by reducing emissions that harm health directly and that increase global warming. In other words, clean, renewable energy is not just an environmental issue, but a public health issue.

As a public health non-profit dedicated to community lung health, Respiratory Health Association is committed to advocating for policy, systems, and environmental changes that improve air quality for all. Since burning fossil fuel harms local air quality and drives global warming, Respiratory Health Association supports efforts to increase reliance upon clean, renewable energy. Respiratory Health Association is committed to bringing together the public health, environmental, medical, and patient communities to engage in a coordinated effort to improve air quality and address the impacts of climate change.

II. What are Clean, Renewable Sources of Electricity?

Definitions can vary, but some of the most common forms of renewable energy generation include wind, solar, hydroelectric, geothermal, and biomass. Fossil fuels, such as coal, natural gas and oil, are non-renewable because they draw from finite geological resources, which can be expensive to extract as well as environmentally damaging to retrieve. Energy efficiency initiatives are a crucial partner to clean, renewable energy in lessening our dependence on fossil fuels.

While wind, solar, hydroelectric, geothermal and biomass energy are all considered renewable, some have lower environmental impacts than others, making them both *clean* and *renewable*. As of 2016, renewables made up nearly 15 percent of U.S. energy generation.[3] The different kinds of renewable energy are described below:

Wind

Wind turbines, typically placed atop towers that can be hundreds of feet tall, use long wing-like blades to capture the wind and use the properties of lift to turn a rotor, which in turn spins a generator that makes electricity. Wind turbines can be used stand-alone by an individual or business to supplement their power supply, but more commonly, dozens to hundreds of wind turbines are grouped together in a "wind farm," connected to the electric grid.[4] Aside from being clean and renewable, wind energy on a regional basis is a reliable and a consistent source of power for the electricity grid. Constantly improving technology has enabled increasingly taller towers and larger turbines that can catch faster wind more of the time, so more power can be generated with greater reliability and availability. As of 2016, wind energy was second among sources of renewable energy, generating about 5.6 percent of the nation's electricity.[5] Reports indicate that as of February 2017 wind has overtaken hydroelectric generation as the nation's biggest source of renewable energy.[6]

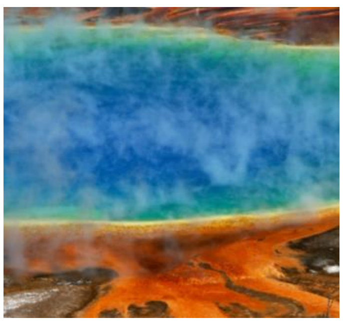
Solar

Solar power systems convert the energy of sunlight into electricity. The most common solar technology converts sunlight directly to electricity through a process called the photovoltaic effect (PV).[7] Individual solar cells made of semiconductor material are assembled into modular solar panels.[8] Unlike other ways of generating electricity, this process does not require a generator. These panels can be installed on rooftops, or in large ground-level solar farms. Solar power can also be generated through the use of large, concentrating solar power plants. These expansive installations use large lenses or mirrors to direct concentrated sunlight to a receiver, which in turn uses the heat from solar energy to create steam to turn a generator.[9] As of 2016, solar energy generated about 1 percent of the nation's electricity,[10] but is rapidly growing with installed PV growing 95 percent in 2016 alone.[11]

Hydroelectric

Hydroelectric power uses flowing water to generate electricity. This is done by building a dam and creating a reservoir on a river. Water passes from the reservoir through the dam and spins a turbine generator to produce electricity. Hydroelectric produces 6.5 percent of the electricity in the U.S. and was recently passed by wind as the largest source of renewable energy.[12] There are many challenges with hydroelectric development, particularly because hydroelectric projects require the damming of many miles of a river, are by their nature large and lengthy construction projects and are limited in where they can be built. Dam reservoirs can disrupt fish migration and are also significant generators of methane, a powerful greenhouse gas.[13] For these reasons, hydroelectric, while renewable, is not considered as clean or as viable an option as wind or solar.

Geothermal



Geothermal energy utilizes the earth's internal heat to power steam turbines in electric generation stations.[14] The source of geothermal energy can be hot water or hot rocks close to the surface, or even magma farther down in the earth.[15] While this source of energy is renewable and reliable, geographically, there are relatively few places in the U.S. that can take advantage of this resource. Most geothermal power plants in the U.S. are limited to western states. California, Nevada, Alaska, and Hawaii, are among the states that have geothermal power stations, but even in those locations geothermal still does not account for a large percentage of overall electricity production.[16, 17] In the U.S., geothermal generates only 0.4 percent of electricity.[18] There are some air pollutants and greenhouse gases produced by geothermal energy as gases are released from underground sources, however, the total emissions are still considerably lower than for fossil fuel plants.[19, 20] Despite limited use in electricity generation, geothermal energy can be widely utilized as an energy efficiency strategy in heating buildings, as using a heat pump to extract heat stored underground can eliminate the burning of fossil fuels.[21]

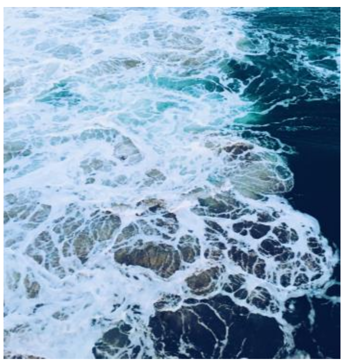
Biomass

Biomass refers to the burning of organic matter to generate electricity. The most common biomass fuel for generating electricity is wood, though certain grasses, organic residues, and waste can also be burned to generate electricity.[22] While biomass energy relies on harvesting plant matter, it is technically a renewable energy source because plants can (at least in theory) be fully replenished over time. In fact, biomass energy has increasingly utilized fast-growing crops, grown with the specific purpose of being able to be quickly regrown and harvested for energy generation.[23] Biofuels have also been used as a supplemental fuel in coal plants in a process called "co-firing" as a way to reduce some pollutants. However, the engineering challenges and economics of the practice have greatly limited opportunities for this strategy.[24, 25]

While biomass is theoretically a renewable energy source, it isn't necessarily a clean, renewable energy source since it produces significant local air pollution emissions from combustion and can produce as much or more immediate CO_2 emissions as using fossil fuels.[26, 27, 28] However, so long as biomass fuels are continually replenished, the same plants used to generate energy would also be absorbing CO_2 in the atmosphere generated by the combustion process.[29] Much debate continues on the wisdom of biomass generation, since the types of trees and grasses used can make huge differences in greenhouse gas emissions.[30] Long-term soil viability is another potential issue.

Biomass can also create gases that can be combusted to generate power. Garbage landfill methane gas recovery, which can be burned in a turbine to generate electricity, is one example.[31] Another method is gasification of plant matter in a sealed chamber at a controlled temperature to create a gas fuel that can then burned to spin a turbine-generator, and make steam to generate additional electricity. In addition to being highly dependent on geographic availability and cost of fuel, compared to wind, solar or hydroelectric power, biomass is generally a more expensive option for large-scale energy production.[32] As of 2015, biomass generated only about 1.5 percent of the nation's electricity and it has not experienced the same level of growth as wind or solar.[33, 34]

Other



Less-common forms of renewable energy also exist, including tidal energy from the oceans and hydrogen energy.[35] However, like biomass, emissions can vary widely depending on how hydrogen is produced. These forms of electricity generation are relatively small in scale.

An additional way to make more efficient use of energy is "combined heat and power," otherwise known as "cogeneration." Cogeneration systems use the waste heat from electricity generation to heat or cool buildings.[36] Heat from cogeneration is most commonly employed in large industrial, commercial, or institutional facilities. While cogeneration has traditionally been limited to these sectors, it can provide "highly efficient electricity and process heat" for such kinds of large installations.[37] However, while this energy efficiency strategy reduces fuel use, emissions created are still dependent on what fuel is utilized.

Energy Efficiency

Energy efficiency refers to making better use of the energy we already have, or in other words, eliminating wasted energy.[38] Energy efficiency mechanisms aim to reduce the amount of energy consumed – and thereby produced – while still providing the same or better level of service to consumers. At the household level, energy efficiency initiatives can include use of smart electric meters, smart thermostats, LED lights, more efficient heating and air conditioning systems, better insulation and windows, and EnergyStar rated appliances. Commercially, energy efficiency mechanisms are often aimed at improving HVAC systems, installing better windows, using motion sensor lights, or even using daylight to limit the need for electrical lighting. Energy efficiency measures have costs upfront, but they can result in decreased energy costs and have long term additional financial benefits. Financial incentives for energy efficiency efforts, including programs run by utilities that lessen the initial costs, or provide access to funds to do projects that result in energy savings.[39] Given the amount of energy in the U.S. that is wasted – and pollution created – through using inefficient technologies, energy efficiency mechanisms are, according to the U.S. Department of Energy, "[among] the easiest and most cost effective ways to combat climate change, clean the air we breathe . . . and reduce energy costs for consumers."[40]

II. Why is Clean, Renewable Energy Better for Respiratory Health?

Burning fossil fuels generates fine particulate matter ('soot') and ground-level ozone ('smog') from chemical byproducts in the exhaust. Both of those byproducts affect respiratory health. There are many other non-respiratory health concerns involved in extraction and use of fossil fuels, such as consumption and pollution of water, health effects from environmental degradation, and occupational hazards for those in the fossil fuel industry. Burning fossil fuels also contributes to climate change. Climate change poses a number of threats to respiratory health, which are discussed below, but climate change could also negatively impact health by way of decreased food security, access to potable water and shelter, and psychological stress.

Investing in clean, renewable energy instead of fossil fuel energy generation has a number of health benefits, including reducing pollutants that directly harm human health (e.g., soot and smog) and reducing pollutants that drive climate change. Each of those topics is discussed below.

Fossil fuel emissions result in immediate and long-term negative health impacts

Fossil fuel emissions are regulated federally under the Clean Air Act as "criteria pollutants."[41] These federally-regulated pollutants include ground level ozone, carbon monoxide, nitrogen oxides, sulfur dioxide, particulate matter ("soot"), and lead.[42]

Emissions from fossil fuel power plants, which include or are formed from criteria pollutants, have been associated with premature death, asthma exacerbations, heart disease, dementia, and other chronic diseases.[43, 44] Ozone 'smog', for example, is formed in the atmosphere when nitrogen oxides and volatile organic compounds react. Exposure to elevated smog levels has been linked to respiratory and heart disease.[45]

Worldwide, air pollution is estimated to kill 5.5 million people annually.[46] In the U.S., air pollution is responsible for more than 200,000 premature deaths each year.[47]

Fossil fuel use drives climate change, which will have many respiratory health consequences

Aside from producing "criteria pollutants," fossil fuel-based electricity generation is a leading producer of greenhouse gases that contribute to climate change.[48] Some greenhouse gas reduction efforts focus on methane, nitrous oxide (N_2O), and chlorofluorocarbons, but the largest and most impactful greenhouse gas reduction efforts are focused on reducing emissions of CO_2.[49] Electricity generation is the largest source of CO_2 emissions in the U.S., accounting for just under one third of total emissions.[50] Coal power plants account for 70 percent of the electricity sector's carbon emissions, with natural gas plants accounting for most of the remainder.[51] Comparatively, the global warming impact of the entire life cycle of renewable energy is minimal.[52]

Climate change is now recognized by the American Public Health Association as the preeminent public health threat of the 21st century.[53] From a respiratory health perspective, climate disruptions will pose a number of challenges for those living with chronic lung disease, such as: an increase in **extreme weather events**, including heat waves, extreme precipitation events, and droughts; an increase in **wildfires and wildfire smoke**; an increase in **particulate matter (soot)**; an increase in **aeroallergens**, including plant pollens and mold and fungus spores; an increase in **insect and water borne diseases**; and higher levels of **ground-level ozone (smog)**. Climate change poses the greatest threat to the young, elderly, impoverished, those living with chronic disease, and those living in isolation.[54]

Climate change is projected to bring about longer, hotter summers, with longer and more intense heatwaves.[55] Heat is the number one cause of weather-related deaths and is particularly threatening to those with poor circulation.[56] Climate change will also bring more intense precipitation.[57] With longer, hotter summers, increased precipitation will not come evenly throughout a year, but via more intense rainfalls, separated by periods of drought.[58] These events can lead to more flooding,[59] which can separate people with chronic disease from essential support services. Increased flooding can also drive mold growth in buildings, which can exacerbate respiratory conditions.[60]

Longer and more frequent droughts can also increase the amount of particulate matter in our air.[61] More heat and more droughts can also spur increased wildfires.[62] Smoke from wildfires can travel for hundreds of miles, reducing air quality far from its original source.

Longer, hotter summers will also increase the use of air conditioning and increase peak demand for electricity. If fossil fuel generated electricity is not replaced by clean, renewable energy, more harmful emissions will be pumped into the air during the hottest times of the year. Longer, hotter summers and increased fossil fuel emissions would also mean increased levels of ground-level ozone (smog). Ozone is a respiratory irritant that can cause shortness of breath, coughing, inflammation, chest pain and tightness. Ozone is also a leading trigger of asthma exacerbations, with children being especially susceptible.[63] Increasing ozone concentrations would lead to more air quality alerts being issued, where people would be advised to reduce or avoid strenuous physical activity.

Increased levels of CO_2 in our atmosphere could also affect allergy rates. Studies suggest that many pollen-producing plants are responsive to the increasing temperatures and atmospheric CO_2 levels caused by climate change.[64] Warmer temperatures mean longer pollen seasons. In addition, some plants like ragweed produce higher amounts of pollen at higher concentrations of CO_2. Some poisonous plants have also been found to produce more intense poisons when exposed to higher levels of CO_2.[65] With more pollen being produced over longer pollen seasons, allergic symptoms could worsen and trigger more asthma attacks.[66]

Finally, climate change could increase the spread of vector-borne diseases. Warmer winters will enable insects like ticks and mosquitos to spread farther north and west from their current habitats and further the spread of disease such as Lyme disease, Chikungunya, and Zika.[67] Increased flooding could also increase the spread of Hantavirus[68] and Legionellosis.[69]

The health effects of climate change can be successfully mitigated by replacing carbon emitting fuel sources with clean, renewable energy. Even as far back as 2009, an analysis by the Union of Concerned Scientists found that “a 25 percent by 2025 national renewable energy standard would lower power plant CO_2 emissions 277 million metric tons annually by 2025 – the equivalent of the annual output from 70 typical (600 MW) new coal plants.”[70] Similarly, a 2012 analysis by the U.S. Department of Energy’s National Renewable Energy Laboratory found that renewable energy technologies available at that time could support 80 percent of the U.S. energy needs by 2050 while reducing fossil fuel generated carbon emissions by 80 percent.[71] Vigorous debate continues on how a system dependent on 100 percent clean renewable electricity could be structured.[72]

Displacing fossil fuel use with clean, renewable energy has substantial economic benefits derived from reduced health impacts

When a region increases its supply of power from clean, renewable sources and captures the benefits of energy efficiency, it decreases demand for other sources of power such as coal, natural gas and oil, which in turn "displaces" the emission of criteria pollutants, their precursors and greenhouse gases.

The health effects of such a change can be substantial, although they can vary from region to region, depending on what fossil fuel energy sources are displaced and which new sources of energy are utilized. This is because the degree to which each region currently relies on fossil fuels versus nuclear power can vary greatly. Although nuclear power construction is contentious for many reasons, existing nuclear power has been classified as low-carbon.[73] Comparatively, burning coal, natural gas and oil produces various harmful emissions. Emissions from burning coal can vary based on what type of coal is used in a region and whether the power plants in that region use pollution scrubbing technology.

Likewise, some regions are better able to utilize wind or solar than others, based on geographical characteristics and existing electric grid transmission constraints. There are also temporal characteristics – solar photovoltaics only generate electricity during the day, so they tend to displace intermediate-level sources of electricity, like natural gas. Wind, like nuclear power, can operate at all hours, including at night when power demand is lowest. Therefore, an investment in wind energy in an area that has a large percentage of nuclear power (like Illinois) now tends to displace nuclear rather than fossil fuels, which can be turned on/off at peak times of demand and can shift more quickly to match the diurnal (daily) temperature-driven fluctuations in power demand.

These issues are diminishing in importance over time as the grid is steadily being modified to make it easier to move large amounts of clean renewable electricity from where it can be produced cheaply to where it is most needed. The declining cost of large scale electricity storage will also increase the flexibility to use electricity from clean renewable sources.

Practically speaking, reduced fossil fuel emissions results in fewer unhealthy air days, less morbidity and mortality from ambient air pollution, and mitigating climate change impacts.

Improving air quality by way of displacing dirty energy sources with clean, renewable sources can reduce the negative health consequences associated with exposure to air pollution and thereby reduce healthcare and loss of productivity costs.[74] Practically speaking, reduced fossil fuel emissions results in fewer unhealthy air days,[75] less morbidity and mortality from ambient air pollution, and mitigating climate change impacts. Replacing fossil fuel power generation sources with clean, renewable energy has been found to reduce premature deaths, as well as reduce productivity losses and healthcare costs.[76] While greenhouse gases have global climate effects regardless of where they were emitted, criteria pollutants have a greater local or regional impact on health. Public policy efforts to reduce reliance on fossil fuels can, therefore, have meaningful benefits to local and regional health. Because of the short period those pollutants remain in the atmosphere, the health benefits of reducing criteria pollutants and their precursors can be felt almost immediately.[77] Likewise, as criteria pollutants "tend to dissipate over time and space," reducing the emission of pollution from sources located in or near populous areas would have a greater positive impact on health than in less populous areas.[78]

While there are many studies that demonstrate how clean, renewable energy can reduce criteria pollutants and greenhouse gas emissions,[79] there are relatively few studies that quantify the *direct public health* benefits that could result from clean, renewable energy. However, recent research has begun to estimate the *economic benefits associated with public health improvements* from displacing emissions from dirty power sources.

In 2015, Harvard researchers published their findings from a predictive model that examined how wind, solar, and energy efficiency mechanisms would displace fossil fuels in the Midwest and Mid-Atlantic.[80] Their model found that even a moderate amount of solar, wind, and energy efficiency mechanisms[i] could save a region between $5.7 million and $210 million annually, based on the dollar value of human life.[81] In this study, the model found that in the Chicago area, displacing a moderate amount of CO_2, NO_x, and SO_2 emissions with wind power would result in $210 million in health savings, compared to only $110 million in Virginia, Cincinnati, or New Jersey for an equivalent effort.[82] However, solar would only result in $37 million in health benefits from displacing the above pollutants, compared to $89 million in Virginia or $100 million in Cincinnati.[83]

Similarly, a 2016 study by the U.S. Department of Energy's Lawrence Berkley National Laboratory and the National Renewable Energy Laboratory examined just solar energy, and estimated the quantifiable health benefits of various solar energy investment scenarios.[84] The study ultimately found an energy system in which the U.S. would derive 14% of its power from solar by 2030 and 27% of its power by 2050 would result in $400 billion in nationwide environmental and public health benefits.[85] Those benefits would come through reductions of greenhouse gas emissions, criteria air pollutants, and water use by the energy sector as a result of displacing fossil fuels energy generation.[86]

III. What is the State of Clean, Renewable Energy in Illinois?

The two most prominent forms of renewable energy in Illinois, both current and prospective, are wind and solar. The wind energy industry in Illinois has been fast growing. Illinois' flat geography, expansive farmlands, and typical wind patterns give the state great potential for increased wind energy production. Currently, there are more than 2,400 wind turbines in the state, with a combined capacity of 4,026 MW.[87] As of 2016 the state ranked 6th in the nation in installed wind capacity.[88] Many more wind energy projects, totaling many hundreds of MW, are planned or currently underway as well. The vast majority of these existing installations have appeared only in the last decade, having been spurred by Illinois' adoption of a renewable portfolio standard in 2007. In terms of solar, as of 2016 there were 66 MW of solar energy installed in Illinois, enough to power about 9,500 homes.[89] Illinois ranks 27th nationally in current solar power capacity.[90]

While Illinois ranked near the top in terms of wind energy capacity, issues with Illinois' renewable energy portfolio abounded. In 2007, the Illinois General Assembly created a state renewable portfolio standard, enumerating a goal of 25 percent renewable energy by 2025. However, progress halted when wind energy investments faltered due to uncertainty and instability in Illinois energy policies. While ambitious and well-intended, the law was ultimately weighed down by loopholes and legal complications that resulted in funds going to already-constructed wind farms in other states,

[i] The study simulated the effects of four different renewable energy and energy efficiency scenario's: 500MW wind, 500 MW solar, 500 MW peak demand-side management, and 150 MW baseload demand-side management.

rather than spurring new wind generation construction in Illinois.[91]

After many years of campaigning, Respiratory Health Association and a broad coalition of partners advocated successfully for a new Illinois energy bill that addressed these shortcomings and made additional progress. In December 2016, Illinois passed one of the largest, most comprehensive energy bills in the country.

Known as the **Future Energy Jobs Act**, this legislation fixed several flaws and loopholes in the state's renewable portfolio standard and re-established progress towards the state goal of 25 percent renewable energy by 2025. The Act also greatly increased energy efficiency program requirements and created a "zero-emission standard" for nuclear plants. Finally, the Future Energy Jobs Act provided for low-income solar development and training to generate thousands of new jobs in the green energy sector.[92] This provision strengthened by measures that ensure the state's clean energy credits come from new wind and solar projects in Illinois. The Environmental Law and Policy Center estimates this requirement will bring more than 1,350 MW of new wind and 2,700 MW of new solar capacity to Illinois by 2030.[93]

A 2017 analysis of the health impacts of this change in policy conducted by the National Resources Defense Council, is heartening.[94] Due to a combination of large increases in solar and wind generation driven by the new act, electricity demand reductions driven by an aggressive energy efficiency program, and a mechanism to prevent the premature closure of existing nuclear energy generation capacity, the new law will have a significant health impact. Between 2018 and 2030 when completely phased in, the Act is expected to prevent 17,890 asthma attacks, 1100 asthma emergency department visits, 780 hospitalizations, 1650 heart attacks, and up to 2800 premature deaths.[95] These numbers only account for the health effects of reducing and preventing criteria pollutants from fossil fuel power plants, and do not include health benefits of mitigating climate change.

IV. Conclusion

The production, generation, and consumption of energy from fossil fuels is associated with significant respiratory illness, as well as numerous other health consequences. Reducing our dependence on coal, natural gas, and oil for energy generation will improve public health both immediately and in the long run. Clean, renewable energy sources such and wind and solar have the ability to provide the Midwest and the nation with reliable and affordable power, while also improving air quality and mitigating the health dangers of climate change. Air pollution does not respect state borders or lines on a map. Likewise, climate change is a global problem, driven by increases in greenhouse gasses, regardless of where those gasses are emitted. For these reasons, renewable energy can no longer be treated simply as an environmental issue, but as a critical public health issue.

Smart energy policies and closely related economic and technological advances that enable more extensive use of clean renewable electricity should continue to lessen the burden of health costs on people that are now driven by fossil fuel emissions. Long term, this path must lead to a reality where 100 percent of electricity is obtained from clean, renewable energy sources.

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