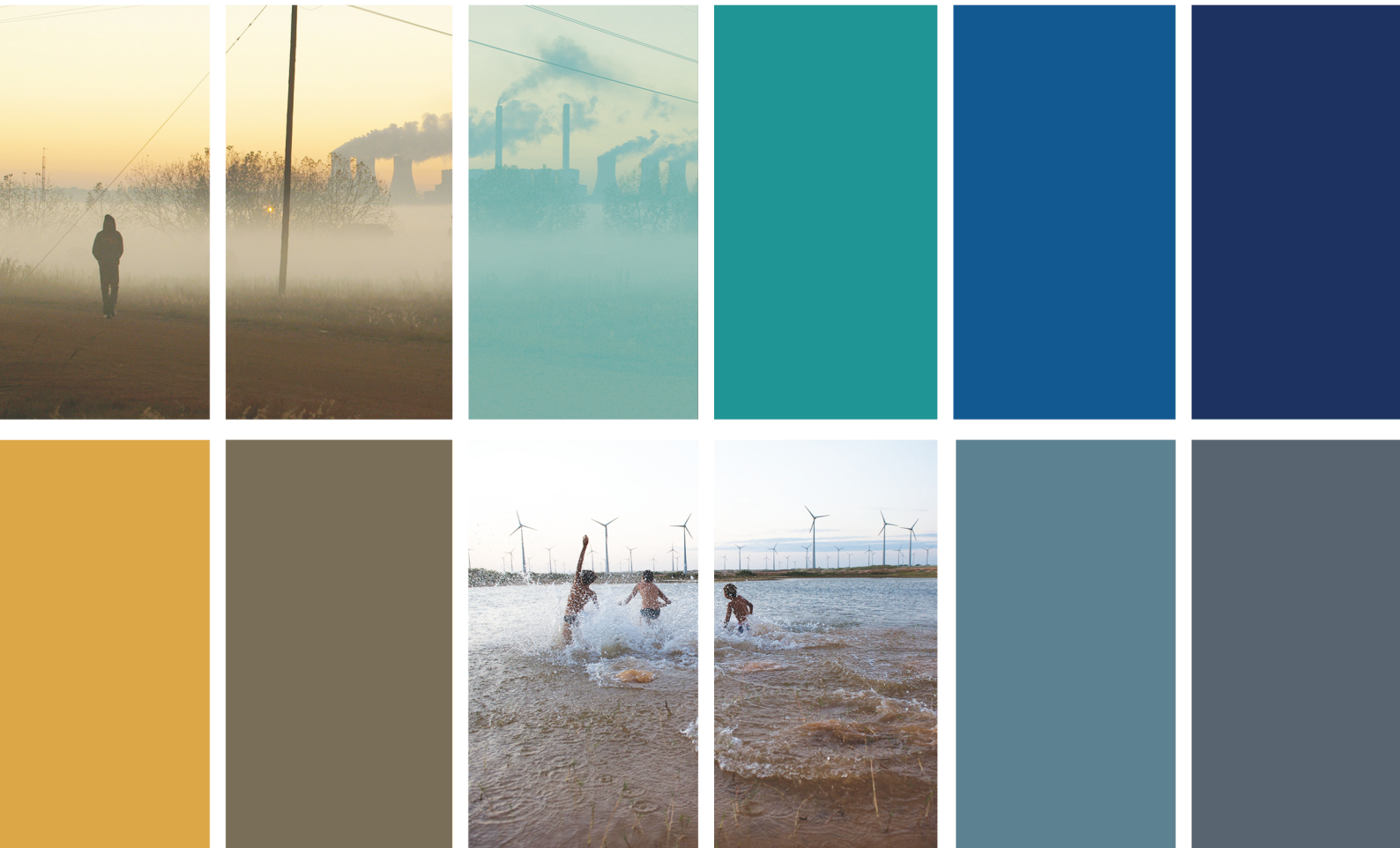
Health Care Without Harm

healthy energy initiative

The Health Impacts of Energy Choices

A Briefing Paper for the Health Community



About this resource

The Health Impacts of Energy Choices is a resource produced by the Healthy Energy Initiative. Developed for health care and public health professionals around the world, as well as a wider audience, this briefing paper provides an overview of key health considerations in energy systems and energy policy. It recommends actions that can be undertaken by health professionals and policy makers to support energy choices that protect health.

About the Healthy Energy Initiative

The Healthy Energy Initiative is a global collaboration of health professionals, health organizations, and health researchers engaging in science-based advocacy for a move away from fossil fuel-based power generation—particularly coal—and toward clean, renewable healthy energy options. The Healthy Energy Initiative is led by Health Care Without Harm, with partners in Australia, China, Europe, India, the Philippines, and South Africa.

- Visit us at www.healthyenergyinitiative.org to find additional resources, news, and opportunities to get involved
- Follow us on Twitter at @healthyenergyi to interact and share the latest developments
- Email healthyenergy@hcwh.org to let us know what you think about this resource

About Health Care Without Harm

Health Care Without Harm (HCWH) is an international coalition of more than 500 members in 53 countries that works to transform the health care sector worldwide, without compromising patient safety or care, so that it becomes ecologically sustainable and a leading advocate for environmental health and justice.
www.noharm.org

Written by

Jennifer S. Wang, MS
Healthy Energy Initiative Coordinator, Health Care Without Harm

Peter Orris, MD, MPH, FACP, FACOEM
Professor and Chief of Service, Occupational and Environmental Medicine, University of Illinois Hospital and Health Sciences System

Acknowledgements

The authors thank Josh Karliner, Renzo R. Guinto, and Benn Grover (Health Care Without Harm), Vlatka Matkovic Puljic (Health and Environment Alliance), Rico Euripidou (groundWork), and Fiona Armstrong (Climate and Health Alliance) for their valuable input.

Photo Credits

Cover: Simon Waller; Creative Commons via https://flic.kr/p/7vrKhj
Page 2: Megan Lewis / groundWork
Page 3: Amirtharaj Stephen / Community Environmental Monitoring
Page 4: Creative Commons via https://flic.kr/p/puaUtE
Page 5: USAID Powering Health via http://www.poweringhealth.org/index.php/resources/media/photos#Guyana; Creative Commons via https://flic.kr/p/vLuA1r
Page 7: Amirtharaj Stephen / Community Environmental Monitoring; Creative Commons via https://flic.kr/p/7bDUp9
Page 9: Pacific Hydro; Kaiser Permanente
Page 10: Creative Commons via https://flic.kr/p/dMMixj; Dean Sewell / Greenpeace

Design Mitzi Sabando

Published by Health Care Without Harm, October 2015

Introduction

Access to energy for cooking, heating, transport, and productive activities is essential to human health. [1] Access to electricity is also critical to improving health service delivery, strengthening health systems, and achieving universal health coverage. As the World Health Organization (WHO) observes, "energy access in health facilities is a critical enabler of access to many medical technologies, and thus to health services access. Without energy, many life-saving interventions cannot be undertaken." [2] Yet 1.3 billion people around the world lack access to electricity and the potential it offers for improving the social and environmental conditions that support better health. [3]

At the same time, the generation, distribution, and consumption of energy can have marked adverse impacts on health. In particular, the exploitation of fossil fuels for energy generation has serious implications for human health through its contribution to both local pollution and global climate change. These health impacts accrue into a heavy and largely unaccounted-for economic burden borne by communities, governments, and health systems. [4]

Despite strong scientific evidence documenting the harms of fossil fuel-based energy generation, the health sector has made limited progress in engaging with the energy and environmental sectors to ensure that health is a key consideration in energy policy decision-making. For instance, even though air pollution has long been recognized as a major disease risk factor resulting in large part from fossil fuel energy generation, only in 2015 did the World Health Assembly call on member states to take multi-sectoral preventive action. [5] Unlike with sanitation and the protection of drinking water, the protection of air quality has generally not been within the purview of health officials. And while governments, international institutions, and philanthropic organizations spend billions of dollars combatting HIV/AIDS, malaria, and tuberculosis, the death toll from air pollution in 2012 was more than double that from these three prominent health problems combined. [6]

By demonstrating leadership in addressing air pollution and other health impacts of fossil fuels, the health sector can improve public understanding of the health impacts of energy choices and strengthen policy responses that promote healthy energy.

The generation, distribution, and consumption of energy – particularly fossil fuels – can have adverse impacts on health.

Key Health Considerations for Global Energy Provision

Although villagers in South Africa's Highveld region live near a coal-fired power station and coal mine, they are without electricity and must burn coal indoors for cooking and heating. They are exposed to both indoor and outdoor air pollution, which together caused 7 million premature deaths globally in 2012.

Public Health

From mining to transport, and combustion to waste disposal, the lifecycle of fossil fuel production pollutes the environment and exacts a toll on population health and the political and economic stability of entire nations. Because pollutants can be transported through the air, water, and soil, fossil fuels pollutants may be distributed well beyond their point of origin.

Outdoor (or ambient) air pollution – which primarily originates from power plants, factories, and vehicles – is one of the leading causes of death worldwide. In 2012 it was responsible for 3.7 million premature deaths from heart attacks, strokes, chronic obstructive pulmonary disease (COPD), lung cancer, and acute lower respiratory infections in children.[7] People living in poverty in low- and middle-income countries in the World Health Organization's Southeast Asia and Western Pacific regions bear the brunt of these health burdens.[8] The combustion of fossil fuels for energy and other sectors releases both primary pollutants and secondary air pollutants. Primary pollutants are emitted directly at the source and have potential for local health impacts, while secondary pollutants are formed through reactions of primary pollutants in the atmosphere and have potential for wider, more regional health impacts.[9]

Among materials used to generate energy, coal is arguably the most damaging.[10,11] It is also widely available and used, constituting approximately 40% of global electricity production.[12] In addition to contributing to local and

Power plant pollution impacts water quality and availability, leading to declining fish catches in many parts of the world such as in Visakhapatnam, Andhra Pradesh, India.

regional air pollution, the lifecycle of coal contaminates water sources and uses more water per unit of energy produced than natural gas, wind, and solar. [13] Coal combustion is also the largest source of anthropogenic emissions of mercury – a potent neurotoxin that is especially dangerous for developing fetuses and young children – affecting local and regional populations through air and water pollution. The global health community has called for a rapid-phase out of coal from the worldwide energy mix in order to protect public health and tackle climate change. [14,15]

The oil, gas, and nuclear energy production lifecycles also elicit considerable public health concerns. Communities near oil refineries and natural gas power plants are exposed to a range of toxic air pollutants. [16] Large-scale oil spills can cause injuries and fatalities, food contamination, and mental health disorders. [17] Oil combustion also yields a range of air pollutants, and waste from oil processing may have health effects similar to those of coal waste. [18] Unconventional oil and gas development[i] poses public health risks associated with air pollution, water pollution, the release of radioactive materials to the surface, as well as boom-town social disruption. [19,20] It also emits methane, a much more potent greenhouse gas than carbon dioxide.[21] Nuclear energy production leads to radioactive and chemical emissions and waste streams, which can contaminate drinking water and food chains. [22] Additionally, nuclear power plant accidents are rare but result in intense radiation exposure leading to potentially severe physical and mental health effects. [23]

Renewable energy sources such as wind and solar require some public health considerations including those related to noise pollution and waste disposal, respectively. However, their overall population health burdens are much lower than for fossil fuel-based sources. [24] Substantial public health co-benefits can be realized with a shift towards clean, renewable energy choices. [25]

Recommended Actions to Protect Public Health

- Advocate for local and regional health impacts to be assessed as part of the planning, costing, and approval processes for new energy projects. Ensure that health impact assessments are based on quality research and conducted by appropriately qualified independent health professionals.
- Take an active role in air quality governance processes, e.g. where ambient air quality standards are exceeded and public health is at risk.
- Provide health expertise and help build the tools and capacity to enable rigorous, lifecycle health impact assessments for energy projects.
- Comment publicly on the health dimensions of new and existing energy policies, such as emissions standards for power plants.
- Participate in efforts spurred by the WHO resolution on Addressing the Health Impact of Air Pollution, including engaging in multi-sectoral cooperation to integrate health concerns into all national, regional, and local air pollution-related policies.

[i] Unconventional oil and gas development is so named because the fuels are found deep below the earth's surface and require water and chemical intensive production techniques.

Occupational Health

Workers in the energy industry, and coal miners in particular, are exposed to physically challenging and dangerous work conditions.

Energy systems are supported by millions of workers involved in construction, extraction, processing, transport, waste disposal, and end use. Many workers, particularly in low- and middle-income countries, are exposed to physically challenging work conditions that put them at risk of injuries, lung disease, cancer, poisoning, hearing loss, heat stroke, and radiation effects. [26]

Although the health burden of fossil fuels is larger in aggregate for the public as a whole, workers in the coal, oil, gas, and nuclear industries generally suffer greater health risks per person. [27] For example, a global review of 250 studies on coal mining revealed that up to 12% of coal miners develop debilitating and often fatal lung conditions called coal workers' pneumoconiosis (Black Lung Disease) and silicosis due to the inhalation of dust during mining operations. [28] The same report noted that small scale mines, many of which are found in developing countries, are often more hazardous due to poorer safety precautions, resulting in higher rates of accidents and injuries. [29] While there have been successes in some countries in reducing occupational risks from the energy sector over the last 50 years, the implementation of best practices in mines, construction sites, and power stations is still limited. [30]

Not only are there considerable health co-benefits afforded by transitioning to clean, renewable energy, but it will also help to reduce what WHO described as "several tens of thousands of additional deaths… attributable to silica, asbestos, and coal dust" among workers in mining, construction, and other occupations. [31]

Recommended Actions to Protect Occupational Health

- Demand enactment of health-based standards to control the occupational diseases inherent in energy generation.
- Advocate for occupational health and safety impacts to be assessed as part of the planning, costing, and approval process for new energy projects.
- Advocate for the implementation of best practice occupational health management and prevention programs in the energy industry.
- Support fair labor practices, allowing energy workers the right to represent themselves in assuring healthy workplaces without fear of retaliation.

Climate Change and Health

The accumulation of greenhouse gases in Earth's atmosphere has destabilized the planet's climate and threatens to undermine the last half century of gains in development and global health. [32,33] The majority of greenhouse gases emissions – including carbon dioxide (CO_2), methane, and short-lived climate pollutants such as black carbon – come from the burning of fossil fuels. [34] The increased use of coal relative to other energy sources has reversed the long-standing trend of gradual reduction in the CO_2 intensity of the world's energy supply, with coal responsible for 44% of global CO_2 emissions from fuel combustion in 2012. [35,36] Climate change poses threats to human health through direct pathways such as heat stress, floods, drought, and intense storms, as well as indirectly through adverse impacts on air pollution, the spread of disease vectors, food insecurity and under-nutrition, displacement, and mental ill health. [37]

Because of its wide-ranging health implications, climate change is viewed as one the greatest challenges to global public health, and tackling it could be the greatest global health opportunity in the 21st century. [38,39] Additionally, many climate pollutants contribute to outdoor air pollution and its health risks.

A transition toward climate-friendly, renewable energy sources would not only protect global public health from the direct and indirect impacts of climate change, but it would also offer more immediate co-benefits to public health and occupational health.

A transition to climate-friendly, renewable energy can offer immediate health co-benefits. Left: Solar panels at rural health facilities in Guyana support cold chain refrigerators and other important clinic functions. Right: Solar lanterns allow children to study at night in typhoon-affected areas in the Philippines.

Recommended Actions to Protect Planetary Health

- Advocate for policies at the national and international levels that enable a rapid phase out of coal and transition to clean, renewable energy.
- Support collaboration between Ministries of Health and other government departments, and the empowerment of health professionals, to take multi-sectoral action on climate change.
- Support efforts to better quantify the health co-benefits of climate action, including avoided burden of disease, reduced health care costs, and enhanced economic productivity.

Cross-Cutting Issues

1 Household Energy Use

The energy sources employed at the household level have important health consequences both within and beyond the household, and efforts to provide clean, renewable energy through on-grid and off-grid systems could ameliorate these health consequences.

Approximately 40% of the world population is exposed to health-damaging air pollution from the combustion of fuels for household uses, with larger proportions in developing countries and in women and children. [40] According to the WHO, indoor air pollution was linked with 4.3 million premature deaths in 2012 – from strokes, heart attacks, COPD, acute lower respiratory infections in children, and lung cancer – in households cooking with coal, wood, and biomass stoves. [41]

The full health burden of household energy use is likely to be even greater. Some evidence links household air pollution with diseases and conditions such as tuberculosis, cancers of the upper aero-digestive tract and the uterine cervix, low birth weight, and stillbirth. [42] Space heating, lighting, and non-solid cookfuels such as kerosene also produce household air pollution with demonstrated adverse health effects. [43] Additionally, household cooking with solid fuels has been shown to be a significant contributor to ambient fine particulate air pollution ($PM_{2.5}$) in areas that are home to more than half of the global population in 2010. [44]

2 Health Costs

Continued investment in, and subsidization of, coal and other fossil fuels for energy generation puts a tremendous strain on health systems and charges society with an "unpaid health bill". [45]

Worldwide, post-tax consumer subsidies for fossil fuel companies have been estimated at US$5.3 trillion in 2015. [46] Nearly half of these subsidies represent inadequately charging for premature deaths from air pollution. Among different energy products, coal accounts for the largest subsidies, given its high health and environmental damages, and because no country imposes meaningful taxes on its consumption. [47] Eliminating post-tax energy subsidies by properly charging for externalities such as health damages would reduce the number of premature deaths from outdoor air pollution by 55%, with coal accounting for a 93% share of this reduction. [48] Internalizing the health costs of fossil fuel use would controvert arguments that fossil fuels are "cheap" and necessary to alleviate poverty, and would level the playing field for clean, renewable energy sources.

A group of leading economists has stated that the cost of implementing climate mitigation policies could be more than offset by the cost savings associated with the resulting health gains. [49] Further, the elimination of fossil fuel subsidies could pave the way for financing universal health coverage and other social priorities. [50]

3 Health Equity

People living in poverty bear a disproportionate health burden from fossil fuels due to both higher exposures (e.g., from reliance on solid fuels for cooking, or living in polluted neighborhoods) and greater vulnerability to factors such as malnutrition and poor access to health care. [51] Additionally, new energy projects are sometimes sited in economically disadvantaged, minority, indigenous, or otherwise marginalized communities, where the promise of economic development overshadows health considerations.

The burdens of climate change will also fall disproportionately on the poor, despite their meager contribution to the problem, having lower per capita greenhouse gas emissions. They are also least able to adapt to the risks of diseases and other impacts of climate change. [52]

Mitigation policies to combat climate change may inadvertently harm vulnerable populations by, for example, increasing biofuel production that could accelerate deforestation, raise food prices, and convert food farms to fuel farms. [53] The implementation of climate change regulation, such as a carbon tax, could also be regressive: as corporations pass on the cost of regulation to people, those in the lowest income groups may end up paying the most as a proportion of their income. [54]

Communities living near sites of energy generation do not necessarily benefit from the energy produced. Singrauli, the power capital of India, generates close to 10% of India's overall energy needs. Ironically, the majority of residents in Singrauli and nearby villages do not have reliable electricity, often facing power cuts for more than 15 hours a day.

4

Energy Access

Access to clean, reliable, and affordable sources of energy is critical to improving health across the globe, particularly in developing countries. 1.3 billion people around the world – 84% of whom live in rural areas – lack access to electricity [55] and the potential it offers for improving the social and environmental conditions that support better health, including employment, education, and safety. Access to electricity is also critical to improving health service delivery, strengthening health systems, and achieving universal health coverage.

Additionally, nearly 2.7 billion people suffer from the health effects of relying on the traditional use of biomass for cooking. [56]

The fossil fuel industry argues that efforts to reduce fossil fuel use and mitigate climate change will deprive the poor of cheap fuel and burden them with perpetual energy poverty (or lack of energy access). [57] These arguments ignore the high external health costs of coal and other fossil fuels, and the fact that forecasted energy investment will not appreciably serve the billions of energy-poor households. [58] Fossil fuel and nuclear energy systems, which typically rely on a centralized energy grid for distribution, are vulnerable to power failures and outages during periods of peak demand. Extension of the grid to remote areas – where energy poverty is concentrated – can be prohibitively expensive and inefficient. [59] Instead, rural regions may be better served by village-level mini-grids or isolated off-grid energy systems, which have no transmission and distribution costs. [60] Improving household energy access (and reducing indoor air pollution) requires expansion of cleaner burning gases and efficient, clean cookstoves. [61] For health facilities, the limitations of grid power and the falling cost of renewable energy technologies present opportunities for increased adoption of renewables as either primary or backup energy sources. [62]

Energy poverty can be alleviated by distributed generation of clean energy. Community-based solar engineers in Tinginaput, Orissa, India.

A Comparison of the Health Impacts of Energy Choices

The following table provides a high-level summary of the public health, occupational health, and climate-related health implications of various energy sources. [63,64,65,66]

	Source	Public Health Risks	Occupational Health Risks	Climate Risks
FOSSIL FUELS	Coal	Mountain-top removal and strip mining induce ecological damage, stress nearby communities, increase risk of mudslides, contaminate water sources. Transport involves noise and dust exposure, injuries and fatalities from crashes, and air pollution from diesel emissions. Combustion results in primary and secondary pollutants including particulate matter (associated with cardiovascular and respiratory diseases and cancer), ozone (associated with asthma, hospital visits, mortality), and mercury (central and peripheral nervous system toxicity). Coal waste contains toxic metals such as arsenic, lead, mercury, cadmium, and chromium, as well as radioactive materials.	Injuries, silicosis and coal workers' pneumoconiosis, lung cancer, heat, noise, ergonomic hazards, and carcinogen exposures.	44% of global CO_2 from fuel combustion; methane; short-lived pollutants.
	Oil	Communities near refineries are exposed to a range of air toxics. Large-scale spills can cause injuries and fatalities, food contamination, and mental health disorders. Oil sands industry can cause health effects related to social disruption. Combustion (primarily for use as transportation fuel) yields a range of air pollutants as with coal. Waste may have health effects similar to those of coal waste.	Injuries, ergonomic hazards, noise, vibration, chemical exposures (some carcinogenic).	35% of global CO_2 from fuel combustion; methane; short-lived pollutants.
	Gas	Conventional gas: Air pollution from power plant operations. Unconventional gas: Hydraulic fracturing is highly water intensive and can contaminate water sources with methane and toxic chemicals. Communities near production sites could also be exposed to air pollutant emissions, seismic activity, and radioactivity.	Exposure to toxic chemicals in unconventional gas production.	20% of global CO_2 from fuel combustion; methane; short-lived pollutants..
	Nuclear	Each step in nuclear energy production leads to radioactive and chemical emissions and waste streams, which can contaminate drinking water and food chains; possible increased cancer rates among children living near nuclear reactors; low-probability but high-impact radiation exposure and resulting physical and mental health effects from accidents.	Radiation-induced cancer; possible endocrine disruption; acute radiation, physical trauma, heat stress, and psychological distress from accidents.	Minor climate impact from construction.
RENEWABLES	Solar	Overall, the health impact of solar power is likely to be far less than that of any fossil fuel. Environmental emissions are generally low. However, waste management and end-of-life product disposal remain challenges.	Hazards typical of manufacturing industries, including injuries, noise, and chemical exposures.	Minor climate impact from equipment manufacture.
	Wind	No pollutant emissions during operation; no routine waste stream. Health concerns center on noise from moving gear trains and turbine blades, which can disturb sleep or contribute to stress related disorders. However, overall population health impacts appear to be far lower than for fossil fuels.	Hazards typical of manufacturing industries, including injuries, noise, and chemical exposures.	Minor climate impact from equipment manufacture.
	BioFuels	Combustion results in less air pollution compared to fossil fuels. Diversion of farmland to grow biofuel feedstock instead of food, resulting in rising food prices that may threaten nutrition and food security. Biofuel production may also result in decreases in water availability, water quality, forests, wildlife habitat, and ecosystem services, which affect the social determinants of health.	Injuries, ultraviolet radiation, exposure to dust and other toxins, and other risks from commercial forestry.	Climate benefit from reduced combustion emissions may be negated by fossil fuel inputs, land use changes, and other factors.
	Hydroelectric	Large scale dam construction often involves involuntary displacement of vulnerable populations, resulting in impoverishment, collapse of social support networks, homelessness, and unemployment. Alteration of local hydrology may result in increased risk of infectious diseases such as schistosomiasis and malaria. Dam failures can be catastrophic to downstream communities. The public health risks of small scale hydroelectric projects have not been well-documented and are assumed to be minimal.	Chemical exposures, diesel fumes, drowning, electrocution, noise, and other hazards involved in construction and operation, primarily for large dams.	Varies from construction and operation; relatively low overall.

The Way Forward

A Golden Opportunity

Achieving healthy energy requires reducing dependence on dirty sources of energy, using energy more efficiently, and increasing investment in clean, renewable energy choices. Together, these strategies yield health and climate co-benefits: reduced greenhouse gas emissions, reduced air pollution, and improvements to public health.

Using existing technology, the world could be powered entirely with renewable energy within 20-40 years at a cost comparable to that of conventional, fossil fuel-based energy. [67] The 2015 Lancet Commission on Health and Climate Change concluded that "the technical expertise, technology, and finance required to turn climate change from a public health threat into an opportunity is readily available, but politically restricted." [68]

A Vital Role for the Health Sector

The health sector has a vital role to play in bringing its expertise and public esteem to inform policy decisions in the energy sector.

In addition to the actions recommended throughout this guide, the health community – health professionals, academics, policy makers, hospitals, and health systems – can take the following steps towards healthy energy:

- Facilitate education, conversation, and action on the health impacts of energy choices in our institutions, communities, and countries.
- Advocate for health impact assessments and health economic evaluations to be integrated in decision-making on energy projects and energy policy.
- Where our institutions have financial resources invested in the market, consider divesting these resources from fossil fuels.
- Lead by example by investing in clean energy solutions in health offices, health centers, hospitals, and health systems, and by using health care's purchasing power to decarbonize the health care supply chain.

A transition to clean, renewable energy will combat climate change, while also reducing the burden of disease from local pollution and occupational hazards.

In addition, the health community can engage with local and national governments, as well as international institutions, to advocate for the following:

- Cease the deadly and costly dependence on fossil fuels by eliminating fossil fuel subsidies, avoiding new coal projects, and phasing out coal-fired power generation.
- Prioritize and finance development based on clean, renewable energy sources in order to protect public health.
- Reach an international agreement that fosters the transition to clean, renewable energy by, in part, transferring technical and financial resources to countries least able to make this transition.
- Invite greater health sector participation in energy and climate decision-making at all levels of governance.
- Require health impact assessments to be conducted by qualified experts as a part of statutory requirements for the permitting and siting of new energy projects.
- Include considerations for health impacts, as well as health costs and benefits, in policy, legal, and financial decision-making on energy projects.

The health sector has a vital role in informing policy decisions that promote healthy energy choices.

References

[1] World Health Organization (2005). "Energy and Health." http://www.who.int/indoorair/publications/energyhealthbrochure.pdf?ua=1

[2] Smith KR et al. (2013). "Energy and Human Health." *Annual Review of Public Health* 34:159-88. http://dx.doi.org/10.1146/annurev-publhealth-031912-114404

[3] International Energy Agency (2015a). "Modern Energy for All." http://www.worldenergyoutlook.org/resources/energydevelopment/. Accessed 18 September 2015.

[4] Coady D et al. (2015). "How large are global energy subsidies?" International Monetary Fund Working Papers. https://www.imf.org/external/pubs/cat/longres.aspx?sk=42940.0. Accessed 18 September 2015.

[5] World Health Organization (2015). "Health and the Environment: Addressing the health impact of air pollution (WHA68.8)." http://apps.who.int/gb/ebwha/pdf_files/WHA68/A68_R8-en.pdf

[6] World Health Organization (2014). "7 million premature deaths annually linked to air pollution." http://www.who.int/mediacentre/news/releases/2014/air-pollution/en/. Accessed 18 September 2015.

[7] *Ibid.*

[8] *Ibid.*

[9] Smith KR et al. (2012). "Chapter 5: Energy and Health." In *Global Energy Assessment - Toward a Sustainable Future.* http://www.iiasa.ac.at/web/home/research/Flagship-Projects/Global-Energy-Assessment/GEA_Chapter4_health_lowres.pdf

[10] Burt E, Orris P, Buchanan S (2013). "Scientific Evidence of Health Effects from Coal Use in Energy Generation." Health Care Without Harm and University of Illinois at Chicago. http://noharm.org/lib/downloads/climate/Coal_Literature_Review_2.pdf

[11] Health and Environment Alliance (2013). "The Unpaid Health Bill: How coal power plants make us sick." http://env-health.org/IMG/pdf/20052015_hr_coal_report_turkey_final.pdf

[12] International Energy Agency (2015b). "Key Coal Trends." *IEA Statistics.* http://www.iea.org/publications/freepublications/publication/KeyCoalTrends.pdf

[13] Mielke E, Diaz Anadon L, Narayanamurti V (2010). "Water Consumption of Energy Resource Extraction, Processing, and Conversion." Energy Technology Innovation Policy Discussion Paper Series. http://belfercenter.ksg.harvard.edu/files/ETIP-DP-2010-15-final-4.pdf

[14] Watts N et al. (2015). "Health and climate change: policy responses to protect public health." *The Lancet Commissions.* http://dx.doi.org/10.1016/S0140-6736(15)60854-6

[15] World Federation of Public Health Associations (2015). "The Kolkata Call to Action." http://www.wfpha.org/images/events/150216_Kolkata_Call_to_Action_FINAL.pdf

[16] Smith KR et al. (2012). *Op. cit.*

[17] Smith KR et al. (2012). *Op. cit.*

[18] Smith KR et al. (2012). *Op. cit.*

[19] Shonkoff SBC, Hays J, Finkel ML (2014). "Environmental Public Health Dimensions of Shale and Tight Gas Development." *Environmental Health Perspectives* 122(8):787-795. http://dx.doi.org/10.1289/ehp.1307866

[20] Smith KR et al. (2012). *Op cit.*

[21] Howarth RW, Santoro R, Ingraffea A (2011). "Methane and the greenhouse-gas footprint of natural gas from shale formations." *Climactic Change* 106:679-690. http://dx.doi.org/10.1007/s10584-011-0061-5

[22] Smith KR et al. (2012). *Op. cit.*

[23] Smith KR et al. (2012). *Op. cit.*

[24] Smith KR et al. (2012). *Op. cit.*

[25] Buonocore JJ et al. (2015). "Health and climate benefits of different energy-efficiency and renewable energy choices." *Nature Climate Change.* Advance online publication. http://dx.doi.org/10.1038/nclimate2771

[26] Smith KR et al. (2012). *Op. cit.*

[27] Smith KR et al. (2012). *Op. cit.*

[28] Stephens C and Ahern M (2001). "Worker and community health impacts related to mining operations internationally: A rapid review of the literature." International Institute for Environment and Development. http://pubs.iied.org/pdfs/G01051.pdf

[29] Ibid.

[30] Smith KR et al. (2012). Op. cit.

[31] World Health Organization (2002). "Selected occupational risks." The world health report. http://www.who.int/whr/2002/chapter4/en/index8.html. Accessed 18 September 2015.

[32] International Panel on Climate Change (2014). "Summary for Policymakers." *Climate Change 2014: Mitigation of Climate Change. Contribution of Working Group III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_summary-for-policymakers.pdf

References

[33] Watts N et al. *Op cit.*

[34] International Panel on Climate Change. *Op cit.*

[35] International Panel on Climate Change. *Op cit.*

[36] International Energy Agency (2014). "CO2 Emissions from Fuel Combustion Highlights, 2014 edition." https://www.iea.org/publications/freepublications/publication/CO2EmissionsFromFuelCombustionHighlights2014.pdf

[37] Watts N et al. *Op cit.*

[38] Costello A et al. (2009). "Managing the health effects of climate change." *Lancet* 373(9676):1693-1733. http://dx.doi.org/10.1016/S0140-6736(09)60935-1

[39] Watts N et al. *Op cit.*

[40] Smith KR et al. (2012). *Op. cit.*

[41] World Health Organization (2014). *Op cit.*

[42] Smith KR et al. (2014). Supplemental Material to "Millions Dead: How do we know and what does it mean? Methods used in the comparative risk assessment of household air pollution." *Annual Review of Public Health* 35:185-206. http://dx.doi.org/10.1146/annurev-publhealth-032013-182356

[43] Smith KR et al. (2012). *Op. cit.*

[44] Chafe ZA et al. (2014). "Household Cooking with Solid Fuels Contributes to Ambient $PM_{2.5}$ Air Pollution and the Burden of Disease." *Environmental Health Perspectives* 122(12):1314-1320. http://dx.doi.org/10.1289/ehp.1206340

[45] Health and Environment Alliance. *Op cit.*

[46] Coady D et al. *Op cit.*

[47] Coady D et al. *Op cit.*

[48] Coady D et al. *Op cit.*

[49] The Global Commission on the Economy and Climate (2014). "Better Growth Better Climate: The New Climate Economy Report, Synthesis Report." http://2014.newclimateeconomy.report/

[50] Gupta V, Dhillon R, Yates R (2015). "Financing universal health coverage by cutting fossil fuel subsidies." *Lancet Global Health* 3(6):e306-e307. http://dx.doi.org/10.1016/S2214-109X(15)00007-8

[52] Smith KR et al. (2012). *Op. cit.*

[52] Patz J et al. (2007). "Climate change and global health: quantifying a growing ethical crisis." *EcoHealth* 4:397-405. http://dx.doi.org/10.1007/s10393-007-0141-1

[53] *Ibid.*

[54] Kolstad CD (2014). "Who pays for climate regulation?" *Stanford Institute for Economic Policy Research, Policy Brief.* http://siepr.stanford.edu/?q=/system/files/shared/pubs/papers/briefs/SIEPR_PolicyBrief_Kolstad_v4.pdf

[55] International Energy Agency (2015a). *Op cit.*

[56] International Energy Agency (2015a). *Op cit.*

[57] Goldenberg S (2015). "The truth behind Peabody's campaign to rebrand coal as a poverty cure." *The Guardian.* http://www.theguardian.com/environment/2015/may/19/the-truth-behind-peabodys-campaign-to-rebrand-coal-as-a-poverty-cure. Accessed 18 September 2015.

[58] Granoff I and Hogarth JR (2015). "Universal energy access: can we make it sustainable?" Overseas Development Institute. http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/9868.pdf

[59] International Energy Agency (2013). "Chapter 2 – Extract: Modern energy for all." *World Energy Outlook 2013.* http://www.worldenergyoutlook.org/media/weowebsite/energydevelopment/WEO2013_EnergyForAll.pdf

[60] *Ibid.*

[61] Granoff I and Hogarth JR. *Op. cit.*

[62] World Health Organization and World Bank, 2014. "Access to modern energy services for health facilities in resource-constrained settings: A review of status, significance, challenges and measurement." http://www.who.int/hia/green_economy/modern-energy-services/en/. Accessed 18 September 2015.

[63] Climate and Health Alliance (2014). "Background to Position Paper: Health and Energy Choices." http://caha.org.au/wp-content/uploads/2014/11/Health-Energy-Choices-Bkgd-Briefing-Paper-201411081.pdf

[64] Smith KR et al. (2012). *Op. cit.*

[65] Smith KR et al. (2013). *Op. cit.*

[66] International Energy Agency (2014). *Op cit.*

[67] Jacobson MZ and Delucchi MA (2011). "Providing all global energy with wind, water, and solar power, Part I: Technologies, energy resources, quantities and areas of infrastructure, and materials." *Energy Policy* 39(3):1154-69. http://dx.doi.org/10.1016/j.enpol.2010.11.040

[68] Watts N et al. *Op cit.*