GREEN ENERGY

Fueling the Path to Food Security

Channing Arndt, Siwa Msangi, and James Thurlow

SUMMARY Energy is vital to the global food system and food security, but countries will need to explore greener energy paths to address climate change. Opportunities for achieving both green energy and food security goals include solar and hydropower in Africa, biofuels in poor countries, and energy-saving cookstoves.

Two major events in 2015 have placed green energy and food security at the forefront of the global development agenda. In September, governments from across the world adopted the 17 Sustainable Development Goals (SDGs), which, among other things, aim to reduce hunger and food insecurity (SDG 2), and to ensure access to sustainable, reliable modern energy for all (SDG 7). In December, at the 21st Conference of the Parties (COP21), governments negotiated a global agreement to tackle climate change. Countries pledged to progressively reduce their future contributions to global greenhouse gas (GHG) emissions.

Achieving universal food security and energy access while switching to greener energy sources will be a tremendous challenge. The United Nations estimates that there are still 795 million undernourished people in the world.[1] The International Energy Agency (IEA) estimates that one-fifth of the world's population lacks access to electricity, and that two-fifths still burn traditional biomass, such as wood, for heating and cooking.[2] Beyond these challenges, even if all countries meet their commitments under the new climate agreement, food systems may still be threatened by rising global temperatures.[3] Exploiting synergies between the development and climate goals will be crucial to success.

To better understand these synergies, this chapter reviews energy's role in the global food system and outlines the scale of effort needed to chart a greener energy path for developing countries. Major potential synergies between global energy and food security goals are identified, including promising opportunities

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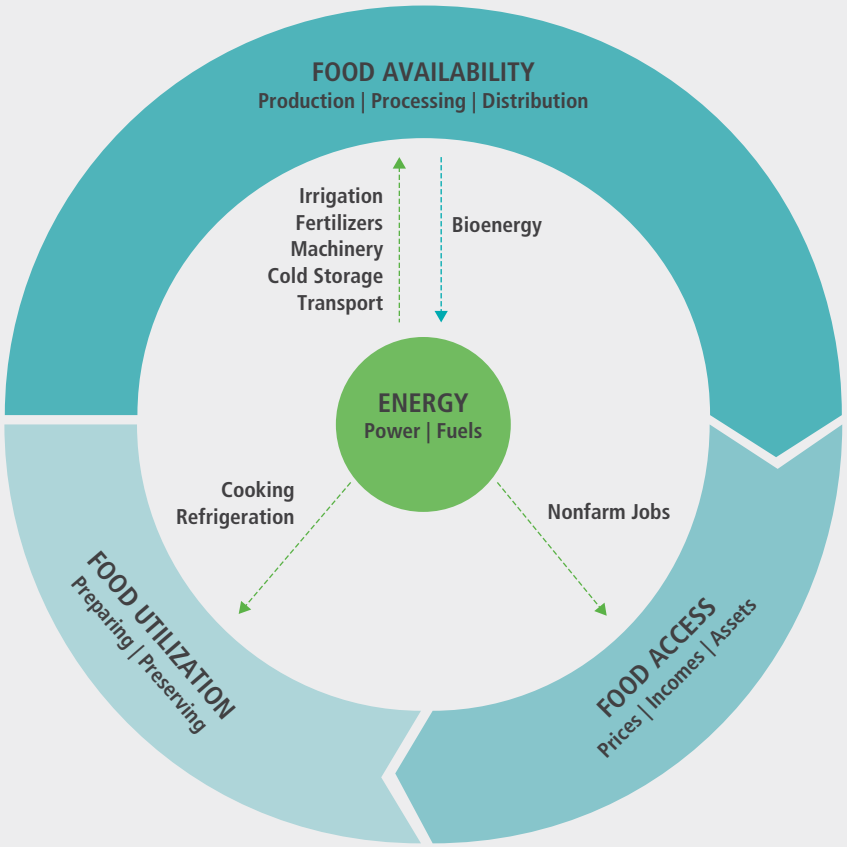
FIGURE 1 Energy's links to food security



Source: Authors.

in South Asia and Africa south of the Sahara, where two-thirds of the world's undernourished people live and where access to modern energy is extremely limited. Taking advantage of such opportunities will require both long-term investments and more immediate policy action.

LINKING GREEN ENERGY AND FOOD SECURITY GOALS

Energy and food security are closely interlinked (Figure 1). Energy is used throughout the food system—in production of crops, livestock, and fish; in processing, storage, and distribution of food products; and in preparation and preservation of food within households. Some uses are readily apparent—petroleum is used to run tractors, boats, and trucks; electricity powers irrigation schemes and cold storage facilities. Other energy uses are embodied within agricultural inputs, such as natural gas used to produce chemical fertilizers and pesticides. The Food and Agriculture Organization of the United Nations (FAO) estimates that in total, the global food system consumes about one-third of the world's available energy, with only about 25 percent of this energy consumption devoted to food production; the remainder is used downstream in processing, storage, transport, and preparation.[4] Agriculture is also a supplier of energy, for example, when households burn wood and other biomass for cooking

or when farmland is used to grow crops for biofuel production.

Achieving global food security requires more energy and greater efficiency

Global demand for food will rise as the world's population grows and becomes more affluent. To prevent an increase in food prices and food insecurity from accompanying this growth, global food production will have to increase by about 70 percent by 2050, according to projections from the International Food Policy Research Institute (IFPRI) and FAO. A 70 percent increase will require substantial investments in technologies and infrastructure to raise farm productivity.[5] Asia's Green Revolution provides an indication of what is needed to achieve these productivity gains. Much of Asia's success in raising crop yields resulted from adoption of modern seed varieties. However, it also involved greater use of chemical fertilizers, irrigation, and machinery, all of which use more energy than traditional farming—as a result, the Green Revolution greatly increased the energy intensity of Asia's food system (that is, the amount of energy used per hectare or per unit of food). Demand for energy will continue to rise as Asia develops into a high-income region.

Today, food systems in high-income countries use five times more energy per person than food systems in low- and middle-income countries.[6] A simple extrapolation from the global food system's current energy use suggests that feeding a population of 9.6 billion people in 2050 will require a 20 percent increase over the world's current energy supply. This projection assumes "business as usual," so it may overstate future energy demand growth. Under the new climate agreement, fossil fuel use may be constrained by policy, which may lead to greater reliance on more expensive alternatives. But even if the climate agreement fails, the IEA predicts a long-term upward trend in fossil fuel prices.[7] Global food systems will therefore face incentives to become more energy efficient.

Improving energy efficiency in the food system can also help stabilize food security. Food stability means that households have adequate access to food *on a continuous basis*. An increase in global energy prices, for example, was one of the main drivers behind the sharp rise in food prices in 2008, which reduced households' access to affordable food and worsened food insecurity in the years that followed.[8] Conversely, the decline in energy prices in 2015 has lowered food prices, which should benefit net food consumers—generally urban residents and poorer farmers.[9] However, while lower food prices may benefit the poor today, fluctuations in global food prices may reduce incentives for productivity-enhancing investments along the food chain. Improving the energy efficiency of food systems is therefore an essential step toward ensuring long-term food security.

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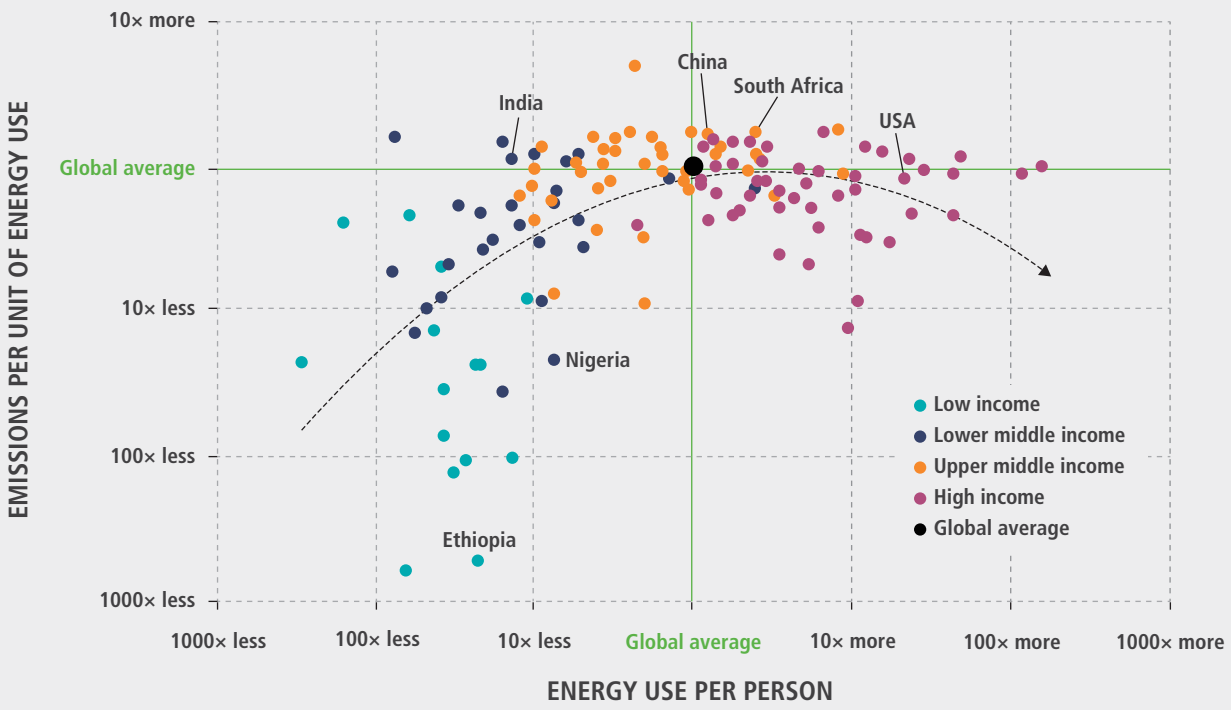
Reducing emissions despite rising energy demand is a daunting task

The global food system is not the main source of rising energy demand. The Organisation for Economic Co-operation and Development (OECD) predicts that the global economy will be 4 times larger in 2050 than it is today, implying far more rapid expansion outside of the food system.[10] Economic growth has long been synonymous with rising energy demand. People living in low-income countries consume 5 times less energy than the average person in the world, and 10 times less than the average person living in high-income countries (Figure 2). As poor countries develop, they will account for a disproportionate share of the increase in global energy demand. Therefore, while improving energy efficiency is essential—both in the food system and elsewhere—greater efficiency is unlikely to prevent energy demand from rising in the future.

FIGURE 2 Energy use rises with development, and emissions intensity eventually falls



Source: Authors' calculations using the World Bank's World Development Indicators data for 2011 (accessed in October 2015).

Note: Both the *x*-axis and *y*-axis show the natural log of the ratio of each country's energy or emissions to the global average. The figure is based on the 132 countries where data are available. Trend line is a fitted polynomial.

High-income countries not only use more energy per person than low-income countries, but they also generate three times more GHG emissions per unit of energy, which is referred to as the "emissions intensity" of energy use (Figure 2). The emissions intensity of energy use tends to rise as poor countries move toward upper-middle-income status; it then falls as countries develop further. This decline in emissions intensity is not rapid enough to offset the increased emissions from rising energy demand—average emissions per person in high-income countries is still twice that in upper-middle-income countries. If poor countries today were to replicate the energy trajectory of developed countries, the accumulation of GHGs in the atmosphere would reach levels associated with severe climate change by the latter half of the 21st century.[11]

Reducing emissions is important for global food security

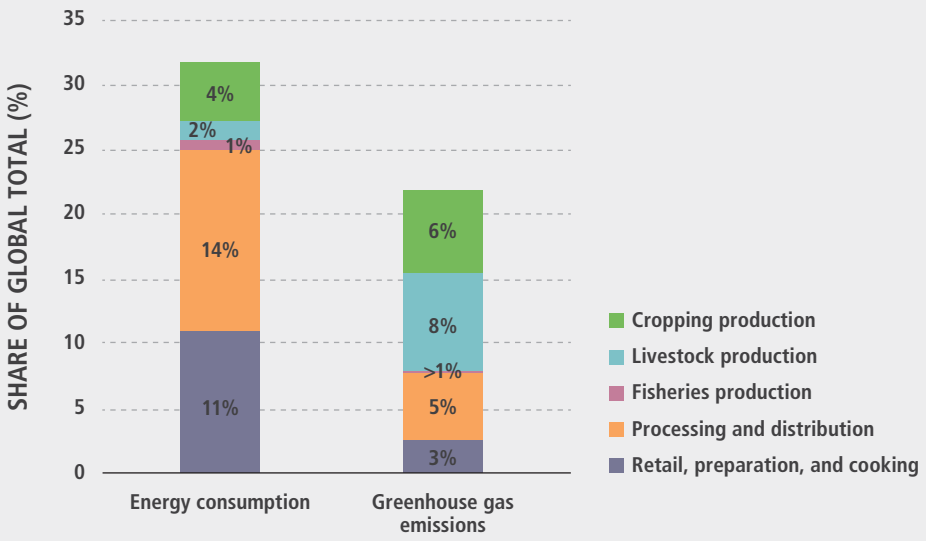
Time will shape the impacts of climate change on the global food system. Plausible projections suggest that by 2050 climate change will cause agricultural productivity growth to slow, particularly in poor countries where food insecurity is already a major concern.[12] IFPRI estimates that damage to agricultural production from climate change will mean a slower rate of reduction in malnourishment—leaving 10 percent more malnourished children in developing countries by 2050 (in comparison with a scenario without climate change).[13] Research also indicates that the entire food system may be vulnerable. Recent country studies from Africa suggest that the indirect effects of climate change—notably, damage to rural road

networks—may have a greater impact on welfare than direct harm to agricultural production.[14] In general, from now until 2050, climate change is expected to slow but not reverse current progress toward achieving global food security.

If GHG emissions grow unchecked beyond 2050, however, temperature increases and other associated impacts are expected to be well outside of historical experience, with deeply uncertain and potentially profoundly negative implications for both the environment and human welfare. Poor people in poor countries would likely be among the first to suffer. Demand for energy to maintain necessary refrigeration, climate-control of food storage, and handling facilities (such as the "cold chain" in the dairy or meat sector or low-humidity cereal storage) will increase with rising temperatures. Failure to meet these rising energy needs would have serious implications for food safety, human health, and the viability of those sectors. Avoiding severe climate change is highly desirable and may require mitigation policies that are more ambitious than those offered by the new climate agreement.

Of course the food system is not only on the receiving end of climate change. It is also a major emitter of GHGs and will need to play its part in reducing future emissions. The FAO estimates that the global food system still generates one-fifth of the world's GHG emissions (Figure 3). Two-thirds of these emissions come from the production of crops, livestock, and fish. However, only about half of these *on-farm* emissions are from energy use—the rest are methane from rice paddies and ruminant livestock. Adopting green energy sources can therefore reduce only part of the food systems' emissions. However, there are opportunities to reduce *off-farm* emissions. Consistent with the high share of energy use downstream from the farm discussed above, the FAO estimates that more than half of food system emissions in high-income countries are attributable to the energy used during food processing, distribution, and preparation. In contrast, only a quarter of food system emissions in lower-income countries are off-farm. With greener energy sources, emissions from food systems in poor countries can be substantially contained even as these systems are transformed and modernized.

FIGURE 3 The food system's contribution to total global energy consumption and greenhouse gas emissions



Source: Adapted from FAO (Food and Agriculture Organization of the United Nations), *"Energy Smart" Food for People and Climate* (Rome: 2011).

Modest progress has been made toward greener energy

Can poor countries chart a greener path to meeting their future energy needs while also improving food security? Based on global progress, it would appear that they can. Renewable energy technologies accounted for almost half of the world's newly installed electricity generation capacity over the last two years.[15] In addition, various countries, including India and Indonesia, have used lower oil prices as an opportunity to reduce fuel subsidies. For these and other reasons, including an economic slowdown in China, the relationship between global economic growth and emissions growth has weakened for the first time in at least four decades.

Most of the recent expansion in renewable energy has occurred in Europe and East Asia. Not surprisingly, the lowest-income and most food-insecure regions of South Asia and Africa south of the Sahara have not been leading the global transition to green energy sources. The degree and timing of engagement in an energy transition presents difficult choices for policymakers in poor countries. Clearly, poor countries do not wish to compromise their development prospects, especially their food security. However, a stabilized climate requires very low or even negative net emissions globally, which implies eventual global participation in any effective mitigation regime. Fortunately, low-income countries are often well endowed with sun, wind, and hydropower resources, opening the possibility for substantial synergies between green energy and food security. There are other green energy opportunities, such as nuclear power, but their potential contribution to reducing global food insecurity is less certain. Below, we identify three major opportunities for exploiting greener energy sources while also significantly addressing global food insecurity.

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PROMISING OPPORTUNITIES

Solar power and hydropower in Africa

Undernourishment is most prevalent in Africa, and unlike in the rest of the world, the number of undernourished Africans has risen since 1990.[16] Africa is also the region where access to modern energy is most lacking. More than 600 million Africans live without access to electricity, and even those with access must contend with high energy prices and an unreliable supply.[17] To complicate matters further, Africa's population is expected to double to 2.5 billion people by 2050, and its economy will be, by conservative estimates, four times larger than today's.[18] The task of feeding and fueling Africa's population and contributing to its economic growth would be enormous even in the absence of climate change. As it is, Africa must accomplish this task while both coping with the global warming already built into the climate system and aiming for a transition to green energy sources.

That transition may come soon, because renewable energy options are plentiful in Africa and could provide the power needed to transform its food system. Hydropower is already the main source of electricity in the region, but there is huge potential for expansion. The IEA estimates that if fully exploited, hydropower could supply three times more electricity than is currently available in Africa, and at a lower cost than any other technology.[19] Importantly, most of the unexploited potential lies in Central and East Africa, where undernourishment is highest and energy access is lowest.

Of course, hydropower is not without its own challenges. It is vulnerable to seasonal and long-term climate change and raises concerns about environmental damage. While some dams could provide water for irrigated agriculture, they may also flood farms and displace communities. And while hydropower is a viable option for bulk electricity supply, it

will need to compete against Africa's massive fossil fuel reserves, which are expected to last for centuries at current extraction rates. Nevertheless, if these challenges are managed, hydropower in Africa is perhaps the single largest opportunity to promote both green energy and global food security.

Even with hydropower, connecting everyone to national electricity grids will be difficult. One-quarter of all Africans—mostly those in remote and food-insecure rural areas—will still be off-grid by 2040, largely because the relatively low population density in Africa makes infrastructure development a challenge in terms of connecting people to roads, water, or electricity.[20] Africa's renewable energy resources provide a possible solution, however. Although solar power is not yet a cost-competitive option for bulk electricity supply, recent research suggests that mini-grid solar (photovoltaic) power may already be the lowest-cost technology option for as many as 55 million people in rural Africa.[21] This number, estimated more than five years ago, has likely grown as solar technologies have improved and costs have declined by a factor of two or more.[22]

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Biofuels production in poor countries

Greening transport systems is a high priority, not least because food distribution via those transport systems becomes a larger component of the food chain as countries develop. Biofuels offer one means of reducing transport's fossil fuel use. In fact, the IEA considers biofuels (and to a lesser extent, electric vehicles) the main means of reducing transport emissions, at least through 2040.[23] Despite dropping prices for fossil fuels, global demand for biofuels is expected to continue to increase, driven by mandates in major economies including the European Union (EU) and the United States. Biofuels will almost inevitably be an integral part of the global response to climate change.

Biofuels are often treated with suspicion by people concerned about global food security. As mentioned, rising demand for biofuels in developed countries was likely a contributing factor to the sharp rise in world food prices in 2008. Climate scientists are also concerned that clearing land to make way for biofuel crops could contribute to GHG emissions. The overlap between biofuel production, emissions reductions, and food security may therefore be a negative one. This concern has prompted numerous responses. The EU imposes strict "sustainability criteria" on imported biofuels to ensure a net reduction in emissions. In the United States, the state of California has adopted a low-carbon fuel standard as an incentive for reducing the carbon intensity of the overall fuel pool, which has been proposed as a replacement for or supplement to the national Renewable Fuel Standard. The current national standard favors corn-based ethanol, with few incentives to reduce emissions outside the transport sector.[24]

Despite these concerns, biofuels may offer an opportunity to improve food security. Most research focuses on how biofuel policies and production in developed countries (and Brazil) affect food imports and prices in developing countries.[25] Yet, for many poorer countries in Africa and elsewhere, biofuels may be better viewed as a potential export or as a means for reducing fossil fuel imports. A growing body of research suggests that producing conventional biofuels in low-income countries could raise rural incomes beyond what is required to offset rising food prices.[26] Studies in Ethiopia also found that farmers' participation in biofuel programs encouraged greater use of fertilizers and improved farming technologies, leading to higher food-crop productivity and better food security during the year.[27] One precondition for success, however, was farmers' access to high-quality, productive biofuel crops. Efforts to promote Jatropha as a biofuel crop in many parts of Africa, for example, have failed due to the use of low-yielding varieties and inadequate extension services.[28]

In summary, experience indicates that when poorly structured, biofuel policies in developing countries lead to negative outcomes for both the environment and food security. However, with properly structured and applied policies, biofuels have potential to contribute simultaneously to goals related to the environment, energy accessibility, and food security. More research is needed to determine when and where biofuels can be a positive force in low-income countries.

Improved cookstoves and better sourcing of biomass

Burning biomass for cooking accounts for almost half of the energy used by food systems in developing countries.[29] Not only is this form of cooking inefficient and unhealthy, but it is also a major source of GHG emissions. Using more energy-efficient cookstoves would lower emissions, either by reducing the amount of biomass burned or, better yet, by substituting cleaner fuels such as natural gas for biomass. Tackling climate change will require major expansion of the use of efficient cookstoves. One of the IEA's more ambitious climate change mitigation scenarios includes 1.6 billion people gaining access to their first clean cookstove.[30] Such cookstoves can lower emissions, improve health outcomes, and reduce the time households spend collecting firewood, thus possibly raising households' agricultural productivity and incomes.

> Using more energy-efficient cookstoves would lower emissions, improve health, and possibly raise incomes.

Equally important is access to better-quality biomass. Scavenging for receding fuelwood sources is not a sustainable pattern of energy use, and charcoal use cannot simply be wished away. Although a number of countries are trying to outlaw charcoal production, urban households will continue to use charcoal even if connected to electricity grids, due to unreliable service. Pushing for higher-productivity, agroforestry-based methods of producing biomass quickly and making the conversion of biomass more efficient will avoid GHG emissions (and lost carbon sequestration) from deforestation. It will also reduce the long distances that women and children must travel to find energy for their households.[31]

The link between improved cookstoves and food security is somewhat indirect, and more research is needed to confirm the time benefits and income gains from using these stoves. Research is also needed to identify those cookstove technologies that are both economically viable and most effective at improving health outcomes. However, the sheer magnitude of the problem and its possible solution could make this one of the largest synergies between green energy and global food security.

NOW IS THE TIME TO ACT

Achieving universal food security and access to modern energy is an enormous challenge, further complicated by climate change and the need to transition to greener energy sources. In the coming decades, more energy will be needed to support food system transformation in developing countries, particularly within the world's poorest regions. Unfortunately, these are also the regions where energy supply is most lacking and energy distribution systems are ill-equipped to reach many of those in need, namely the rural poor. Exploiting synergies between the SDGs and the global climate agreement will be essential if both goals are to be achieved within their established time frames.

There are three areas where we see potential. First, Africa is home to most of the world's undernourished people and to an immense renewable energy resource base; there is huge potential to harness low-cost hydropower and reach more remote rural populations using solar power. Second, rising global demand for biofuels provides an opportunity for low-income countries to reduce their dependence on fossil fuels while also raising rural incomes. More research is needed on how to minimize emissions from land-use change and prevent adverse effects on food production and prices. Finally, the developing

world burns a lot of biomass for cooking, which results in one of the largest sources of global GHG emissions. If new cookstoves lead to even modest improvements in fuel efficiency, this improvement would go a long way toward reducing poor countries' food system emissions.

To take advantage of these opportunities, governments in developing countries need financial support and technology transfers, largely from developed countries. The COP21 climate agreement promises to provide at least some of these resources, but major infrastructure investments take time. Countries must also search for more immediate policy actions to promote energy efficiency and reduce emissions in their food systems. Many of these actions are well known, such as reducing fossil fuel subsidies and reducing food loss and waste. Now is the time to act on the many potential synergies between global efforts to promote green energy and food security. ■