SPECIAL FEATURE **SEAR**

THE CLIMATE CHANGE–ENERGY ACCESS NEXUS

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INTRODUCTION

As the *Turn Down the Heat* series of reports from the World Bank makes clear, climate change complicates development efforts:

> "Data show that dramatic climate changes, heat, and weather extremes are already impacting people, damaging crops and coastlines, and putting food, water, and energy security at risk. . . . The task of promoting human development, of ending poverty, increasing global prosperity, and reducing global inequality will be very challenging in a 2°C world, but in a 4°C world there is serious doubt whether this can be achieved at all. Many of the worst projected climate impacts could still be avoided by holding warming to below 2°C. But, the time to act is now. "
>
> —*Turn Down the Heat: The New Climate Normal* (WB, 2014a)

One of those development efforts would be achieving sustainable energy access for all. If the world is to have a reasonable chance of preventing global temperatures from increasing beyond 2°C above pre-industrial levels, net emissions of carbon dioxide (CO2) and other long-lived greenhouse gases (GHGs) must approach zero in the second half of this century (OECD, 2013). This will have implications for virtually all aspects of the energy system, given the large and dominant role of energy-related emissions in our current carbon budget (Le Quéré, C. et al., 2014). At the same time, the effort under way to expand energy access through the Sustainable Energy for All (SE4ALL) objectives—universal access to modern energy services, double the share of renewable energy in the global energy mix, and double the global rate of improvement in energy efficiency—will have significant consequences for existing energy systems, especially if all three objectives are to be achieved (SE4ALL, 2014).

On the bright side, emerging linkages between the energy access and climate change agendas offer opportunities to simultaneously bring energy access solutions to scale, achieve mitigation objectives, and create more resilient and sustainable communities. And there are some signs of initiatives under way or being considered that try to seize these opportunities. For example, at the December 2015 climate change negotiations in Paris (under the auspices of the UN Framework Convention on Climate Change), an agreement was adopted that defines multiple objectives that, taken together, strengthen the global response to the threat of climate change (I4CE, 2015). At the same time, it incorporates new terms and concepts, including "climate justice" and "the right to development" that link the global mitigation effort to the UN Sustainable Development Goals (Wuppertal, 2016).

The Paris Agreement's structure—including "contributions" from all countries and a technology framework that addresses access and finance for those technologies that shift away from fossil-based infrastructure—is critical for improving resilience and the eventual reduction of GHGs in countries that still lack access to modern fuels. This point has been reinforced by recent World Bank research (Hallegate et al., 2016) that shows that very poor, agriculture-focused countries typically do not consume a lot of energy. In fact, in 2011, the 900 million people (13 percent of the population) living in the 50 poorest countries emitted only 0.8 percent of global CO2 emissions, yet they are among the most vulnerable to climate impacts.

Thus, one policy approach to address the global mitigation challenge—but not disadvantage the poor—would be to sequence fossil fuel subsidy removal, leaving the removal of liquefied petroleum gas (LPG) subsidies for later on. Similarly, carbon taxes can be combined with policies that help the shift to modern energy, such as low-cost financing for clean cookstove purchase or targeted subsidies for modern energy (for example, recycling carbon tax revenue through cash transfers or programs that help the poor) (Hallegate et al., 2016). This would have the double dividend of addressing energy access and climate challenges while increasing resilience and providing multiple localized development benefits (for example, better health, forest protection, and gender empowerment) to those who are most vulnerable to the impacts of climate change.

LINKS BETWEEN CLIMATE CHANGE AND ENERGY ACCESS

The linkages between the climate and energy access challenges have typically been framed in terms of the carbon "footprint" of achieving the SE4ALL goals—in other words, mitigation—which the literature shows has been and is expected to be negligible. One recent study finds that improvements in household electricity access contributed 3-4 percent of the national GHG emissions growth in India over the past three decades (Rogelj, et al., 2013). Another study reports that the climate impacts of achieving universal access to modern energy carriers and technologies by 2030 are negligible or might even be negative (Pachauri et al., (2012). The International Energy Association (IEA, 2011) estimates that achieving universal modern energy access by 2030 would raise CO_2 emissions as compared to their current practices scenario by only 0.7 percent.

But a broader view of the "climate change—energy access nexus" also accounts for adaptation challenges that rising temperatures and extreme weather will create for achieving the SE4ALL goals (see Box 1). This is vital given that damages from extreme weather alone have risen fourfold over just the last three decades (World Bank, 2013). As new infrastructure is deployed to increase access to modern fuels, expand renewable generation, and increase efficiency, it must be resilient in the face of harsher environmental conditions and able to cope with the "new normal" climatic conditions that will occur in future decades. At the same time, expanded access is critical for communities that currently lack access so that they can become more resilient. After all, energy access is essential to power early warning systems, improve emergency responses, and enable coping mechanisms for new weather extremes.

Fortunately, addressing climate change and energy access can go hand-in-hand. But success on both fronts requires establishing a careful balance of mitigation, adaptation, and finance concerns.

Mitigation

Energy access goals could provide an important point of entry for mitigation of both long-lived GHGs (like carbon dioxide, methane, and nitrous oxide) and short-lived climate pollutants (SLCPs) (like black carbon, methane, and hydrofluorocarbons). Many of the solutions that provide energy to poor, rural communities (like renewable mini-grids and more efficient cookstoves) have the added benefit of reducing emissions of global warming pollutants that contribute to climate change as well as other air pollutants that worsen air quality. Integrated assessment models have shown that many scenarios that achieve all three SE4ALL goals are consistent with levels of climate mitigation that have a high probability of limiting warming to 2°C

BOX 1

Challenges for Energy Access in a Warmer World

The world is currently on course for global average surface temperatures to warm by 4°C or more by the end of the century. The projected impacts span a wide range of climatologically sensitive areas – including highly unusual and unprecedented heat extremes, rainfall regime changes and water availability consequences, agricultural yields and food security, terrestrial and marine ecosystem impacts, sea-level rise, glacier loss, and increased social vulnerability (World Bank, 2014a).

These climate changes will directly affect the provision of energy services and alter energy demand. Increased air and water temperatures can decrease the efficiency of generation and increase the need for cooling, exacerbating supply limitation (ADB, 2012, and World Bank, 2011). Changes in precipitation patterns and surface water discharges, as well as an increasing frequency or intensity of droughts, may adversely impact hydropower generation and reduce water availability for cooling purposes to thermal and nuclear power plants – although large decreases in precipitation may also be associated with decreased cloud cover and increased solar potential. Extreme weather events, such as stronger or more frequent storms, can reduce the supply and potentially the quality of fuel (coal, oil, and gas), reduce the input of energy (water, wind, sun, and biomass), damage generation and grid infrastructure, reduce output, and affect the security of supply. Coastal structures are influenced by higher sea levels, and adaptation options often require extra energy supply (for example, where major rivers meet the ocean, additional pumping facilities could be required).

At the regional level, there are bound to be big variations. In Latin America, the concomitant increase in energy demand during heat extremes and the decrease in energy supply through reduced river flow and low efficiencies may put existing energy systems under increasing pressure. In the Middle East and North Africa, projected impacts are primarily related to lower thermal conversion efficiency, decreased volume and efficiency of water for cooling, and extreme weather impacts on production and distribution systems. In Central Asia, careful management of reservoirs may be able to balance agricultural needs with increased demand for hydroelectricity. But in the Western Balkans, lower precipitation will likely intensify the challenges of meeting additional hydro-demand while thermal and nuclear plant cooling capacity is simultaneously reduced (World Bank, 2014a).

Thus, there will need to be both enhanced risk screening of new energy access projects and consideration of whether the failure of existing infrastructure might create additional energy access needs—for example, about 25 percent of future demand growth is projected to stem from higher cooling demand owing to warmer temperatures (IPCC, AR5).

(Rogelj, et al., 2013)—and thus would also bring tremendous public health benefits attributed to cleaner air.

Universal access to modern fuels—in particular—would result in large regional reductions of black carbon emissions that, as a component of fine particulate air pollution, have enormous public health consequences in areas like South and East Asia. Black carbon can also affect ecosystem health by depositing on plant leaves and increasing their temperature, dimming sunlight that reaches the earth, and modifying rainfall patterns. The latter can have far-reaching consequences for ecosystems and human livelihoods (for example, by disrupting monsoons, which are critical for agriculture in large parts of Asia and Africa) (CCAC, 2014). In addition, all SLCPs can help reduce near-term warming and provide greater time for adaptation to climate change, thereby lengthening and improving the quality of lives (CCAC, 2014).

Plus many energy access solutions—that often both expand energy access and reduce emissions of GHGs, SLCPs, and other air pollution—provide multiple benefits for sustainable development (World Bank, 2014b). Renewable or more efficient technologies can save energy and reduce financial flows to purchase or subsidize fossil fuels, offsetting some of the capital expense associated with those technologies. And energy access investments in a single sector can have multiplier and forward linkage effects across the economy that can yield broader output and employment gains, which are not always recognized in project financial analysis. Lower emissions choices reduce climate change and improve air quality, providing agricultural and public health benefits and reducing future losses that can be monetized.

But if we are to address the energy priorities of the poor and disconnected while simultaneously recognizing the long-term mitigation challenge and associated benefits, we will need to carefully balance interventions to support access objectives while achieving net zero carbon levels by the end of the century. This means recognizing the synergies that come from pursuing both efficiency gains and more renewable energy generation—for example, Rogelj et al. (2013) find that the SE4ALL 2030 targets for primary energy from renewable energy are reduced by 20 percent if the energy efficiency objectives are achieved simultaneously. It also means carefully planning for a judicious deployment of "transition" fuels (like LPG, whose emissions may need to be offset), along with a rapid scale up of sustainable solutions (like biogas).

Furthermore, recognizing the health, agricultural, employment, and economic benefits of access programs—and accounting for their full social value—will strengthen the case for action and for finance (both public and private). At the project level, these benefits have often been left out of economic analyses because many health and environmental benefits were not easily quantifiable. However, recent efforts to better estimate the full impacts of proposed development projects have produced several new analytical tools and models that allow economists to more fully assess the multiple impacts of pollutants, estimate the value of emission reductions, and model the synergistic impacts of harms and benefits as they flow through the economy (World Bank, 2014b).

Adapting Energy Access to Ensure Energy Resilience

Of course, mitigation will need to be complemented by adaptation. Here, two key questions arise. What constitutes full access in a hotter world? And what do climate projections and resilience planning mean for energy system deployment and integrity?

Starting with how one defines "appropriate" access, it is worth considering that the end-use demand is sensitive to temperature in general, but particularly to heat waves, which calls into question whether emergency cooling constitutes access (ADB, 2012). Disaster response needs (like early warning systems and hydro-meteorological services) to other extreme weather events (like typhoons and flooding) should be considered when establishing the level of access deemed appropriate.

Pragmatically, the resilience imperative may add constraints to energy access programs. For example, flooding may have the biggest impact for a wide range of generation technologies, but higher water temperatures or reduced water availability may result in the most severe impact where energy systems are dependent on water for cooling (ADB, 2012). Transmission and distribution grids are notoriously sensitive to storm damage, and thus distributed technologies may represent an appropriate adaptation strategy for energy systems in general, while providing solutions for rural populations without access.

Adaptations for key access-related energy systems can include: (i) more robust design standards (wider range of operating temperatures, able to withstand weather extremes); (ii) enhanced passive airflow cooling under roof-mounted solar systems; and (iii) transmission and distribution redundancy in control systems and routes or underground distribution (ADB, 2012). From a planning perspective, adaptation and resilience advice for energy planners (ADB, 2012) is equally relevant to energy access planning and includes:

- Understanding current climate variability and how the climate might change in the future, and therefore which measures are warranted at the level of specific projects.
- Improving energy sector (and broader) decision making by improving local weather and climate knowledge, regardless of whether large climate changes are expected.
- Improving access to existing meteorological and hydrological data and developing better mechanisms so that local weather and climate data are archived for the public good.

CLIMATE FINANCE

From a technical and economic perspective, providing almost universal access to electricity and modern cooking fuels by 2030 will require global investments of $36-41 billion annually, which is about 3 percent of total energy infrastructural investments (Pauchauri, 2012). But one recent study (Cameron et al., 2015) finds that efficient policy design (mainly targeted stove and fuel price supports) can achieve energy access and climate goals while counteracting the effects of climate policies on cooking fuel prices in South Asia—although international financial transfers under effort-sharing scenarios may be needed to enable price support policies in developing countries. Climate finance could play a catalytic role, along with other underlying sources of finance, in unlocking this potential and financing the interventions that expand energy access.

Securing these funds requires financing and business models within the energy access community to be understood and embraced by operating entities of the Financial Mechanism of the UNFCCC (the Green Climate Fund, the Global Environment Facility, and the Standing Committee on Finance). Examples include the creation of windows of patient (10 or more years), subordinated, mezzanine debt, and convertible grant instruments for decentralized energy, especially mini-grids (Practical Action, 2015). In India, the mini-grid experience suggests that clustering community-scale projects enables the establishment of critical O&M services, and bundling projects can be helpful in minimizing transaction costs to attract venture capital funding and carbon finance credit (GNESD, 2014). In Bangladesh, grants and soft loans with strong government support are the key to solar home programs (see Box 2).

The dual challenges of weak enabling environments and lack of access to capital make it doubly hard to ramp up renewable and other modern energy use in low-income countries. But two recent models for financing energy access show how it can be done.

Program for Scaling Up Renewable Energy in Low Income Countries (SREP). Launched in 2010, under the Climate Investment Funds (CIF), SREP started as a small program with six pilot countries (Ethiopia, Honduras, Kenya, Maldives, Mali, and Nepal). Its objective is "to pilot and demonstrate, as a response to challenges of climate change, the economic, social, and environmental viability of low carbon development pathways in the energy sector by creating new economic opportunities and increasing energy access through the use of renewable energy." Through a country-led process of developing and implementing investment plans with the support of multilateral development banks (MDBs), SREP created a platform to build institutional capability and mobilize investments (public and private) to expand energy access through renewable energy. Since its creation, the amount of climate finance contributed and pledged has increased from $300 million to $800 million, and the number of pilot countries has grown to 27. A wide range of technologies have been supported, from geothermal, solar, wind, small hydro, and biomass to renewable mini-grids and clean cookstoves (see Box 3).

Climate and Clean Air Coalition (CCAC). This coalition was formed in 2012 to reduce SLCPs at the global level. As of May 2016, it counted over 100 partners (including governments, multilateral institutions and private organizations). It supported a study group led by the World Bank to review potential strategies for financing projects that can significantly reduce black carbon emissions. Significant finance for clean residential energy solutions (including clean cooking, heating, or lighting) could have both large climate benefits (depending on geographic context and intervention design) and improve the health and well-being of millions who lack access to cleaner modern fuels.

FUTURE PROSPECTS AND PROJECTIONS

Once connected and provisioned with modern fuels, new users of energy may increase their energy use rapidly, possibly leading to a climate mitigation challenge; hence providing them clean energy access is paramount. Climate-smart solutions for energy access—solutions that expand access, lower emissions, and yield other development benefits that are consistent with energy access for the poor—are being deployed already. These include cleaner (low-emission) technologies now being used in remote locations (like clean cooking and renewable mini-grids).

Many of these cleaner solutions have reached (or nearly reached) price parity with more polluting alternatives. A recent review of access solutions finds that in South Africa, commercial wind is at grid parity with coal; in East Africa, grid-scale solar is competitive; and in Nigeria, solar lanterns are hundreds of times cheaper than kerosene (in $/lumen-hour) and solar home systems are competitive with diesel generators (Practical Action, 2015). Scaling up these solutions will only further reduce costs.

BOX 2

Bangladesh's IDCOL as a Model for Nationally Supported Solar Home Programs

Using donor funding, Bangladesh's Infrastructure Development Company Limited (IDCOL) is a public–private partnership that provides subsidized financing (grants and soft loans) to sellers and installers of solar home systems, along with certifying equipment, vendors, and ensuring quality control, technical assistance, and monitoring after deployment of a solar home system (Practical Action, 2015).

The tremendous success of this program in delivering low-cost solar electricity access to the poor and disconnected (more than 2.6 million units bring energy service to 12 million people) argues for replication of this approach. This could be done by expanding this program or undertaking similar private sector initiatives—for example, Tanzania's off-grid electric program, which leverages pay-as-you-go technology and serves 60,000.

BOX 3

Kenya Uses SREP to Show How Carbon Finance Can Support Access

Kenya had the first investment plan endorsed by the Program for Scaling Up Renewable Energy in Low Income Countries (SREP) governing body in 2011. Following an extensive consultation with stakeholders, the government proposed three priority areas for SREP support:

GEOTHERMAL. Kenya has an ambitious plan to develop about 5,000 megawatts of electricity from geothermal by 2030. SREP support should help bring down the financing and resources risks associated with the drilling of appraisal and production wells and power generation in Menengai, so that the project structure can be replicated in other geothermal fields.

HYBRID MINI-GRID SYSTEMS. This project proposes to increase the proportion of renewable energy (solar and wind) in existing and planned mini-grids and to replace the current unsustainable diesel-based mini-grid electricity supply. The project will make electricity more affordable for the poor and increase generation capacity that will enable more connections and increase access. It is expected to mobilize private sector participation in the isolated mini-grids and to promote a standardized scale-up approach that will allow a systematic scaling-up of access to electricity.

SOLAR WATER HEATING. This project aims to remove market barriers for the wide adoption of solar water heating systems and to reduce both energy use and peak demand. SREP intervention will enhance the private sector's engagement in this market and strengthen the banking sector's capacity and experience to finance renewable energy development.

The projects to be funded by the SREP are expected to bring transformative impacts on renewable energy development in Kenya and benefit millions of poor people with modern energy services.

Plus even in cases where access technologies are not quite at price parity with more polluting alternatives, the poor are now paying much higher prices for available energy services (such as kerosene and cell phone charging), justifying investments that would make marginally more expensive energy choices more accessible. In addition, recent research (Alstone et al, 2015) demonstrates that mobile phones and virtual financial services can enable rapid deployment and scale-up of these technologies.

These options become even more cost-competitive when economic analysis factors in the full economic value of benefits from employment (mini-grid finance authorities or distributors, energy service companies, electricians, and stove distributors or manufacturers) and avoided crop losses (reduced co-emitted methane and other air pollution precursor emissions)—as well as the social value associated with improved health (reduced cook smoke and offset coal plant pollution) and mitigation (less fossil fuel and deforestation).

However, as pointed out earlier, boosting energy access does not mean a significant increase in GHG emissions. In addition, integrated assessment modeling studies show a far greater improvement in air quality as a result of accelerating energy access policies than increased stringency of mitigation, highlighting the important benefits of policies that aim at achieving many objectives—such as climate protection, clean air and energy access—concurrently, instead of in isolation (Rogelj et al., 2014).

A recent study (Pachauri et al., 2012) examines a range of future energy access scenarios to encourage a more rapid transition away from solid fuels for cooking based on price support mechanisms (such as smart subsides to reduce the cost of less polluting fuels; grants; and micro-lending to make access to credit easier and lower households' cost of borrowing). These scenarios also achieve electrification objectives by adding between 9 and 22 gigawatts of new capacity through 2030.

The key finding is that universal access and electrification by 2030 is possible with no increase—or a negligible net increase—in GHG emissions, as well as a significant decrease in black carbon emissions. But it requires smart policies that target services that work for the poorest and most remote populations (whom, it is assumed, would use decentralized off-grid and micro-grid solutions). It also requires strong government support coupled with financial incentives that target the populations that need them.

From a climate standpoint, it is important to note that this negligible change in GHG emissions is relative to a baseline that assumes no new access policy but a rising (nearly doubling) of demand and perhaps a tripling of GHG emissions due to a large transition away from solid biofuels that (arguably) have little impact on net GHG emissions (it is assumed that the associated CO2 emissions are taken up again when new biomass is grown to replace what is burned). This raises two important points. First, much of the solid biomass currently used for fuel in regions with low energy access are not sustainably harvested, and thus are not carbon-neutral. Second, if we are to limit warming to 2°C, all countries must achieve zero net emissions in the latter half of this century—but, as small as the contribution of emissions due to access programs is, it is still not zero in 2030.

Fortunately, the answer to the second point may lie in the first one. Energy access programs coupled with strong landscape reform programs stand to achieve access objectives and potentially fund such initiatives through REDD+ carbon financing while making environmental progress toward sustainability goals. In addition, it might make sense for the designers of grid-expansion energy access programs to consider the emissions implications up front and make renewable energy priorities more prominent in the design and financing of some programs.

Aside from the mitigation challenge, there are more practical reasons to factor climate change into the design of energy access. For example the fraction of the poor and "unplugged" that will achieve access in 2030 by means of grid expansion will need to worry (along with current electricity users) about how thermal power plants will be able to achieve their cooling needs with increased droughts and warmer temperatures significantly affecting the cooling potential of rivers and other surface waters. Estimates of "minimal access" demand requirements, or even "sustainable" levels of demand, may need to be revised in the face of heat waves that result in tens of thousands of heat-related deaths absent electricity to power cooling stations and air conditioning access for elderly or vulnerable populations (Hallegate et al., 2016).

RECOMMENDATIONS FOR MAXIMIZING IMPACT

Given the range of issues that tie energy access and environmental, climate, and sustainability concerns together, policy makers will need to deploy an optimal mix of mitigation, access, and financial strategies. For example, the principles of energy access require programs with strong government engagement that combine targeted subsidies and microcredit programs with local community engagement and support (Pauchauri et al., 2012). At the same time, ensuring that mitigation concerns are included offers a point of engagement for climate finance by prioritizing renewable generation and landscape management aspects of these programs.

Success in either of these challenges requires that communities be resilient in the face of climate impacts. This means that energy access programs must be robust to temperature and weather extremes. It also means that mitigation strategies must account for GHG emissions that are essential for achieving access objectives and include sequestration options that offset any residual emissions during a transition to carbon-free energy access for all.

The role of finance is paramount. The development community needs to account for the broader context of these multiple development objectives (access, resilience, mitigation, public health, and ecosystem services) and identify flexible sources of finance that may not fit neatly into a single category. Governments, too, will need to step up embracing these programs and providing support at the community level, enabling financiers to bundle or cluster community-scale projects into national on-lending schemes.

With careful consideration of the multiple objectives and multiple benefits associated with energy access schemes that provide climate resilience, GHG and air pollution mitigation, and sustainable environmental practices, universal energy access by 2030 can be achieved while minimizing costs and environmental impacts.

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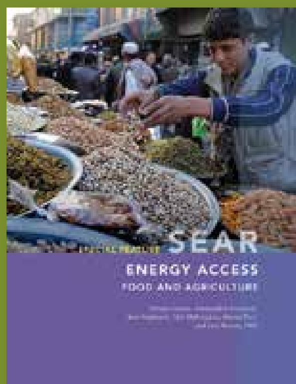

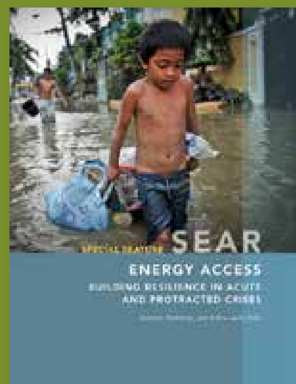

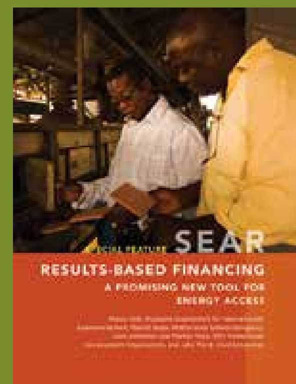

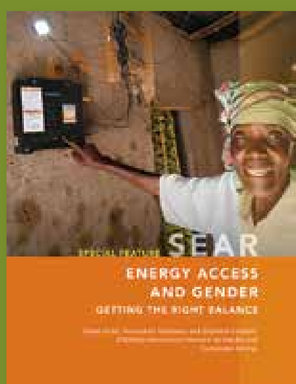

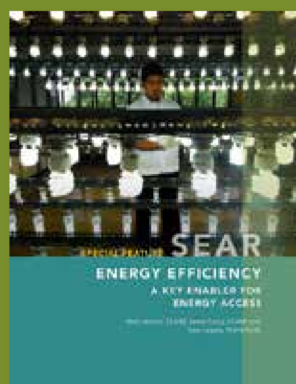

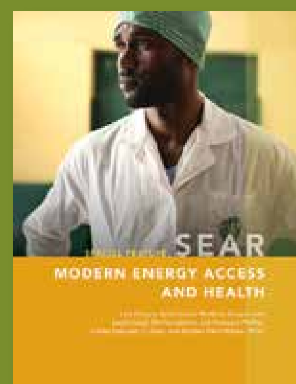

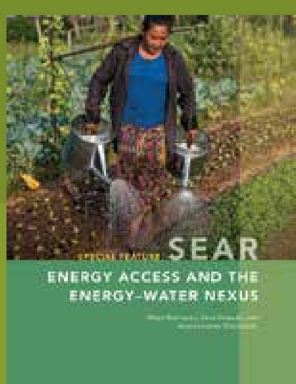

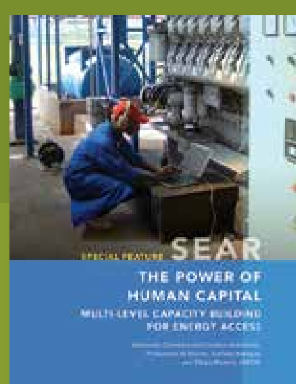

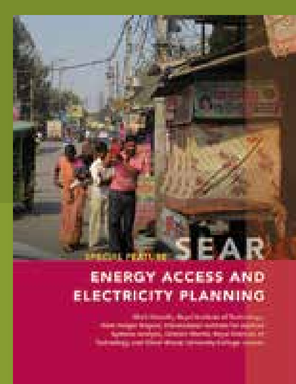

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