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SPECIAL REPORT

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ABOUT THE REPORT

In the context of the civil war with no end in sight in South Sudan, this report outlines how a donor-led shift from the current total reliance on diesel to renewable energy can deliver short-term humanitarian cost savings while creating a longer-term building block for peace in the form of a clean energy infrastructure. The report is supported by the Africa program at the United States Institute of Peace.

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David Mozersky and Daniel M. Kammen

South Sudan's Renewable Energy Potential A Building Block for Peace

Summary

- Shortly after independence in 2011, South Sudan fell into civil war. A regional peace agreement has effectively collapsed, and the international community has no clear strategy on how to proceed.
- The war has destroyed South Sudan's limited infrastructure, triggering an economic implosion. What electricity it has—and it is the least electrified country in the world—depends entirely on imported diesel to run generators.
- Insecurity and hyperinflation have made diesel scarce and created a thriving black market, leading to some of the highest energy costs in the region.
- The UN peacekeeping mission and international humanitarian operations have a combined budget of more than \$2 billion per year. These operations are almost exclusively diesel powered.
- Renewable energy costs have dropped dramatically in recent years, and usage has increased accordingly worldwide. These gains have not yet reached South Sudan and other conflict settings.
- Transitioning internationally supported humanitarian operations from diesel to renewable energy would unlock numerous near-term and longer-term benefits.
- As building blocks for peace, these benefits would help expand and diversify South Sudan's energy sector and contribute to a green pivot to help soften a crippling dependence on fossil fuel.
- The transition could occur in three contexts: individual nongovernmental organization compounds, health facilities such as hospitals and clinics, and the humanitarian operations servicing internally displaced persons camps outside the destroyed regional capitals of Bentiu and Malakal.

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JANUARY 2018

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- International humanitarian funding generally operates on short-term cycles and thus is poorly suited for large infrastructure purchases such as solar-and-storage systems. New, innovative financing mechanisms may be required to facilitate this transition.
- Such a program needs to be coupled with local training and capacity building if it is to empower a South Sudanese solar community to maintain, support, and grow the sector well beyond the current crisis.

Introduction

Things have not gone according to plan for the world's newest country, South Sudan. After gaining independence from Sudan in 2011 amid great hope and international celebration, South Sudan has seen stagnating economic and political progress exacerbated by a new civil war that erupted in late 2013. Since then, tens of thousands have been killed, more than 30 percent of the population has been displaced, the economy has imploded, and the country has once again become the center of a major humanitarian crisis—as highlighted by the declaration in February 2017 of famine in several northern states.¹ A regionally sponsored peace agreement signed in mid-2015 has effectively collapsed, and fighting seems likely to continue for the foreseeable future. There is no obvious way to escape the current cycle of conflict, and regional and international mediators have no clear strategy for moving forward.

International donor governments continue to support the billion-dollar-per-year humanitarian operations in the country, but humanitarian funding is under stress across the globe, and the South Sudan crisis shows no signs of abating.² Most donors do not want to support the current government directly because they fear that funds could be diverted to military efforts, which are likely to target civilians, and donors also recognize that short-term humanitarian programming alone will not end the crisis.

What can be done to generate new opportunities and momentum for a more peaceful future when the outlook is so bleak? This report argues that a systemwide donor-driven transition to renewable energy—and specifically solar power—to support humanitarian programming is a viable way forward both now and over the longer term. Although such a transition alone will not end the conflict, it offers donors a more strategic alternative to the current practice. In the near term, a pivot to renewable energy will offer significant cost savings in a nation where electricity generation is one of the highest recurring costs in humanitarian budgets. Over the longer term, this approach will create long-lasting, reliable energy infrastructure and building blocks for peace and development in the least electrified country in the world.

At a minimum, a shift to greater domestic reliance on renewable energy will help decouple economic growth from the geopolitics of oil and gas at a time when the growing impacts of climate change highlight South Sudan's vulnerabilities.³ More generally, such a shift offers the country an opportunity to expand its economy with less interregional and intertribal tension than exists today.

Even before the outbreak of conflict in 2013, South Sudan had the lowest electricity consumption per capita in the world and ranked near the bottom in many global development indicators.⁴ The modest progress achieved during the peaceful years between 2005 and 2013 has largely been undone by the conflict since then, and much of the infrastructure—energy and otherwise—has been destroyed or looted. The electricity generation that does exist across the country is intermittent and comes almost entirely from imported diesel for generators. The lack of electrification affects all sectors of society, with government offices, hospitals, and even the national parliament coping with regular blackouts.⁵ As the economy has collapsed and security worsened, diesel supply lines have become less reliable and more

expensive. Rampant inflation has exacerbated the problem, the national consumer price index increasing more than 2100 percent between December 2015 and July 2017, making fuel and other staple products that much more expensive.⁶

Renewable energy offers tangible and immediate benefits that bear out over the long term. The cost of solar power in particular has dropped dramatically in recent years, and solar now is both a cheaper and a more consistent power source than alternatives in South Sudan. Solar panels can be easily scaled and can last for more than twenty years. Donor support for a solar push could help create new jobs and enhance the sustainability of local capacity. Renewable energy alone cannot end the conflict, of course, but it does offer a way to better leverage international aid flows for both short- and long-term gains.

Three immediate opportunities are anchored in humanitarian programming where solar investment by donors can yield benefits. One is onsite energy generation in individual nongovernmental organization (NGO) compounds. The second is in neutral national health institutions such as hospitals and clinics. The third involves the protection of civilians (POC) sites for internally displaced persons (IDPs) outside the destroyed regional capitals of Bentiu and Malakal; in these locations, solar systems would also create energy assets that could transition to support reconstruction and the return of IDPs to the cities in years to come.

A shift to renewable energy could also launch a far less contentious resource base than the current fossil fuel status quo. The negative impacts of a reliance on diesel have been discussed in a number of publications.⁷ A solar pivot could enable a poor nation to move toward sustainability (see table 1). The same factors that make renewable energy a win-win approach in South Sudan also make sense for humanitarian actors and donors in other comparable conflict and crisis settings.

A solar pivot could enable a poor nation to move toward sustainability.

Table 1. Energy System Options

| System | Cost of Energy ¹ | Reliability | Noise | Pollution |
|------------------------------|---|---|--|---|
| Diesel generators | From \$0.50/kilowatt hour (kWh) in nonconflict areas of East Africa to well over \$2/kWh. | Require regular maintenance and difficult logistical supply lines. | Loud, which can be particularly disruptive in densely populated relief camps. | Onsite storage, can leak and be a target for thieves. Particulates have a significant health effect, particularly on children in relief camps. ² |
| Solar-plus-storage solutions | Ranges from \$0.40 to \$1/kWh. | No moving parts and very limited maintenance requirements. Generates energy when the sun is out. May not provide all-hour access to energy. | None | None ³ |
| Wind-plus-storage solutions | Ranges from \$0.20 to \$1/kWh. | Mechanical system, subject to maintenance and potential moving part failures. Availability can be unpredictable given weather variability. | Can produce a low-frequency sound, dissipates quickly and may be negligible at moderate distances. | No local pollution. ⁴ |

Source: Authors’ compilation.

1. The levelized cost of energy is a standard energy measurement that allows for price comparisons across different types of energy technology, taking into account relevant parameters, costs, and other factors over a given time, typically twenty years.
 2. Stephen Okello, *The Energy Situation in the Dadaab Refugee Camps, Kenya* (London: Royal Institute of International Affairs/Chatham House, 2016).
 3. Peter Alstone, Dimity Gershenson, and Daniel Kammen, “Decentralized Energy Systems for Clean Electricity Access,” *Nature Climate Change* 5 (2015): 305–14.
 4. Ibid.

A Brief History

South Sudan has traveled a hard road over the last century. A largely ignored part of British colonial administration, it was unceremoniously lumped together with its northern neighbor Sudan just before independence from Britain in 1956. Fifty years of struggle followed, during which multiple southern rebel movements challenged successive administrations based in the northern capital of Khartoum. Central governments coveted the south's rich natural resource base, particularly after oil was discovered there in the late 1970s, but generally neglected the southern region. Institutionalized inequality and scant development spending by Khartoum fueled anger and resentment in the south. The split was also along cultural and religious lines, with northern governments promoting a national vision built primarily on the idea of Sudan as an Arab and Muslim country, identities that were sometimes forcefully imposed on the African and non-Muslim southerners. The first civil war ran from 1956 to 1972, ending with a settlement that brought a decade of peace and gave the south its first regional administration. The second civil war broke out in 1983 and continued until the Comprehensive Peace Agreement (CPA) was signed in 2005 between Khartoum and the rebel Sudan People's Liberation Movement/Army (SPLM/A), paving the way for South Sudan's independence in 2011 (for the borders of the new state, see figure 1).

Development during the war years was scant, and southern Sudan was split between government-controlled garrison towns and the countryside, where the SPLM/A held sway. International engagement was mostly limited to humanitarian aid. Millions of southerners fled to the north or to neighboring countries as refugees, receiving access to education and services that were not widely available in the south during the conflict. Over time, a growing number of southern Sudanese voiced a demand for self-determination as the ultimate solution to their conflict with Khartoum.

The Comprehensive Peace Agreement

A combination of international pressure, combat fatigue, economic hardship, and visionary leadership led to the signing of the CPA in 2005 after almost three years of negotiations in neighboring Kenya. The agreement enjoyed strong international support and ushered in a period of relative peace and prosperity—albeit one that witnessed the gradual emergence of ominous trends around corruption, mismanagement, and authoritarianism. The deal created a six-year implementation period that would culminate in a self-determination referendum for southerners to opt between remaining part of Sudan or independence. The CPA also created a semi-autonomous SPLM-led southern regional government, mandated the rebel Sudan People's Liberation Army to be the national army for the south, and allocated 50 percent of all revenue from oil wells in the south to the southern regional government based in the southern capital of Juba.

That government received close to \$13 billion in oil revenue between 2005 and mid-2011, oil accounting for more than 98 percent of the total intake.⁸ Over the same period, the international community spent approximately \$5 billion in development aid in South Sudan, and invested another \$5.76 billion in the UN Mission in Sudan (UNMIS), which covered both South Sudan and parts of northern Sudan.⁹

After the CPA was signed, South Sudan became a darling of the international community, particularly the United States. UNMIS was established to support implementation of the agreement, and donors lined up to fund a range of governance, security sector, social service, and infrastructure projects. Despite this support, a variety of problems became evident. The new southern government had weak administrative systems and was made up primarily of members of a former rebel movement who had little fiscal management experience; these same people were tasked with administering a region and managing billions of dollars in

***After the CPA was signed,
South Sudan became a
darling of the international
community.***

Figure 1. South Sudan and Neighboring States



Source: Central Intelligence Agency, *The World Factbook*, September 27, 2017.

oil revenue. Much of the oil money was used to support a big-tent political and military strategy to keep various armed groups and potential spoilers on the same side, and corruption began to take root. This emphasis on military patronage was part employment strategy and part calculated military deterrent; it was intended to bolster southern unity and thus increase pressure on Khartoum to uphold the agreement and allow the self-determination referendum to proceed.

Despite the money flowing through South Sudan, little energy-related infrastructure was built. Government electrification plans centered around the construction of several Chinese-led mega-dams along the White Nile, projects that never broke ground, as part of a long-term plan to build out a national grid. In the meantime, international donors, UN agencies, NGOs, the regional government, and private-sector actors spent hundreds of millions of dollars on generators and diesel fuel to power both aid and development efforts. Diesel was widely available from northern Sudan, which ran its own domestic oil refinery.

The Juba government was able to pay for this fuel using Sudanese currency received for its oil sales from the central government in Khartoum. In Juba and other southern cities, networks of diesel generators were installed or expanded to power new city grids. A Norwegian-supported hydroelectric project at the Fula rapids, near the border with Uganda, was developed to provide power to Juba, but progress was slow.

Thanks in part to the South Sudan experience, energy scholars are beginning to recognize the limitations of traditional energy planning modeling—which assumes long timelines and general stability—in fragile and conflict-affected states. Adjusting long-term assumptions to reflect the unique challenges in fragile states can lead to a different set of viable conclusions, including greater emphasis on smaller-scale and renewable energy systems.¹⁰

Several other projects were launched to build domestic oil refineries, but these too moved slowly and had ground to a halt by 2014 because of the economic crisis and the new civil war, and none was ever completed.¹¹ In March 2017, the government announced its latest plan to build a new oil refinery in South Sudan, to be operational by mid-2017, but by December 2017 no updates on the project had been made public.¹²

From Peace Back to War

On July 9, 2011, South Sudan became the world's newest country, but its honeymoon would be short-lived. Sudan and South Sudan had been negotiating the terms of separation since the summer of 2010, but little had been concluded by the time of independence. The negotiations were being brokered by a high-level African Union panel headed by former South African president Thabo Mbeki and covered a range of sensitive issues, including borders, currency and trade, security, and citizenship (specifically, the status of southerners in the north and of northerners in the south). The most high-profile issue was oil, which was a major economic lifeline for both Juba and Khartoum. Oil was a main economic driver for Sudan and the largest source of government revenue and foreign currency, but approximately 70 percent of the oil produced came from oil wells inside South Sudan. As a newly independent country, South Sudan no longer had to submit to the 50/50 revenue-sharing arrangement with Khartoum that had existed during the CPA period, but Juba still relied on the oil pipeline that ran through Sudan to get South Sudan's oil to market via the Red Sea. Sudan hoped to charge high transit fees for the use of the pipeline to make up for its lost oil revenue; South Sudan offered a much lower transit fee, hoping to leverage a broader transitional payment to facilitate agreements on other outstanding issues. As the negotiations continued, the oil continued to flow with no formal agreement in place.

In January 2012, the government of Sudan took matters into its own hands and began unilaterally offloading southern oil directly from the pipeline at Port Sudan and reselling it internationally. For five months—since southern independence—Khartoum had allowed southern oil through its pipeline without any payment, waiting for a breakthrough in the negotiations. As the economic impact of reduced oil revenue began to bite, the Sudanese government sought to make up the difference by taking southern oil as it was offloaded at Port Sudan as payment in kind. The move drew widespread international condemnation, and South Sudan explored the idea of taking the matter to international court.

In late January 2012, the South Sudanese government made an historic decision: to shut down its entire oil production rather than have the oil taken by Khartoum. The popular decision was initially cheered in the streets of South Sudan, which viewed it as a symbol of the young nation's independence from its old oppressor. Harsh reality quickly set in, however, as the economy ground to a halt. Southern officials scrambled around the region trying to find support for building an alternate pipeline to the sea—through Kenya or Ethiopia and Djibouti—but no short-term solution could be found. Meanwhile, government foreign currency

reserves began to dry up and the economic situation worsened. Tensions increased within the SPLM ruling party, and the big-tent patronage politics that had facilitated the peace in the years leading up to independence began to falter.

Electrification suffered immediately. The diesel generators powering Juba broke down in 2012, and funding to maintain an adequate flow of diesel or to repair the generators ran short. Juba needed to use its foreign currency reserves to purchase fuel imports, and dollars were suddenly scarce. South Sudan's economy began slowly but steadily to collapse. Plans to build domestic oil refineries stalled indefinitely. The negotiations on pipeline access with Sudan continued, but the leverage had now shifted significantly in Khartoum's favor. An agreement was eventually reached, and pipeline access and southern oil production resumed in spring 2013. Sudan sought to press its advantage and again threatened to close the pipeline that summer. Meanwhile, the internal fault lines in the south continued to widen.

In late July 2013, South Sudanese President Salva Kiir dismissed his entire cabinet, including longtime Vice President Riek Machar, and a number of other senior leaders. His newly appointed cabinet included members with more conciliatory approaches to Khartoum than the recently deposed SPLM leaders, and the Sudanese threat to reclose the pipeline was soon lifted.

These internal divisions were managed peacefully for several months, but in mid-December 2013, a dispute within the ruling SPLM spilled over into fighting within the Presidential Guard. The violence quickly took on an ethnic dimension as Dinka (the largest tribe, and that of President Kiir) troops and militia targeted Nuer (the second largest tribe, and that of the former vice president) soldiers and civilians throughout Juba. Thousands fled to the UN peacekeeping base in Juba for protection. Within days, fighting spread across much of the country, largely along Nuer-Dinka lines. Civilians were consistently targeted, and UN bases across the country were forced to open their doors to provide protection for civilians fleeing the violence. President Kiir sought to round up his political opponents, but Machar escaped Juba and soon came to head what was initially a largely Nuer-based opposition, the SPLM in Opposition.

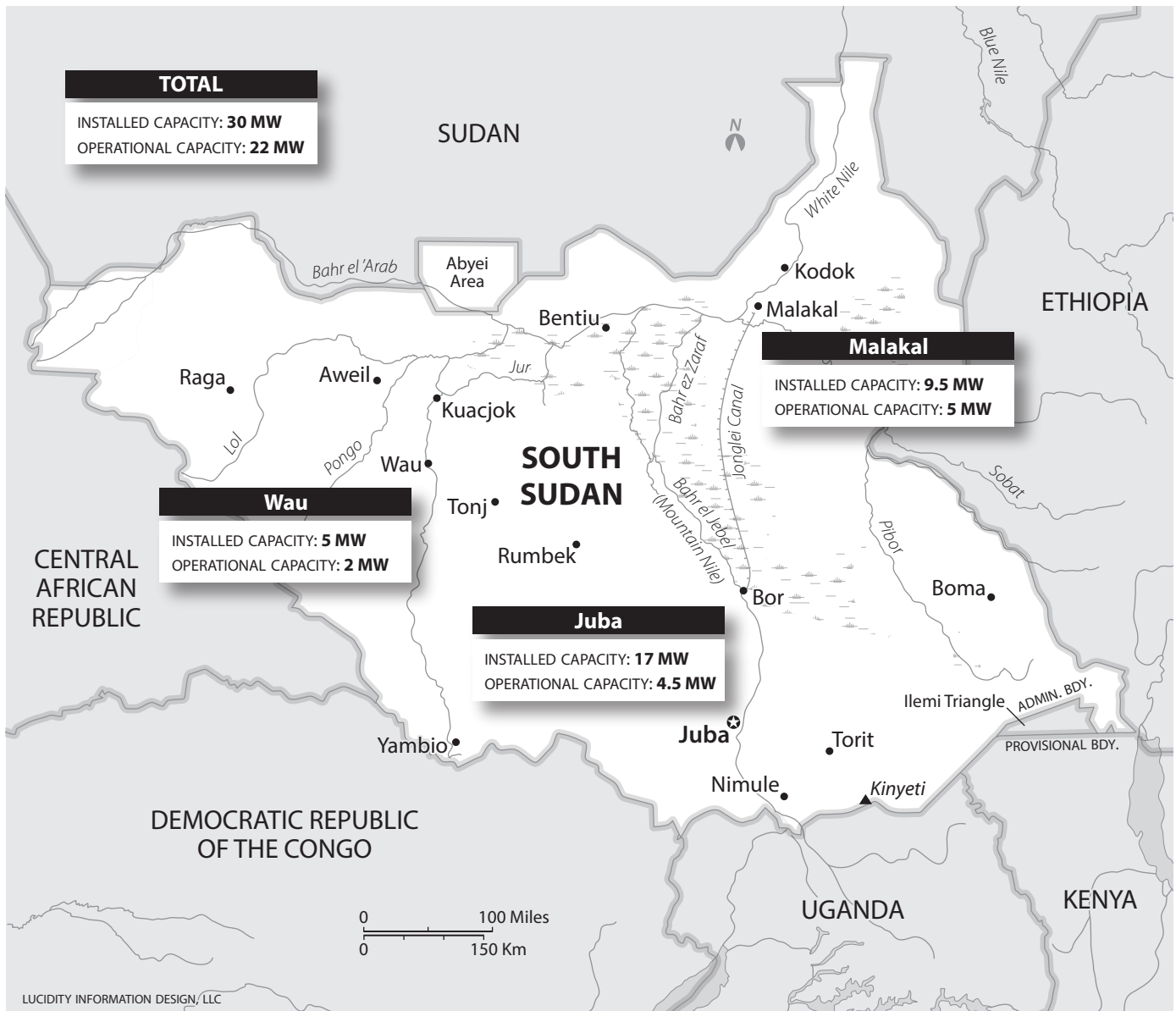
As the parties waged war and southern Sudanese civilians suffered the consequences, the international community mobilized a large-scale lifesaving humanitarian operation. The conflict was initially mostly within the Greater Upper Nile region, the northeastern third of the country that is home to both the bulk of the Nuer population and the country's oil fields. The fighting shut down the Unity State oil fields early on, cutting the country's production roughly in half. These oil fields have yet to be reopened. The conflict spread significantly in 2016, heavy fighting and humanitarian fallout stretching across Equatoria, the southern third of the country.

Impact of Renewed Conflict and Economic Collapse

Before the 2013 civil war, South Sudan had just 22 megawatts of operational installed electricity generation capacity (out of a total of 30 megawatts), coming exclusively from diesel and heavy fuel generators, most of them located in a handful of cities (see figure 2).¹³ For comparative purposes, 22 megawatts is equivalent to the electricity required to power approximately 3,600 homes in the United States. As of August 2017, operational generation capacity was almost certainly considerably lower, given the extent to which power generation had been disrupted or destroyed in fighting since 2013.

The impact of the precipitous drop in southern oil production caused by the closure of the Unity State oil fields has been exacerbated by the dramatic drop in global oil prices. In December 2013, the average price of Brent crude was just over \$110 per barrel; global prices began to drop sharply in mid-2014, averaging under \$50 per barrel for 2015 and 2016 and

Figure 2. Snapshot of Electricity Supply in South Sudan

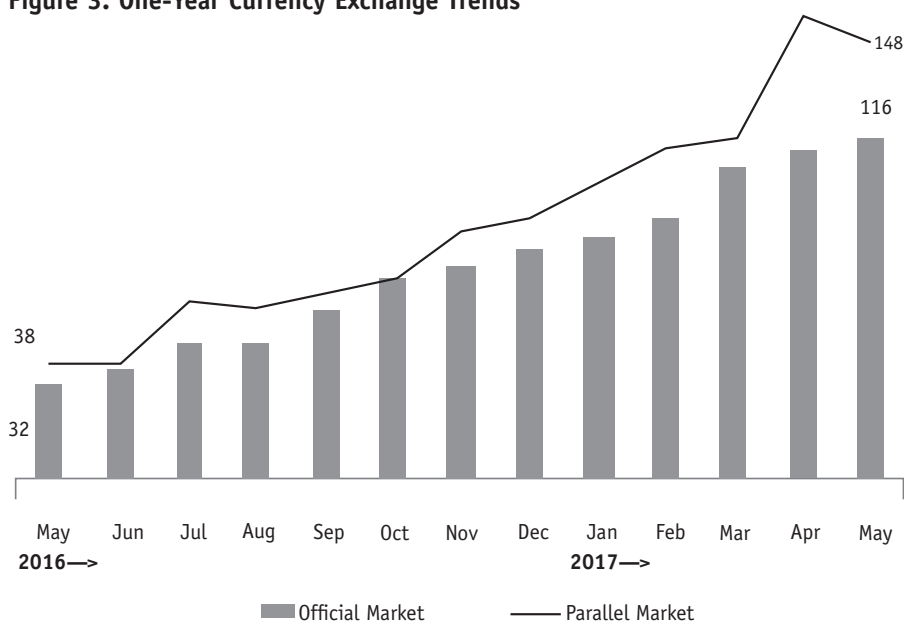


Source: Central Intelligence Agency, *The World Factbook*, September 27, 2017.

Note: Map does not reflect losses during the civil war.

just over \$51 per barrel by August 1, 2017.¹⁴ The Dar blend from South Sudan's still-operating Upper Nile fields trades at an additional discount on the international market because of its lower quality. Furthermore, the Juba government must pay other costs (such as profit-sharing and processing fees) to the oil companies and the pipeline transit fees to Khartoum. Oil production remains the government's primary source of revenue but has brought in very little of it since 2014. The lack of hard currency from oil sales made it impossible for South Sudan's Central Bank to defend its currency's pegged exchange rate, and thus the gulf between the official exchange rate and the black market rate grew wider. In December 2014, the Central Bank was forced to float the South Sudan pound (SSP), leading to hyperinflation in both the official and the black markets from 2015 into 2017. During this time, the official exchange rate depreciated from a pegged rate of SSP 2.9 to the US dollar in December 2014 to SSP 116 in May 2017. Figure 3 shows how sharply the exchange rate of the South Sudan pound against the dollar rose in a single year, from May 2016 to May 2017.

Figure 3. One-Year Currency Exchange Trends



Source: World Food Programme, “South Sudan Monthly Market Price Monitoring,” June 2017.

The rapid devaluation of the South Sudan pound has destroyed the purchasing power of South Sudanese civilians. Everything, including staple foods such as beans and rice as well as diesel fuel, has become far more expensive. According to the World Food Programme’s market price monitoring, which tracks changes in prices of goods across the country, the cost of a single liter of diesel has increased dramatically (see table 2). A 2016 report by the Juba-based Sudd Institute observed that the dramatic increase in the price of petrol and diesel following the devaluation of currency led to a noticeable reduction in demand, with fewer people being able to afford it.¹⁵ One effect of this trend is that internationally funded programming now offers the best entry point for renewable energy in South Sudan.

Despite the economic crisis, the government continues to import and heavily subsidize (by as much as 80 percent) the domestic sale of petrol and diesel, which are supposed to be sold to the public through petrol stations for SSP 22 per liter. Nonetheless, the black market for both petrol and diesel has remained active, and the price for a liter of fuel not only varies widely across the country but also is well above the official rate in every location (see table 2). The black market for fuel is visible on street corners in Juba, where lines of cars waiting at petrol stations stretch down streets and around blocks. South Sudanese academic John Akec describes a local subeconomy in which traders make a fortune buying up government-subsidized petrol and then reselling it on the black market for up to five times the price they paid. Akec, who is the vice chancellor of the University of Juba, estimates that the government of South Sudan may spend as much as 20 percent of its entire 2017 budget on fuel subsidies. He notes that the benefits are being captured by a group of traders rather than being distributed among the population at large.¹⁶ The deepening fuel crisis, which saw a liter of diesel fetching as much as SSP 400 in Juba in late July 2017, eventually prompted a government reaction.¹⁷ Amid continued promises by senior government officials to end the fuel subsidies and crack down on black market trade, James Meth, a senior official in the state oil company, was arrested in early August on charges of smuggling subsidized fuel into the black market.¹⁸ Reports in early December 2017 indicated that the government had quietly ended its fuel subsidies because it did not have the resources to back them.¹⁹

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Table 2. Diesel Costs in Major Markets in South Sudan

| Market | September 2016 (SSP) | One-Year Change (%) | Five-Year Change (%) |
|--------------------------|----------------------|---------------------|----------------------|
| Konyokonyo Market (Juba) | 60 | 900 | 908 |
| Kapoeta South | 46 | 475 | 475 |
| Torit | n/a | n/a | n/a |
| Bor | 40 | 300 | 368 |
| Minkaman | 60 | n/a | n/a |
| Rumbek | 200 | 1,076 | 1,851 |
| Aweil Town | 168 | 885 | 1,246 |
| Malakal | 130 | n/a | 920 |
| Bentiu | n/a | n/a | n/a |
| Yida | 135 | n/a | 718 |
| Agok | 122 | n/a | n/a |

Source: Author's compilation based on World Food Programme data.

The Opportunity for Renewable Energy

As a global resource, renewable energy has come of age, with the sector seeing its largest annual increase in capacity in 2015. Wind power and solar photovoltaics (PV)—the most popular form of solar power, seen in most solar panels today—accounted for more than three-quarters of new energy installations globally in 2015, followed by hydropower. The world now adds more renewable power capacity annually than it adds (net) capacity from all fossil fuels combined. By the end of 2015, installed renewable capacity was enough to supply almost one-quarter of global electricity.²⁰

Although advances in all areas of renewable energy supply are relevant, the evolution of the solar energy sector, and in particular of solar PV, has—potentially—the most immediate importance for South Sudan. Solar PV is notable for its ease of installation and operation at all scales, from solar lanterns to rooftop systems for houses, the fast-growing area of minigrids, and large utility-scale systems.

As a point of reference, the United States established the SunShot Initiative, which encompassed a dedicated office within the US Department of Energy and a goal to reduce the PV system cost to \$1 per watt (approximately \$0.05 per kilowatt hour for the levelized cost of PV electricity and \$0.50 per watt for the PV module) by 2020.²¹ This program will very clearly make PV electricity cost competitive with grid electricity rates in the United States (see figure 4), thus reaching “grid parity.”²² In late 2016, the Department of Energy announced that the goal had been achieved, three years ahead of schedule.²³

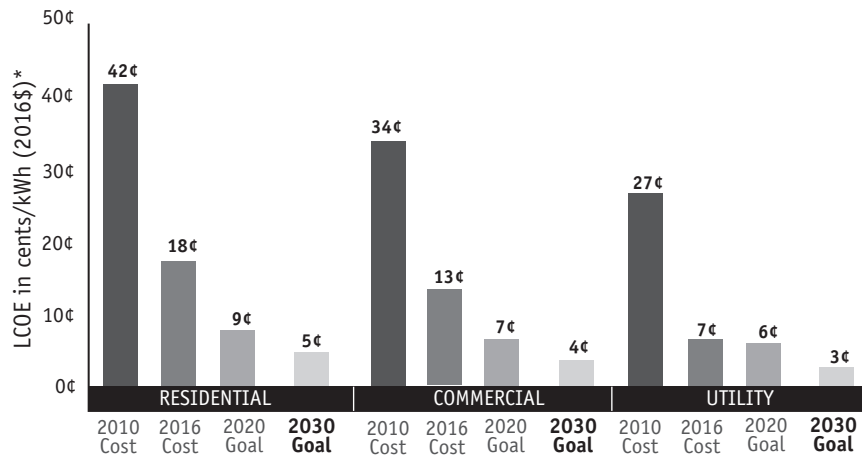
Recent price declines in solar PV power are attributable to the confluence of greatly expanded global production and a globalized research, development, and deployment environment.²⁴ The US achievement reflects an expansion in solar energy from 0.1 percent of total generation in 2011 to more than 1 percent six years later. Forecasts for the near term are more aggressive.

A particularly important aspect of the evolution of solar PV energy for South Sudan is its scalability. At the bottom end of the scale, the off-grid, pay-as-you-go market has exploded in East Africa; a range of companies now offer systems in the 0–150 watt peak range that are attractively priced, often require no down payment, and can run appliances such as radios, televisions, and refrigerator-freezers.

A particularly important aspect of the evolution of solar PV energy for South Sudan is its scalability.

Figure 4. Solar PV Price History and SunShot Initiative Goals

SunShot’s 2030 Goals



*LCOE progress and targets are calculated based on average US climate and without the ITC or state/local incentives. Utility-scale PV uses one-axis tracking.

Source: US Department of Energy.

Solar power also plays a key role in minigrids, which can be 1 megawatt or more in size and can be powered by solar-plus-storage systems (that is, solar panels plus batteries, which store energy for use when the sun is not shining) or by solar-hybrid systems in which solar energy is combined with diesel, wind, hydro, or other technologies to provide energy for communities or businesses, or a combination of the two. This rapidly expanding sector brings many of the benefits of large utility-scale grids without the larger infrastructure costs (and vulnerabilities) that war-torn regions such as South Sudan will struggle to overcome for the foreseeable future.

Systems at each of these scales could play valuable roles in the “green pivot” proposed for South Sudan. Because large, utility-scale solar projects are not feasible until the country is more stable, the immediate focus is smaller-scale systems. When stability is achieved, smaller-scale systems could become a major component of a vibrant domestic and export clean energy economy.

Advantages of Solar Power for South Sudan

Renewable energy, particularly solar power, has the potential to be transformative in South Sudan for several reasons. First, compared with energy produced by diesel generators, renewable energy is cheaper, cleaner, and longer lasting; whereas a diesel generator requires new diesel to burn and the generator itself must be replaced every few years, a solar panel can reliably produce electricity for up to twenty-five years. Second, South Sudan has ample sunshine with strong solar power potential (high solar irradiance). Third, as the conflict drags on, internationally funded humanitarian programming can launch an expansion in solar power generation, offering short-term energy benefits and cost savings while building an enduring infrastructure that will outlive the conflict and contribute to peace and stability over time.

Despite donor fatigue, large-scale international humanitarian aid funding is likely to continue in South Sudan for the foreseeable future. Currently, international donor governments cover the high energy costs—the purchase of generators and diesel—for individual NGO compounds and programs, UN agencies and peacekeeping bases, and POC camps. These costs can account for a significant proportion of program budgets, particularly for activities outside Juba, and must be paid year after year, leaving nothing to show for the expense.

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Given the high price of diesel in South Sudan, renewable energy systems could quickly pay for themselves, potentially saving millions of dollars in the years to come.²⁵

Unfortunately, existing diesel usage and energy figures are not readily available from international donors or humanitarian NGOs. Some limited information about fuel usage by the UN Mission in South Sudan (UNMISS, the successor mission to UNMIS, which ended in July 2011) is publicly available, but the information is not broken down explicitly between energy and transportation usage. A late 2014 audit report shows that the peacekeeping mission signed a fuel contract in March 2014 that was capped at \$325 million over the three-year life of the contract. During the previous three years, from July 2011 to May 2014, UNMISS had received 68.7 million liters of diesel fuel, which was used for vehicle transport and to power generators.²⁶ As of June 2015, UNMISS owned and operated 195 diesel generators in twenty-two locations across the country.²⁷

The need for international organizations and NGOs to reduce costs is increasing as the gap between humanitarian funding needs and funding pledges widens. In August 2016, US Secretary of State John Kerry threatened to halt US government aid to South Sudan if the warring leaders did not do more to end the conflict.²⁸ The US government is by far the largest donor to South Sudan, having spent more than \$2.15 billion between 2014 and March 2017.²⁹ The cuts in US foreign aid proposed by the Trump administration may well affect US funding in South Sudan.

US-funded humanitarian operations, as well as those of the United Nations and other international actors in the country, could make better use of their diminishing resources. A few but highly instructive NGOs and individual agencies in South Sudan use solar power successfully. Internews, which supports local radio stations across the country, for example, struggled for years with expensive generator maintenance and inconsistent diesel supply lines before transitioning its more remote radio stations to 100 percent solar-plus-storage power. Following the successful transition to solar energy at its station in Turalei, in the Bahr el-Ghazal region in the northwest of the country, Internews worked with other community radio stations to help them make a similar transition and improve their energy supply.³⁰

Such success stories should not obscure the significant challenges facing widespread solar adoption in South Sudan. Looting and destruction of humanitarian agency property during the civil war have targeted solar panels (and diesel generators) in population centers and rural humanitarian outposts. This tendency in part explains international donor hesitancy to invest in solar systems (which are more expensive to purchase initially than diesel generators). Another impediment is the limited capacity in terms of trained personnel and the economic and security environment of the solar sector. These challenges can be at least partially mitigated, however. Security risks can be minimized with the strategic placement of solar systems. Local capacity can be built and supported through donor-led investment in training and capacity building to help ensure that South Sudanese benefit from such a transition and that solar systems are adequately maintained.

A Donor-Led Transition to Renewable Energy

The advantages of a systemwide, donor-led pivot to renewable energy for the humanitarian sector in South Sudan are many. The transition would pay for itself and begin to generate cost savings within two to five years. It would create desperately needed energy infrastructure while supporting ongoing humanitarian operations. These long-lasting, clean energy assets could support future reconstruction and health, education, and social service delivery and would carry the additional benefit of being in place and, likely, of having been paid for. The pivot would also create new entry points for conflict resolution and peacebuilding. For example, the transition from a solar system that serves a humanitarian program to one that

supplies a local institution (such as a local utility or hospital) would generate opportunities for cooperation between communities driven apart by the civil war to determine issues such as the placement, oversight, management, and maintenance of the solar system. Such a shift would create physical assets for peace that could support both physical reconstruction efforts and provide new hooks for conflict resolution.

Donor-level support for this kind of a transition is important for two reasons. First, and most obviously, donors provide the funding to sustain current humanitarian operations, including existing diesel energy budgets. Donors are thus the primary option for funding a systemwide transition to solar power. Other conflict-affected countries—Syria and Yemen among them—have seen piecemeal efforts to use solar power, but nowhere has a concerted effort to accomplish a large-scale transition been undertaken.³¹ Second, if solar energy infrastructure is to transition to local ownership or to benefit local communities in the mid- to long term, it needs to be managed and maintained by actors likely to remain in South Sudan over a similar period. Unlike individual humanitarian organizations, donor governments generally operate with a national or regional lens and a longer-term perspective. Their mandates and missions will evolve to support development and reconstruction when the situation allows for it. Donor-level support for a shift to solar power could thus ensure continuity and help create and anchor a framework for managing the next phase of such a program.

Making a systemwide transition would break new ground for such a comprehensive use of renewable energy in other crisis settings. Although some humanitarian actors are beginning to explore the potential for renewable energy, it has yet to become mainstream practice. In May 2017, the UN High Commissioner for Refugees and the Ikea Foundation opened a new 2-megawatt solar farm in Jordan to power the Azraq refugee camp, the first of its kind.³² This was followed in November 2017 with a second, larger project in Za'atari refugee camp in Jordan, supported by the German government.³³ The Moving Energy Initiative—funded by Britain's Department for International Development—is an ambitious multiorganization consortium that is exploring how to integrate renewable energy into refugee camp settings, focusing first on Kenya, Jordan, and Burkina Faso. The United Nations has started to look at renewable energy in its peacekeeping operations under its Greening the Blue Helmets program, but that program is still in its inception and focused (at least initially) on reducing the UN environmental footprint rather than on the economic, local electrification, or peace benefits that could come from transitioning to renewable energy.

The transition to solar energy is possible in at least three distinct types of humanitarian programs or operations in South Sudan: individual NGO compounds, hospitals, and POC sites.

Individual NGO Compound Solar Systems

Practically all electricity in South Sudan is self-generated, as mentioned, by diesel generators. Internationally funded humanitarian NGOs and UN agencies run their own generators to power their compounds and programs—as do government ministries and offices, even in the main ministerial compound in Juba. Relatively small-scale solar systems could be installed in individual NGO compounds and positioned on the ground or on rooftops or shipping containers. As noted, solar systems are often coupled with backup battery storage, and hybrid systems include both a solar component and a diesel generator. Unlike some peace dividends that have proven elusive in postconflict settings, a solar system would yield immediate observable benefits by reducing diesel costs and reliance on inconsistent supply chains.³⁴ More important, once in place, these systems could easily be extended and connected to neighboring compounds or houses to create local minigrids, which could eventually be connected to a larger city grid.

Donors may have to create incentives for their humanitarian grantees to make such a switch. Most NGOs are not in the business of creating access to energy, so a strong push from donors and their continued involvement will be necessary to build out minigrids anchored around internationally funded, NGO-compound-based solar systems.

Hospitals and Health Infrastructure

South Sudan's health infrastructure was weak before the civil war and has declined further since fighting resumed in 2013. The main hospitals in the regional capitals of Malakal and Bentiu have been targeted during the fighting. On the long list of needs for most hospitals and clinics, energy supplies are near the top. For example, Juba Teaching Hospital, the country's only referral hospital and the main civilian hospital in the capital, has struggled through regular and extended power outages since the Juba grid collapsed in 2012. The hospital depends on inconsistent diesel stipends provided by the Ministry of Health. During the two outbreaks of fighting in Juba in December 2013 and July 2016, the hospital was flooded with patients and struggled with blackouts because the fighting shut down diesel supply lines. Even when diesel is available, the hospital is forced to ration its fuel supplies by shutting down its generators overnight, and sometimes it must resort to purchasing additional diesel on the black market. Similar constraints have affected hospitals and health clinics across the country.

Diesel-powered generators are a dirtier form of energy than renewable energy and may cause even more pollution. A report published in September 2016 found that diesel sold in Africa was the dirtiest in the world, its average sulfur content at least four times higher than that found in any other region and two hundred times higher than European levels. This variance is due primarily to lax national regulations and unscrupulous petroleum actors. It is associated with a range of negative health impacts, including increases in respiratory and cardiovascular diseases.³⁵ The report did not include South Sudan, but anecdotal evidence suggests that much of the diesel being sold in South Sudan is of particularly low quality and contains many impurities, causing significant problems for running generators and leading to lower productivity and higher maintenance costs.

Support for the health sector, and service delivery more generally, is an attractive choice for international donor funding. Investment in renewable energy for hospitals and clinics could significantly improve health-care capacity simply by providing consistent and reliable energy. Hospitals would also benefit from the same economic savings that NGO compounds with solar systems would enjoy as a part of a local minigrid, thereby increasing energy access for the surrounding communities.

South Sudan's international partners face a dilemma: whether to support or circumvent the state. Most do not want to provide budgetary support to the government because they believe funds may be diverted to military efforts, which are likely to target civilians. At the same time, international partners appear to believe in state continuity. When Juba was at risk of falling, international partners supported the existing order, perhaps believing it to be the only alternative to state fragmentation or collapse. Many donors are managing this dilemma by switching their assistance to the humanitarian sector and disbursing it through international organizations and local NGO partners. The problem with this approach is that the South Sudanese state is now withering into the space created by its own tribalized security forces. This process is further militarizing society and undermining civil spaces everywhere. But civil spaces still exist. In many churches and mosques, schools and universities, and hospitals and health centers, civilians are trying to maintain shared spaces and protect their shared identities.

Supporting spaces that resist the militarization and tribalization of society offers at least three potential peacebuilding gains. First, it is a way of preventing a drift toward genocide or a further violent deterioration of interethnic relations.³⁶ Second, it supports the survival of nonmilitarized social and political values and possibilities, crucial for any future peace agreement to take root. Third, it supports a decentralized version of development, which could help mitigate the centralizing tendencies of the security state.

POC Camps in Malakal and Bentiu

Perhaps the most compelling case for investing in renewable energy systems is in the large POC sites—IDP camps housed within UN peacekeeping bases and home to more than two hundred thousand civilians who have fled the violence in Juba, Bor, Bentiu, Malakal, Wau, and Melut. The Bentiu and Malakal POC sites are two of the largest camps in the country, housing approximately one hundred ten thousand and thirty-five thousand IDPs, respectively. Both camps are situated on the outskirts of regional capitals that were destroyed during the civil war. These displaced populations are supported by large humanitarian operations powered entirely by diesel; the annual cost of powering each camp's humanitarian operations is approximately \$1 million. Malakal has relied on air shipments of diesel fuel (and everything else) for most of the last four years because of insecure road and river access; Bentiu is accessible by road for part of each year, which makes for slightly lower—but still very expensive—diesel costs.

Because of the high cost of diesel, renewable energy systems in these camps would offer rapid cost savings for humanitarian operations; the cost of installing renewable systems in Malakal would likely be recouped (by lower spending on diesel) in three years; the outlay for Bentiu would be repaid within three to four years. Large-scale civilian returns to Bentiu and Malakal are unlikely in the near term given the ongoing conflict and continued local and national tensions, but the civilian populations will probably opt to return to their homes when adequate peace, security, and stability are restored. Investment in renewable energy infrastructure today can help build the power plants of tomorrow for these cities. Continuing with the status quo of diesel power will mean that when the situation improves enough for displaced civilians to return to their homes, humanitarian actors will either pack up and leave or transition to new locations, and donors will begin to think about supporting reconstruction in the cities. Creating new solar systems for humanitarian operations now would create an energy infrastructure that can transition from camp to city to support reconstruction and returns in Bentiu and Malakal in the years to come.

In addition to being subject to broader conflict dynamics, both Bentiu and Malakal struggle with local conflict drivers that must be resolved for peace to take hold. Building these solar systems with battery storage would create pro-peace assets that could both serve as entry points for promoting local cooperation and conflict prevention, and form the core of a new local electric grid. If the security of the solar systems is a concern, the systems could remain physically located within UN bases and connected to the cities by wire.

The near- and long-term advantages of solar systems for Bentiu and Malakal could also be enjoyed at other locations in South Sudan, including in the POC sites in Wau and in refugee camps hosting Sudanese civilians in Maban and Yida.

Donor funding generally operates in distinct categories: South Sudan's aid is primarily humanitarian crisis funding, which usually operates on short-term funding cycles and is distinct from reconstruction or development funding. Renewable energy can bridge these categories. It offers an immediate cost-saving strategy while creating building blocks for future peace. The POC projects in particular have to navigate tricky political currents. UNMISS has at times been unhappy that its bases are still being used to host and protect more than two hundred thousand civilians. It also remains sensitive to infrastructure projects that carry any hint of

Donors and humanitarian agencies need to take a longer-term view of their programming.

“permanence” in the camps. Living conditions in the camps remain abysmal, and several camps have had multiple security breaches to which the UN peacekeepers were slow to respond. Those who remain in the POC sites do so voluntarily because they fall on the wrong side of an ethnic divide and perceive a direct risk from government forces outside the camps.

The Bottom Line on Cost

Renewable energy systems are more expensive to purchase outright, which is one reason so many humanitarian actors continue to rely on diesel. Short-term funding cycles define most humanitarian crisis funding, creating a structural barrier to adopting renewable energy. However, although crisis funding is often short term, many humanitarian crisis situations drag on for years. Given this grim reality, donors and humanitarian agencies need to take a longer-term view of their programming in South Sudan, making the case for renewable energy all the more compelling, because the economic value of renewable energy is unlocked over time.

As noted, the cost of diesel varies in different parts of South Sudan, depending on access to foreign markets, the reliability of the supply chain, and the security situation, but diesel is expensive countrywide relative to South Sudan’s neighbors and most of the world. In conflict-affected, landlocked parts of the country such as Malakal, diesel is so expensive that a large-scale solar-plus-storage system to support humanitarian operations would pay for itself—that is, the savings for a humanitarian agency on diesel fuel would pay for the full cost of the renewable energy system—more quickly than in Juba, which has access to cheaper fuel by road via Kenya and Uganda. Given that solar systems have a lifespan of twenty years or more, the economic benefits of a solar system will only increase with time. In Malakal, it may take only two to three years to recoup the cost; in Juba, where diesel is less expensive, it may take four to five years.

At July 2017 prices, the cost of buying and installing a 650-kilowatt solar-plus-storage system in Malakal POC would be around \$1.8 million, which at the May 2017 official exchange rate of SSP 116 equates to SSP 208 million. The specific costs and economics of other projects across the country could be researched and assessed as part of an initial donor-supported assessment for solar transitions in the country.

How to Pay for the Transition

The dramatic growth of renewable energy around the world has been aided by a range of financing mechanisms, including tax credits and leasing schemes similar to home mortgages that have allowed solar developers, businesses, and homeowners to pay down the cost of solar systems over time. Such credit or leasing facilities do not exist in South Sudan or in most other conflict-affected societies. Most humanitarian agencies and the vast majority of South Sudanese citizens do not have the resources to buy renewable energy systems outright.

Donors could help fund a pivot toward renewable energy in several ways. One option would be to create a funding pool for outright purchase, rationalizing such a large, one-time up-front cost as the price to achieving much lower energy expenditures over time while creating a long-lasting energy infrastructure that also serves social service and peacebuilding goals. A second option would be to extend multiyear, lease-like payment options to humanitarian grantees or to provide guarantees of multiyear funding so that individual organizations could seek their own financing. International solar developers were actively exploring South Sudan before the resumption of fighting, and a Norwegian company, Kube Energy, is currently looking at developing a solar leasing business for humanitarian actors in South Sudan. A third, complementary option is to create a financing mechanism specifically

to support renewable energy in conflict and crisis settings, such as the Peace Renewable Energy Credit (PREC).³⁷

Maximizing Benefits and Mitigating Risks

As noted, solar systems have been destroyed or looted in the civil war—a fact that may discourage donors and investors from funding a switch to renewable energy. The danger should be put in perspective, however: unlike in some other conflict settings, in South Sudan, solar panels are no more likely to be stolen than other forms of power generation. Furthermore, some of the potential security risks can be mitigated thanks to the nature of the three settings discussed. The POC camps are located within UNMISS bases, behind fences and protected by UN peacekeepers. Although hospitals and other components of the country's health infrastructure have suffered, certain locations—such as the Juba Teaching Hospital—have survived, perhaps because they are recognized as safe and neutral spaces. The NGO compounds are primarily walled compounds with their own security measures, and solar panels could be installed on roofs to deter theft.

To enhance the sustainability of a solar initiative, and to ensure that South Sudanese benefit from the outset of a transition, new investment in renewable energy should be coupled with a significant commitment to fund local capacity building and training programs in solar energy. Donor support for such a transition would help bring foreign solar developers to the country, create opportunities for South Sudanese to get into the business of installing and maintaining solar systems, and provide a critical economic building block through electrification capacity. Increased competition would bring a variety of benefits, including lower prices.

Conclusion and Recommendations

This report purposely avoids a deep analysis of the current conflict dynamics, the state of regional politics, or the status of the peace agreement. These issues are discussed elsewhere in great depth, and no consensus has yet been reached in South Sudan, regionally, or internationally on the best way forward.

South Sudan is without question stuck in a deadly, self-reinforcing cycle of conflict, the roots of which date back decades. It is situated in a tough region, surrounded by self-interested neighbors with extensive histories of cross-border meddling, and has faced a perfect storm of economic challenges. Its leadership has failed to navigate a peaceful path and has resorted to violence and narrow tribal politics at the expense of a shared national vision. Everything in South Sudan is zero-sum at the moment.

Renewable energy is not a solution to these myriad challenges and will not resolve the problems that drive the conflict. However, current international humanitarian funding streams do provide an opportunity to chip away at these dynamics by building cleaner, cheaper, long-lasting energy infrastructure—whether in the form of small systems for individual NGO compounds, larger systems serving hospitals and health clinics, or extensive systems in POC camps.

International donors are understandably hesitant to invest in infrastructure projects in South Sudan given that so much has been destroyed over the past few years, including significant international humanitarian assets. Most of the international investment interest has dried up, except in oil and mining activities.

Investing in renewable energy systems anchored in humanitarian activities differs from more traditional infrastructure investment in two key ways. First, donors are already funding expensive diesel systems for virtually all their humanitarian grantees. Transitioning to

South Sudan is without question stuck in a deadly, self-reinforcing cycle of conflict.

renewable energy would be a cost-saving strategy for future humanitarian programming. Second, these systems would generally be protected within contained compounds and could be mounted on containers or rooftops. Larger systems for POC camps would be located within the larger perimeter of the extended UN bases and well protected.

This solar energy infrastructure offers cleaner, cheaper, and long-lasting electricity generation and creates a new pro-peace asset. It would be a broader opportunity for South Sudan to escape its development path, one that does not depend exclusively on the petroleum sector. Natural resource extraction has been the primary strategy for generating government revenue, but it has not served South Sudan well. Rather than relying solely on the construction of mega-dams and a national grid to electrify the country—a scenario that seems many years away even in the best-case scenario, given the conflict and economic crisis—solar power offers an easily scaled solution that works on and off the grid, in rural and urban settings.

An investment in renewable energy would provide tangible, de facto evidence to civilians and politicians alike of the country's opportunity to leapfrog older technologies and embrace a green development path that takes full advantage of technological developments and broader global political and investment interest in environmentally friendly strategies. Providing basic energy services through PREC investment, then, is a unique opportunity to jumpstart peacebuilding. Similar efforts include national government investments in trust funds such as the World Bank's Energy Sector Management Assistance Program and NGO campaigns that address landmines or gender equality.

South Sudan is one of the most challenging situations facing the international community today. Divisions within the region, and between the neighboring countries and the broader international community, have hampered mediation efforts and continue to undercut attempts to end the fighting. Domestically, the government's support base continues to narrow, and the war has expanded from Greater Upper Nile to Equatoria and parts of Bahr el-Ghazal. New approaches are needed to help chart a path out of the crisis and to recapture the hope and optimism that defined South Sudan's future just a few years ago. International humanitarian donors can adapt to this longer-term lens, but doing so calls for new thinking and innovative approaches. As national leaders and international donors struggle to find a way to break the cycle of conflict, renewable energy presents a rare win-win opportunity, with benefits both in the short term and for years to come.

The following recommendations are intended to help international donors seize this opportunity and exploit it to its fullest:

- Assess current energy spending among UN and humanitarian grantees to create more transparency on energy costs and usage in South Sudan. Encourage relief organizations to publish their actual energy supply and maintenance costs on a standard, leveled cost-of-energy basis.
- Begin donor-level discussions on existing or new mechanisms to pool funds to help finance renewable energy systems for humanitarian grantees with multiple donors.
- Implement pilot projects to determine the relative economics and payback periods (length of time for diesel cost savings to equal cost of solar systems) for both small and large relief settings.
- Convene a global summit of humanitarian support groups to share the results of these pilot studies and encourage consideration of a transition to clean energy by the aid and relief community as a whole.
- Explore options and scenarios for transitioning the energy infrastructure for local benefit, to include maintaining donor involvement—including possibly ownership—in

the protection and management of newly installed renewable energy systems, as well as planning for new training and capacity-building programming to support South Sudan's solar sector.

- Commission independent groups to evaluate the planning issues involved in designing solar-plus-storage energy systems to become the new backbone of clean energy infrastructure as IDPs and refugees gradually move back to the towns.³⁸

Notes

1. "Famine Declared in Region of South Sudan—UN," UN News Centre, February 20, 2017. This was the first famine to be declared anywhere in the world since 2011. It was soon followed by famine warnings for Somalia, Yemen, and northern Nigeria.
2. International humanitarian aid requirements have spiked since the fighting began in December 2013, expenditures since 2014 totaling more than \$4.5 billion—a staggering figure that falls short of the full requested amount, a sign of growing donor fatigue. Total humanitarian funding reached \$2.02 billion in 2014, \$1.35 billion in 2015, and \$1.29 billion in 2016. In mid-February 2017, the United Nations and international partners launched a \$1.6 billion aid appeal. The consolidated humanitarian response plan funding request was 88 percent covered in 2014, 66 percent covered in 2015, and 85 percent covered in 2016. As of December 6, 2017, the 2017 appeal was 83 percent funded. Figures are from the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) financial tracking service (<https://fts.unocha.org/countries/211/summary/2017>).
3. Jean-Luc Stalon and Biplove Choudhary, "Confronting Climate Change in South Sudan: Risks and Opportunities," *Sudan Tribune*, June 27, 2017.
4. According to the International Energy Agency (IEA), South Sudan averaged only 39 kilowatt hours of electricity consumed per capita for the entire year of 2014. This put South Sudan alongside Haiti at the bottom of the IEA 2016 national rankings. This figure may exaggerate electricity consumption in South Sudan, because the figure was the same in the previous year, which had been based on pre-civil war data. By comparison, Ethiopia averaged 70, Kenya 171, Mexico 2,169, and the United States 12,962 (OECD/IEA, "2016 Key World Energy Statistics," 2017, 48–57).
5. Peter Alstone, Dimitry Gershenson, and Daniel Kammen, "Decentralized Energy Systems for Clean Electricity Access," *Nature Climate Change* 5 (2015): 305–14.
6. World Bank, "HFS Market Surveys in South Sudan (2012–2016)," 2016.
7. See, for example, Alstone, Gershenson, and Kammen, "Decentralized Energy Systems," 305–14.
8. Republic of South Sudan, *South Sudan Development Plan 2011–2013* (Juba, August 2011), www.grss-mof.org/wp-content/uploads/2013/08/RSS_SSDP.pdf.
9. According to OECD aid data, the international community spent more than \$15 billion in development and humanitarian aid in Sudan from January 2005 through July 2011. The data, however, do not disaggregate spending between North and South Sudan prior to independence in 2011, and the \$15 billion includes funding for both South Sudan and Darfur. South Sudan received roughly one-third of all funding from the UN work plan and Common Humanitarian Fund during this time, and it is reasonable to assume that it would have received roughly one-third of all international funding—about \$5 billion—as well (OECD Development Assistance Committee data, www.aidflows.org; Global Humanitarian Assistance, "Resource Flows to Sudan: Aid to South Sudan," July 2011). UNMIS headquarters were in Khartoum and the organization also had a presence in South Kordofan and Blue Nile states in northern Sudan, but the majority of the peacekeepers and personnel were based in South Sudan (see "UNMIS Facts and Figures," www.un.org/en/peacekeeping/missions/past/unmis/facts.shtml).
10. Morgan Bazilian and Debabrata Chattopadhyay, "Considering Power System Planning in Fragile and Conflict States," EPRG Working Paper 1518, University of Cambridge, November 3, 2015.
11. The most successful electrification effort was in the area of the Upper Nile state oil fields, near Paloich, which came online in late 2006 after a second pipeline to Port Sudan was completed. The PetroDar oil consortium electrified the areas immediately around the oil fields and extended power lines to the local towns of Melut and Paloich. The town of Renk, which sits on a finger of land jutting north into Sudan, was also electrified, courtesy of the Sudanese electricity grid. In late July 2017, the South Sudan government reached an agreement with neighboring Uganda to extend the Ugandan grid to electrify the South Sudanese border towns of Nimule and Kaya ("Uganda to Export Electricity to South Sudan Border Towns," *Radio Tamazuj*, July 30, 2017).
12. "South Sudan Hopes Oil Refinery Works in Four Months," *Sudan Tribune*, March 8, 2017.
13. Jemma Nunu Kumba, Minister of Electricity and Water Resources, Republic of South Sudan (presentation at the African Utility Week and Clean Power Africa 2015, Cape Town, South Africa, May 2015); Altai Consulting, "South Sudan: Mapping the Supply Chain for Solar Lighting Products," July 2014. The Altai report was based on field research conducted in May and June 2013 on behalf of the World Bank's Lighting Africa program.
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16. John A. Akec, "South Sudan's Economy: Is Fuel the New Dollar?" JohnAkecSouthSudan (blog), December 11, 2016, <http://johnakecsouthsudan.blogspot.com/>.
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ISBN: 978-1-60127-697-1

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25. Diesel costs for humanitarian operations have exceeded \$3 per liter in both Malakal and Bentiu when fuel supplies have had to be delivered by air due to insecurity or lack of supply (interviews with International Organization for Migration officials in Bentiu and Malakal, December 2016).
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29. This figure includes funding for South Sudanese refugees in neighboring countries (USAID, "South Sudan—Crisis," Fact Sheet #5, Fiscal Year 2017, March 3, 2017).
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37. The Peace Renewable Energy Credit was developed as a new variant of the Renewable Energy Credit (REC) mechanism. RECs represent one megawatt hour of renewable energy generated and trade successfully in billion-dollar markets in North America and Europe, allowing both public and private-sector actors to meet their renewable energy commitments by purchasing these virtual claims. PRECs could be generated from renewable energy projects in South Sudan, for example, sold back into the voluntary renewable energy markets to link existing renewable energy markets to fragile settings, and create a new revenue stream to help promote clean energy in support of peacebuilding goals. For details, see the work of Energy Peace Partners at www.energypeacepartners.com, and Renewable and Appropriate Energy Laboratory ("RAEL Holds First Workshop on the Peace Renewable Energy Credit," May 17, 2007, <http://rael.berkeley.edu/conflict> and rael.berkeley.edu/2017/05/rael-holds-first-experts-workshop-on-the-peace-renewable-energy-credit).
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Of Related Interest

- *Managing Conflict in a World Adrift* edited by Pamela Aall, Chester A. Crocker, and Fen Osler Hampson (USIP Press, February, 2015)
- *Conflict Management Training for Peacekeepers: Assessment and Recommendations* by Alison Milofsky, Joseph Sany, Illana M. Lancaster, and Jeff Krentel (Special Report, August 2017)
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