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Matchmaking power: expanding climate finance for off-grid solar electricity

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Gregor Vulturius

Heidi Tuhkanen

Key messages

- **Achieving Sustainable Development Goal (SDG) 7 – to supply affordable, clean and reliable energy to all by 2030 – will require bringing electricity to about 840 million people who lack access to it today.**
- **Off-grid solar (OGS) and other renewable energy solutions are expected to provide more than half of all new access to electricity by 2030. OGS can also significantly reduce emissions from kerosene lamps and support development, adaptation and resilience.**
- **Seed and concessional financing is urgently needed to scale up OGS. However, multilateral climate finance institutions now account for only a fraction of total investments in OGS.**
- **The reasons for this missed opportunity include the complexities of approving projects that integrate mitigation, adaptation and development benefits; the focus of funds on larger projects; and lack of guidance for OGS companies.**
- **Blended finance, carbon markets and bonds could also support OGS expansion, at specific stages of scaling and for larger projects. Accounting for black-carbon emission reductions and associated benefits to resilience would make OGS more attractive to carbon markets.**
- **Key strategies for multilateral climate finance institutions to scale up OGS include: offering more concessional financing for business and market development; expanding the use of blended finance to de-risk investments and "crowd in" commercial equity; helping OGS companies to access local-currency lending; establishing a uniform methodology to assess the climate benefits of OGS; mobilizing debt finance from the labelled bond market for OGS; and developing innovative ways to pool or securitize smaller OGS investments to make them more attractive to bond investors.**

Sustainable Development Goal (SDG) 7 calls for universal access to affordable, clean and reliable energy by 2030. Despite notable progress in the past 10 years, around 840 million people still lack access to electricity (IEA et al. 2019). Even after accounting for policies and targets announced by governments, an estimated 650 million people are expected to remain without electricity in 2030, 90% of them in sub-Saharan Africa.

More investments and political action are thus needed. However, there is also a risk that expanding energy access could conflict with efforts to achieve SDG 13 on climate action. Extending the power grid, for example, could increase carbon emissions if the electricity comes from fossil fuels. Investing in renewable energy, on the other hand, can help achieve universal energy access while protecting the climate and achieving the goals of the Paris Agreement.

IMAGE (ABOVE): Solar power in rural Tanzania © MBEO OGEYA / SEI

Even after accounting for policies and targets announced by governments, an estimated 650 million people are expected to remain without electricity in 2030, 90% of them in sub-Saharan Africa.

Off-grid solar (OGS) technologies have shown promise for providing low-carbon electricity to those living in energy poverty, especially in rural areas. A progress report by the SDG 7 custodian agencies found that off-grid solar has become a key driver of rural energy access, reaching over 60 million people in Africa already (IEA et al. 2018). Indeed, the International Energy Agency estimates that decentralized solutions, including OGS, will provide half of new electricity access by 2030 – and if SDG 7 is actually to be achieved, 72% of new access would come from decentralized systems, with roughly 195 million people reached by OGS and other off-grid solutions (IEA 2017).

A growing number of developing countries, such as Zambia, Burkina Faso and Malawi, are including OGS in their Nationally Determined Contributions (NDCs) under the Paris Agreement. Globally, investments in OGS exceeded US$1.35 billion in 2018, reflecting increased interest from public and private investors (Wood Mackenzie 2019).

This brief explores the development and climate benefits of OGS; the opportunities it represents for climate finance institutions, including multilateral climate finance mechanisms; and the potential impact of new funding sources such as blended finance, carbon markets, and the labelled bond market.

The analysis focuses on stand-alone OGS technologies such as solar lanterns, multi-light systems and solar home systems, which together account for about 85% of the global off-grid electricity market (IEA et al. 2019). It is based on a comprehensive literature review and interviews with experts.

The development benefits of OGS

Access to electricity is associated with a wide range of benefits. The extent to which OGS technologies aid development depends on how much energy they provide and the services they support. The World Bank has developed a multi-tier framework for defining and measuring energy access that takes into account different types of services, reliability and duration of service, and the number of beneficiaries (Bhatia and Angelou 2015). This multi-tier framework is now being used by the UN's Sustainable Energy for All (SEIforALL) programme.

Table 1 shows the capacity, OGS technologies and services associated with different electricity access tiers, as well as the number of people served by OGS sold by affiliates of the Global Association for the Off-grid Solar Energy Industry (GOGLA). Most people only have small amounts of electricity, to power portable lanterns and multi-light systems. Larger solar home systems have a much-smaller market share due to their higher cost.

Along with electricity access, OGS can provide multiple additional development benefits. For example, one review of scientific studies found that OGS enables children to spend more time spend learning and improves the quality of education (Lemaire 2018). Another study found strong evidence that OGS can reduce the use of kerosene, leading to improved indoor air quality and health benefits (Lam et al. 2018). Research further suggests that OGS can save households money, as they spend less on fuel for lighting (Mazzoni 2019).

GOGLA estimates that OGS supplied by its members has saved households more than US$10.5 billion in energy-related expenditures and helped them generate an additional US$4.9 billion in income (GOGLA 2019a). Comparative research has also shown that small, affordable solar lanterns can have similar benefits in terms of lighting, health and cost savings as larger, more expensive solar home systems (Bond et al. 2012).

Table 1: Electricity access and services provided by OGS technologies, by access tier

Electricity access tier	Power/Technology	Electricity service	People impacted as of June 2019*
Tier 0 **(Partial access to Tier 1 services)**	0 – 1.499 Wp Portable lanterns	Single light only	11.6 million
	1.5 – 2.999 Wp Portable lanterns	Single light and phone charging	33.9 million
Tier 1	3 – 10.999 Wp Multi-light systems	Multiple lights and phone charging	16.0 million
	11 – 49.999 Wp Solar home systems	Multiple lights, phone charging, radio, fan etc. using high-efficiency appliances	4.0 million

* Only GOGLA affiliates.7 GOGLA estimates that sales of its affiliates represent around 30% of all solar lanterns and multi-light systems sold globally and 60–80% of off-grid SHS with panel larger than 11 Watt-peak (Wp).
Source: GOGLA (2019a).

The climate mitigation benefits of OGS

The primary climate benefit of OGS is that it reduces the need for kerosene lanterns. Kerosene is a significant source of black carbon (soot), which remains in the atmosphere for only a few days, but warms the atmosphere several hundred times more during its short lifetime than carbon dioxide does over 100 years (Jacobson et al. 2013).

Sources of black carbon can also emit other particles that cool the atmosphere. However, research has shown that kerosene lamps have a net warming effect, as they convert 7–9% of the fuel into black carbon without creating other particles that have a cooling effect. While emission rates vary between different models, overall, kerosene lamps are estimated to emit 270,000 tonnes of black carbon annually, equivalent to about 240 million tonnes of CO_2. The warming effect of residential kerosene lighting is particularly strong where most kerosene is used and electricity access is poor, such as Africa, India, southeast Asia and Central America (Lam et al. 2012).

Solar-powered lamps require more energy for manufacturing than kerosene lamps, but only solar energy when in use. Life-cycle analysis has shown that solar lanterns have an energy payback period of 1–3 months and save 15–45 times the energy that is required to produce them over two years depending on the size of the system (Alstone et al. 2014).

Climate mitigation benefits also depend on the reduction of kerosene use for lighting. In some households OGS replaces kerosene lamps altogether, while in others, kerosene lamps are kept for additional or backup lighting. Depending on the context and technology, OGS has been estimated to reduce kerosene consumption by 50–100% (Lighting Global 2014).

GOGLA calculates the amount of CO_2 and black carbon emissions avoided through OGS based on the assumption that one unit of OGS technology over its estimated lifespan (usually 3–4 years) will replace one kerosene lantern with annual emissions of 0.37 tonnes of CO_2 equivalent. Based on this calculation, and accounting for discarded or replaced units, GOGLA estimates that OGS sold by its members since 2010 will reduce emissions by 66.6 million tonnes of CO_2e over their expected lifetimes (GOGLA 2019a). Interviews with experts suggest this is a reasonable estimate, though assumptions about kerosene lamp replacement are not always easy to verify.

Adaptation and resilience-related benefits of OGS

Yet another potential benefit of OGS is to increase resilience to extreme events and climate change impacts. Just having access to phone chargers, research has shown, improves people's access to information about impending extreme weather events and where to seek shelter before or after a disaster (Scott et al. 2017). Solar lamps can also increase safety and security in the aftermath of extreme events – and OGS can provide sustained access to electricity during disruptions to the power grid. The durability, portability and serviceability of OGS are of great importance in this context.

The aftermath of tropical storm Idai in Mozambique in 2019 highlights the role that OGS can play in disaster relief. OGS companies partnered with NGOs and development agencies to supply solar home systems to relief camps and shelters across the country (D'cruz 2019). Research suggests that packaged OGS solutions that provide electricity for lighting, information communication technology (ICT), and security are very suitable for emergency relief, due to their quick deployment potential, affordability and low maintenance needs (Franceschi et al. 2014).

Stand-alone OGS can also help improve agriculture practices and the quality of health care. For example, solar-powered water pumps can help farmers with irrigation, which can increase crop yields and income, while solar-powered refrigeration for storing food and medicine has the potential to improve food security and public health. However, sales of solar-powered water pumps and refrigerators are still very low due high upfront costs, low public awareness, and the uneven availability of groundwater (GOGLA 2019a).

Nevertheless, confidence in OGS to improve rural livelihoods is growing, as shown by the recent tender for 272,579 solar-powered water pumping systems by the International Solar Alliance (ISA 2019). Thus, advances in increasing the efficiency, lower prices and new use-cases represent future opportunities for OGS to deliver broader development and climate benefits.

Investment needs and challenges of OGS

Between 2010 and 2018, US$1.35 billion in publicly disclosed investments were made in OGS. From 2014 and 2018 alone, investments grew from US$75 million to 352 million. However, the investment landscape of OGS is highly concentrated, with almost 60% of all investments since 2010 going to East Africa and more than 80% going to the 10 largest companies (Wood Mackenzie 2019).

Additional investments are thus needed to support OGS companies in different regions, at all stages of development, to rapidly expand clean energy access in line with SDGs 7 and 13. Table 2 shows the estimated investment needs of OGS companies in both established and latent markets in sub-Saharan Africa. Overall, the sector needs US$943 million in grants, US$11.3 billion in equity and US$13.4 billion in debt to provide a third of households in the region access to electricity by 2030. (Shell Foundation and Catalyst 2017)

Importantly, much more capital is needed to support companies at all stages of business development, promote competition within established markets, and unlock latent markets. GOGLA has recently published an investor guide which details funding needs at the different stages of business development (GOGLA 2019b):

Table 2: Investment needs for OGS to help achieve SDG 7 in sub-Saharan Africa

Established markets*	Latent markets**
Market of 22 million households	Market of 104 million households
1st Generation companies - US$80 million in grants - US$1.1 billion in equity - US$2.3 billion in debt	1st Generation companies - US$211 million in grants - US$2.9 billion in equity - US$4.5 billion USD in debt
2nd and 3rd generation companies - US$56 million in grants - US$617 million in equity - US$555 million in debt	2nd and 3rd generation companies - US$596 million in grants - US$6.7 billion in equity - US$6.4 billion in debt

* Kenya, Tanzania, Uganda and Rwanda, with a total market penetration of 6% of households in 2018.
** E.g. Nigeria, Ethiopia or the Democratic Republic of Congo

Source: Shell Foundation and Catalyst (2017).

- Early-stage capital is needed from the blueprint through the validation and preparation stage up until the scaling stage.
- At the blueprint stage, second- and third-generation companies require US$10,000–1 million in seed capital (as grants) to develop their business plans.
- As companies validate their business and prepare to scale their operations, they need grants and increasing amounts of concessional equity and debt from specialized funds and development finance institutions – US$250,000–5 million for business validation and US$ 3–10 million to prepare to scale.
- When companies scale up their business and move into new markets, as many existing first-generation companies are starting to do, they need even more private equity and commercial debt – more than US$10 million.

Raising capital is especially challenging for OGS companies, however, because the equipment is expensive, there are disparate repayment risks, and it is costly to repossess assets when needed. These risks are exacerbated by financial and regulatory barriers, including lack of local-currency lending and uncertain VATs and import tariffs applications (Wood Mackenzie 2019). Therefore, financial mechanisms that de-risk commercial investments and "crowd in" private equity are needed to diversify and scale funding (Zahir-Bill and Gomes 2018).

Financial and regulatory challenges also differ based on the sales model. Sales are either cash-based or pay-as-you-go (PAYGo). In both cases, OGS companies pay for solar lanterns or solar home systems in foreign currencies but receive payments for the systems in local currencies. This exposes them to substantial financial risks from currency fluctuations (Wood Mackenzie 2019). OGS companies using PAYGo face additional financing risks stemming from the delay between paying for OGS assets upfront and receiving instalments from customers over time.

Yet many PAYGo companies struggle to finance outstanding instalments from existing customers while attracting new investments to further grow their business (Waldron et al. 2018). Therefore, regular injections of working capital and access to affordable debt are both critical. Capital needs increase further when OGS companies offer additional products with their solar technologies, such as water pumping or crop insurance (Wood Mackenzie 2019).

OGS and multilateral climate finance

The term "multilateral climate finance" describes a broad range of public and private finance for projects which support climate change mitigation, adaptation or both. The United Nations Framework Convention on Climate Change (UNFCCC) has established a mechanism to facilitate the provision of climate finance, operated by the Green Climate Fund (GCF) and the Global Environmental Facility (GEF).

The GCF works through partnerships with "accredited entities", including national governments, but also welcomes private-sector participation through its Readiness Programme and Private Sector Facility. This allows the GCF to leverage additional financing and use concessional loans, guarantees and equities to help de-risk investments and facilitate innovation. The GCF has co-funded small-scale solar projects, including a rooftop solar project and a groundwater recharge and solar micro-irrigation project in India, as well as an off-grid solar project in East Africa, through a mix of grants and equity (GCF n.d.).

The GEF hosts several funding programmes under its current investment cycle, GEF-7, that are relevant to promoting OGS. These include climate-related innovation and technology transfer for sustainable energy breakthroughs. The Small Grants Programme prioritizes low-carbon energy access. In its Non-Grant Instrument programme, the GEF works with the private sector through official partner agencies, such as international development banks or other organizations (GEF 2018).

The Climate Investment Funds (CIFs) are another source of multilateral climate finance, jointly managed by donor and recipient countries and multilateral development banks. The Scaling Up Renewable Energy Program in Low Income Countries (SREP) aims to increase investments in renewable energy solutions to increase energy access. The private sector can join a funding proposal of a recipient country or lead Private-Sector-Set-Aside (PSSA) projects. The PSSA funding includes concessional finance (loans), non-grant funding, grants and first-loss guarantees (CIF 2020).

The SREP has already invested in OGS. For example, Rwanda's Renewable Energy Fund (US$49 million) aims to give 1.8 million people access to electricity by 2023 through off-grid technologies and facilitate private-sector participation in renewable off-grid electrification. However, the fund is struggling to leverage the envisioned co-funding from OGS companies, local savings and credit cooperative societies and banks (World Bank 2019). Though these investments by multilateral climate finance institutions are significant, they amount to a tiny fraction of the total US$1.35 billion invested in OGS between 2010 and 2018 (Wood Mackenzie 2019). This is a missed opportunity to capitalize on the climate and development benefits the sector has to offer.

One reason why multilateral climate funds have invested so little in OGS may be that the funds draw strong distinctions between mitigation, adaptation and development activities and end-goals, while OGS technologies integrate the three, which could complicate the project preparation and approval processes. Another reason may be that multilateral climate finance tends to focus on larger projects and companies, which would preclude early-stage funding for OGS. There is also a need for better guidance on how smaller OGS companies can access funding from multilateral climate finance mechanisms.

Blended finance, carbon markets and bonds

Another option that is already known to the OGS sector is blended finance arrangements that combine public and private funding. More and larger blended-finance arrangements are needed to provide at least US$1 billion in early-stage capital annually to allow the OGS sector to move beyond established markets (Shell Foundation and Catalyst 2017). The funds can come in the form of concessional finance and grants from the public, donor sector or impact investment sector. However, finance experts warn that they should not crowd out private investments (Wood Mackenzie 2019). This could happen if governments subsidize OGS below the market price, undermining the commercial market. Still, a comprehensive review of blended finance for clean energy found that investments in decentralized energy access in sub-Saharan Africa offers private investors opportunities for high environmental and social impact (Tonkonogy et al. 2018).

The Facility for Energy Inclusion Off-Grid Energy Access Fund is a blended finance debt fund, managed by LHGP Asset Management, designed to provide loans to off-grid energy companies working in Africa, in local and hard currencies, to increase households' access to off-grid, clean electricity and attract local financial institutions as co-lenders. Of the targeted US$100 million, US$30 million has so far been provided by the Africa Development Fund, US$10 million by Calvert Impact Capital, US$8.5 million by the GEF, and US$6.5 million by the Nordic Development Fund (AfDB 2018). In early 2019, the OGS company BBOXX received a loan equivalent to US$8 million in Rwandan Franc to scale up its business in Rwanda.

The KawiSafi Ventures Fund in East Africa (2015–2021) is another blended finance mechanism. The GCF is funding 23% of the total US$110 million under management. The fund aims to invest US$2–10 million in 10–15 small and mid-sized solar energy companies initially targeting customers in Kenya, Rwanda and Uganda. The fund partners with larger investment firms to invest in the scale-up of these businesses. It expects to benefit 16% of the three countries' total population, directly or indirectly, and to reduce emissions by 1.5 million tonnes of CO_2e over the funded projects' lifetime (GCF n.d.).

A further potential source of climate finance for OGS is the voluntary carbon market – particularly through the Gold Standard and the Verified Carbon Standard (VCS), the two largest programmes. Both require reductions to be real, additional, measurable, and verified by a third party. Unlike in compliance markets, offset prices in voluntary markets vary greatly, averaging US$3–6 /t$CO_2e$ (Hamrick and Gallant 2018). Since 2017, The Gold Standard for the Global Goals (GS4GG) has supported climate security and sustainable development in an integrated fashion (impacts to SDG 13 plus at least two other SDGs). Verra, the organization behind the VCS, has also launched a standard supporting SDGs, SD Vista, which can be used alongside VCS.

Carbon trading under the Paris Agreement offers further opportunities, though progress on implementing Article 6, which proposes the creation of a global mechanism to trade Internationally Transferable Mitigation Outcomes (ITMOs), has stalled. The largest existing system, the Clean Development Mechanism (CDM), which the new mechanism would replace, allows several small projects, OGS introductions typically entail, to be aggregated into a Programme of Activities (PoA). In the meantime, the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) may offer another potential market for carbon offsets from OGS.

Carbon markets currently don't recognize the climate benefits of OGS. The Gold Standard has developed a methodology to quantify climate-related emission

reductions of black carbon due to the replacement of inefficient cookstoves, but it hasn't addressed reductions of black carbon emissions from kerosene-powered lamps when they are replaced by OGS. Black carbon emissions are not addressed by the VCS or the CDM, either.

The labelled bond market (i.e. self-identified "green", "social impact" and "sustainable" bonds) could be another source of capital for OGS companies, especially as the sector grows and needs more debt finance. Labelled bonds are still only a fraction of the international bond market, but already exceeded US$240 billion in 2019 (SEB 2019). So far, labelled bonds have not been widely used in the OGS sector. In 2016, the investment firm Oikocredit International and BBOXX issued US$500,000 in bonds backed by 2,500 existing OGS contracts (Clover 2016). However, plans to scale this model of security-backed debt finance to US$2 billion have not been achieved yet.

Sovereign labelled bonds offer one more option. The government of Nigeria has issued two green bonds so far in support of its NDC under the Paris Agreement, which will in part finance off-grid solar. Sovereign bonds are arguably more attractive to investors because they are larger and come with a better credit rating than bonds from an OGS company. Another option could be green bond programmes of multilateral development banks, to mobilize debt finance for OGS. The World Bank, for example, has used proceeds from its green bond programme to fund solar home systems in Peru (World Bank 2020).

Key strategies for climate finance to scale up investments in OGS

Off-grid solar technologies could play a key role in achieving both SDG 7 – universal access to affordable and clean electricity by 2030 – and SDG 13 – reducing climate risks. More widespread adoption of OGS could significantly reduce emissions from kerosene lamps, build resilience to extreme weather events, and improve the economic situation of millions of households in the Global South.

Given its enormous potential, the OGS sector is a prime candidate for climate finance – and it sorely needs more investment. Based on the analysis presented above, we recommend the following strategies for climate finance to help scale up OGS deployment in developing countries:

1. **Offer more concessional financing for early-stage business and market development.** Multilateral climate funds – including the GCF, GEF and CIFs – and other climate finance institutions should invest in developing modalities to provide seed concessional financing, in the form of grants or convertible debt, to OGS companies to develop and validate their business case. OGS companies will also need guidance and capacity-building to learn how to access these funds.
2. **Expand the use of blended finance to de-risk investments and crowd-in commercial equity.** Blended finance mechanisms such as the KawiSafi Ventures Fund have shown great potential in leveraging investments in OGS by lowering the risks for mainstream investors. Combining concessional finance in the form of first-loss capital and impact investment can attract risk-averse commercial investors. Unlocking mainstream investments is crucial for OGS companies to grow their business after they've made their business case and identified a market. However, blended finance mechanisms should be careful not to crowd-out commercial investments.
3. **Help OGS companies to access local-currency loans.** OGS companies are critically dependent on local lending to minimize their exposure to currency volatility. Multilateral climate finance institutions may want to consider ways to help domestic banks provide working capital to OGS companies.

4. **Establish a uniform methodology to assess the climate benefits of OGS.** It should include an approach to verifying reductions of black carbon emissions from kerosene-powered lamps, which could help OGS companies in attracting additional revenues from carbon markets. The methodology could also cover the resilience-related benefits of OGS, such as solar-powered irrigation and disaster preparedness.
5. **Mobilize debt finance from the labelled bond market for OGS companies.** Multilateral climate finance institutions could use proceeds of their own labelled bonds to fund OGS or provide technical assistance to OGS companies and countries to issue labelled bonds to finance OGS.

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SEI Stockholm Environment Institute

Published by
Stockholm Environment Institute
Linnégatan 87D, Box 24218
104 51 Stockholm, Sweden
Tel: +46 8 30 80 44

Author contact
gregor.vulturius@sei.org
heidi.tuhkanen@sei.org

Media contact
karen.brandon@sei.org

Visit us: sei.org
Twitter: @SEIresearch
@SEIclimate

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