Rwanda's Off-Grid Solar Performance Targets

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The United Nations Statistical Commission's Inter-Agency and Expert Group on Sustainable Development Goals (IAEG-SDG) settled on 230 guidelines to assess the 17 SDGs and 169 Targets. The clause of "Leave No One Behind" and scarcity of data in most deserving countries made the UN 2030 Agenda agree on 169 Targets. Recently in *Energy Policy*, Bisaga et al. used synergies and trade-offs of SDG7 to assess Rwanda's off-grid solar energy sector performance against the 169 Targets of the UN 2030 Agenda.

By 2015, the United Nations (UN) member states agreed to offer a successful, friendly, imperishable, and liveable world by 2030. The 17 sustainable development goals (SDGs) are individually inseparable interconnected systems that are used to measure country-level preparedness for policy and financing.[1] Rwanda recognizes the capacity of its off-grid solar energy sector to supply a large section of its population.

The study pinpoints the interdependencies between the solar energy market and SDGs to provide an analysis for future clean energy electrification and investment planning. Electricity access has gradually increased; the Pay As You Go (PAYG) business model enables the collection of real-time energy-use data to predict energy-demand trends and inform energy-systems design improvements as well as funding arrangements.[1,2]

The Economic Development and Poverty Reduction Strategy (EDPRSs I & II) enabled energy access scale-up through the implementation of Electricity Access Rollout Programme (EARP) and Sector-Wide Approach (SWAp) between 2009 and 2017 by the Rwanda Energy Group (REG), World Bank, Ministry of Infrastructure (MININFRA), and Rwanda Utilities Regulatory Authority (RURA) as key stakeholders.[1,3]

The Rwanda off-grid solar electrification strategy comprises solar lanterns,[1] solar home systems (SHSs), solar mini-grids, solar water pumps, and solar water heaters. Although a country-wide SHS subsidy program is underway, it is pertinent to evaluate how this unfolding energy market will configure and impact the execution of the SDGs in Rwanda.

The study used the global mapping of synergies and trade-offs[1,4] and structured it to Rwanda. The two study questions were the following: whether (1) the SDG Target call for action related to off-grid solar systems in Rwanda and (2) synergies and trade-offs exist between the SDG Target and decisions about off-grid solar systems in keeping with SDG7 in Rwanda?[1]

Responses to the first of the study questions indicate that 86 Targets (50.9%) were the activities satisfied by the off-grid solar energy in Rwanda, whereas those to the second question confirm that 85 Targets (50.3%) were the synergies and trade-offs achieved relative to the UN 2030 Agenda.

Also, only SDG14 (Life Below Water) was not satisfied by Rwanda because it is landlocked[1,2,5,6] and has no direct access to the seas and oceans. Furthermore, the majority of trade-offs involve SDG2 (Zero Hunger) and SDG12 (Responsible Consumption and Production). The results were clustered into three domains: (1) SDGs (1, 3, 4, 5, 10, and 16), (2) infrastructure and service delivery (SDGs 2, 6–9, 11, and 12), and (3) environment and other resources (SDGs 13–15).[1] Also, the quality of life and economic wellbeing of rural dwellers in Rwanda is rooted in the government's enhanced rural infrastructural development that includes energy.

About 44 Targets (44 synergies and 3 trade-offs) pinpointed as SHSs upgraded the physical and economic wellbeing of households by removing kerosene polluting lighting fuels (Targets 3.4 and 11.1) and increasing income generation possibilities (Targets 1.1 and 10.1). Additionally, the restricted capacity of the off-grid solar systems places a constraint on using greater power agricultural machinery, thereby limiting some targets (Target 2.3).[1,6]

Rwanda's off-grid solar energy solutions are critical for realizing healthy living that promotes wellbeing at household and community levels (Targets 3.1–3.4 and 3.9). Furthermore, they empowered and built friendly and inclusive communities by providing the following: secure living conditions (Target 11.1); equal access to information and communication technology, which connects people beyond their localities (Target 9.c); and women with energy access decision-making and broader socioeconomic development (Target 5.5).[1]

Access to physical and social infrastructure is vital to poverty alleviation in Rwanda, and 58 Targets were authenticated in this category (58 synergies and 5 trade-offs).[1] SDG2 (Zero Hunger)

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https://doi.org/10.1016/j.joule.2020.12.016

depends on energy to drive agricultural equipment for effective and continuous food production. SDG2 trade-off with SDG7 leads to land competition for arable crops and solar energy mini-/micro-grid development and groundwater reduction because of rising solar irrigation (Targets 2.1–2.4).[1] Off-grid solar energy supports good health (SDG3) in health centers (Targets 3.1–3.3) and access to information and early warning signals in rural settlements (Target 3.d). It has enabled curriculum development in higher-learning institutions (Targets 4.3 and 4.4). Clean electricity access has created profitable energy uses for the populace (Target 8.3) like mobile money, logistics, and real estate (Targets 8.5 and 8.6).[1]

Off-grid solar underpins Sustainable Cities and Communities (SDG11), enhances the Environmental Footprint of Cities (SDG13), and supplies larger-power equipment like refrigerators using smart energy management of SHS-based mini-grids.[1] Twenty-one Targets of synergies and trade-offs including SDG7 (17 synergies and trade-offs) are used to reduce natural resource dependency and maintain environmental continuance in Rwanda. Solar energy has also raised the proportion of renewables in the Rwandan energy mix (Target 7.1) mainly for electricity production while solar cooking is in its infancy (Target 7.2).[1]

Solar energy has assisted resilient and sustainable industrialization (SDGs 8, 9, and 12) by applying mini-/micro-grids to drive cutting-edge business models (SDG9) in Rwanda. Solar irrigation boosts continual agricultural production and water-resources management (Targets 2.4 and 6.4). However, an e-waste management plant is necessary for handling obsolete, damaged, or faulty solar products and devices in the country or nearby.[1,7]

The study spotted symbiosis and bargains among Rwanda's off-grid solar energy goals and targets in the context of the UN 2030 Agenda that satisfy clean energy development. Rwanda's off-grid solar energy success is attributed to the government's unwavering support and realization that energy (SDG7) is the prime mover and foundation for any meaningful sustainable development.

The endurance, disaster-reduction, and intra-family-assessed gaps are difficult to measure, and cooling technologies are largely unnecessary because Rwanda is temperate.[1,8] Also, straightforward and coherent standards for disposing of obsolete, damaged, or faulty products and for using energy-efficient gadgets to optimize the benefits of clean energy past the rudimentary levels could be developed.

The study indicates that Rwanda's off-grid solar sector satisfactorily used SDG7 to account for 16 out of the 17 SDGs. Although a conducive environment by the government has favorably impacted electricity access and solar off-grid development, loss of livelihoods caused by the coronavirus disease 2019 pandemic could lead to energy poverty unless concrete cushioning measures are implemented to stem the tide.

Furthermore, the applied structural framework fails to competently track the fast-changing circumstances marked by volatile market-driven forces and new distribution patterns. Consequently, policymakers can encourage data sharing between academia and industry practitioners by supplying funding and partnership intermediation services and by ordering a harmonized data-reporting format.

The benefits of Rwanda's solar off-grid synergies and trade-offs study could be extended to other developing countries to reveal the gaps, disparities, and discontinuities that enable policymakers to use data and research results to inform decisions.

Above all, the recognition of synergies and trade-offs of using SDG7 as a metric against the UN 2030 Agenda supports the notion of concentrating on people, communities, most-at-risk populations, and those "left behind."

1. Bisaga, I., Parikh, P., Tomei, J., and To, L.S. (2020). Mapping Synergies and Trade-Offs Between Energy and the Sustainable Development Goals: A Case Study of Off-Grid Solar Energy in Rwanda. Energy Policy. https://doi.org/10.1016/j.enpol.2020.112028.

2. Niyonteze, J.D.D., Zou, F., Norense Osarumwense Asemota, G., Bimenyimana, S., and Shyirambere, G. (2020). Key technology development needs and applicability analysis of renewable energy hybrid technologies in off-grid areas for the Rwanda power sector. Heliyon *6*, e03300, https://doi.org/10.1016/j.heliyon.2020.e03300.

3. Bisaga, I., Parikh, P., Mulugetta, Y., and Hailu, Y. (2018). The Potential Performance Targets (imihigo) as Drivers of Energy Access Planning and Extending Access to Off-grid Energy in Rural Rwanda. WIREs Energy and Environ. *8*, e310, https://doi.org/10.1002/wene.310.

4. Fuso-Nerini, F., Tomei, J., To, L.S., Bisaga, I., Parikh, P., Black, M., Borrion, A., Spataru, C., Castan Broto, V., Anandarajah, G., et al. (2018). Mapping Synergies and Trade-offs between Energy and the Sustainable Development Goals. Nat. Energy *3*, 10–15, https://doi.org/10.1038/s41560-017-0036-5.

5. Kennedy, R., Numminen, S., Sutherland, J., and Urpeleinen, J. (2019). Multilevel customer segmentation for off-grid solar in developing countries from solar home systems in Rwanda and Kenya. Energy *186*, 115728, https://doi.org/10.1016/j.energy.2019.07.058.

6. Bimenyimana, S., Asemota, G.N.O., and Li, L. (2018). The State of the Power Sector in Rwanda: A progressive Sector with Ambitious Targets. Front. Energy Res. *6*, 1–14, https://doi.org/10.3389/fenrg.2018.00068.

7. Sinha Khetriwal, D., Magalini, F., and Mugabo, C. (2017). Sustainable Management of E-Waste in the Off-Grid Renewable Energy Sector in Rwanda. Energy Africa Compact –Rwanda Evidence on Demand (United Kingdom Department for International Development).

8. Bimenyimana, S., Asemota, G.N.O., Niyonteze, J.D.D., Nsengimana, C., Ihirwe, J.P., and Li, L. (2019). Photovoltaic Solar Technologies: Solution to Affordable, Sustainable, and Reliable Energy Access for All in Rwanda. Int. J. Photoenergy *2019*, 1–29, https://doi.org/10.1155/2019/5984206.