



SCALING UP SOLAR ENERGY INVESTMENTS IN YEMEN

By: Akram M. Almohamadi & Rafat A. Al-Akhali

EXECUTIVE SUMMARY

Poor electricity services remain a key barrier to sustainable economic development in Yemen, exacerbated by the ongoing conflict and related damages to the electricity sector's infrastructure.

Given Yemen's high average hours of annual daily sunshine and a significant level of solar irradiation, solar energy is a viable and cost-effective alternative to the currently prevalent fossil fuel-based electricity supply.

This brief provides an introduction to electricity provision in Yemen and explores the viability of specific solar energy applications for Yemen's fragile context.

It further considers the feasibility of partnering with the private sector in the solar energy sector, and finally presents recommendations and practical steps to address

challenges to scaling up investments in this sector in Yemen. It argues that a paradigm shift is needed to address the energy crisis in Yemen and kickstart meaningful economic activity: from an exclusive focus on large, fossil fuel-based centralised power generation plants to a stronger prioritisation on smaller, distributed renewable power generation plants that could provide jobs and livelihoods to Yemenis; from centralised planning and implementation to empowerment of local authorities and local Public Electricity Corporation branches to lead in this sector; from an overemphasis on supporting small stand-alone solar systems delivered by international non-governmental organisations and development agencies to a stronger prioritisation on innovative financing models and market-creating interventions supporting the sustainability of the sector at scale.

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1. INTRODUCTION

Electricity access, even before the current conflict, has been one of the main challenges for sustainable socioeconomic development and basic service provision in Yemen. The public electricity sector has been substantially impacted by the ongoing armed conflict and has suffered considerable physical and non-physical damages, presenting multiple new challenges for the recovery and reform of the electricity sector in Yemen.^[1] Moreover, the recent increase of the price of fossil fuels globally has been reflected in the cost of electricity generation in Yemen. This has placed a significant fiscal burden on the public budget due to the subsidised electricity prices in areas controlled by the Internationally Recognised Government (IRG). This has also made electricity access even more unaffordable, especially to low-income households in areas controlled by Ansar Allah (also known as Houthis), where commercial tariffs apply with no government subsidy.

Over the last few years, the declining costs of energy produced from renewable and clean energy sources have prompted many countries to plan and invest in renewable energy technologies. Many of these countries have adopted ambitious targets to diversify their energy mix by increasing the share of renewable energies. This reality has also provided an opportunity to enhance energy security and to respond to climate change concerns.

In Yemen, the National Strategy for Renewable Energy and Energy Efficiency of 2009 set a target of 15 percent renewable energies in the generation mix by 2025.^[2] However, progress towards this target has been non-existent. At the eighth Development Champions Forum (DCF) in Amman, Jordan, held from October 28 to November 2, 2022, the Development Champions therefore focused on solar energy in Yemen. This policy brief highlights the potential and critical need for investing in solar power generation projects in Yemen. It also identifies the key challenges facing the solar energy sector and presents practical recommendations to scale up solar energy investments in Yemen.

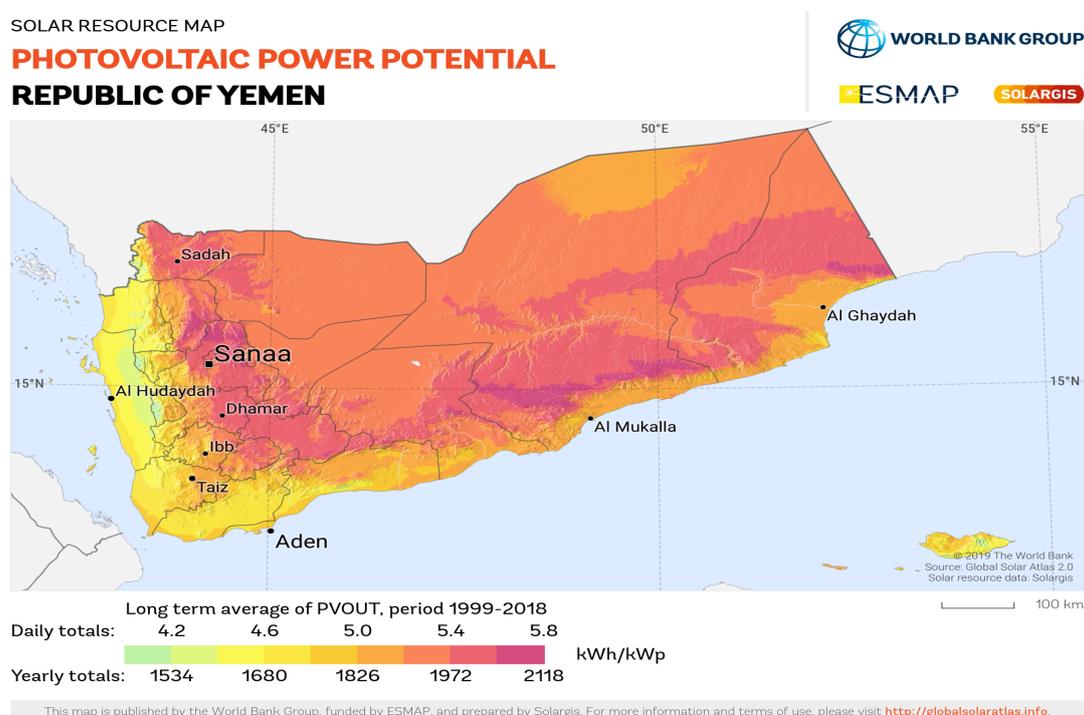
[1] Akram M. Almohamadi, "Priorities for the Recovery and Reform of the Electricity Sector in Yemen," Rethinking Yemen's Economy, Policy Brief No. 24, DeepRoot Consulting/Sana'a Center for Strategic Studies/CARPO, November 2021, https://devchampions.org/uploads/publications/files/Rethinking_Yemens_Economy_No8_En-1.pdf (Accessed 4 November 2022).

[2] "National Strategy for Renewable Energy and Energy Efficiency," MOEE, 2009, <https://moee-ye.com/site-ar/364/> (Accessed 4 November 2022).

2. Why Solar Energy?

Yemen is a sunbelt country with one of the highest levels of solar irradiation and an annual daily sunshine exceeding eight hours.^[3] This means that the different solar energy technologies for heating (e.g., Solar Water Heaters (SWHs)) and for electricity production (e.g., solar photovoltaic (PV)) have considerable potential in Yemen. As most of the population in Yemen live in rural areas and are geographically dispersed, it is costly to connect them to the main grid, making distributed solar PV solutions a critical part of any electrification strategy in Yemen.^[4] Figure 1 shows the photovoltaic power potential in Yemen.

Figure 1: Photovoltaic (PV) Power Potential



Source: "Global Solar Atlas", World Bank, 2019, <https://globalsolaratlas.info/download/yemen> (Accessed 5 November 2022).

Imports of fossil fuels for electricity generation have placed a significant and increasing fiscal burden on the Yemeni government over the years, in addition to their impact on foreign currency reserves and balance of trade. Solar energy has the potential to address this challenge and reduce the burden. While high initial investment costs in utility-scale solar generation used to be a limiting factor, this has drastically changed over the past decade and the Levelised Cost of Electricity (LCOE)^[5] of utility-scale solar PV power generation is now less than that of fossil fuel (see figure 2) and is expected to continue declining in the foreseeable future.^[6]

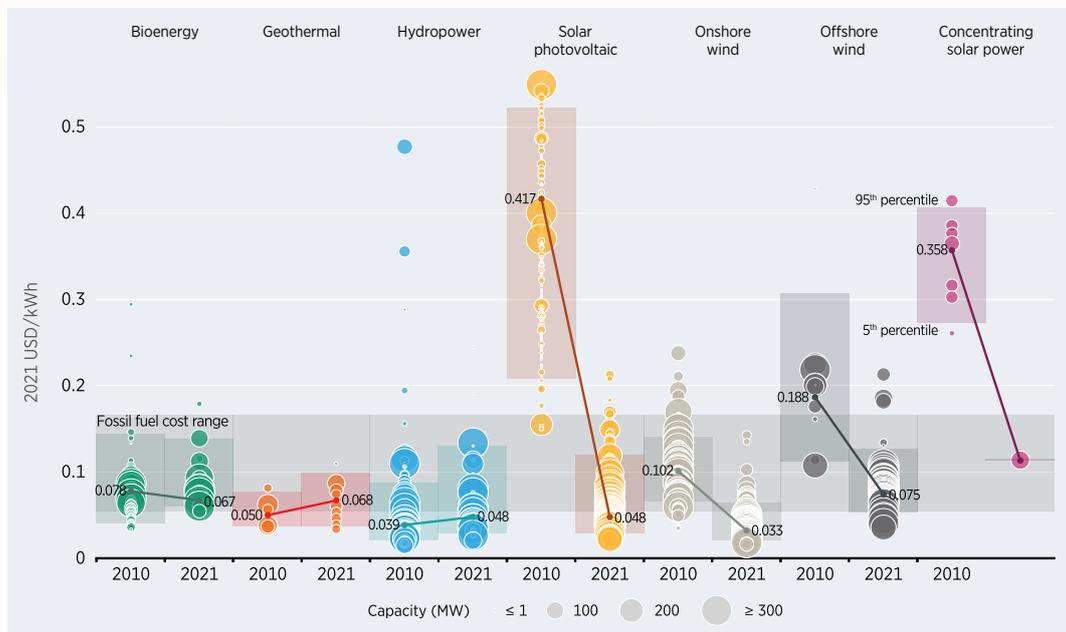
[3] Ali Q. Al-Shetwi, et al., "Utilisation of Renewable Energy for Power Sector in Yemen: Current Status and Potential Capabilities," 2021, <https://ieeexplore.ieee.org/document/9442686> (Accessed 5 November 2022).

[4] Abdulkareem Qasem, "Applications of Renewable Energy in Yemen," Journal of Fundamentals of Renewable Energy and Applications, 08(02), January 2018, https://www.researchgate.net/publication/326014541_Applications_of_Renewable_Energy_in_Yemen (Accessed 5 November 2022).

[5] The LCOE is the ratio of all lifetime costs (e.g., capital costs and operations and maintenance costs) to lifetime electricity generation, both of which are discounted back to a common year using a discount rate that reflects the average cost of capital.

[6] "Renewable Power Generation Costs in 2021," IRENA, July 2022, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2022/Jul/IRENA_Power_Generation_Costs_2021.pdf?rev=34c22a4b244d434da0acde7de7c73d8 (Accessed 18 November 2022).

Figure 2: Global weighted average LCOE of newly commissioned utility-scale renewable power projects



Source: "Renewable Power Generation Costs in 2021," IRENA, July 2022, <https://www.irena.org/publications/2022/Jul/Renewable-Power-Generation-Costs-in-2021> (Accessed 18 November 2022).

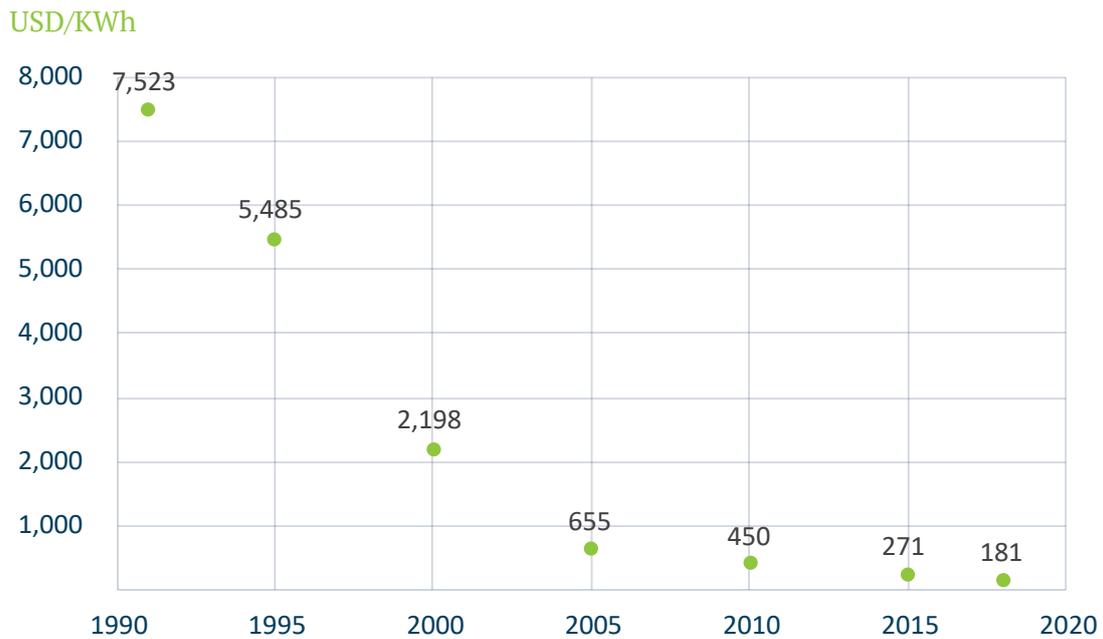
Notably, in fragile and conflict-affected countries with contexts similar to those in Yemen, Afghanistan awarded a solar PV Build-Own-Transfer (BOT) contract at United States Dollar (USD) 7.3 cents/kilowatt-hour (kWh) in 2016, Zambia at USD 6 cents/kWh in 2016, and Senegal at USD 4.7 cents/kWh in 2017.^[7] This can be compared to the average price of more than USD 25 cents/kWh that the Government of Yemen currently pays for diesel-based purchased energy from private producers (fee of the rental generators plus cost of fuel). It is worth highlighting that the lowest prices of solar PV were achieved in Saudi Arabia (USD 1.04 cents/kWh in 2021) and in the United Arab Emirates (USD 1.35 cents/kWh in 2020), taking advantage of the abundant solar energy resources and the favourable investment environment that enables low financing and investment costs.^[8]

[7] "Designing Renewable Energy Auctions: A Policymaker's Guide, Scaling Up Renewable Energy Project," USAID, 2019, <https://www-origin.usaid.gov/energy/auctions/policymakers-guide> (Accessed 18 November 2022).

[8] "Renewables 2022, Analysis and forecast to 2027," IEA, January 2023, <https://cutt.ly/h8HY3GC> (Accessed 15 January 2023).

In addition, the price of lithium-ion batteries has continued to drastically fall in the past two decades, from USD 2,198/kWh in 2000 to USD 181/kWh in 2018,^[9] as shown in figure 3.^[10]

Figure 3: Price of lithium-ion batteries



Source: "The price of batteries has declined by 97% in the last three decades," Our World in Data, June 2021, <https://ourworldindata.org/battery-price-decline> (Accessed 18 November 2022).

[9] "The price of batteries has declined by 97% in the last three decades," Our World in Data, June 2021, <https://ourworldindata.org/battery-price-decline> (Accessed 18 November 2022).

[10] Although the upfront cost of high-quality lithium-ion batteries is relatively high, such batteries improve the economic viability of using renewable energy compared to using other technologies, such as lead acid batteries, which have a shorter lifespan and lower efficiency, and which require several replacements over the life of the lithium-ion batteries.

3. Classes of Solar PV Projects

Solar PV projects can be implemented at different scales. The following sections present three classes of solar PV projects and analyse their current status in Yemen and the key challenges that face scale up efforts.

3.1 Utility-Scale Solar Projects

Utility-scale solar projects are large power plants that typically generate electricity to the power utility grid or to large consumers through power utility transmission lines. They can be owned and operated by the government (or its public utility), or by a private sector company via a Power Purchase Agreement that typically lasts between 5 and 20 years.^[11] In Yemen, there are currently no utility-scale solar power plants in existence.

It is not currently feasible to build utility-scale solar projects in Yemen with funding from the state budget due to the current fiscal situation. Therefore, any such projects can only materialise either through a Public-Private Partnership (PPP) model or with funding from international donors.

On the international donors' front, the Ministry of Electricity and Energy (MoEE) in Aden announced, in December 2022, the signing of a cooperation agreement with the United Arab Emirates' Masdar, the Abu Dhabi Future Energy Company, to finance and build a 120MW solar power generation plant in Aden. The agreement also includes the construction of transmission lines and substations for the transmission and distribution of electricity generated by the plant.^[12] This project will be the first donor-funded project in the utility-scale solar sector in Yemen and can serve as an important pilot if it moves forward to implementation.

Before this, in early 2020, the MoEE and the Public Electricity Corporation (PEC) in Aden announced a tender that aimed to install seven solar power projects with a total capacity of 97MW under a Build-Own-Operate-Transfer (BOOT) model.^[13] The tendering process faced a number of obstacles and had still not concluded successfully at the time of writing this brief. The key challenge has been a lack of sufficient legal and financial guarantees to attract competitive bids and give sufficient confidence to investors to take the investment risks entailed in such projects.

The International Finance Corporation (IFC) is currently evaluating possible investments in this sector in Yemen, which could potentially improve the prospects of launching the first private sector investment in utility-scale solar power under a BOOT model.

[11] "Utility-scale solar: what is it, how does it work?," Solar Reviews, 22 September, <https://www.solarreviews.com/blog/how-does-utility-scale-solar-work> (Accessed 26 November 2022).

[12] "Agreement to build the first project to generate electricity by solar energy in Aden," MoEE, 2022, <https://moee-ye.com/site-ar/2352/> (Accessed 29 December 2022).

[13] "Tenders for supply, installation, testing, commissioning, operating & maintenance solar power plant under Build-Own-Operate-Transfer (BOOT) model," MoEE, 2020, <https://moee-ye.com/site-ar/897/> (Accessed 2 December 2022).

The key challenge facing the participation of private sector investors in utility-scale solar projects in Yemen is addressing the high political and economic risks. Such projects require higher upfront investments and longer payback periods, and investors therefore require clear and transparent procurement processes (e.g., auctions, Feed-in Tariffs etc.), a clear legal and regulatory framework, sufficient financial guarantees, and access to innovative financing instruments that could de-risk some areas of the investment. In addition to the challenge of high political and economic risks, other challenges include the deteriorated state of the national grid and electricity distribution networks, the lack of experience of Yemeni companies in developing large-scale projects, and the management of social and environmental risks related to land use (given the large areas of land required for such projects).

3.2 Solar Mini- and Micro-Grids

A mini-grid can be defined as “a set of small -scale electricity generators interconnected to a distribution network that supplies electricity to a small, localised group of customers. It usually operates independently from the national transmission grid,”^[14] but can be eventually connected to the national grid once it reaches that location.^[15] The generation capacity of a mini-grid usually ranges from 10kW to 10MW, with a smaller generation capacity of 1kW to 10kW referred to as micro-grids.^[16]

Renewable energy mini-grids (especially solar, wind, or hybrid) are cost-effective and viable options to provide reliable and high-quality electricity, especially to rural populations and businesses. Mini-grids can be owned by the private sector, community-based organisations, the public utility, or a combination of all three.

Since the beginning of the current conflict, private diesel-operated mini-grids have emerged to serve urban areas that the public utility stopped providing for, especially in Ansar Allah-controlled areas. However, renewable energy mini-grids have only recently been piloted with support from donor funding.

The successful results from three micro-grid pilots (up to 20kW each), set up by local community microenterprises and supported by the United Nations Development Programme (UNDP) in rural areas of Yemen, led to additional funding from the European Union (EU) and Sweden to implement 163 micro-grids by 2025.^[17] In addition, UNDP (under the same EU/Sweden funded program) is currently piloting a hybrid solar/wind mini-grid with a capacity of approximately 200kW in Al-Shamayatain district in Ta’iz.

[14] “What’s so important about mini-grids?,” UNIDO, 2021, <https://www.unido.org/stories/whats-so-important-about-mini-grids> (Accessed 3 December 2022).

[15] “Mini Grids,” USAID, 2018, <https://www.usaid.gov/energy/mini-grids/policy/national-planning> (Accessed 3 December 2022).

[16] “Mini-Grid Policy Toolkit,” Africa-EU Renewable Energy Cooperation Programme (RECP), <https://cutt.ly/k8D9jTR> (Accessed 3 December 2022).

[17] “A Yemeni Frontline Woman Inspires 163 Communities,” UNDP, March 17, 2022, <https://www.undp.org/yemen/stories/yemeni-frontline-woman-inspires-163-communities> (Accessed 2 December 2022).

The impact of solar mini- and micro-grids extends beyond improving electricity access, as the business model of such projects provides livelihood and economic empowerment opportunities especially for women and youth. A success story from the three micro-grid pilots by UNDP is that one of them is owned and managed by a group of women, who have now been able to generate sufficient income and establish themselves as an inspiration to their community.^[18]

There is significant potential to reduce the cost of electricity generation and scale up energy access in Yemen by hybridising existing diesel-based mini-grids with solar energy or developing new solar and hybrid solar/wind mini- and micro-grids. However, this will require overcoming a number of challenges including the absence of government policies, incentives, and regulatory frameworks for mini-grids; the lack of focus on this sector by central authorities, which are typically preoccupied with large generation projects in key urban centres; the lack of innovative financing models to scale up investments in this sector (e.g., results-based financing facilities); low awareness levels of renewable mini-grids and available opportunities amongst communities and the private sector; and affordability challenges on the consumer side given the overall macroeconomic situation in Yemen.

[18] Ibid.

3.3 Small- and Medium-Scale Solar Systems

Small and medium-scale solar systems are used to electrify households, public facilities (such as schools or health clinics), commercial/agricultural consumers (such as retail shops or farms), and others. On-grid solar systems can be used in areas where the national grid and/or mini-grids are available. In contrast, stand-alone or off-grid solar systems, which include energy storage systems, are usually used by a single household/facility/establishment, so they are used in the areas where the national grid and/or mini-grids are unavailable or infeasible.

Stand-alone small solar systems have been the most common solar applications used in Yemen since the conflict started, especially in the central and northern areas of the country where public electricity ceased to be provided. By 2019, it was estimated that 75 percent of the population were relying mainly on stand-alone solar systems, mostly used for lighting,^[19] and the installed capacity of solar PV in Yemen reached 500 MWp in 2017.^[20]

This sector has also been the most attractive for funding from large donors such as the World Bank,^[21] the EU and Sweden^[22]/SIDA,^[23] amongst others. These donors have allocated over USD 200 million to provide public service facilities, agricultural users, and households with solar systems either directly or by subsidising them through microfinance institutions. However, there is still a significant need in this sector.

The key challenge facing this sector is the high upfront costs of these systems, further complicated by the double taxation and customs levied on all imported goods (including solar energy products) by the fragmented authorities, and the import restrictions on solar energy products enforced in most Yemeni ports.^[24]

The high costs make these systems out of reach for the majority of the population due to its low purchasing power and lack of affordable access to finance solutions. In the absence of national quality standards for solar components, this has led to the market being dominated by cheap poor-quality products which break down or require replacement shortly after purchase.

[19] Naoko Kojo and Amir Althibah, "Yemen Monthly Economic Update," World Bank, March 2020,

<https://documents1.worldbank.org/curated/en/339571587498517757/pdf/Yemen-Monthly-Economic-Update-March-2020.pdf> (Accessed 2 December 2022).

[20] Dawud Ansari et al., "Yemen's solar revolution: Developments, challenges, opportunities," February 2019, https://eadp.eu/uploads/WP201902_Yemen_Solar_EN.pdf (Accessed 2 December 2022).

[21] "World Bank Increases Funding to Expand Electricity Access in Yemen," World Bank, June 2020,

<https://www.worldbank.org/en/news/press-release/2022/06/30/world-bank-increases-funding-to-expand-electricity-access-in-yemen> (Accessed 2 December 2022).

[22] "Supporting Resilient Livelihoods and Food Security," UNDP, <https://www.undp.org/yemen/erry-jp> (Accessed 2 December 2022).

[23] "Supporting Resilient Livelihoods and Food Security in Yemen Joint Programme (ERRY II)," UNDP,

<https://www.undp.org/yemen/projects/supporting-resilient-livelihoods-and-food-security-yemen-joint-programme-erry-ii> (Accessed 2 December 2022).

[24] Dawud Ansari et al., "Yemen's solar revolution: Developments, challenges, opportunities," February 2019, https://eadp.eu/uploads/WP201902_Yemen_Solar_EN.pdf (Accessed 2 December 2022).

Combined with weak technical knowledge and capacity in the market and poor after-sale services, this vicious cycle has been threatening the sustainability of the stand-alone solar market in Yemen as consumers increasingly lose trust in solar-based systems and solutions after having negative experiences.^[25]

An additional challenge in this sector is the environmental impact. There are currently no proper waste management policies or mechanisms in place to process used solar PV systems components, such as batteries and solar panels, which include significant amounts of recyclable as well as toxic materials.

[25] "Boosting Access to Affordable Solar Energy in Yemen," World Bank, July 2022, <https://www.worldbank.org/en/results/2022/07/18/-boosting-access-to-affordable-solar-energy-in-yemen> (Accessed 2 December 2022).

4. The Role of the Private Sector

As evident in the previous section, the private sector can play a critical role in scaling up solar power generation in Yemen, especially in the utility-scale and mini-grids sectors. Public-Private Partnerships (PPPs) are long-term contracts between public and private sector parties for procuring and implementing infrastructure projects and/or providing services. Under PPP mechanisms, the public and private sector parties share risks and responsibilities, enabling the private sector to provide capital and expertise to build infrastructure, and government institutions to focus on policy, planning, and regulation.^[26] Figure 4 shows the different modalities of private sector participation.

Figure 4: Private sector participation modalities



Source: IISD, "Harnessing the Power of Public-Private Partnerships: The role of hybrid financing strategies in sustainable development," 2012, <https://d3i71xaburhd42.cloudfront.net/5136ed51fab441cfa5109a2414cc6f273eb7b4f7/8-Figure1-1.png> (Accessed 18 November 2022).

Investments in the power generation sector in Yemen in general, and specifically in solar renewable power generation, require significant institutional and financial capacity that the public sector currently lacks. That is why partnering with the private sector can represent a key part of the solution to the challenges in the electricity sector. The Electricity Law No.1 of 2009, which is the main legal framework governing the electricity sector in Yemen, recognised the value of the private sector and included provisions to allow several models of private sector participation such as leasing facilities, Operation and Management (O&M), Build-Operate-Transfer (BOT) and Build-Own-Operate-Transfer (BOOT).^[27] In addition to the provisions in the Electricity Law, a PPP law was drafted in Yemen in 2014, but the conflict erupted before it was ratified by parliament.^[28]

Currently, apart from supplying spare parts and maintenance services through contracts with the Public Electricity Corporation (PEC), private sector participation in the electricity sector in Yemen is limited to three models. The first model, which started in the early 2000s and continues to be practiced by the PEC in the

[26] "About Public-Private Partnerships," World Bank, <https://ppp.worldbank.org/public-private-partnership/about-public-private-partnerships> (Accessed 18 November 2022).

[27] "Electricity Law No. 1 of 2009," MoEE, 2009, <https://moee-ye.com/site-ar/302/> (Accessed 26 November 2022).

[28] "Draft Public Private Partnership Law," MOEE, 2014, <https://moee-ye.com/site-ar/438/> (Accessed 26 November 2022).

IRG areas, consists of short-term contracts (often six months to one year) signed by the PEC with private companies, which own power stations consisting of small diesel generators and which supply electricity to the grid while the government supplies them with the fuel.

The second model, which emerged after the conflict primarily in Ansar Allah-controlled areas, consists of small private owners of diesel generators supplying electricity to consumers directly in certain neighbourhoods or districts. In December 2022, a Prime Minister's decree was issued by the Ansar Allah in Sana'a to regulate the activities related to private diesel generators.^[29] The MoEE in Sana'a has also issued a tariff table for the electricity sold by private generators that takes into consideration the fluctuation of the diesel prices in the market in order to regulate the price of privately supplied electricity.^[30]

A third model has also emerged in Sana'a, where concessions have been granted to two private sector companies to distribute electricity produced by public power plants and collect the bills from consumers. None of the current models utilise solar energy and they have led to an expensive and inefficient provision of electricity to consumers due to reliance on costly and polluting fossil fuel (e.g., diesel). In addition, they have evolved without a strategic vision and lack any proper evaluation.

[29] "Prime Minister Decree No. (33) for the year 1444 AH regarding the regulation of the temporary activity of owners of electric generators, for the generation and distribution of electric power to consumers," MoEE, December 2022, <https://bit.ly/3YZ83zR> (Accessed 30 December 2022).

[30] "The Ministry of Electricity announces the new price per unit of electricity sold," MoEE, December 2022, <https://www.moee.gov.ye/en/news/topic/279> (Accessed 30 December 2022).

5. Key Recommendations

Electricity is an absolute prerequisite for the transition out of the current humanitarian crisis and for economic growth in Yemen. A paradigm shift is needed to address the energy crisis in Yemen and kickstart meaningful economic activity that could provide jobs and livelihoods to Yemenis.

Government entities need to shift from an exclusive focus on large, fossil fuel-based centralised power generation plants, to a stronger prioritisation of smaller, distributed renewable power generation plants. This paradigm shift also requires empowering local authorities and local PEC branches with decision-making powers to take the lead in this sector.

International donors need to shift from an overemphasis on supporting small stand-alone solar systems delivered by international non-governmental organisations and development agencies, to a stronger prioritisation on innovative financing models and market-creating interventions supporting the sustainability of the sector at scale.

Establishing a coordination mechanism, such as a cluster or a working group, for renewable energy in Yemen that brings together international development institutions, relevant government authorities, private sector representatives and international organisations active in the field, is critical to ensuring a collective and more effective approach to scaling up this sector.

The following sub-sections provide a short list of practical recommendations that are feasible to implement within the current context of Yemen to scale up investments in the different sub-sectors of solar energy provision.

5.1 Utility-Scale Solar Projects

- The National Strategy for Renewable Energy and Energy Efficiency needs to be updated, setting realistic targets and an executable action plan. This can be supported by the World Bank's Yemen Emergency Electricity Access Project that was announced recently. It could also benefit from conducting a Renewable Readiness Assessment through the International Renewable Energy Agency (IRENA) of which Yemen is a member country,^[51] and can incorporate outputs from UNDP's recent study "Yemen Renewable Energy Investment Planning and Design".

[51] "Renewable Readiness Assessment (RRA)," IRENA, <https://www.irena.org/Energy-Transition/Country-engagement/RRA> (Accessed 30 December 2022).

- Since it is unlikely that any new laws will be legislated by parliament in Yemen in the near future, focus should be on creating policy and procurement instruments and model PPP contracts that can regulate the relationship between the public sector and private investors. Existing projects to provide advisory services and technical assistance by the World Bank, EU, and IFC can provide valuable support in this area.
- International donors, especially large regional ones such as donors from the Gulf Cooperation Council (GCC), should consider utilising some of their funds to establish innovative financing mechanisms that can catalyse private sector investments in renewable energy. Examples of such mechanisms include USAID's USD 10 million incentive funding that employs an innovative reverse auction platform to select an Independent Power Producer (IPP) to build, own, and operate a 10MW Kandahar Photovoltaic Power Plant in Afghanistan. This enabled the first-ever private sector investment in Afghanistan's renewable energy sector which began commercial operation in October 2019.^[32] Another example is the EUR 50 million program of financial guarantees by the EU and European Bank for Reconstruction and Development (EBRD) aimed at scaling up renewable energy investments in Ukraine, Jordan, Lebanon, and Tunisia. The program aims to provide guarantees in order to allow the lenders, e.g., local commercial banks, to finance projects alongside EBRD loans. It is expected that the guarantees will help generate total investments of up to EUR 500 million.^[33]
- In considering any utility-scale solar project, attention should be paid to environmental and social considerations, especially those related to the use of land to avoid creating new conflicts.
- Beyond electricity generation, a decentralised concession model which extends from generation to distribution should be considered. Yemen's legacy with local cooperatives can be built on, and concessionaires can comprise consortiums of private sector, public sector, and local cooperatives (or investors) from the target district/governorate.

[32] "10 MW Kandahar Solar Power Plant," USAID, December 2017, <https://vdocuments.mx/10-mw-kandahar-solar-power-plant-built-and-operated-power-plant-of-this-capacity.html?page=1> (Accessed 3 December 2022).

[33] "EBRD and EU agree €50 million financial guarantee to boost renewable energy in EU Neighbourhood", EBRD, January 2022, <https://www.ebrd.com/news/2020/ebrd-and-eu-agree-50-million-financial-guarantee-to-boost-renewable-energy-in-eu-neighbourhood.html> (Accessed 3 December 2022).

5.2 Solar Mini- and Micro-Grid Projects

- Establish regulations under the existing legal framework to organise the scaling up of renewable mini- and micro-grids.
- International donors and development agencies should consider establishing results-based financing facilities, such as the Universal Energy Facility (UEF), which provides results-based financing for verified energy connections across Africa.^[54] The UEF is currently supporting mini-grid development in Benin, Madagascar, and Sierra Leone.
- International donors and development agencies that are currently piloting renewable micro-grids and mini-grids, such as the EU, World Bank and UNDP, should set an objective for these pilots to serve as a catalyst for replication by private sector and community-based organisations, and not only be used to make the case for further donor funding for development agency interventions in the sector. To do this, the details of these pilots, including feasibility studies, technical specifications, business models, detailed financial performance results, and other information should be made available publicly and promoted to the relevant stakeholders using a variety of outreach activities.
- Renewable community-based energy projects have huge potential in Yemen, especially in the small and scattered rural areas that are not attractive for the private sector. Governmental and non-governmental organisations (e.g., UN agencies, local councils, civil society organisations, General Authority for Rural Electrification, etc.) can play an important role in raising awareness of the positive impact of community-based mini-grids, developing the capacity of communities to manage projects, supporting participatory governance structures at the community level that can contribute to project success, and providing financial support.

[54] "Universal Energy Facility," Sustainable Energy for All, <https://www.seforall.org/results-based-financing/universal-energy-facility> (Accessed 3 December 2022).

5.3 Small- and Medium-Scale Solar Systems

- Interventions to increase access to finance at reasonable interest rates and repayment periods through, for example, revolving funds should be supported by international donors to encourage a more widespread and equitable adoption of these systems.
- National quality standards should be adopted for solar energy products. Although enforcement of the standards in the market is not feasible given the current situation and enforcement capacity in most of Yemen, adopting national quality standards will allow some market corrections and can at least be enforced to some extent at entry ports for products imported through formal channels.
- Programs and campaigns by civil society organisations can be supported by government entities and donor programs to build technical and vocational capacity and to raise awareness of standards and best solar system design practices amongst consumers.
- Import restrictions on solar energy products should be lifted, and incentive programs (such as tax and customs exemptions) considered.
- Proper policies and processes for the disposal and waste management of used solar system components (e.g., batteries and solar panels) should be developed and adopted.

About the Authors:

Akram Almohamadi is an energy researcher working as a Sustainable Energy Expert at the Regional Center for Renewable Energy and Energy Efficiency (RCREEE), Egypt. He has sound experience in energy policies and regulatory frameworks, renewable energy, energy efficiency, project management, research, and analysis. He participated in the implementation of several projects related to renewable energy, power sector, and energy efficiency in the Arab region, including Yemen. He has also led several research projects funded by international organizations such as the World Bank, EU, UNDP, UNOPS, and UNEP, amongst others.

Rafat Ali Al-Akhali is a development practitioner dedicated to addressing development challenges in fragile and conflict-affected situations. He is the Convenor of the Council on State Fragility at the Blavatnik School of Government, University of Oxford. He previously managed the LSE-Oxford Commission on State Fragility, Growth, and Development and led the secretariat of Pathways for Prosperity Commission on Technology and Inclusive Development. He previously served as a Minister in the Government of Yemen and, prior to that, led the government's policy reforms team. He holds a master's degree in public policy (MPP) from the University of Oxford and a master's degree in business administration (MBA) from Ecole des Hautes Etudes Commerciales (HEC), Montréal, Canada.

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