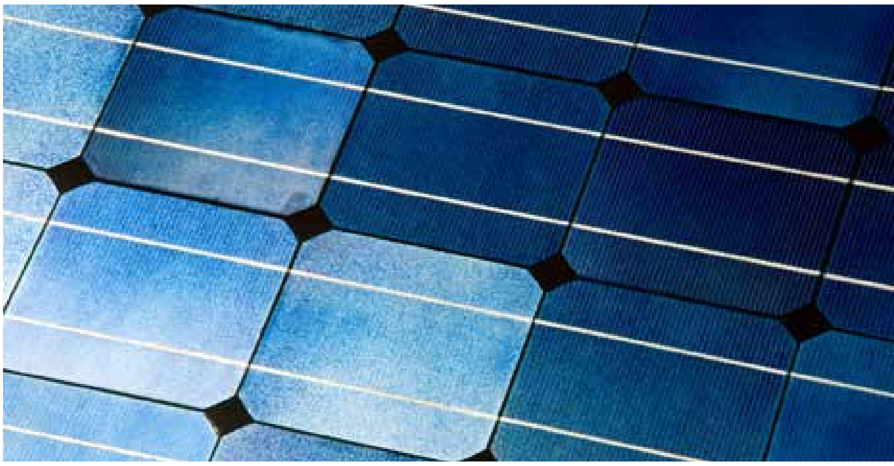
UNHCR
The UN Refugee Agency

IRENA
International Renewable Energy Agency

RENEWABLES
FOR REFUGEE SETTLEMENTS

SUSTAINABLE ENERGY ACCESS IN HUMANITARIAN SITUATIONS



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About IRENA

The International Renewable Energy Agency (IRENA) is an intergovernmental organisation that supports countries in their transition to a sustainable energy future and serves as the principal platform for international co-operation, a centre of excellence, and a repository of policy, technology, resource and financial knowledge on renewable energy. IRENA promotes the widespread adoption and sustainable use of all forms of renewable energy, including bioenergy, geothermal, hydropower, ocean, solar and wind energy, in the pursuit of sustainable development, energyaccess, energy security and low-carbon economic growth and prosperity.

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Sustainable energy bridges
the gap between humanitarian
response and development,
lets refugees pursue education,
supports businesses and social
enterprises, spurs innovation
and exponentially enhances
the well-being of people
and communities

KEY FACTS

- The International Renewable Energy Agency (IRENA) is helping the UN Refugee Agency, UNHCR, address the need for **efficient, clean, affordable and reliable energy** in humanitarian situations.
- IRENA has contributed to UNHCR's ***Global Strategy for Sustainable Energy 2019-2024***.
- The present study examines energy needs at **four refugee settlements** served by UNHCR and other humanitarian partners in Iraq and Ethiopia.
- In Iraq, **blackouts and brownouts** remain frequent even at grid-connected settlements, leaving refugees and the humanitarian community dependent on expensive, polluting diesel generators.
- In Ethiopia, most refugees **lack any reliable access** to electric lighting.
- Standalone solar systems with battery banks could **cushion the impact** of voltage fluctuations on the grid.
- Larger solar parks can supply **electricity in and around settlements** while providing an **enduring asset** for host communities.
- Solar mini-grids can boost the efficiency of humanitarian operations, **avoid costly diesel consumption**, and support first-time refugees with immediate, reliable electricity access.

FOREWORD

As the world enters a new decade focused on Sustainable Development Goals, more than 70 million people are displaced from their homes. About 26 million, mostly under 18 years old, endure as refugees abroad, where unreliable energy supply often exposes them to additional and unnecessary risks.

The refugee energy challenge, however, can be met effectively and sustainably. On-site solutions based on renewable sources are increasingly available and affordable, as well as clean and climate-safe.

Developed in co-operation with UNHCR, this study examines energy needs and identifies renewable-based solutions for refugee sites in Iraq and Ethiopia. It highlights prime opportunities to strengthen any humanitarian operation which can be replicated in other similar situations.

Energy improves safety, security, productivity and health in refugee settlements. Sustainable energy access bridges the gap between humanitarian response and development, lets refugees pursue education, supports businesses and social enterprises, spurs innovation and exponentially enhances the well-being of people and communities. The benefits extend beyond refugee settlements to host countries, humanitarian organisations and the environment.

Renewables deliver quick and substantial returns in the humanitarian context. I hope this report facilitates the uptake of such solutions, which could soon become essential to the humanitarian toolkit.

Francesco La Camera
Director-General, IRENA

Photograph: Shutterstock

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This study aims to help address the need for efficient, clean, affordable and reliable energy in humanitarian situations

ABBREVIATIONS

AC	alternating current
ARRA	Administration for Refugee and Returnee Affairs
DC	direct current
ELPA	Ethiopian Electric Power
ETB	Ethiopian Birr
IFC	International Finance Corporation
IQD	Iraqi dinar
IRC	International Rescue Committee
IRENA	International Renewable Energy Agency
JCC	Joint Crisis Coordination centre
KRI	Kurdish region in Iraq
kVA	kilovolt-ampere
kW	kilowatt
kWh	kilowatt-hour
LED	light-emitting diode
LPG	liquefied petroleum gas
MW	megawatt
NRDEP	Natural Resources Development and Environmental Protection
O&M	operations and maintenance
PAYG	pay as you go
PoC	persons of concern to UNHCR, which includes refugees, returnees, stateless people, the internally displaced and asylum-seekers
PPA	power purchase agreement
PV	photovoltaic
SDG	Sustainable Development Goal
USD	United States dollar
UNHCR	United Nations High Commissioner for Refugees
Wh	watt-hour

EXECUTIVE SUMMARY

- With the number of refugees and globally displaced people reaching alarming numbers, the world is witnessing an unprecedented level of human displacement. Most refugees and displaced persons rely on energy resources that are unsustainable and that pose high risks to their health and well-being. Renewable energy in refugee settlements can help in quickly spurring socio-economic development in addition to enhancing safety, security, productivity, and health for refugees, host countries and humanitarian organisations.

- The report provides a summary of the collaboration between IRENA and UNHCR in assessing four refugee settlements in Iraq and Ethiopia to identify the ideal renewable energy solutions to provide the refugees and the humanitarian organisations operating in the settlements with clean, cost-effective and reliable energy.

- The report presents findings and recommendations based on data collection from a field mission to the Darashakran and Domiz refugee settlements in Iraq from 7 to 20 September 2019 and a mission to the Tsore and Sherkole refugee settlements in Ethiopia from 22 September to 4 October 2019. The data collection consisted of household surveys with the refugees, focus group discussions with community leaders, interviews with humanitarian organisations and government representatives, as well as detailed energy assessments of infrastructure and facilities operated by humanitarian organisations.

- The study found that, generally, little information is available on the generation and distribution of electricity in refugee settlements. Information is lacking on the consumption of electricity among refugees as well as by support facilities such as offices, schools and health clinics. Simple steps on data collection, validation, processing and analysis could be taken to provide a background for improving service delivery through, for example, increasing the availability and utilisation of renewable energy.

- While humanitarian organisations have increased the deployment of renewable energy systems to support infrastructure in refugee settlements, more attention to proper operation and maintenance is needed to fully capitalise on the benefits. Examples of deployed systems include the use of solar installations at boreholes for water extraction, which has reduced the reliance on diesel generators, and the increasing distribution of solar street lights in all the settlements visited. However, the lack of routine maintenance of the renewable energy infrastructure has, for example, resulted in inefficiencies due to dirty solar panels and assets not being repaired.

- Although refugees and humanitarian organisations are connected to the national grid at the assessed settlements in Iraq, frequent power cuts and drops in voltage make operating electrical appliances a challenge. To compensate, refugees rely on diesel generators operated by humanitarian organisations and by private neighbourhood grid suppliers that connect households, which increases energy-related costs and emissions. Standalone solar systems and larger grid-tied solar power plants can increase the sustainability of the electricity supply in the settlements.

- The lack of access to energy for cooking poses a high security risk for refugees in Ethiopia. The refugees are highly dependent on collecting firewood in areas around the settlements, which has led to degradation of forests and conflicts with the host communities. Refugees that collect firewood reported on risks of abuse and harassment when collecting firewood, with many expressing that, as a result, they had insufficient fuelwood for cooking. Market-based approaches can increase the refugees' access to sustainable energy for cooking and greatly increase refugees' protection.

- The results showed that all households in Iraq had access to electricity either through the grid or via diesel gensets for 16 to 24 hours daily, and that in Ethiopia, only 7% of the refugees had electricity access through a generator for roughly 4 hours daily.

- The energy assessments in the four refugee settlements have also highlighted the various benefits that can be achieved with the deployment of renewable energy solutions. Large solar arrays and standalone solar systems in Iraq can largely reduce the voltage fluctuations in the local grid and provide reliable and cost-effective electricity to the refugees, humanitarian organisations and host communities. Solar mini-grids in Ethiopia can aid in reducing the exorbitant cost and consumption of polluting diesel generators in the settlements and provide the refugees with reliable electricity for everyday purposes.

- Solutions for de-risking the technical and financial aspects of renewable energy solutions are becoming more widely available, also in humanitarian settings. Different arrangements such as leasing and power purchase agreements can enable the private sector to take ownership of the electricity supply, while enabling humanitarian organisations to maintain their financial and operational practices during the transition to renewable energy, with associated economic, financial, environmental and social benefits.

- This report could represent a blueprint for implementing renewable energy solutions in refugee settlements at different tiers of energy access. It includes possible business models that can be considered in humanitarian settings for increasing the uptake of renewables and enabling the participation of private actors in the supply of renewable energy in humanitarian operations. It can also be used as a template for energy assessments done by different organisations in the humanitarian context.


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1. INTRODUCTION AND BACKGROUND

The world is witnessing an unprecedented level of human displacement, as confirmed in the latest Global Trends report from the office of the United Nations High Commissioner for Refugees (UNHCR). According to UNHCR, around 70.8 million people globally have been forced from their homes, among them nearly 25.9 million refugees, over half of whom are under the age of 18 (UNHCR, 2019a).

Most refugees depend on energy resources for everyday use that pose risks to their security, safety and well-being. Furthermore, when responding to other urgent needs, humanitarian organisations may not be able to adequately address or prioritise requirements pertaining to access to safe, reliable and clean energy for persons of concern (PoC). With insufficient funding as well as limited policies and practices on sustainable and clean energy provision within the humanitarian community, current energy practices in refugee settlements are often inefficient, polluting, unsafe for the users and damaging to the surrounding environment.

Access to clean and sustainable energy can deliver quick returns in humanitarian settings, such as enhancing protection, safety, security, productivity, and health for PoC, host communities, humanitarian organisations and the environment. It can also serve as a powerful means for bridging the gap between humanitarian response and development; create opportunities to pursue education, businesses and social enterprises; and spur innovation.

UNHCR and its partners rely highly on diesel generators to provide refugee settlements with electricity for common everyday needs, such as lighting, as well as to operate the infrastructure and services in the settlements. Apart from the environmental and health-related drawbacks, this results in high costs, underpinning the urgency for delivering reliable and cost-effective sustainable energy solutions in refugee settings. UNHCR spends more than USD 35 million annually on diesel fuel to produce electricity, including funds given to partners for the same purpose.[1]

UNHCR also needs to pay for security, maintenance and operation costs for generators, in addition to logistics costs for delivery and storage of diesel and spare parts. In most refugee settlements, the generators are mostly oversized with minimal controls or monitoring, and many issues exist with regard to generator maintenance and fuel theft, resulting in higher replacement and fuel costs. The methods used by UNHCR and its partners to generate and consume electricity do not make the best use of modern technologies, equipment and potential efficiencies.

At most of the refugee settlements there is minimal metering of energy (unless electricity is supplied through the grid). This causes difficulties for UNHCR or partner staff in actually calculating the potential savings that could result from the deployment of renewable energy, energy conservation practices and energy efficiency solutions that are meant to optimise the energy supply and usage. UNHCR does not have relevant or reliable data on diesel consumption or energy use at most of the field locations, necessitating expert assessments to obtain these data, which are essential to define actual energy needs and to evaluate optimal solutions.

IRENA and other development partners are supporting UNHCR in addressing the issue of efficient, clean, affordable and reliable energy supply in PoC settlements, with each partner focusing on its individual areas of expertise and geographical focus.

1 Based on estimates provided by UNHCR.

For this purpose, IRENA has supported UNHCR in addressing the issue of efficient, clean, affordable and reliable energy supply in four selected refugee settlements. IRENA intended to tackle the issue of unavailability of reliable energy data and to analyse technically and financially sound renewable energy options for UNHCR to implement in the selected field locations.

The present report encompasses the collaboration between IRENA and UNHCR in performing detailed energy assessments of four selected refugee settlements and presents the findings and renewable energy solutions identified to provide the refugees with clean, reliable and affordable energy for everyday purposes, as highlighted in UNHCR (2019b).

As part of this collaboration, IRENA also contributed to UNHCR's new Global Strategy for Sustainable Energy 2019-2024. One of the main objectives of this new strategy is to increase the use of renewable energy sources to minimise environmental impact, in a manner that also includes the host communities and other stakeholders while at the same time improving the protection and well-being of refugees. To deliver appropriate, clean and sustainable energy solutions in displacement settings, the current and expected energy needs of refugees, host communities and other stakeholders must be fully understood.

The four strategic priorities or action areas that have been identified by UNHCR to address over the course of this new strategy are:

1) increasing sustainable electrification of community and support facilities, while limiting overall energy consumption;
2) improving access to sustainable, safe and affordable household cooking energy;
3) addressing the energy needs of refugee households from the onset of an emergency; and
4) increasing sustainable household electrification (UNHCR, 2019b).

IRENA supported UNHCR in addressing the issue of energy supply in four selected refugee settlements. The overall objective of this collaboration is to assess the current and expected/future energy consumption in the four selected settlements and to identify solutions for a more reliable, affordable and environmentally friendly energy supply using clean and sustainable renewable energy resources.

The aim of this study is to identify clean, efficient and cost-effective solutions for everyday uses such as lighting, cooking and commercial activities / productive uses in households and communal and institutional settings in the refugee settlements, as well as to encourage the adoption of different market-based business models to achieve further cost reductions and better management of energy supply. A central objective of this study was also to propose a methodology for conducting energy assessments that humanitarian organisations can then use as a blueprint for conducting further assessments in refugee settlements across the world. This would allow UNHCR to have access to a standard data set for each of its operations, enabling consistent analysis and benchmarking. In this light, mission reports from Iraq and Ethiopia include comprehensive information on the activities conducted and on data collection tools used during the mission.

The geographical scope of the mission consisted of two UNHCR country operations, in Ethiopia (two refugee settlements) and Iraq (two refugee settlements). The study focused on two main types of situations or stages of a refugee settlement. The two settlements in Iraq are currently in a post emergency or early development phase, while the settlements in Ethiopia are in the development or protracted situation stage. Table 1 gives an overview of the selected UNHCR settlements where the detailed energy assessment and surveys for this collaboration took place.

Table 1. Overview of refugee settlements

Refugee settlement	Location	Current estimated population*	Refugee operation stage
Darashakran	KRI, Iraq	11 608	Post emergency / early development
Domiz 1 and 2	Duhok, KRI, Iraq	42 487	Post emergency / early development
Sherkole	Assosa, Ethiopia	10 619	Development (protracted situation)
Tsore	Assosa, Ethiopia	14 153	Development (protracted situation)

*Ethiopia updated as of 4 December 2019. Iraq updated as of 25 June 2018

This report presents four case studies to illustrate how such initiatives can be expanded upon to achieve four strategic priorities outlined in the UNHCR global strategy for sustainable energy (UNHCR, 2019b): addressing households' energy needs; improving access to cooking energy; expanding household electrification; and expanding sustainable electrification of community and support facilities. Each case study is then used to highlight challenges at three levels: households and residences, service delivery points and offices, as well as the settlement as a whole.

The findings and recommendations in the report are based on data collection from a field mission to the Darashakran and Domiz refugee settlements in Iraq from 7 to 20 September 2019, and a mission to the Tsore and Sherkole refugee settlements in Ethiopia from 22 September to 4 October 2019. The data collection consisted of a household survey of the refugees, focus group discussions with community leaders, interviews with humanitarian organisations and government representatives, as well as detailed assessments of compounds operated by humanitarian organisations. The key findings are discussed in the following sections, with recommendations for next steps based on the case studies discussed in the conclusions. For more detailed information on the scope of work, see the Annex.

The current report is the first deliverable of an ongoing collaboration between IRENA and UNHCR on renewable energy solutions for refugee settlements.

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2. KEY FINDINGS

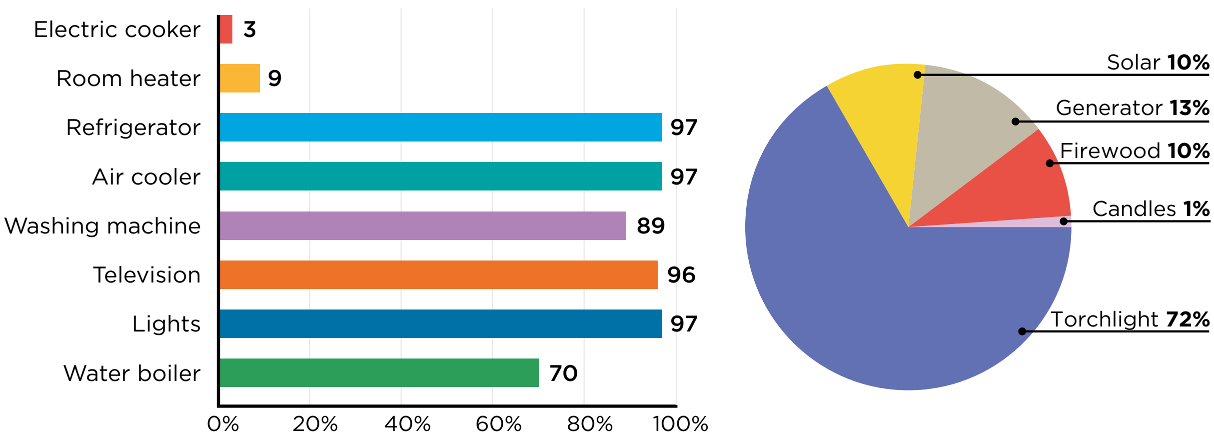
1. The energy situation for refugees reflects the development level of the host community.

Refugees' access to electricity was found to be very different in Iraq compared with Ethiopia. In Iraq, all households have access to electricity from either the national grid or neighbourhood diesel generators for 16 to 24 hours per day. In Ethiopia, 7% of refugees were found to have access to lighting from a generator for four hours per day. This discrepancy reflects differences in energy access in the host countries, where 100% of the rural population in Iraq had access to electricity in 2017 compared to only 31% of the rural population in Ethiopia (World Bank, 2019).

The energy situation for cooking also reflects national differences between Iraq and Ethiopia. Results from the household survey conducted during the mission show that all households in Iraq were found to use liquefied petroleum gas (LPG) in cook stoves as their primary cooking facility, which according to UNHCR is the most common cooking method in Iraq. In Ethiopia, 87% of the refugees responded that they used firewood in a traditional three-stone fire, reflecting national statistics indicating that 96% of Ethiopian household energy needs are fulfilled by wood, charcoal and dung (World Bank, 2018).

The access to electricity is also reflected in the electrical appliances that were present in households in Iraq and Ethiopia. The bar chart in Figure 1 shows the distribution of appliances in the Domiz refugee settlements in Iraq, while the pie chart shows the distribution of the main source of lighting in the Sherkole refugee settlement in Ethiopia. These figures were similar for the other settlements visited in Iraq and Ethiopia. The findings show that more than 95% of refugees in the Domiz settlements stated that they had cooling, refrigerators, televisions and lights, whereas, on the opposite side of the energy access spectrum, 67% of respondents in Sherkole stated that their main source of light at night was battery-powered torchlight.

Figure 1. Distribution of appliances in Domiz (left) and main lighting source in Sherkole (right)



2. Brownouts and blackouts lead to over-reliance on expensive diesel generators in Iraq.

While refugees and humanitarian organisations are connected to the national grid in Iraq, which provides free electricity to refugees, frequent cuts in operations and drops in voltage make operating electrical appliances challenging. To compensate, diesel generators are operated for 3-8 hours per day by humanitarian organisations and by private neighbourhood grid suppliers that are connected to all households, at a high electricity price. This greatly increases energy-related costs and emissions for refugees and humanitarian organisations. More details on this can be found in the Iraq section below.

3. The lack of access to energy for cooking poses a high protection risk for refugees in Ethiopia.

The refugees in Ethiopia are highly dependent on collecting firewood in areas around the settlements. This has led to degradation of the vegetation and to conflict with the host community on the use of forest resources. Refugees that collect firewood reported a high risk of abuse and harassment when collecting firewood, with many expressing that, as a result, they had insufficient fuelwood for cooking. Partly as a consequence, in the household survey 74% of the refugees responded that they had traded food rations for energy for cooking during the week prior to taking the survey. More details on this are found in the Ethiopia section below.

4. Large potential benefits arise from increasing the use of renewable energy in refugee settings.

The findings from both Ethiopia and Iraq illustrate the potential benefits for refugees and humanitarian operations of increasing the use of renewable energy in the refugee settlements. In Iraq, the inclusion of standalone solar systems with battery storage can reduce the impacts of voltage fluctuations in the grid. Furthermore, the installation of large solar parks can generate sufficient electricity to cover a significant share of the requirements of the refugee settlements and the host community, while providing an asset that will continue to generate electricity for decades to come – regardless of how long the settlement will be in place – as the host community will likely be there for longer than the life of the system.

In Ethiopia, connecting the offices to properly sized mini-grids can greatly increase the productive time and reduce the fuel waste related to running diesel generators at a very low load factor by up to 50%. Additionally, the deployment of a 60 kilowatt (kW) solar system with a 150 kilowatt-hour (kWh) battery bank would displace 60% of the current diesel consumption. Beyond reducing the operating costs of the humanitarian organisations, these grids can improve the power quality and be extended to directly supply electricity to refugees.

5. The lack of data leads to improperly sized electricity supply systems.

Overall, the available data were found to be lacking on the energy consumption of refugees, facilities and the offices, guesthouses and service delivery points of humanitarian organisations. Of the 78 facilities visited, only a handful had diesel consumption logs readily available, and none measured the electricity consumption. The general lack of awareness about consumption was evident in a mismatch between the size of the generators compared to the loads they were serving. While the timing of both missions to Iraq and Ethiopia was during periods of the year when there is typically low need to use energy-intensive climate control (air conditioners or heaters), 90% of the compounds included in the study were found to have oversized generators. Seventy-six percent of the generators were found to have an average load of less than 25% of the optimal running load of the generator, leading to fuel consumption losses of around 20% and to increased maintenance costs.

The fuel consumption losses due to poor load factor mean that the economic argument for investing in more efficient generation assets – such as solar photovoltaic (PV) systems with battery storage systems – is strong. To make sure that this equipment is appropriately sized, the organisations need to start logging the electricity consumed at all locations where they currently have access to electricity. The cheapest energy loggers can be bought for USD 60 and are easy to install. The monitors can be connected to the Wi-Fi of the office and can store information in an online platform. Alternatively, the monitors also have internal memory cards that record data, which would have to be manually downloaded from each logger, which is less practical than the Wi-Fi option. Having data on energy consumption for a representative year is a key element for optimising generation, including for the design of renewable energy systems. An example of such a monitor can be seen in Figure 2.

Figure 2. Efergy E2 monitor installed in a distribution box

Photograph: Kube Energy

Electricity data loggers can help with sizing renewable energy systems and finding ways to reduce consumption

3. SUSTAINABLE ENERGY ACCESS IN SITUATIONS OF DISPLACEMENT

In September 2015 the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development together with the 17 UN Sustainable Development Goals (SDGs), providing a framework for international co-operation to achieve both development and climate objectives and to achieve a better and more sustainable future for all. The SDGs outline a path to eradicate poverty while ensuring prosperity and protecting the planet and its inhabitants. Developed from the success of the Millennium Development Goals (MDGs), the SDGs have the objective to go further to eradicate all forms of poverty globally (IRENA, 2017).

3.1 Renewable energy and the Sustainable Development Goals

During the early negotiation period for the 2030 Agenda, energy was quickly recognised as essential to spur socio-economic development and meet the objective of completely eradicating poverty (Fuso Nerini et al., 2018). Therefore, a specific goal to ensure access to affordable, reliable and modern energy for all was included in the SDGs. SDG 7 has the aim of providing universal access to affordable and clean energy, and one of its main targets is to greatly increase the share of renewable energy in the global energy mix.

Figure 3. Interlinkages of SDG 7 with other SDGs

Based on IRENA (2017)

To achieve SDG 7, connecting households to the national grid is not enough to spur social and economic development. Instead, energy must be available in a reliable and affordable manner not only for households but also for local businesses and public services. New opportunities are being offered through improvements in and the declining costs of decentralised renewable energy technologies for delivering energy access specifically to remote areas and in displacement settings. Nevertheless, vast challenges remain in providing reliable and affordable electricity access to remote locations.

SDG 7 is closely interlinked with and indispensable for achieving most of the other SDG targets. The achievement of modern energy access for all is related to most of the SDGs and is key in developing the pathways necessary to keep the increase in global temperature well below 2 degrees Celsius. The interlinkages between SDG 7 and the correlated SDGs are illustrated in Figure 3.

In humanitarian settings, achieving modern energy access for all can aid in successfully meeting other SDG targets. The deployment of clean, renewable energy solutions in displacement settings can directly or indirectly support the achievement of most of the other SDGs, which are interlinked across the three dimensions of sustainable growth, environmental sustainability and human development (IRENA, 2017).

Decentralised renewable energy solutions in refugee settlements play a vital role in providing clean, cost-effective and reliable energy access. They can drastically reduce the costs incurred from supplying electricity using conventional polluting diesel generators and are therefore a prerequisite in eradicating poverty (SDG 1) as well as in spurring socio-economic development. Furthermore, clean water solutions such as solar-powered water pumps can aid in increasing food security and improving nutrition, which are essential for achieving zero hunger (SDG 2). Renewable-powered mini-grids can also be used to power refrigerators for storing and preserving food, thereby diminishing food waste. Solar water pumping solutions are essential for providing refugees and displaced people with clean drinking water (SDG 6).

A leading cause of death in displaced settings, particularly for women and children, is the pollution that comes from cooking with traditional biomass. With the use of improved cook stoves and renewable energy for cooking, this issue can be resolved. Renewables can also be used for powering hospitals and medical centres to refrigerate vaccinations and to power medical equipment, ensuring healthier lives and promoting the well-being of refugees and displaced people (SDG 3). Decentralised renewable solutions such as solar street lights, solar lamps, solar home systems and mini-grids with storage can also aid in providing clean and reliable electricity for lighting schools at night and improving education (SDG 4).

The deployment of renewable technologies and clean energy for cooking are key in achieving gender equality and in empowering women and girls (SDG 5). For example, with improved cook stoves women no longer would be subject to gender-based violence from collecting firewood for cooking. Systems such as solar street lights could improve the safety of women at night and allow them to attend community or educational activities after dark. Renewables are key in providing decent work and economic growth (SDG 8), in building resilient grid and transport infrastructure (SDG 9), and in creating jobs and small businesses, which then lead to overcoming barriers to development and reducing inequality (SDG 10).

Access to clean and renewable energy (SDG 7) is also directly or indirectly interlinked with SDGs 11 (sustainable cities and communities), 12 (responsible consumption and production), 13 (climate action), 14 (life below water), 15 (life on land), 16 (peace, justice and strong institutions) and 17 (partnerships for the goals).

3.2 Tiers of energy access

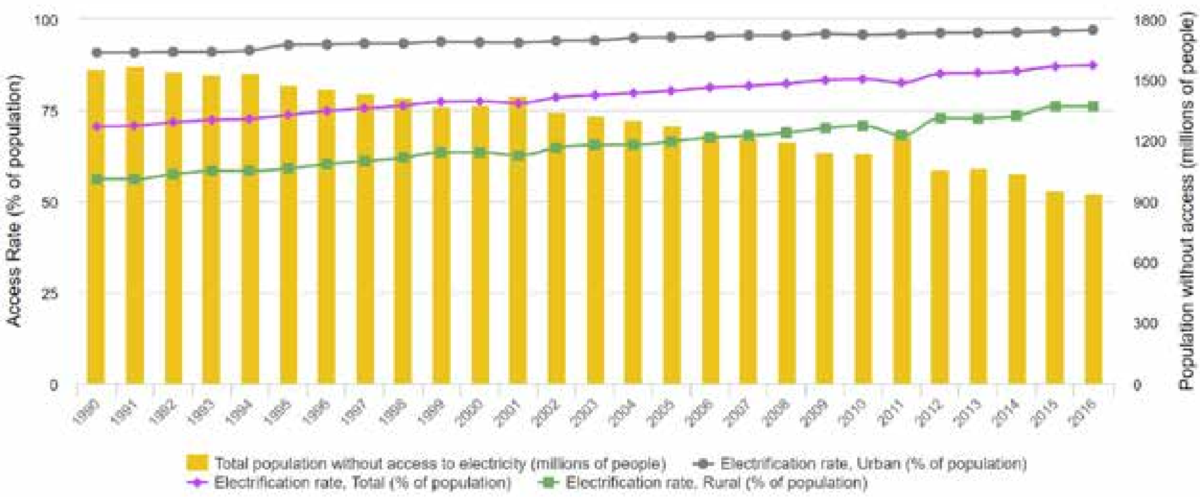
Although access to electricity has advanced more rapidly in recent years compared to historical trends, it remains a critical issue. As of 2018 around 850 million people worldwide still did not have access to electricity (IEA, 2019), making the deployment of sustainable and low-carbon electrification solutions crucial, both to achieve universal access for all (SDG 7) and fulfil the Paris Agreement. Of the current population living without access to electricity, around 95% is in Asia and sub-Saharan Africa.

The latest global roadmap prepared by IRENA (IRENA, 2019), illustrates that even though the power sector has seen a significant amount of decarbonisation, the progress of the energy transition needs to be accelerated, and the global energy system must undergo a profound transformation to replace conventional fossil fuels. Figure 4 shows the progress in global electricity access from 1990 to 2017.

Energy access remains a serious challenge, especially in humanitarian settings, with most refugees not having access to clean, reliable or cost-efficient energy for everyday purposes, and often not even for basic lighting. Where electricity is available from the local grid, it is usually very unstable, with frequent power outages, leading humanitarian agencies to rely on expensive and polluting diesel generators to supply electricity as back-up for the grid. In locations where the grid is not present, humanitarian organisations usually rely almost exclusively on diesel generators to supply refugees or displaced persons with electricity, when this is at all possible. Access to clean, renewable energy in displacement settings can spur socio-economic development and is needed for multiple applications across households, community infrastructures (for example, medical centres, schools, local businesses, offices) and productive uses.

An important parameter required for identifying and quantifying the future electricity demand of a specific location is the target level of electricity access. This involves estimating the electricity consumption per person per year depending on the appliances used or expected to be adopted in the household, also accounting for affordability. The six tiers of energy access, along with their indicative daily consumption per household and the typical technology used to supply electricity, are shown in Table 2.

Figure 4. Progress in global electricity access, 1990 to 2017



Source: World Bank, 2019

Table 2. Tiers of energy access

	Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Indicative appliances powered	None, only kerosene lamps or candles	Task lighting + phone charging or radio	Tier 1 + general lighting + fan + television	Tier 2 + medium-power appliances	Tier 3 + high-power or continuous appliances	Tier 4 + heavy or very high-power appliances
Daily capacity per household		Minimum 12 Wh	Minimum 200 Wh	Minimum 1.0 kWh	Minimum 3.4 kWh	Minimum 8.2 kWh
Typical technology		Solar lighting kits	Standalone or home solar system	Generator or mini-grid	Generator or grid	Grid

Note: Adapted from Bhatia and Angelou, 2015

Depending on the various appliances present in a household, the daily consumption can increase from a minimum of 12 watt-hours (Wh) for a Tier 1 household up to a minimum of 8.2 kWh or more for a household with Tier 5 access. The level of access or tier of a household is determined by several factors or attributes such as: capacity, quality of the electricity provided, availability or duration of daily supply, reliability and affordability. As the tiers increase, so does the consumption per capita per year, as well as the powered appliances in the households. The tier levels begin from Tier 0, where no modern energy appliances are present, and range up to Tier 5, where heavy or continuous appliances such as air conditioners are present in the households. Although the ultimate aim would be to achieve Tier 5 access for all households, even moving from one tier to the next represents an important milestone and can provide various benefits, with the lower the tier, the higher the value of a kWh.

A household with a level of access of Tier 0 would typically have only candles or kerosene lamps to provide lighting. In a Tier 1 household, typical appliances present would include task lighting, phone chargers and radios. A Tier 2 household includes all the appliances in a Tier 1 household plus general lighting, television and a fan. Tier 3 households would generally include the appliances present in the previous tier as well as medium-powered appliances. For a Tier 4 household, the number of appliances starts to increase and include heavy-powered appliances such as microwaves. Finally, Tier 5 of energy access consists of a household with all the appliances present in Tier 4 in addition to very heavy-powered appliances such as air conditioners.

Table 2 displays not only the different tiers, the indicative appliances and the daily consumption, but also the type of technology that would be best suited to meet the requirements of each tier of access. Typically for a household with Tier 1 access, a solar lighting kit is sufficient to meet the requirements as long as it provides a minimum lighting of 1 000 lumen hours per day. For a Tier 2 household, a standalone or home solar system is enough to power light appliances such as a television, a fan or general lighting. As the daily or yearly consumption of a household starts to increase, so does the size of the appropriate technology to meet that demand. For example, for Tier 3 access, a mini-grid or generators start being used to satisfy the energy needs of the household. Mini-grids can power medium appliances such as washing machines, televisions, general lighting, etc. When the level of access increases to Tier 4 and Tier 5, then the ideal technologies to supply electricity and meet the necessary load become generators and eventually connecting the household to the local grid.

4. RENEWABLE ENERGY TECHNOLOGY OPTIONS FOR HUMANITARIAN OPERATIONS

At the household level, the primary technologies considered in this analysis were related to improving the sustainability of energy for cooking and expanding household electricity access. This entailed assessing the supply of biomass for cooking and the efficiency of the cook stoves used. To increase access to electricity for households, the analysis considered the distribution of solar lanterns and solar home systems, where a small solar panel (15-30 watts) is connected to a lithium-iron-phosphate battery to power lights and other small appliances.

For the service delivery points and offices, the main focus was on the current sources of electricity and on the possibilities to transition the compounds towards greater use of solar power. Three main options were considered: 1) solar water pumping, where the electricity from the solar array is fed directly to a variable-speed water pump; 2) diesel-controlled solar systems, where the diesel generator provides 60-90% of the required power and solar panels reduce the running load on the generator, thus lowering diesel consumption; and 3) solar-controlled systems, where the solar array provides 60-90% of the power and the generator provides the balance. Battery banks are used to store energy produced by the solar array during the day for use at night.

At the settlement level, the main consideration was on understanding the aggregate demand for energy and identifying opportunities for using solar parks to improve the sustainability of electricity supply. One option that was considered was to create mini-grids within the refugee settlements that connected offices and service delivery points, as well as households. The electricity in these grids could be generated through either a diesel- or a solar-controlled system. Another option that was considered in both Ethiopia and Iraq was to use a solar park to support the grid. This would mean supplying electricity directly to the grid from the solar array, or from an array assisted by a grid-sized battery bank. The grid-supporting solar plants could be sized to cover the electricity requirements of the settlements, or to generate more electricity than the settlements require during the day and then deliver the excess electricity to the host community through the grid.

Figure 5. Standalone solar system with containerised battery bank

Photograph: Kube Energy

4.1 Solutions to consider for clean electricity supply

The key renewable energy solutions that were considered for providing a clean supply of electricity to the refugee settlements in Iraq and Ethiopia, and to the various infrastructures and offices of humanitarian organisations operating in the settlements, included: solar lighting kits, solar home systems, mini-grids with solar PV and battery storage, the grid plus renewable energy and solar water pumping solutions.

Solar lighting kits

One option that was considered for providing refugees with clean electricity, especially for the settlements in Ethiopia where most refugees do not have any access to electricity, was the provision of solar lighting kits. Solar lighting kits are very versatile and can be used for different applications. They can be used in rural settings to provide refugees or displaced people with good-quality, clean and affordable lighting, as opposed to using kerosene lamps that provide poor-quality lighting, create indoor pollution and pose a fire hazard, in addition to being expensive to run. Solar lighting kits also often come with the possibility to recharge a mobile phone, a service that is highly valued in rural areas that have a mobile phone connection but no electricity supply. Typically, such kits are composed of a solar panel, one or more LED (light-emitting diode) light bulbs, a battery, a charge controller and the necessary cables.

Figure 6. Solar lanterns charging at a school in Chuuk, Federated States of Micronesia

Solar lighting kits are versatile, portable and clean

Standalone solutions and solar home systems

Standalone solutions refer to the provision of electricity using technologies appropriate for individual households and small businesses. Solar home systems are standalone PV systems with battery storage that can provide clean and cost-effective electricity to rural households. Such systems are generally used to power individual households and small businesses. They can provide refugees with basic energy needs beyond general lighting, such as powering a fan or television. Larger solar home systems can also power efficient refrigerators. Typically, a solar home system consists of a solar PV module, a battery bank and a charge controller. In some systems a small inverter can power alternating current (AC) appliances in addition to dedicated, high-efficiency direct current (DC) appliances.

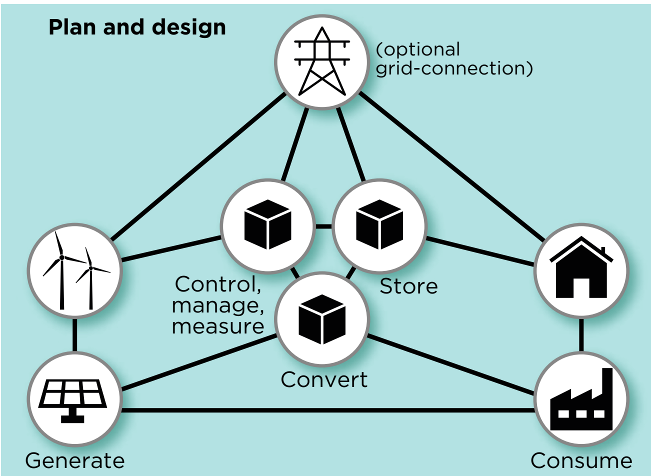
Figure 7. Chuuk school using standalone solar PV with battery storage

Photograph: IRENA/E. Taibi

Mini-grids

One of the main options that was considered for supplying the refugees and humanitarian organisations present at the four selected refugee settlements was the deployment of mini-grids. Renewable energy mini-grids can provide clean, sustainable energy to rural communities in remote areas where there is no access to electricity or modern energy services. Compared to solar home systems, mini-grids can deliver higher levels of service and can fulfil the load requirements of a Tier 3 household by powering general lighting and medium-powered appliances. Moreover, mini-grids can be designed for and can deliver power at different levels of service and can be tailored to demand needs. With the rapid reduction in battery storage costs and the low cost of solar PV, mini-grids today can competitively supply up to Tier 5 electricity requirements.

Figure 8. Functionalities of a mini-grid



Based on IRENA (2016)

Renewable mini-grids provide reliable, affordable energy in remote areas

Grid extension plus renewable energy

When the local electricity grid is in the vicinity of the rural household, it can be interconnected with the deployed mini-grid to provide back-up power to the mini-grid when demand exceeds solar PV generation, for example for multiple days of very cloudy weather. Thus, one possible solution that was considered for the refugee settlements was to connect a future mini-grid with the local grid. This is usually done for higher levels of energy access such as Tier 4 or Tier 5, when the households have heavy- or very heavy-powered appliances such as air conditioners that consume large amounts of energy. Keeping the mini-grid in place even when grid connection might be available can ensure more-reliable service and better power quality, which is often a challenge for grid electricity in remote rural areas, including those surveyed in this report.

Solar water pumping

Another technology that was considered for providing refugees with clean and cost-effective energy services was solar water pumping. Solar-powered water pumping systems can provide various advantages to refugees, such as reliable water supply, irrigation (if sufficient water is available), improved crop yields, increased income, reduction of fuel usage and improved food security.

Figure 9. A solar plant installed at a borehole in the Darashakran refugee settlement

4.2 Solutions to consider for clean cooking

The collection of traditional biomass for cooking poses a great threat to the safety and security of many refugees, mainly women and children, and is also harmful for their health when used, especially for indoor cooking. The two modern bioenergy solutions considered to provide refugees with clean cooking were ethanol and biomass briquettes.[2] Either option could help to address the limited availability of sustainable biomass in the area surrounding the settlements in Ethiopia, with the aim of increasing the efficiency of biomass use (thereby reducing its use) while also alleviating the security issues and health impacts associated with the collection and use of traditional biomass. A third option worth further consideration is biogas produced from the refugees' wastewater. Because biogas is not currently exploited in the settlements that were assessed, it is not included in this analysis. Nevertheless, it remains an option to consider where applicable.

Ethanol

Cook stoves based on ethanol can be used for clean, sustainable cooking and can avoid the high health-related risks that come from cooking with traditional firewood. Ethanol, which is produced from crops with high starch and sugar content such as sugar cane, corn and other sources of biomass, has a key advantage over traditional biomass for cooking purposes in that it is more efficient and much less polluting. Because ethanol burns very cleanly, the emissions and particulates produced are lower than those from firewood or charcoal. Furthermore, ethanol-fuelled stoves provide faster cooking and make more efficient use of the energy in the fuel, in addition to producing no smoke or soot.

Briquettes

An alternative option considered for clean cooking was the use of biomass briquettes in improved cook stoves. This fuel source is made by compressing dried woody biomass into a solid block and provides various benefits compared to traditional firewood. Briquettes are efficient to burn due to their low moisture content and to their high energy density. Moreover, due to their compressed shape they burn for a longer time and, due to the low moisture, they do not create smoke or soot. Given the higher efficiency of burning briquettes in improved cook stoves, this is an affordable option. When produced from biomass and used efficiently, briquettes can be considered a renewable fuel source.

Figure 10. Household kitchen in the Sherkole refugee settlement

Photograph: Kube Energy

2 Mainly for the settlements in Ethiopia where refugees rely solely on traditional firewood for cooking purposes.

5. BUSINESS MODELS

Non-traditional procurement models can relieve humanitarian organisations from technical and financial risks when procuring solar infrastructure. As the costs of solar components have declined sharply in the last decade, various new business models have been created to make this technology more available for new customer groups. Traditionally, if humanitarian organisations were to procure solar equipment, they would establish the technical specifications for the system, purchase the equipment through a tender, hire a company for the installation and take responsibility for the operations and maintenance themselves. This means that organisations take risks if there are technical difficulties with the installation, and they would be required to cover the full cost of the installation upfront.

New business models that depart from the purchase model are increasingly becoming available for humanitarian organisations. These models include leasing, where organisations pay a monthly fee for the solar equipment, and power purchase agreements (PPAs), where organisations pay only for the electricity produced by the solar equipment. In both of these models, the organisations avoid taking responsibility for designs by putting out a tender specifying their needs for electricity. If the solar installation does not deliver according to the requirements, the responsibility can be shifted to the solar company rather than being with the organisations themselves. In both the leasing and PPA models, the organisations' upfront payments can be much lower than a traditional procurement for equipment and for engineering, procurement and construction (EPC) services only.

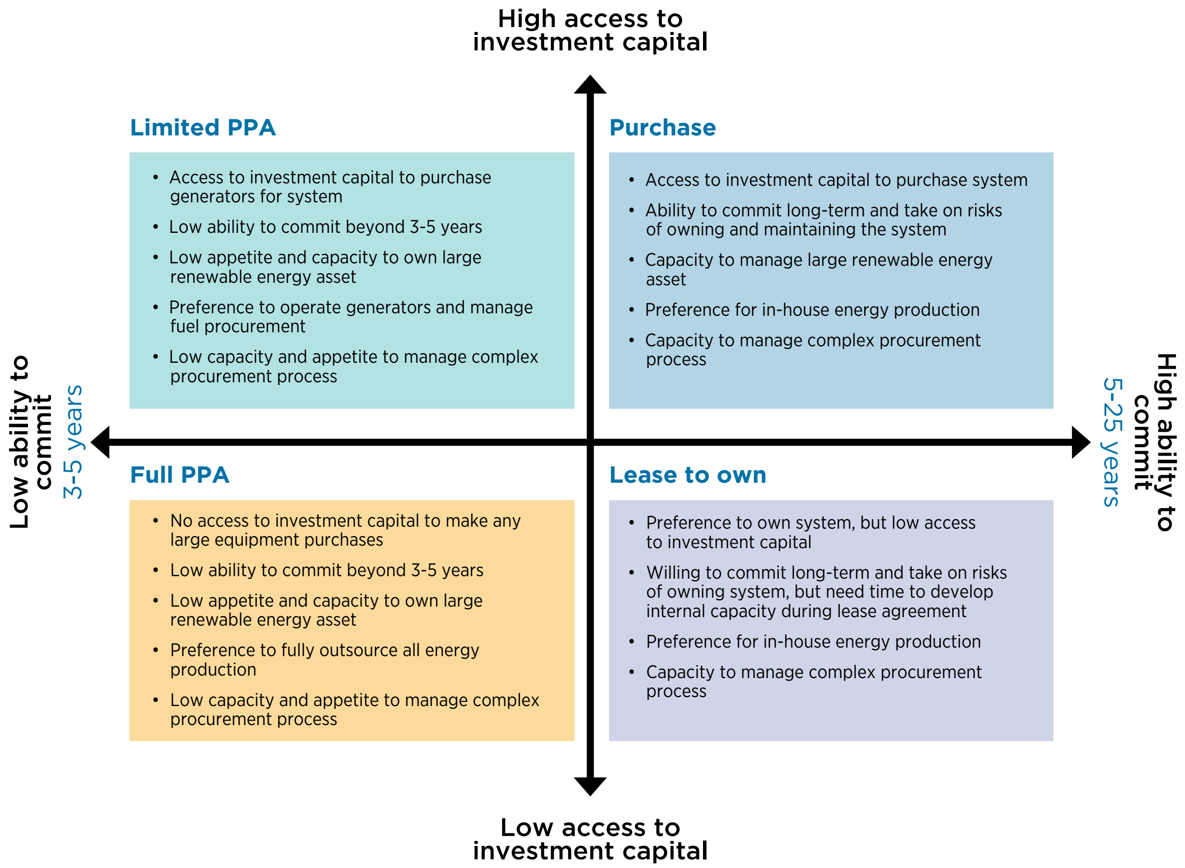
In addition to leasing and PPA models, an alternative option that UNHCR can explore is the pay-as-you-go (PAYG) business model. In a PAYG model, a renewable energy developer or company essentially rents a solar home system (consisting of a PV panel, a charge controller and a battery system) to a consumer, providing the basic energy needed to power general lighting, small appliances and phone charging. Through the PAYG model, companies can automate the receipt of payments, and customers in rural areas and remote locations can get immediate access to basic energy needs. This is a major advantage of PAYG as opposed to extending the local grid and connecting households, which can supply more energy to power more appliances but can also take many years to complete in addition to considerable investment. UNHCR can adopt the PAYG model to provide refugees, especially in Ethiopia where electricity supply options are very limited, with solar home systems to supply electricity for basic needs.

Photograph: Shutterstock

Other options that UNHCR can consider as possible business models to adopt are mini-grid solutions where the excess power generated by the systems is sold directly to the local grid, and public-private partnerships where UNHCR can be a bulk buyer of electricity from a renewable energy installation (a mini-grid or a standalone power plant) that supplies electricity to the local grid and/or host communities.

The use of private sector approaches can also be applied to the operations and maintenance (O&M) of solar systems. If the assets are owned by humanitarian organisations, the O&M can be outsourced to specialised solar service companies that provide these services. With a solar lease, O&M responsibilities can be specified in the contract with the solar company.

Figure 11. Overview of available business models for solar procurements



PPA= Power purchase agreement
Note: For the limited PPA, organisations will need access to investment capital to procure generators
Source: Kube Energy

6. RESULTS AND FINDINGS

The two countries where the mission was conducted highlight different challenges that refugees face in accessing energy, a difference that reflects the context in which the displacement has taken place. In Iraq the refugees are connected to the national grid, but the electricity infrastructure has not kept up with the expanding settlements, resulting in daily occurrences of voltage drops and power cuts. In Ethiopia, meanwhile, refugees have no access to electricity and depend on surrounding forests for firewood for cooking. However, growing numbers of refugees have led to increasing deforestation and hostilities with host communities.

Although the context varies widely between the two settings, many of the challenges for humanitarian organisations have remained the same. There has not been a concerted focus on energy, as this has not traditionally been part of the organisations' key competencies. In both Iraq and Ethiopia few depictions are available of the electrical infrastructure leading to the refugee settlements or of the distribution of power within them. Furthermore, electrical installations at humanitarian compounds are old and in poor condition. Diesel generators are oversized for the loads they are servicing, leading to inefficiencies and losses. In addition, there is a general lack of data relating to energy consumption or the requirements of refugees.

However, a series of new initiatives and projects demonstrate that this might be about to change. In all of the refugee settlements visited in the study, the installation of solar power has alleviated the reliance on diesel generators. Trees have been planted in efforts to rehabilitate land that has been deforested or degraded. Solar street lights have been installed to light up key locations in settlements, and some refugees have access to solar lamps to keep the lights on after dark.

Table 3 provides an overview of the access to electricity in the refugee settlements in the study. This shows the large differences between the settlements in Iraq and Ethiopia. The affordability category is relative to household income, and further studies are required to provide a complete overview of how spending on energy impacts the overall purchasing power of the refugees.

An overview of the energy used for cooking in the studied refugee settlements is provided in Table 4. While all households in Iraq said LPG gas was their main source of energy for cooking, the variance in responses was higher in Ethiopia. Most refugees stated that firewood was their main source of energy for cooking, followed by charcoal and briquettes. Most of the firewood was collected from the vegetation around the settlements or by trading food rations in the market.

Table 3. Overview of the electricity situation in the selected refugee settlements

	Darashakran	Domiz 1 & 2	Sherkole	Tsore
Tiers of household energy access	Tiers 4-5	Tiers 4-5	Tiers 0-1	Tier 0
Availability	Frequent brownouts and blackouts	Frequent brownouts and blackouts	N/A	N/A
Affordability	National grid was free and diesel grid was moderately expensive	National grid was free and diesel grid was expensive	N/A	N/A

Note: N/A = data not available

Table 4. Overview of the energy situation for cooking in the selected refugee settlements

	Darashakran	Domiz 1 & 2	Sherkole	Tsore
Type of fuel used	LPG	LPG	Firewood	Firewood*
Availability	Available	Available	Available but increasingly scarce and dangerous to collect	Available but increasingly scarce and dangerous to collect
Affordability	Affordable	Affordable	Low: some refugees have to trade food rations for firewood	Low: some refugees have to trade food rations for firewood

*A few households have access to ethanol and briquettes.

6.1 Findings from Darashakran and Domiz in the Kurdish region of Iraq

The Kurdish region in Iraq (KRI) received a large influx of refugees as the violence in Syria escalated starting in 2013. Many of the Syrian refugees were of Kurdish origin and were generally well received by the majority Kurdish host population in KRI. UNHCR explained that it had conducted intention surveys in the refugee settlement and that a large proportion of the refugee population had indicated plans to stay in the medium term. UNHCR's government counterpart in the Erbil, the Joint Crisis Coordination centre (JCC) stated that it increasingly included the KRI refugee settlements in development plans for the region, including in plans for the expansion of electrical infrastructure. UNHCR stated that one of its key strategic goals for the refugee response was to transition away from emergency response and towards development planning.

The refugee settlements visited during the mission in Iraq, Darashakran and Domiz 1 & 2, were established during 2013-2015, and the infrastructure was gradually developed over time. The refugees live in brick houses with running water, sewage connection and kitchens. All households in the settlements were connected with 6-10 ampere breakers to the national grid for electricity (1.4 kW to 2.3 kW at nominal voltage of 230 volts), as well as to 3 ampere breakers to neighbourhood diesel grids (0.7 kW at nominal voltage of 230 volts) that operated if the national grid was not working. The combined availability of electricity through these grids was reported to vary by time of year, with more breaks in power during the summer and winter months when regional electricity consumption is high because of energy use for climate control by air coolers, air conditioners and space heaters. During the time of the visit, refugees had between 20 and 24 hours of electricity in the settlements.

Figure 12 shows the daily load profile of electricity consumption in the Darashakran refugee settlement and the two settlements in Domiz. The estimates are based on information from the Department of Electricity, the household survey, the technical assessments of offices, guesthouses and service delivery points, load measurements of the neighbourhood diesel generators, as well as interviews with the co-ordinators of the settlements.

The load curves show that electricity consumption decreases when the national grid goes down at around 8 a.m. The consumption in Darashakran decreases more significantly than in the settlements in Domiz, where during the visit the neighbourhood diesel generators were operational whenever the national grid was down. In Darashakran the neighbourhood diesel grid operated for only two hours between 11 a.m. and 1 p.m. The remaining load in Darashakran when the national and neighbourhood grids are not operational is from the electricity used for boreholes and service delivery points.

The consumption of electricity per refugee is estimated to be 2.2 kWh per day in Domiz and 3.5 kWh per day in the Darashakran settlement. The reason the electricity use is higher in Darashakran is that the refugees have a 10-ampere breaker to the national grid. They currently do not pay for the electricity from the national grid but pay a fixed fee of IQD 15 000 (around USD 13) per month to connect to the diesel generators in Darashakran and IQD 26 000 (around USD 22) per month for the connection in Domiz 1 & 2. This creates an artificially inflated demand for electricity, as connection to the diesel generators is a flat fee and grid electricity is free; therefore, consumption must be artificially limited by reducing the size of the circuit breaker when connected to the diesel mini-grid, instead of moving towards a cost-recovery electricity supply model that could enable private sector participation in the electricity supply and pave the way for a transition towards renewable electricity.

The differences in the availability of electricity are also evident in the appliances that the refugees were found to have, as shown in Figure 13. The higher-capacity connection to the national grid in Darashakran makes it easier for refugees to operate cookers and heaters. The case studies discussed below illustrate problems related to blackouts and brownouts in the settlements, particularly in relation to appliances being damaged or broken by drops in voltage levels. The measured voltages in the two Domiz settlements was fairly stable at around 230 volts during the visit for both the national grid and the neighbourhood diesel generator. However, the voltage in Darashakran varied from 230 to 160 volts during the mission.

Figure 12. Typical daily load (kW) of the Darashakran and Domiz refugee settlements

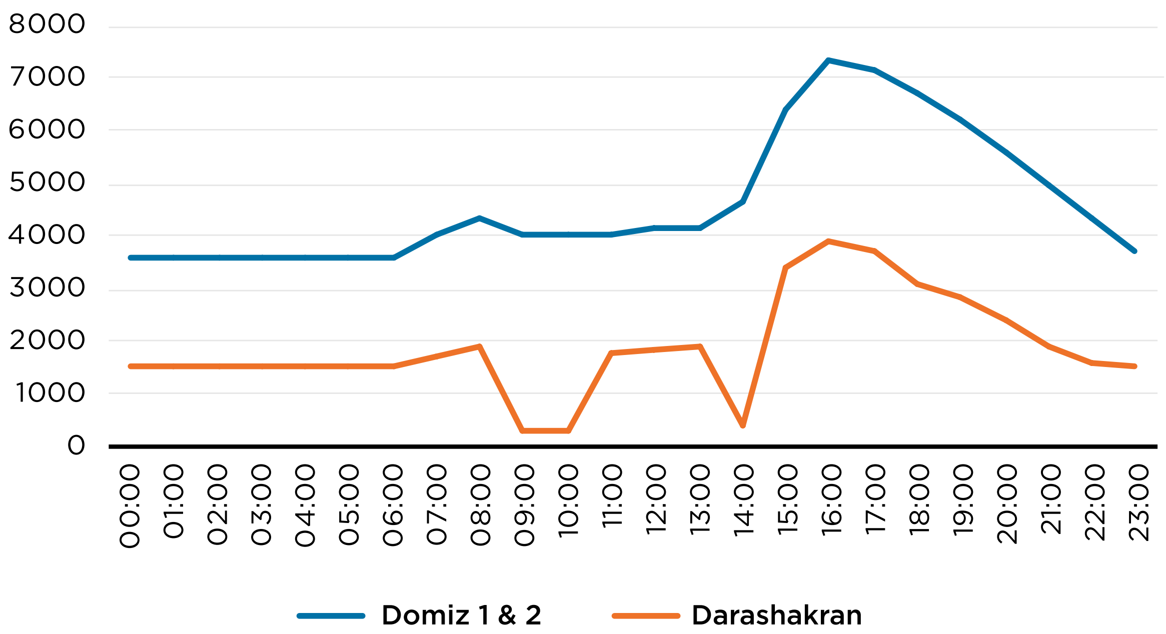
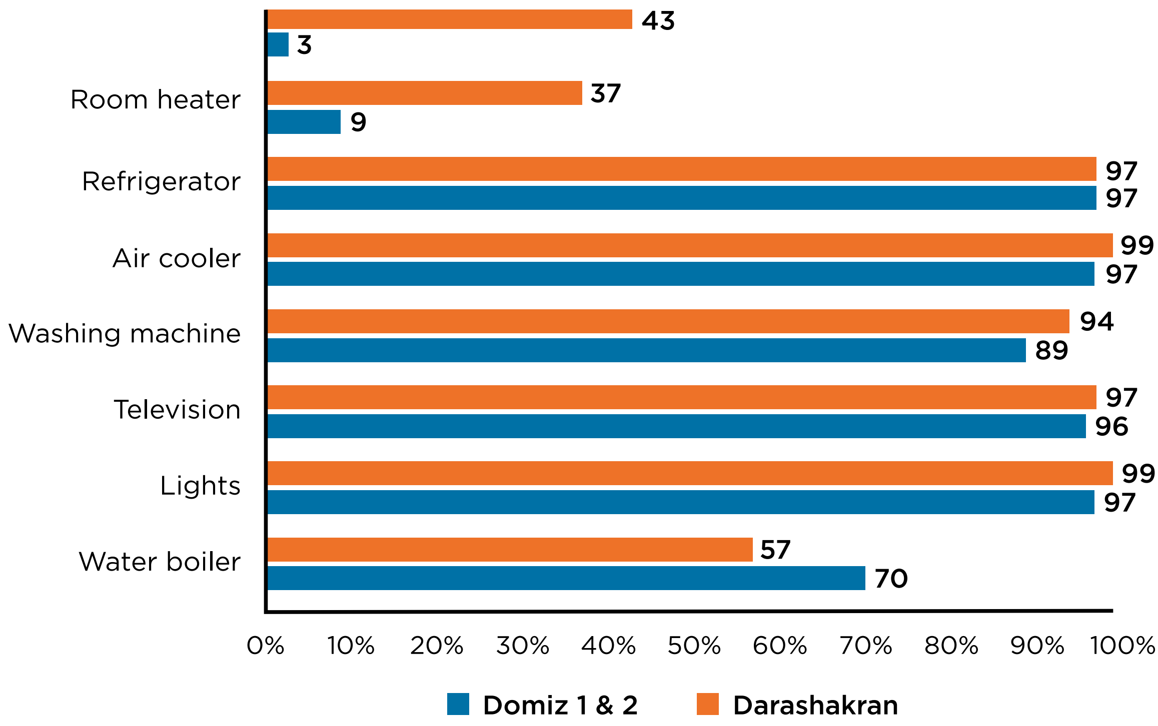


Figure 13. Distribution of appliances in Darashakran and Domiz 1 & 2



A possible solution would be to shift the energy consumption for the Darashakran settlement co-ordination office from the grid to self-consumption based on renewables by installing a standalone solar system. The compound has an average electricity consumption of 250-350 kWh per weekday and 100-150 kWh per day on weekends. The peak power during the visit was measured at 60 kW, and the average load (over a 24-hour period) was 10 kW. The compound had installed around 35 air conditioners, which made up an estimated 90% of overall electricity consumption. The load during the hot summer months was estimated to be 25% higher than during the time of the visit.

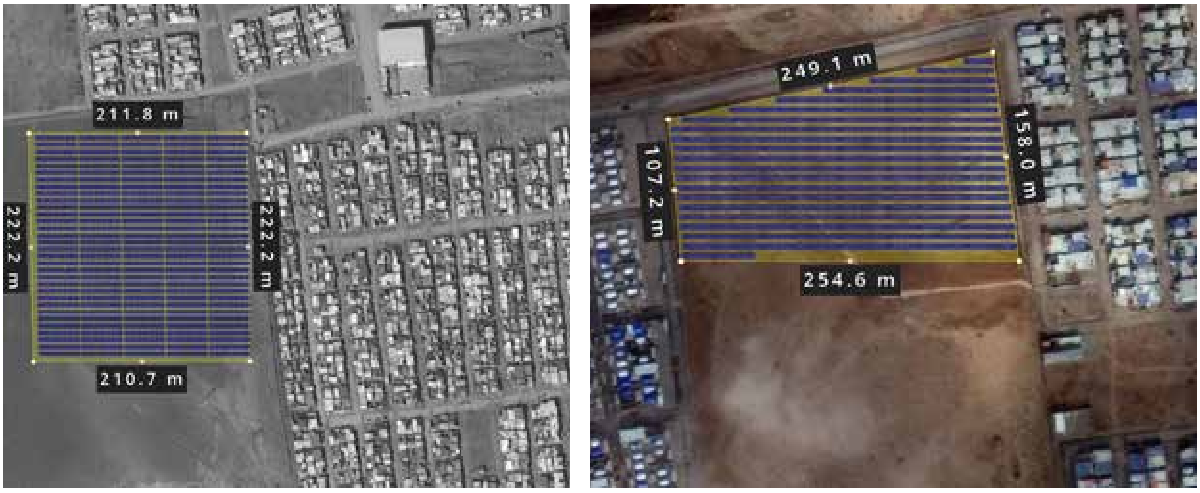
The Darashakran settlement co-ordination office had two sources of power, the national grid and a 150 kilovolt-ampere (kVA) generator. Because the generator was designed for much higher loads than the ones recorded during the visit, the fuel efficiency was low, and the compound used an estimated 1,800 litres of diesel per month. A 60 kW solar system with a 380 kWh lead-carbon battery bank is recommended, which would cover an estimated 75% to 80% of the electricity requirements at the compound and should eliminate the need to run the diesel generator during the day for most of the year, powering the compound using only solar and batteries. The system would provide the users with one day of stored electricity from the battery system, would greatly improve the reliability and power quality of electricity supply, and would thus avoid damage to appliances caused by the voltage drop in the grid. The estimated cost of the solar system with batteries is USD 280 000.

Another example of a solar system that could impact the energy situation in the refugee settlements as a whole would be to install large solar plants that are connected to the settlements through the national grid. Figure 14 illustrates a 6.6 megawatt (MW) solar plant in Domiz 1 and a 2.5 MW solar plant in Domiz 2. These plants would be connected to the 11 kVA feeder lines to the settlements and provide a simulated average daily yield of 40 megawatt-hours. During peak sun hours, the yield would exceed the energy consumption of the settlement, and the excess energy would be available to the host community that is connected to the same feeder line.

The total installed cost of the plants would be around USD 9 million. Instead of employing a traditional donor-based model to finance this installation upfront, private investment could be used, where electricity is sold to the refugees through the national grid. If refugees paid the national rate of IQD 131 per kWh (USD 0.11 per kWh), the average household with 330 kWh per month energy consumption would pay IQD 43 200 per month (around USD 37 per month) in total for the electricity, compared to IQD 26 000 per month to the diesel generators today.

A household income sensitivity analysis would be useful prior to the shift to determine the refugees' need for support to pay the additional costs. An option could be to design a tariff below the current cost of connecting to the diesel, effectively reducing the cost for both the local government (which presently provides free electricity) and refugees, and still providing a reasonable return on investment on the solar system.

Figure 14. Illustrations of a 6.6 MW solar PV installation in Domiz 1 (left) and a 2.5 MW solar PV installation in Domiz 2 (right)



CASE STUDY 1:
DARASHAKRAN REFUGEE SETTLEMENT IN IRAQ

Context: As Darashakran settlement grew, the electricity infrastructure became insufficient and refugees and humanitarian organisations faced increasingly large voltage drops.

Darashakran refugee settlement is located 40 kilometres north of Erbil in the Kurdish region of Iraq. The settlement opened in 2013 and has grown in size with the influx of Syrian refugees. Darashakran is currently the biggest refugee settlement in the Erbil region with 11 608 residents.

The vast influx of refugees into the settlement made it a challenge for UNHCR and the local government to plan infrastructure projects. This was particularly the case for electricity distribution within the settlement. Initially the refugees were provided with low-capacity connection to the national grid, sufficient to operate lights and to charge electrical devices. In 2017 the connection to the national grid was increased to enable refugees to use electricity to cool houses, use washing machines for clothing and use water boilers to access hot water. Today most refugees have all of these appliances, which they have purchased in the local market.

The increase in electricity consumption among refugees put pressure on the national grid (99% of which came from oil and gas in 2017) that supplied electricity to the settlement. The local sub-station in Darashakran was not designed to accommodate the high load, which has led the voltage in the distribution lines to fluctuate widely, particularly during the summer when refugees are using cooling systems and during the winter when electric heaters are used to warm residences. The voltage fluctuations have resulted in breakage of many of the appliances in the settlement, including hospital equipment, computers, air conditioners and household appliances. Around 75% of respondents in the household survey indicated that voltage fluctuations were a big concern, and the mean household reported that on average 1.7 appliances had broken in the previous 12 months due to voltage drops.

To reduce the overall electricity supply to the settlement from the national grid, and thus reduce voltage drops, UNHCR initiated a programme to transition some of the most energy-intensive infrastructure to solar power. Since 2018, all of the boreholes that provide the water supply in the Darashakran settlement have been transitioned to solar. UNHCR reported that a couple of companies in KRI had the capacity to install systems with sufficient quality. The solar systems at the boreholes were directly connected to a variable speed water pump and also provided with an inverter to supply the offices. The pump was also connected to the national grid for power, as back-up. Combined, the solar systems are expected to provide over 90% of the electricity for water pumping and close to 50% of the overall electricity requirements of the humanitarian organisations.

A solar system also has been installed in the settlement's primary health clinic. This installation is designed to prevent the voltage fluctuations from impacting sensitive medical equipment and to ensure back-up power at the clinic in case of blackouts or lack of diesel for the generator. The 20 kW solar array had a 48 kWh lead-acid battery bank and was connected to a portion of the circuit that powered administration, the storage area for medicines and the emergency room.

To improve the energy situation in the Darashakran refugee settlement, several parallel activities are recommended:

1. **Improve energy efficiency at the settlement.**

   This includes advising refugees on ways to insulate houses to reduce energy use for heating and cooling. Households make up an estimated 94% of the overall electricity consumption in the settlement, and insulation can greatly reduce electricity use for heating and cooling during the winter and summer. To further improve the insulation of houses, reducing air flow should be considered. This can entail simple procedures such as plugging leaks around doors and windows, ensuring that doors and windows are tightly closed, and closing any major cracks. Moreover, the construction of new buildings or housing could incorporate known energy efficiency principles such as low air infiltration, appropriate levels of insulation, and making use of trees and other shading.

2. **Continue to install renewable energy at community and support facilities in the settlement.**

   The design of the solar systems at the boreholes, where a solar array connected to an inverter powers a variable-speed AC pump, is a good model for locations with grid connection. For medical facilities and other locations with equipment that is sensitive to voltage fluctuations, using solar in combination with battery banks can improve the quality of the electricity and ensure continuous power to critical appliances. The installation of correctly sized solar systems with batteries at the settlement co-ordination office and the registration office will reduce fuel consumption by limiting the use of the oversized diesel generators to occasional battery charging.

3. **Discuss with the local government the possibility of increasing the capacity of the transformer in the sub-station serving Darashakran.**

   The Ministry of Electricity reported that increasing the transformer from 10 MW to 16 MW would greatly reduce voltage fluctuations and would eliminate the requirement for load shedding to the settlement and neighbouring communities. The timeline for when the new transformer would be installed was not made clear during the mission, and the JCC indicated that it most likely would take place in the next three years.

CASE STUDY 2:
DOMIZ 1 & 2 REFUGEE SETTLEMENTS IN IRAQ

Context: The government is assisting refugees with free power but is unable to maintain sufficient electricity supply, and refugees must turn to expensive neighbourhood diesel generators to keep lights on.

The other refugee settlements assessed in Iraq as part of this collaboration and study were the Domiz 1 and 2 settlements. These two settlements are located adjacent to one other in Domiz, 10 kilometres outside the city of Duhok in the Kurdish region of Iraq. The settlements were opened in 2012 and host a combined population of 44 000 refugees, making them the largest refugee settlements in Iraq (UNHCR, 2019c; UNHCR, 2019d; UNHCR, 2019e).

The settlements share much of the infrastructure with the Duhok urban area, and many refugees commute to the city daily. With the establishment of the refugee settlements in Domiz, the Department of Electricity determined that they should be provided with connection to the national grid without having to pay for the electricity. The host community in Duhok is connected to the national grid with a meter and pays for the electricity on a kWh basis (around USD 0.11 per kWh).

The main power source in the Duhok region is a natural gas-fired power plant, and the electricity produced comes at a marginal cost, where each kWh produced requires extra natural gas as input. This means that the local government in KRI must cover the cost of the electricity that is delivered to the refugees in the settlement. The Department of Electricity stated that it was not in an economic position to provide the refugees with continuous power and reported that the national grid was operational in the settlement for 12 hours per day during the summer and winter, and 20 hours per day for the rest of the year.

To compensate for the cut in service from the national grid, several private actors have established local neighbourhood grids powered by diesel generators. These grids operate during periods when the national grid is not working. The settlement co-ordinator explained that the diesel grid operators received permission from the local government to operate in the settlement, but that the overall regulation for how to operate was not clearly defined. This meant that the diesel grid operators could determine the price of electricity and set the number of hours they would operate the local grids.

While the refugees in the Domiz settlements were provided with a 6-ampere breaker to the national grid, they were provided with a 3-ampere connection to the neighbourhood diesel grid. This meant that the number of appliances they could operate was greatly limited and that using washing machines, water boilers, and electric cook stoves and heaters was not possible. Furthermore, the respondents in the household survey reported that they spent an average of IQD 26 000 per month (around 22 USD per month) for an estimated 25 kWh per month of average electricity consumption from the diesel systems. This would translate to a price of electricity USD 0.88 per kWh, much higher than the electricity price in most countries.

Figure 15. A neighbourhood diesel generator plant in Domiz 1

To improve the energy situation in the Domiz refugee settlements, several parallel activities are recommended:

1. **Install renewable power plants on the feeder lines to the settlements to compensate for the lack of electricity supply.**

   These renewable power plants could be sized to provide excess power that could be fed into the national grid to the benefit of the host community. With the installation of a grid-tied 6.5 MW solar PV power plant in Domiz 1 and a grid-tied 2.5 MW solar PV power plant in Domiz 2, the overall electricity requirements of the settlements would be covered during the peak hours of the summer months when the use of air conditioners is highest. Energy storage could be added to increase the power quality and the number of hours covered by the solar system, although this would greatly increase the cost of the installation.

2. **Facilitate for any investments in infrastructure for the refugee settlement to take place in ways that reduces UNHCR's technical and financial risk.**

   For example, with the use of a power purchase agreement, UNHCR can specify the amount of electricity to be delivered without being required to provide the technical specification of the plant or the investment required to cover the installation.

3. **Push for meters to be installed at households in the Domiz settlements and for refugees to pay for the electricity similarly to the host community, on a kWh basis.**

   The average household with monthly energy consumption of 330 kWh would pay on average IQD 43 500 (USD 36) per month for the electricity, compared to the IQD 26 000 (USD 21) on average that they pay per month for the three-hour connection to the neighbourhood diesel generators. The increase in price would be because the refugees would pay for all the electricity they receive, similarly to the host community, not just for the electricity from the diesel generators. A household income-sensitivity analysis should be done prior to the shift to determine the refugees' need for additional support to pay the increased costs. An alternative option could be to design a tariff below the current cost of connecting to the diesel, effectively reducing the cost for both the local government (which presently provides free electricity) and the refugees, and still providing a reasonable return on investment on the solar system. This would also enable competition in the supply of electricity, creating a framework where overpriced diesel supply would compete with affordable and clean supply from solar PV. In the shelter and settlement strategy 2018-2021 for KRI, the installation of household electricity meters has been planned to facilitate the future integration of the Domiz settlements into the host community.

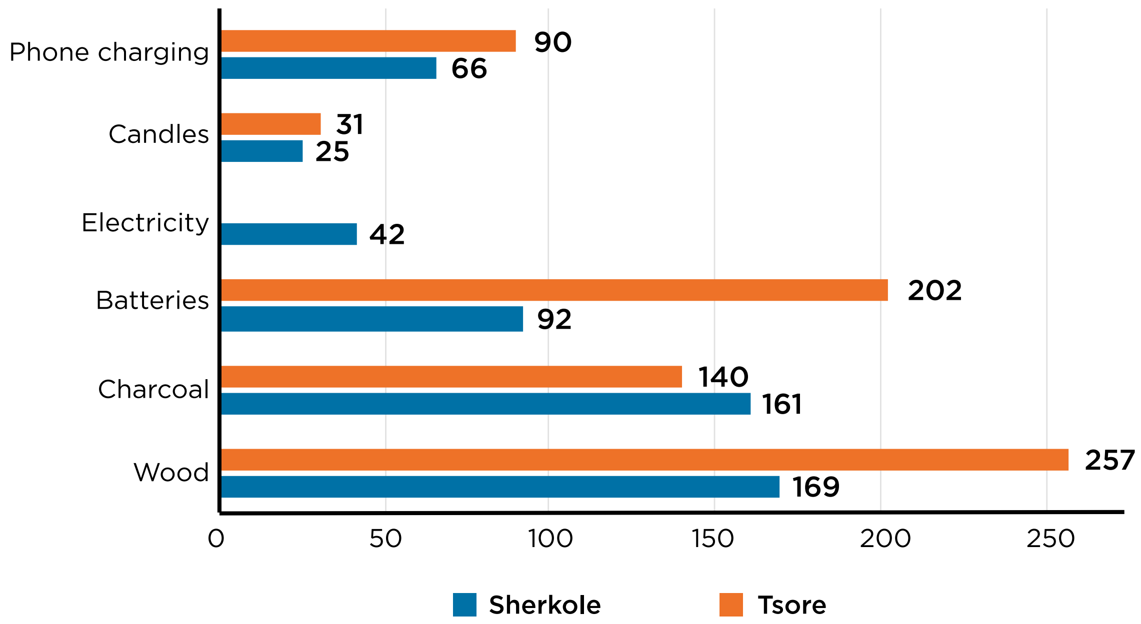
6.2 Findings from Sherkole and Tsore in the Benishangul-Gumuz region in Ethiopia

The Benishangul-Gumuz region of western Ethiopia has a long-standing history of hosting refugees. Continued insecurity in neighbouring states has resulted in sustained refugee movements, either directly as a result of internal conflict and human rights violations, or because of conflict related to competition for scarce natural resources and drought-related food insecurity (UNHCR, 2019e). The situation in the two refugee settlements visited reflects the diversity of the refugees in the region. While Sherkole settlement was opened in 1997 and has a stable population of refugees, Tsore settlement was opened in 2016 and has new arrivals every week.

The Government of Ethiopia has provided the refugees with the right to work and reside out of the settlements, as well as with access to social and financial services. While the refugee settlements have been included in regional plans for infrastructure and service provision, the Ethiopian Government seeks to expand its "out-of-camp policy" whereby refugees are encouraged to cultivate land, seek university education and work outside of the settlements (UNHCR, 2019e). The government counterpart to UNHCR, the Administration for Refugee and Returnee Affairs (ARRA), explained that it expects the majority of refugees to stay for the long term and that it plans to invest in settlement infrastructure accordingly.

One of the biggest challenges for refugees in the Sherkole and Tsore settlements relates to accessing energy for cooking and lighting. Like 96% of the rural population of Ethiopia (World Bank, 2018), 87% of the respondents to the household survey in Tsore and Sherkole rely on firewood for cooking purposes. The difference from other rural populations, however, is that the refugee settlements have a higher population density and thus take a higher toll on the vegetation in areas around the settlement. The settlements are also located close to local communities that feel a level of ownership over the surrounding forests, which has created conflict between the refugees and the host community. On average, the respondents to the household survey reported making two weekly trips to local forests, and UNHCR estimated that each household requires between 15 and 20 kilograms of firewood per day.

Figure 16. Spending (in ETB) per household per month on energy for cooking and lighting



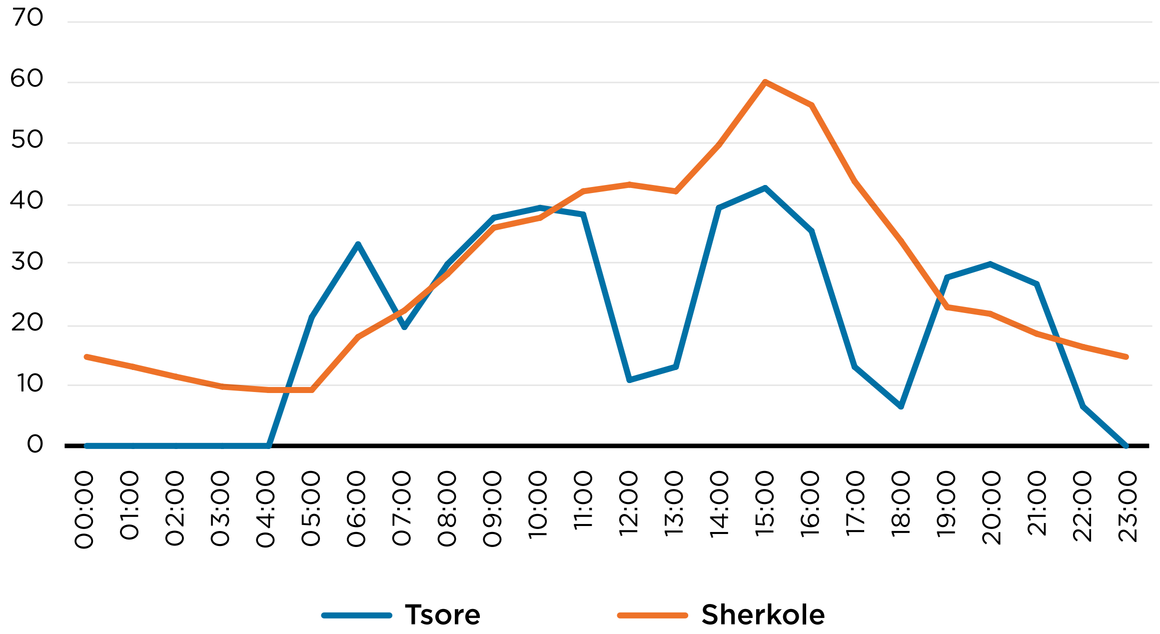
Note: ETB 100 is equivalent to around USD 3.3.

Although data on degradation and deforestation are lacking, ARRA and UNHCR claim that the refugee settlements are having a heavy impact on the surrounding vegetation. The Natural Resources Development and Environmental Protection (NRDEP), an agency of the Government of Ethiopia, claimed that the impact on the forests can be seen in a 25-kilometre radius around the Sherkole settlement and 15 kilometres around the Tsore settlement. The case study from Sherkole (below) describes not only how the lack of energy for cooking poses a protection risk to the refugees when collecting firewood, but also the impact on food security when refugees exchange their food rations for firewood and charcoal in the market. Among the respondents to the household survey, 74% reported to have traded food rations for fuel in the week prior to taking the survey.

Figure 16 shows the reported expenditure on fuel for cooking among the respondents in the Sherkole and Tsore refugee settlements. The total reported costs for energy for cooking and lighting were ETB 555 (around USD 18) per month in the Sherkole settlement and ETB 720 (around USD 23) per month in the Tsore settlement. The difference in spending on firewood could reflect the difference in vegetation around the settlements and the availability of forest. Around Sherkole there are several plantations with eucalyptus and other fast-growing vegetation. The area around Tsore is less densely vegetated, and the availability of fuel is lower than in Sherkole. Another significant difference is that 14% of the respondents in Sherkole reported to have access to electricity for lighting through neighbourhood diesel generators owned and operated by refugees in the settlement. This connection could explain why the average expenditures on phone charging, candles and batteries are lower in Sherkole than in Tsore.

One of the main regional high-voltage distribution lines passes through Sherkole and close to the Tsore settlement. During the time of the mission, most of the humanitarian offices, guesthouses and some of the service delivery points (school, primary health care clinic, community cooking facility) in Sherkole were connected to the national grid. During the 10-day mission, the grid connection in Sherkole was operational for only three days due to vegetation cutting the distribution lines. Although ARRA had been in contact with Ethiopian Electric Power (ELPA) about connecting Tsore to the national grid, there were no plans to extend the grid to the refugee settlement. ELPA stated that it would encourage the humanitarian organisations to apply for a connection with an estimation of the settlement load.

Figure 17. Overall load (kW) measured in the Sherkole and Tsore refugee settlements

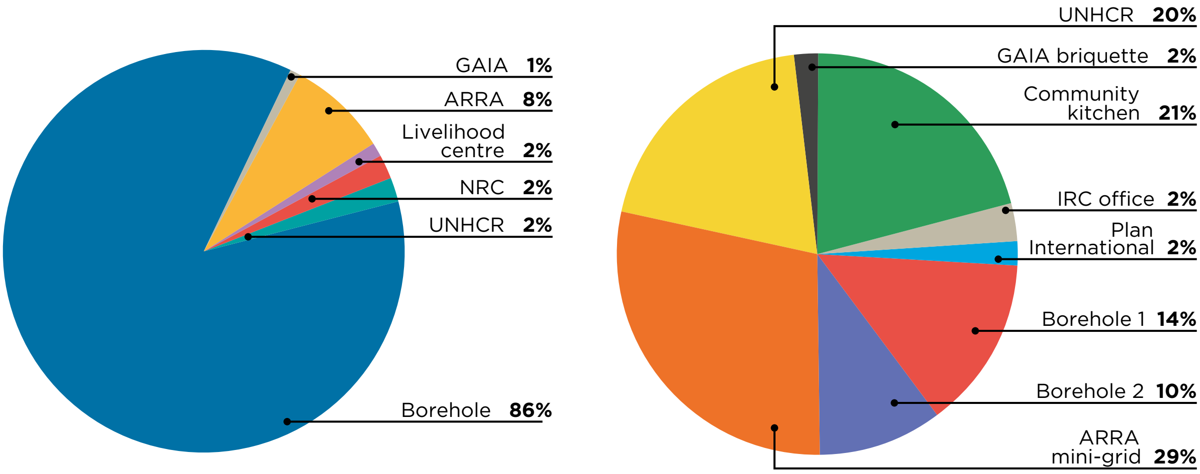


Note: ETB 100 is equivalent to around USD 3.3.

To compensate for the blackouts and lack of connection, all humanitarian offices and many of the service delivery points used diesel generators to power operations. ARRA had established mini-grids powered by central diesel generators in both refugee settlements. While these mini-grids connected some of the core service locations (primary health care clinics and community centres) and offices/guesthouses of humanitarian organisations, many organisations continued to run their separate generators, despite proximity to the grid. Meanwhile, 73% of the compounds in the settlements were found to be operating generators that were designed for much higher loads than measured during the visit.

Figure 17 shows the combined loads of all the locations included in the technical visit. The large fluctuations in electricity consumption in the Tsore settlement are caused by the water pumping station being switched on and off throughout the day. Pumping water was found to consume around 86% of all the electricity produced in the Tsore settlement. The International Rescue Committee (IRC) had installed an 18-kW solar system to power the water pump, but the system was not operational due to challenges in agreeing on water distribution. The other compounds in the settlement did not have air conditioners or space heaters, and most of the electricity was used for powering computers and office equipment, lighting offices and refrigeration.

Figure 18. Electricity consumption in the Tsore (left) and Sherkole (right) refugee settlements



In the Sherkole settlement around 50% of the overall electricity consumption was used to run the humanitarian offices and guesthouses, as well as to power the electric stoves in the communal kitchen. Most of the humanitarian staff that worked in Sherkole also lived in the settlement, and both UNHCR and ARRA maintained 24-hour electricity from the national grid or diesel generators. The water table was higher (and the electricity required for pumping water was therefore lower) in Sherkole than in Tsore. Water pumping was recorded to use 60% less electricity in Sherkole (164 kWh per day) than Tsore (402 kWh per day).

A new solarised borehole outside the Sherkole settlement, completed by the IRC, has a 22-kW solar array with the capacity to supply the necessary water for the entire settlement. The borehole was not operational during the visit due to a conflict with the host community, which demanded to be connected to the water pump as well.

The overall energy situations for refugees and humanitarian organisations in the Tsore and Sherkole settlements are similar. As a result, most of the recommendations provided in the case studies below are applicable to both settlements. Table 5 lists a set of recommended solutions for increasing access to energy among refugees and service delivery points that currently do not have a source of electricity.

Table 5. Recommended solutions for increasing energy access in Sherkole and Tsore

Tier	Wh/day use	Type of loads	Load category	Solution
Tier 1	0 - 200	Lighting, phone charging	Staff accommodation, refugee household	• Grid connection (if near) • IFC Lighting Global-approved solar lantern (up to 40 W) or other internationally approved quality mechanism
Tier 2	>200 - 400	Lighting, smart phone charging, business lighting	One- or two-room school, single-room office, shop, phone charging business	• Grid connection (if near) • IFC Lighting Global-approved solar kit (up to 100 W) or other internationally approved quality mechanism
Tier 3	>400 - 1 000	Lighting, multiple phone charging, business lighting, chest refrigerator	Small office (1-2 laptops), video-cinema room, school office/library	• Grid connection or mini-grid • *For remote sites:* Standalone solar system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CASE STUDY 3:
SHERKOLE REFUGEE SETTLEMENT IN ETHIOPIA

Context: The lack of energy for cooking leaves refugees with a dire choice: either trade their food rations or face protection risks when collecting firewood from the forest.

The Sherkole refugee settlement is located 42 kilometres north of Assosa on the Ethiopian border with Sudan. The settlement was established in 1997 to accommodate Sudanese refugees seeking international protection but hosts large South Sudanese communities and refugees from other countries in Africa. The settlement hosts a population of around 10 619 refugees.

The refugee population in the Benishangul-Gumuz region of Ethiopia make up around 4% of the overall population of the region. One of the most critical challenges facing the refugees in the settlement is accessing sustainable, safe and affordable household cooking energy. Firewood is the main source of energy used by refugees in the settlement, and most households were fully dependent on collecting firewood from the forest or trading food rations in the market to access it. Nine out of ten respondents to the household survey indicated that they primarily used an inefficient three-stone fire with firewood as their primary method for cooking. UNHCR estimates that the average household of six people would require 17.5 kilograms of firewood per day, which would make the aggregated consumption of firewood in the settlement 2 168 tonnes per month.

In the survey, the average respondent reported undertaking two trips per week to collect firewood. All households reported that this collection was insufficient, and they spent an average of ETB 304 (around USD 10) per month to buy firewood from the market. Furthermore, 69% reported having skipped meals during the previous week due to lack of firewood, and 67% answered that they had traded their rations in the last month to buy wood.

Humanitarian actors have provided only a small proportion of the energy for cooking in Sherkole. GAIA, a local non-governmental organisation, has distributed locally produced briquettes and ethanol to refugees in the settlement. The scope of this response has been limited due to a lack of funding from donors. While GAIA indicated that the briquette production was more cost effective than distributing firewood from plantations, the organisation was unable to provide concrete data on costs.

The co-ordinator of the refugee settlement explained that the depletion of vegetation cover was noticeable in a 20-kilometre radius around the settlement and that degradation of forests was the main source of conflict with the local communities. The women's organisation said that collecting firewood posed a big protection risk for the refugees and that confrontations with the local community had resulted in violence, including sexual harassment.

The modern energy sector in Ethiopia is still in a very infant stage, and 94% of people rely on traditional sources of energy such as fuelwood, charcoal and animal dung. Efforts to address the energy needs of the refugees thus needs to be put in context of the region. The Ethiopian Government's Climate-Resilient Green Economy strategy (Federal Democratic Republic of Ethiopia, 2011) states that national strategies for sustainable biomass for cooking include: 1) promoting the increased use of fuel-efficient stoves; 2) scaling up afforestation and rehabilitation of land; and 3) supporting forest management and increasing the use of forest plantations as a source of sustainable fuelwood.

Figure 19. A refugee tending a eucalyptus plantation in the Sherkole refugee settlement

To improve the energy situation in the Sherkole refugee settlement, several parallel activities are recommended:

1. **Promote and support the use of fuel-efficient stoves in the settlement, which could reduce fuel use for cooking by around 30%.**

   A market survey should be conducted to provide an overview of the options. Distribution through cash or voucher-based programmes would allow refugees to choose their preferred stoves. For example, Inyenyeri, a private company in Rwanda, provides a free lease of clean and efficient biomass cook stoves to customers in exchange for their agreement to purchase the associated wood pellet fuel.

2. **Consider a transition to a marked-based approach for providing sustainable biomass for cooking in the settlement – for example, improved cook stoves that use briquettes or ethanol.**

   This could entail a switch from supporting the running of programmes to distribute different fuels to providing refugees with vouchers or cash to purchase the fuels they prefer. The humanitarian organisations could also introduce a licensing system for market actors to ensure that biomass is sourced sustainably and in line with the government's Green Economy Strategy. A household income and expenditure survey should be done prior to the shift, to determine the refugees' ability to pay for any increased costs. This effort could be supported by the transition of humanitarian operations towards cash-based support; or, alternatively, stoves and fuels could be procured by humanitarian organisations and provided at a nominal fee to each household.

3. **Scale up forest plantations and rehabilitate land near the settlement.**

   The NRDEP estimated that 100 hectares of fast-growing biomass would be needed to cover most of the requirements for biomass in the settlement.

CASE STUDY 4:
TSORE REFUGEE SETTLEMENT IN ETHIOPIA

Context: The lack of grid connection keeps refugees in the dark and forces humanitarian organisations to use diesel generators to power health clinics, offices and boreholes.

The Tsore refugee settlement is located 20 kilometres north of Assosa on the Ethiopian border with Sudan. The settlement was established in 2015 to accommodate Sudanese and South Sudanese refugees seeking protection. The settlement hosts 14 153 refugees and is the second most populated refugee settlement in the Assosa region. While the Tsore settlement is located 200 metres from a main power transmission line in the region, it has not been connected to the national grid. This has significant implications for refugees and humanitarian organisations operating in the settlement (UNHCR, 2019f).

Beyond the energy required for cooking, community leaders in the Tsore settlement explained that they needed power for lighting residences at night and for charging devices such as mobile phones and radios. Among the respondents of the household survey, 67% reported that battery-powered torchlights were their main source of power and that they had light for an average of three hours after dark. The average household reported spending ETB 202 (around USD 7) on batteries per month (20 AA batteries) mainly to power lights. The disposal of such a large volume of batteries is a matter of concern as batteries can contaminate groundwater and are particularly polluting and harmful to humans.

Refugees had established small diesel generator grids in two of the zones in the Tsore settlement. These generators were owned and operated by the refugees themselves, and they sold electricity for a fixed amount to households and businesses that were connected. In the household survey, 14% of respondents said that they received electricity through a diesel grid connection and that they paid an average of ETB 145 (around USD 5) per month. The electricity connection was sufficient to provide some lighting in the households and to charge small devices such as mobile phones, radios and torch lights. Eleven percent of respondents said that they had a solar-powered system that they used to charge lights.

The humanitarian organisations rely on diesel generators to power offices and guesthouses as well as service delivery points such as health clinics, boreholes, training centres and livelihood programmes. Technical visits to the various locations showed that the humanitarian organisations consistently ran generators that were greatly oversized compared to the load that they were servicing. For several of the bigger offices, most organisations operated generators that are designed to power loads 10 times larger than the ones they were connected to. This leads to poor energy efficiency and to accelerated depreciation of the generators due to increased maintenance requirements and wear. Furthermore, many of the humanitarian organisations were running the diesel generators simultaneously in compounds in close vicinity to each other, where one generator could have serviced multiple offices.

Humanitarian operations today rely on diesel power for offices, clinics and training centres

Figure 20. Refugees demonstrating their solar lighting/radio system in the Tsore refugee settlement

To improve the energy situation in the Tsore refugee settlement, several activities are recommended to be carried out in parallel:

1. **Establish a mini-grid in the settlement.**

   This could increase the efficiency of the diesel generators by an estimated 50% and greatly reduce maintenance costs, by avoiding running multiple diesel generators at very low load and instead optimising the dispatch of the fleet of existing generators to serve the combined load. UNHCR or ARRA could take the lead in establishing the mini-grid and collect payments from organisations that are connected to the grid by metering each connection point. The use of solar power could further reduce long-term costs and is best implemented through a mini-grid set-up rather than separate standalone systems. A 60-kW solar plant with a 150-kWh battery bank would decrease diesel consumption in the Tsore settlement by an estimated 60%, or around 2 500 litres of diesel per month. The mini-grid could eventually be expanded to provide the refugees with access to electricity. Delivery models such as leasing or PPAs could be employed to reduce the technical and financial risk linked to deploying a solar-based mini-grid.

2. **Initiate market-based solar lamps access initiatives in the settlement to provide refugees with access to improved lighting as well as charging for small appliances such as phones and radios.**

   This must be done in a way that is sensitive to the existing ecosystem for solar lanterns in the settlement to avoid the disruption of existing markets. Any lanterns provided should be approved via an international quality mechanism (for example, IFC's Lighting Global).

3. **Basing on a detailed protection-sensitive lighting needs assessment, increase the use of solar street lights to improve the lighting situation in the settlement.**

   The installation of the lights can initially be concentrated around key points in the settlement, such as health clinics, schools or main roads, and should eventually also be installed in the main residential zones. Responsibilities for maintenance of the lights must be clearly defined to ensure their continuous operation.

4. **Apply for a grid connection for the settlement from Ethiopian Electric Power.**

   ELPA in Assosa explained that it would positively support extension of the grid from the transmission line to the settlement. ELPA explained that this has been discussed previously, but that ARRA had been uncertain of the size of the demand in the settlement. This report and the detailed data analysis to follow can assist ARRA in estimating current and future demand. A national grid connection would also allow for the possible sale of excess electricity from the solar mini-grid to ELPA. However, this must be discussed prior to the request for connection.

7. CONCLUSIONS

This study highlights the findings of the energy needs assessment of four refugee settlements in Iraq and Ethiopia. More specifically, the set goals were to identify technically and financially sound renewable energy and energy efficiency options to increase the sustainability of the settlements. The study has therefore pursued two main objectives: firstly, to outline methodologies to provide humanitarian organisations with recommendations to improve data collection, validation, processing and analysis; and secondly, to illustrate the potential benefits of increasing the use of renewable energy and energy management (efficiency and conservation) in refugee settings.

A key recommendation throughout the study has been that more data needs to be collected to support decision-making on energy-related questions. This study is making suggestions based on limited data acquired during the visits. Conscious of this, some of the discussions in the case studies provide concrete examples of challenges that could reduce the effectiveness of the recommendations presented. This report also highlights the need for regular energy data collection by the humanitarian agencies, which could lead to further improvements in the planning and operations of the energy infrastructure.

One area that illustrates the need for improved data collection is the energy requirements and generation in compounds operated by humanitarian organisations. Existing records of energy use in offices, guesthouses and service delivery points show that diesel generators are greatly oversized compared to the loads that they service, leading to large inefficiencies. By making use of energy loggers that are cheap to buy and easy to install, humanitarian organisations can enable themselves to properly scale and deploy solar systems and optimise diesel generators, thus creating savings that can be employed in improving the quality of services delivered to the refugees. This would require a commitment to have expertise to manage the data logging procedure and to process the results to effectively inform energy decisions in humanitarian operations.

Understanding the income vulnerability of households is another area that is key in determining how to improve refugees' access to energy. In Iraq, transitioning to a meter-based payment system for households in the refugee settlements could improve the availability and quality of electricity supply and be key to attracting investments in renewable infrastructure for the settlements. The economic implications that such an approach would have on refugees would have to be well understood prior to making this transition to ensure that appropriate support mechanisms can be put in place.

In Ethiopia, collecting data on household income would be central in moving towards market-based cash assistance as a way to scale up the supply of energy for refugees. Cash assistance would allow refugees to choose the cheapest fuels that satisfy their preferences for cooking, while supply could be regulated by licensing to ensure the sustainability of biomass. This would avoid establishing special schemes for fuel production such as briquettes or biogas, schemes that have been operating successfully outside the refugee contexts. Cash or voucher-based assistance could also be used to increase the distribution of fuel-efficient cook stoves or solar lamps and solar home systems.

Renewables are key for affordable, reliable, climate-safe access to modern energy services

The humanitarian organisations are well placed to suggest models that can be adopted by governments and host communities in the countries where they operate, as they can draw on international best practises on, for example, cook stoves or renewable energy, thus enabling them to showcase the use of improved technology. While the use of large-scale solar has increased dramatically on a global scale, the use of solar systems in both Iraq and Ethiopia has traditionally been limited to small household systems. Drawing on extensive international expertise on solar power, UNHCR and other humanitarian organisations have an opportunity to showcase the benefits of this technology by using it to improve the situation for refugees.

Beyond merely showcasing technology, the increased use of solar energy in the refugee settlements can contribute to establishing a wider ecosystem that is key in expanding the use of solar across the regions in which UNHCR and other humanitarian organisations operate. This ecosystem includes increasing the competence of the entities designing, installing and maintaining systems, as well as commercial actors that offer services such as the leasing model or PPAs for solar. It can also support governments in improving legislation related to renewable energy and allow for further investments in renewables in other sectors of the economy.

Finally, the study has illustrated that there are considerable synergies to be gained from the collaboration between humanitarian organisations such as UNHCR and specialised agencies on renewable energy such as IRENA in improving the access to sustainable energy for refugees.


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ANNEX: SCOPE OF WORK

To assess the current and expected energy consumption at the selected refugee settlements in Ethiopia and Iraq, IRENA procured the services of Kube Energy, a Norwegian consultancy firm with extensive knowledge and experience of renewable energy in humanitarian settings. Kube Energy collected detailed reliable data from the settlements that were then used to identify the ideal renewable energy solutions for reducing the cost and consumption of diesel at the settlements and providing the refugees with clean, reliable and cost-effective energy for lighting and everyday purposes.

Prior to the missions of the consultants, UNHCR's energy expert visited the refugee settlements during the fourth quarter of 2018 to collect and gather all current data available on electricity consumption for domestic and productive uses, household cooking, community energy, schools and health centres, and other significant sources of electricity consumption for each settlement site. These data were essential to provide the consultants with an overview and clear picture on the information available and on what needed to be collected during the site visits.

The energy assessments were conducted at the compounds of the various humanitarian organisations present in the refugee settlements as well as at the various service points (schools, health centres, etc.). The assessments also included a survey of beneficiaries at the community and the household levels, aiming to understand the refugees' point of view regarding energy consumption and, particularly for Ethiopia, regarding the problems with the neighbouring community for the collection of firewood for cooking.

The main activities for this study in both UNHCR country operations included the following:

1. Interviews with and surveys of beneficiaries at the community and household levels to understand their current energy consumption for lighting, charging and cooking;

2. Detailed energy assessments at the compounds of UNHCR and their partners and at service points (health centres, schools, etc.) to provide high-level recommendations for the installation of renewables;

3. Exploring options for installing a solar PV mini-grid connecting the central compounds in the settlements.

The overall scope of this mission included a brief desk review of available data from UNHCR, a four-week mission to Iraq and Ethiopia to collect data and a brief analysis of data. The data collection during the mission took place at four main levels: household/residential level, service delivery points (schools, primary healthcare clinics, boreholes, community centres, etc.), offices and guesthouses of the humanitarian organisations, as well as the settlement as a whole. Table A.1 shows the methods of assessment used at each level.

Table A1. Methods of assessment for Iraq and Ethiopia

Level	Ethiopia	Iraq
Household/ residential	• Household survey • Household visits • Interviews with organisations working on environmental protection and fuel cooking alternatives	• Household survey • Household visits • Load monitoring of diesel grids in the settlement
Service delivery points	• Energy survey at the delivery point, including load monitoring where relevant • Interviews with humanitarian organisations • Interview with settlement management	• Energy survey at the delivery point, including load monitoring • Interviews with humanitarian organisations • Interview with settlement management
Offices and guesthouses	• Energy survey at compounds, including load monitoring • Interviews with humanitarian organisations	• Energy survey at compounds, including load monitoring • Interviews with humanitarian organisations
Settlement as a whole	• Interview with Ministry of Energy • Interview with settlement management • Visit to sub-stations close to the settlements	• Interview with Ministry of Energy • Interview with settlement management • Visit to sub-stations close to the settlements

Due to a limited amount of time available for the energy assessments, several key locations in each settlement were prioritised based on the list of locations that was provided by UNHCR prior to the missions.

The main facilities and locations that were assessed at the various settlements included: offices and guesthouses of UNHCR and partner organisations, households, schools, briquette plants, grinding mills, boreholes, water treatment plants, health centres, staff accommodation, detention centres and vocational skill centres.

Renewable energy offers prime opportunities to strengthen any humanitarian operation. Solutions proposed for refugee settlements in Iraq and Ethiopia could be replicated wherever displaced people need energy access

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