Research Paper

Infrastructure Management Contracts: Improving Energy Asset Management in Displacement Settings

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About the Moving Energy Initiative

The Moving Energy Initiative (MEI) is working to achieve access to clean, affordable and reliable energy among displaced populations by:

- **Working with humanitarian agencies and donors** to change policies and practices based on evidence from practical projects;
- **Working with the private sector** to design and implement innovative market-based solutions;
- **Improving the evidence base** through original research and the demonstration of new approaches tried and tested in camps and host communities; and
- **Cooperating with host governments and national NGOs** to improve energy security among both local and refugee communities.

The MEI is a collaboration between Energy 4 Impact, Chatham House, Practical Action, the Norwegian Refugee Council (NRC) and the Office of the United Nations High Commissioner for Refugees (UNHCR), with funding from the UK Department for International Development (DFID).

Preface

The Moving Energy Initiative (MEI) is an international consortium seeking to change how the humanitarian system responds to the issue of energy. Initial literature reviews for the project were carried out in 2014, and the consortium was formally inaugurated in 2015 as a partnership between Energy 4 Impact, Practical Action, the Office of the United Nations High Commissioner for Refugees (UNHCR), the Norwegian Refugee Council and Chatham House.[1] Funding for this publication, and for the wider activities of the MEI, has come from the UK Department for International Development (DFID).

In 2015, the MEI report *Heat, Light and Power for Refugees: Saving Lives, Reducing Costs* shone a spotlight on the energy deficit suffered by displaced people, and on the gap in understanding energy access in humanitarian settings.[2] It was the first publication that attempted to quantify the amount of energy used by forcibly displaced people around the world, and to establish how much they paid for it. Subsequently, in 2018 the research paper *The Costs of Fuelling Humanitarian Aid* examined the energy use of humanitarian agencies, showing that around 5 per cent of humanitarian budgets was being spent on energy, and that substantial opportunities for saving money and resources were being squandered.[3]

Within the MEI, reflecting the 'learning by doing' approach that has been part of our process, we have observed substantial opportunity for humanitarian agencies to manage their own energy use better and potentially extend sustainable energy access to the refugees whom they are serving. But developing cleaner and more efficient electricity infrastructure requires appropriate operational models to ensure projects are designed, built and managed to cope with the challenges of humanitarian settings. This paper examines the feasibility of different models and partnership structures, and the possibilities each offers in terms of operational performance, financial incentives, risk management and typical division of responsibilities between partners. It explores the idea of infrastructure management contracts as a way to leverage private-sector expertise, and examines the benefits and current challenges of such arrangements. Using the Kalobeyei refugee settlement in Kenya as a case study, it seeks to provide analysis on various infrastructure options; and by doing so, to provide guidance for future organizations seeking to transform the way that they deliver energy.

[1] For more details on the MEI, see www.movingenergy.earth.
[2] Lahn, G. and Grafham, O. (2015), *Heat, Light and Power for Refugees: Saving Lives, Reducing Costs*, Chatham House Report for the Moving Energy Initiative, London: Royal Institute of International Affairs, https://mei.chathamhouse.org/resources/reports.
[3] Grafham, O. and Lahn, G. (2018), *The Costs of Fuelling Humanitarian Aid*, Research Paper for the Moving Energy Initiative, London: Royal Institute of International Affairs, https://mei.chathamhouse.org/resources/reports.

Executive Summary

Building and maintaining electricity infrastructure to power offices, businesses, households and other operations in displacement settings is difficult. It is especially challenging for the Office of the United Nations High Commissioner for Refugees (UNHCR) and its partner agencies, because supplying electricity is not their core business. Humanitarian agencies mostly manage energy infrastructure themselves. This can lead to periods of system downtime and premature failure of infrastructure due to lack of in-house technical expertise and budgetary ownership. A number of options exist to leverage the expertise of the private sector through 'public–private partnership' (P3) structures. The potential options range from engaging the private sector to design and build systems to offering 'energy as a service' through power purchase agreements (PPAs). P3 mechanisms can promote more efficient management of infrastructure by drawing on private-sector experience and expertise, incentivizing appropriate risk-sharing and providing options to leverage private capital in project development.

This paper presents findings from research by the Moving Energy Initiative (MEI) into options for the design of infrastructure management contracts, with a focus on the specific challenges of establishing appropriate operational models for planned energy infrastructure development in the Kalobeyei settlement in Kenya. The MEI completed initial assessments at the Kalobeyei site in February 2017, while that site was in the early stages of development, and analysed several different scenarios for energy infrastructure.

These analyses showed that a solar/diesel hybrid mini-grid solution was the most economical option (based on net present value) to power an institutional base load of camp services and infrastructure that allowed for a maximum demand of 1,037 kilowatt hours per day (kWh/day). The initial capital investment for this infrastructure was estimated to be in the order of $243,000, with an operating cost of $25,400 per annum. Compared to distributed diesel generation (which required an estimated capital investment of $62,200), the annual savings in operating costs were estimated at $49,880, with the additional investment paid back within 3.6 years. The MEI recommended that such a project could be tendered to the private sector for implementation under an infrastructure management contract if offtake commitments could be guaranteed by humanitarian agencies.

Based on the work completed under the MEI, this research paper draws the following conclusions:

- Private-sector companies exist that are willing and able to develop infrastructure management contracts to provide energy as a service in displacement settings. However, institutional barriers within humanitarian agencies persist, with short budgeting cycles in particular preventing humanitarian agencies from entering into the sorts of long-term service agreements required by the private sector.
- Humanitarian agencies' reliance on short-term donor funding incentivizes short-term procurement rather than longer-term agreements, even though the latter may prove more cost-effective and efficient in the medium to long term.
- In developing infrastructure management contracts, it is challenging to align the economic incentives with the risks inherent to an uncertain funding environment.

- Humanitarian agencies need to be willing to change their policies to enable long-term service agreements. Alternatively (or, more likely, in conjunction with this option), financial mechanisms such as partial risk guarantees need to be developed to offset some of the risks. This change will need high-level support from donors and humanitarian agencies.

The following recommendations are made to support the uptake of infrastructure management contracts:

- Further exploration of financial mechanisms such as partial risk guarantees is needed. Such mechanisms can mitigate the risk of early contract termination and the inability of humanitarian agencies to enter into long-term agreements.
- Humanitarian agency policies should be reviewed to determine how they can be made more conducive to infrastructure management contracts, both through incentives for humanitarian partners to enter into P3 agreements and through changes in procurement that could facilitate longer-term arrangements.
- Donors should review how they provide funding for energy infrastructure in displacement settings, to ensure that the conditions necessary for continued sustainability – either funding for long-term operations and maintenance (O&M) or efforts to incentivize long-term partnerships with the private sector – are considered.

Following the MEI assessments in 2017, a number of developments in Kalobeyei occurred that actually *reduced* the suitability of infrastructure management contracts and the appetite of humanitarian agencies for adopting them. These included the development of two mini-grids, under the German development agency GIZ's results-based financing (RBF) programme; the installation by UNHCR of a standalone solar system at Kalobeyei's main hospital; and the commissioning of a Kenya Power diesel mini-grid in Kakuma town.

However, there remain additional locations outside Kenya, particularly those where diesel prices are high, where infrastructure management contracts can be feasible if the constraints are overcome. The MEI has developed a toolkit[4] in conjunction with Kube Energy, a Norwegian renewable-energy services company, to guide humanitarian organizations interested in transitioning to solar-powered energy. The toolkit considers four options for transitioning to solar, the pros, cons and economic analysis for each of these options, and best practice for organizations to start on this journey.

Once the first infrastructure management contracts can be signed and tested in displacement locations (through the use of donor funding or otherwise) and associated data collected, it will ease the way for future investments in these types of projects.

[4] Moving Energy Initiative and Kube Energy (October 2018), *The Solar Energy Handbook: A guide to institutional solar for organizations working in humanitarian settings*. Toolkit available through the MEI website, https://mei.chathamhouse.org/file/2469/download?token=DFa3HvKW (accessed 27 Feb. 2019).

1. Introduction

Currently, large-scale energy assets in refugee settings are primarily purchased, operated and owned by humanitarian actors. This arrangement can be problematic. Humanitarian agencies rarely have in-house energy experts who can accurately design the systems and optimize their performance. This limits agencies' ability to specify and operate energy assets. Private-sector technology developers and service providers have the technical expertise and financial resources to help the humanitarian sector address these issues, but have insufficient access to refugee camps or incentives to service assets (a situation that reflects a lack of a stake in the ownership and operation of in-camp energy solutions). The financial planning context also provides camp administrators with limited incentive or opportunity to invest in assets/solutions with comparatively low operating costs, if these require high capital expenditure over a period of a few years. Hence, for example, humanitarian budget-holders may find it difficult to justify the cost of a solar system that is more expensive initially than a diesel generator but pays for itself in reduced diesel expenditure over time.

As part of the Moving Energy Initiative (MEI), Energy 4 Impact (E4I) has researched potential contract structures and options for outsourcing the management and maintenance of energy infrastructure in refugee camps to expert private-sector providers. As part of this research, in early 2017, E4I identified options available for providing energy infrastructure at the Kalobeyei settlement in Turkana, Kenya. E4I further evaluated the potential appetite of a variety of stakeholders for providing energy services in displacement settings, along with challenges and opportunities they foresee.

This paper highlights a number of options for managing electricity infrastructure and outlines the challenges, opportunities and operational implications associated with them.

This paper presents the findings of this research. It highlights a number of options for managing electricity infrastructure and outlines the challenges, opportunities and operational implications associated with them. In particular, it takes the Kalobeyei settlement as a case study – exploring the options for delivering energy infrastructure in the settlement and outlining the development of such infrastructure since 2017. Finally, the paper draws conclusions on how energy assets can be more effectively managed through infrastructure management contracts, and on the actions needed to make such mechanisms more feasible.

Kakuma is located more than 700 km from the Kenyan capital, Nairobi, and 130 km from the border with South Sudan. In 1992 the Office of the United Nations High Commissioner for Refugees (UNHCR) and the Kenyan government created Kakuma refugee camp to accommodate 12,000 refugees fleeing war in Sudan. It now hosts approximately 147,000 refugees from across the region,[5] including from Burundi, the Democratic Republic of the Congo, Ethiopia, Somalia and South Sudan. Nearly 60 per cent of its population is under the age of 18, with more men (54 per cent) than women (46 per cent).

[5] UNHCR figures as of 30 June 2018. See http://data2.unhcr.org/en/situations/southsudan/location/1867.

Kalobeyei is a refugee settlement about 15 km from Kakuma camp. It has been developed by UNHCR and the Turkana county government with the intent to integrate refugees within the host community, and to promote self-reliance through better livelihood opportunities and enhanced service delivery. Currently providing for more than 38,000 refugees,[6] Kalobeyei will eventually be split into three villages and has the potential to be expanded to accommodate a population of 45,000. As a relatively new settlement, it is being billed as an opportunity to test new approaches for refugee and host-community integration, private-sector engagement and sustainability.

[6] UNHCR figures as of 30 June 2018.

2. Options for Electricity Delivery

Electricity services in humanitarian settings can be provided through three main options: using in-house staff, assigning responsibilities to the private sector, and adopting a hybrid model that combines in-house and private-sector partners. The following descriptions provide a brief overview both of the in-house model and of public–private partnerships, the latter of which encompass different models in which public agencies may engage the private sector (with varying degrees of responsibility assigned to the private sector).

In-house energy infrastructure management

In this arrangement, in-house staff are assigned to specify, procure, manage, operate and maintain the energy infrastructure. In-house staff may hire outside consultants to support their efforts, but the risk of poor system design will reside with the humanitarian agency itself. Keeping infrastructure management in-house is generally considered an inexpensive way to operate. However, such arrangements often become cumbersome and expensive. This can be due to upfront investment needs, lack of technical expertise in selecting an appropriate technology, unclear organizational schemes to operate and maintain the systems, lack of professional management and accountability, operational inefficiencies and unavailability of after-sales service.

Assessments of existing sites at Kakuma showed that agency staff are generally able to supply uninterrupted power to agency compounds by operating and maintaining existing diesel generators. However, the generator sets are typically underused and inefficiently run. At the same time, several standalone solar photovoltaic (PV) systems (with batteries) that have been installed over the past few years in Kakuma are not working as planned. This is due to a lack of proper operation and maintenance (O&M) practices, inadequate operator training, and limited customer awareness of the availability of after-sales service. These process failures offer lessons that underline the value of considering different infrastructure management approaches.

Public–private partnerships

A public–private partnership (P3) is a broad term encompassing various types of long-term contractual arrangement between a public agency (such as UNHCR) and a private-sector entity, in which the private party bears significant risk and management responsibility for a cost linked to performance. In a P3 agreement, the public sector may hire one or more private firms to provide various services, such as O&M of existing infrastructure or building new infrastructure. When these services are combined in an integrated package, the public agency benefits from the incentive to optimize design and operation over the lifetime of the contract, and the ability to allocate performance risk more comprehensively to the private sector. P3 agreements can also be structured so that the private-sector partner takes on some or all of the capital expenditure financing burden.

Figure 1: Options for structuring P3 arrangements

Operations and maintenance (O&M) agreement	• A servicing arrangement in which a private-sector entity is responsible for all aspects of O&M of the existing energy infrastructure under contract. • Ranges from short-term (2–5 years) to long-term (up to 20 years) contract, with potential provision for renewal. • Can be used to incentivize efficiency and reductions in operating expenditure, including by optimizing asset configurations to reduce fuel consumption. • If not managed well, private operator may underspend on maintenance towards the end of its contract. • Private-sector entities could partner with UNHCR or its member agencies to implement energy-efficiency measures on cost-savings-sharing basis.
Design–build (DB) agreement	• The public entity transfers project design and construction responsibilities to a private-sector entity. • Normally the risk of adequacy of the specification lies with the public owner. The contractor is responsible only for building the system to the design specifications, and does not guarantee that any particular outcome will be achieved. • The private entity has the incentive to make the project design as robust as possible because – notwithstanding the above-mentioned risks on the part of the public partner – it still assumes the risk of design flaws and cost overruns. • Greater potential to save time and reduce cost as there is a close contractual relationship between the design and construction teams. • The contractor generally provides a specified system performance warranty for a limited period. • Arrangements with inclusion of a warranty and agreement to meet specific performance standards, at an additional cost, can be made to shift more project risk to the contractor.
Design–build–operate–maintain (DBOM) agreement	• Combines features of above agreements where the contractor is responsible for design, building, operation and maintenance of the facility for a specified period. • Payment beyond project completion is negotiated on meeting certain prescribed performance standards. • Provides added incentive to the contractor to employ high-quality construction methods and materials to reduce future maintenance expenses. • Allows public owner to specify outputs. Design adequacy risk lies with the private contractor, which takes responsibilty for the builder–operator interface.
Design–build–own–operate–transfer (DBOOT) agreement	• The private entity finances, designs and builds the infrastructure, and will then own and operate it for an agreed time. Thereafter, ownership of the infrastructure is transferred to the public-sector entity. • Various payment options exist, including establishing a power purchase agreement (PPA) in which the buyer (public agency) is the on-site host of the power generation equipment and the service provider (private sector) sells power to the buyer at a price agreed in the PPA. In this case, a guaranteed revenue stream permits the service provider to attract financing, while the buyer can take advantage of predictable electricity prices.
Concession	• The private entity finances, designs and builds the infrastructure, and then owns and operates it for an agreed time. Thereafter, ownership of the infrastructure assets is transferred to the public-sector entity. • In addition to collecting revenue from a public agency/agencies via a PPA or similar mechanism, the private entity uses the assets to provide services to multiple small customers, with which it has direct billing relationships (subject to some form of tariff regulation). • May entail private entity assuming responsibility for legacy assets. • Concession agreement may include targets for expanding service coverage and/or service standards for small customers.

Source: Developed by the authors.

Compared to in-house management, P3 arrangements hold particular advantages and can offer alternative financing and mechanisms for management of public-sector infrastructure assets. P3 arrangements can reduce infrastructure development risks, provide cost-effective and timely infrastructure delivery, offer a potentially higher standard of ongoing O&M, and more effectively leverage limited public-sector resources – all while maintaining an appropriate level of public control over the project.

A variety of models exist for organizing and structuring P3 agreements. In the Kalobeyei setting, the P3 options that could be of interest are summarized in Figure 1.

Financing: donor versus private capital

An important aspect of P3 agreements is financing for the projects. With some mechanisms (such as a design–build–own–operate–transfer agreement or concession), the private-sector partner will fund the project from its own balance sheet and/or by raising additional capital, potentially including commercial debt. This will depend on lenders and other capital providers being able to see a reliable stream of future cashflows that compare favourably to the initial investment, and that are underpinned by a secure future revenue stream, predictable expenditures and a known, dependable project duration.

The challenge in risky and uncertain environments such as refugee camps is that there are often no established financial models to fund such projects. In addition, short-term funding cycles may restrict humanitarian organizations from entering into long-term agreements. Typically, a private company would need at least three to five years to earn back the capital cost of the equipment; it would therefore need this period, if not longer, as a minimum commitment from the humanitarian organization. The possibility that refugee camps may be closed or that agencies' operations inside them downsized or reassigned is also often cited as a risk to infrastructure investment in humanitarian settings. Closure is in fact comparatively rare in crises of a protracted nature[7] (although the Dadaab refugee camp in Kenya has been threatened with closure).[8] But for a specific, individual project, it is unlikely that a provider of commercial capital would be prepared to take this risk. In such a case, it is more likely that the public partner would have to bear any early-closure risk. This obligation would be set out either through contractual terms, for example in the PPA (if applicable) via an early-termination penalty; or through a supporting financial instrument, for example within the scope of a partial risk loan guarantee.

Guarantees provided through donors could enable funding to stretch further than is feasible through direct funding of infrastructure projects. As the guarantee would only be activated when a humanitarian agency was no longer able to pay the power provider, a larger number of projects could be supported for a given level of funding. Another use of donor funding could be to provide concessionary loans to the private sector to finance infrastructure projects. It is expected that once projects in which the private sector provides energy as a service (whether supported by donor funding or other sources of capital) can be proven to be successful in humanitarian settings, commercial lending vehicles will be more inclined to invest.

[7] Kakuma camp was established in 1992. The average length of time that refugees spend in camps is 17 years.
[8] In 2016, the Kenyan government announced its intention to close Dadaab refugee camp. However, in February 2017, a court ruling blocked this decision and Dadaab camp remains operational. For more information, see D'Orsi, C. (2017), 'The world's largest refugee camp: what the future holds for Dadaab', *The Conversation*, 12 December 2017, https://theconversation.com/the-worlds-largest-refugee-camp-what-the-future-holds-for-dadaab-88102 (accessed 27 Feb. 2019).

The use of donor funding to directly finance the full capital cost of energy infrastructure may also be an option for humanitarian agencies. However, this may encourage the agency to engage in a design–build model only (with no agreement for operation or maintenance) to avoid the need for long-term commitments. This can become challenging, especially when the humanitarian agency does not make provision for long-term maintenance of the infrastructure. The above-noted failures of solar PV systems at facilities in the Kakuma area support this argument. Unless agencies are ready to take long-term responsibility for energy infrastructure, it is better to pay higher costs for a complete service and have a system that works over the longer term, rather than paying for infrastructure that goes out of service prematurely.

Other factors that may favour engaging private contractors include a lack of investment capital on the part of humanitarian agencies, a lack of trained workers, and the size and complexity of the infrastructure. For example, an agreement that engages the private sector on a long-term basis could be a better option in a situation where a generation facility is designed and built to meet present needs but must expand gradually as needs grow, or where the service will be provided over a wide area where building, expanding and maintaining the distribution network will be challenging. In such cases, the private sector may be able to provide the expertise to design and manage this evolving infrastructure, and may have the incentives to do so in a cost-effective manner.

Unless agencies are ready to take long-term responsibility for energy infrastructure, it is better to pay higher costs for a complete service and have a system that works over the longer term, rather than paying for infrastructure that goes out of service prematurely.

In locations where humanitarian operations are expected to be temporary (i.e. less than five years in duration), it is possible in theory to deploy renewable-energy systems using containerized solutions that can subsequently be moved to a new location. However, this is costlier than using fixed systems, and the additional costs of relocation also need to be taken into account. In practice, therefore, the infrastructure will typically be built as a permanent installation. The substructures and installation of the system can account for approximately 40 per cent of the project cost, so it is normally not feasible to recommission equipment for use in a new location; this explains why the private sector needs to see a return on investment over a minimum contract period. One option for larger systems could be to transition the system to serving the local community if humanitarian operations were to cease.

Box 1: Case study – Jordan solar farms

On 17 May 2017, UNHCR switched on a 2-megawatt (MW) solar photovoltaic (PV) plant, funded by the IKEA Foundation, in Azraq refugee camp in Jordan.[9] In November 2017, a 12.9-MW plant opened at Zaatari refugee camp, also in Jordan.[10] Funded through KFW Development Bank, this was the largest solar plant in a refugee camp in the world.

Initially electricity in both camps was provided through the national grid for the 'base camp' centre where most humanitarian organizations kept offices. Meanwhile, local diesel mini-grids and standalone solar systems supplied power for street lighting, markets, a hospital and other facilities. Having a sustainable and safe electricity supply for households was identified as a high priority by UNHCR, which manages both camps. UNHCR was also facing high electricity bills and dangerous electrical connections due to refugees accessing power through informal connections to the street lighting network.

To allow the solar plants to supply the camps, the electrical infrastructure within each facility needed to be upgraded. In Azraq this was done with funding from the Saudi Fund for Development, and in Zaatari with funding from the Czech government.

The solar farm in Azraq is being developed in three phases: the first is a 2-MW system inside the camp; the second a 1.5-MW system, also inside the camp; and the third a 1.5-MW system, outside the camp, that will connect straight into the national grid. UNHCR provides power to refugees, local businesses and various operational facilities at the base camp. Non-governmental organizations (NGOs) and other agencies still provide their own power from generators or hybrid solar/generator set-ups for operations outside the base camp.

In Zaatari, UNHCR provides power from the solar farm to refugees and various operational facilities, including those run by the local government. The local electrical distribution company supplies a number of customers in the camp, including UNHCR, other agencies and NGOs, all of which are invoiced directly. NGOs, businesses and other agencies that are not connected to the grid/solar farm provide their own power through generators or hybrid solar/generator set-ups.

In both camps the design, build, operations and maintenance of the plant were tendered to the private sector through an international competitive bidding process. In the case of Azraq, the O&M contract is held with UNHCR for two years and paid for from its operating budget. In Zaatari, there is a three-year O&M contract supervised by the Jordanian government and UNHCR. Refugees have also been engaged in the process, and have been hired by the contractor for construction and O&M of the solar farm in Zaatari.

In both Azraq and Zaatari, connections were made to the national grid to minimize electrification costs; if no national grid had existed, battery storage or other options would have been required. In each case, the solar farm feeds through the distribution network in the camp, and surplus generation is fed to the national grid using a net metering scheme. After the solar plants stop producing at night, each camp is then powered directly from the national grid.

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[9] Azraq opened in 2014, and had a population of 43,000 as of May 2018.
[10] Zaatari opened in 2012, and had a population of 83,000 as of May 2018.

These solar plants illustrate the use of humanitarian aid for assets built to outlast the refugee-hosting period, and thus intended to provide a future legacy of functional infrastructure for the host community. While the private sector has not provided financing for the projects, it has been engaged in their design, construction and long-term O&M. The Azraq installation is currently saving UNHCR around $2 million each year since being upgraded to 3.5 MW in September 2018 through additional funding from the Saudi Fund for Development. Once the solar plant is upgraded to 5 MW and is operating at full capacity, this will increase these savings, further reduce CO_2 emissions and cover 70 per cent of Azraq's energy needs. In Zaatari, the solar plant is expected to reduce annual CO_2 emissions from the camp by 13,000 tonnes and save UNHCR around $5.5 million per year.[11]

Risk allocation in P3 agreements

A key aspect of P3 agreements is the explicit allocation of risks between the parties involved. The general principle is that project risks are allocated to the party best equipped to manage them cost-effectively. For example, in a camp setting it may be more appropriate to allocate political and regulatory risks to the public agency during planning stages, while allocating building and operating risks to the private sector. Table 1 highlights how risks are commonly shared between the private sector and the public agency in different arrangements.

[11] Grafham and Lahn (2018), *The Costs of Fuelling Humanitarian Aid*.

Table 1: Typical allocations of scope and risk for in-house project management vs different P3 arrangements

Scope allocation							
	In-house	DB	O&M	DBOM	DBOOT	Concession	Comment
Operations management	Public	Public	Private	Private	Private	Private	Scope refers to all O&M of the system (note there will be some level of operational oversight even where scope is allocated to private entity).
Design/build management	Public	Private	Public	Private	Private	Private	
Capital financing	Public	Public	Public	Public	Private	Private	System underperforms because original output/overall requirement specifications were wrong.
Retail customers	Public/ n.a.	Public/ n.a.	Public/ n.a.	Public/ n.a.	Public/ n.a.	Private	In many cases there are no retail customers. Where there are, they may be direct customers of the private entity, as in a concession, or the public agency may retain them, as in the other models.
Risk allocation							
	In-house	DB	O&M	DBOM	DBOOT	Concession	Risk description
Adequate output specification	Public	Public	Public	Public	Public	Public	System underperforms because original output/overall requirement specifications were wrong.
Adequate system design	Public	Private	Public	Private	Private		System underperforms because design was not sufficient to meet original output specifications.
Capex overspend	Public	Private	Public	Private	Private		Construction cost exceeds budget.
Build quality	Public	Private	Public	Private	Private		System underperforms because installation/equipment supplied is of poor quality/does not meet design specification.
Operating performance	Public	Public	Private	Private	Private		System underperforms due to operator error, failure to maintain, non-availability of spare parts, staff retention challenges, etc.
Opex overspend	Public	Public	Private	Private	Private		Opex exceeds budget for same reasons as above.
Volume risk (major offtaker)	Public	Public	Public	Public	Public	Public	Demand levels are insufficient to justify/pay for assets installed/ operating infrastructure.
Major offtaker/client credit risk	Public	Public	Private	Private	Private		Revenue/cost of service provision not recoverable from major offtaker/client.
Longevity/stranded assets	Public	Public	Public	Public	Public	Public	Early termination (e.g. due to camp closure) means installed assets no longer serve economic purpose.
Household/small customer risk	Public/ n.a.	Public/ n.a.	Public/ n.a.	Public/ n.a.	Public/ n.a.	Private	Revenues from small customers are insufficient, either because of low demand or poor credit performance.
Ongoing staff/site security	Public	Public	Private	Private	Private		Threats to staff or physical assets from vandalism/crime/political unrest/terrorism.

Notes: The term ‘capex’ refers to capital expenditure; ‘opex’ to operating expenditure; DB to design–build; O&M to operation and maintenance; DBOM to design–build–operate–maintain; DBOOT to design–build–own–operate–transfer. n.a. = not applicable.
Source: Developed by the authors.

In many respects, this table is a simplistic representation. For example, in full contracts, the different risks are dealt with in some detail, and the allocation of a specific risk may well be conditional to some degree on the other party fulfilling an obligation,[12] or the risk may be explicitly shared according to some formula. Any public agency embarking on these sorts of contracts for the first time needs sound advice on these points, particularly as the lawyers representing private-sector infrastructure outsourcing companies are likely to be well versed in the ways of diluting their clients' exposure – which could in turn could increase the risk exposure of the public agency. It should also be noted that the table identifies only two parties ('public' and 'private'), which in itself is a simplification. Typically, other parties are also involved that share some of the risk. Indeed, the main function of some of these parties (e.g. insurance or surety companies) is to assume a specific risk on behalf of either the public or private party. Finally, of course, a contractual allocation of a risk or obligation to one party may be limited by the other party's ability to enforce the contract. Some of the criticism of P3 initiatives engaged in by different governments has centred on the limitations of allocating risk to private companies: if ultimately a private company's contractual obligations render it insolvent, then it will be in no position to absorb the risk as intended.[13]

Ultimately, the variation in risk allocated between the parties will depend on their preferences in different project locations. An example is the allocation of 'volume risk': i.e., if demand for energy services is lower than expected, the level of usage will be insufficient to justify the size (and cost) of the system built, and this risk must be carried by someone. Which party this falls to is often determined by the payment method agreed for the project. The most common payment options are:

- **Monthly flat rate.** The public agency pays a monthly flat rate for power usage within a given range. This option may be favoured by agencies, since a fixed monthly cost is easier to manage for budgeting purposes. In such cases the private sector's profit is measured by the difference between the total costs incurred to operate the facility and the monthly fee received. Hence, for the private party, the emphasis would be on keeping operating costs as low as possible. Further, the private party may implement energy-efficient measures in the agency's operations to keep power usage as low as possible. Since the private sector will assume the operational risk of the facility, it may price this into the monthly fee, raising the cost to the public agency.
- **'Pay as you use'.** The public agency pays the private sector for the actual amount of power used each month, based on a set price per kWh of energy consumed. This arrangement may also include an overhead cost or minimum fixed fee to recover the private sector's investment. Such an arrangement can reduce the risks of excessive cost to the agencies and deficient performance by the private sector. If the agency doesn't need the power, or the private sector can't supply it, then no payment is made (beyond any fixed fee). In such an arrangement, the incentive to manage demand and implement energy-efficient measures is on the public agency, as reducing its energy demand will lower its costs.

[12] A typical example would be a construction contract which is not in effect a 'fixed-price' agreement if the client specifies design changes part-way through the project.
[13] The collapse of Carillion in the UK, for example – albeit as a consequence of wider issues than an inability to fund its P3 obligations – precipitated much media comment along these lines.

- **Application of bonus/penalty payments.** Contracts can also be structured to include provisions to measure the private sector's compensation through incentives tied to the system's output and/or the private sector's ability to meet operating budgets. The private sector is provided with incentives to maximize system output and minimize operational costs. For example, if a private-sector party is unable to provide power due to a system outage, it becomes obligated to pay the humanitarian agency a compensation fee. Alternatively, if the private sector is able to meet all performance and efficiency targets set out by the agency, a bonus may be paid. In addition, incentives can be established for both parties by sharing the cost savings from lowering diesel consumption. This incentivizes the public agency to use energy efficiently and the private-sector party to operate equipment efficiently.

P3 agreements: conclusion

A summary of the respective pros and cons of the P3 approach and in-house management is presented in Table 2. With all P3 agreements, thorough due diligence is needed to understand what is at stake and to make informed, strategic decisions. This includes clear identification of work-specific needs, analysis of revenue streams, transparent assignment of responsibilities, smart negotiation of performance-based payments, and detailed review of terms and conditions. Moreover, clear delineation of each party's responsibility for costs and activities under the contract is necessary, a process that should also form part of the assessment of the economic value of the deal. If details are not worked out carefully, especially when external financing is involved, P3 agreements can become a financial liability for either party (due to the long-term commitment). Further information on the process of designing and structuring P3 agreements is outlined in Annex 1.

Table 2: Summary of the pros and cons of the two main types of electricity delivery options

	In-house energy infrastructure management	Public–private partnership (P3)
Pros	• Infrastructure investment is a one-off expenditure more suited to short-term donor funding cycles. • Provides opportunities for in-house staff training and skills development. • No long-term commitment to pay recurrent expenses. • No negotiation of complex contracting arrangements.	• Introduces private-sector technology, innovation and operational efficiency. • Incentivizes capital efficiency and lowest LCOE.[14] • Incentivizes the private sector for on-time and within-budget project delivery. • Incentivizes long-term and optimal performance of energy infrastructure. • May help to develop local private-sector capabilities through joint ventures with large international firms, as well as through sub-contracting opportunities. • Brings long-term value for money through appropriate risk transfer to the private sector. • Private sector can take on risk of upfront financing.
Cons	• Agencies need to have appropriately qualified staff and capacity to manage their own energy infrastructure. • Agencies may not have the internal capacity to manage complex, large and expanding infrastructure. • Requires upfront capital investment for the infrastructure. • Equipment may not be designed or operated to maximum efficiency. • Can result in premature failure of equipment where agencies don't take ownership and maintain systems.	• Depending on financing structure, P3 arrangements can cost more than traditional in-house procurement and management practices in the initial years. • May require concessional financing or loan guarantees in order to secure private financing for projects. • No unlimited risk bearing. Private entities and their lenders are cautious about accepting major risks beyond their control. • In-house workforce will get limited training and experience in managing evolving infrastructure and operating new energy supply systems.

[14] The abbreviation LCOE refers to 'levelized cost of energy', a measure of the present value of the total cost of building and operating a power plant over its assumed service lifetime.

3. Assessment of Stakeholders' Appetite

Initial assessments indicate a good level of interest from the private sector in partnering with UNHCR and other agencies to provide clean electricity services using some form of P3 model. During the course of its second phase, the MEI had discussions with a number of companies providing such services in the international development and humanitarian assistance contexts. A summary of feedback from these conversations is presented below:

- There is strong interest from private-sector companies in providing energy services in displacement settings, and openness towards a variety of combinations of P3-type agreements.
- Some such companies, such as Kube Energy, have already approached humanitarian organizations to offer energy services, while others are providing P3-type agreements in other off-grid sectors. Ubuntu Power, for example, a Kenyan-based company specializing in providing power, connectivity and water to off-grid communities, has installed a number of standalone systems in Jordanian and Iraqi refugee camps.
- Companies will have preconditions as to the minimum project size and contract length, especially when providing financing for a project.
- Most companies will prefer to design a system from scratch and be involved as early as possible in the project, rather than taking over management of existing assets.[15] In this way the company can guarantee the quality and efficiency of the equipment and design, especially if it is to take on the risk of guaranteeing the system output.
- Humanitarian organizations have limited technical experience and expertise, and require support at all stages of the energy system's design and tendering process. The private sector is willing to offer this support – which would be needed, for example, in completing energy assessments, logging the load profile, carrying out cost–benefit analysis of the transition and submitting proposals. Private-sector support would also be needed for completing design, installation and operation.
- Several companies can provide containerized solutions where the equipment is housed in a shipping container, making it easy and quick to deploy. If a camp closes, the equipment can be redeployed to another location, albeit at additional cost. However, some permanent structures such as poles and wiring are still needed.
- Companies, especially those with a strong social focus, are also looking at other services that can be offered through renewable-energy hybrid systems, and at integrating electricity, water and telecommunication services into their product offerings.
- The private sector is able and willing to provide modular systems that can be built up over time as the needs of a refugee camp grow.

[15] Taking over the management of existing assets may not make sense unless challenges in management are being experienced.

- A number of companies provide innovative standalone systems that could be integrated to meet camp energy needs. Sunna Design, for example, a French firm specializing in solar energy management, has a street lighting system that can also provide electricity to several houses and to a local hotspot for wi-fi services.

Initial assessments by the MEI conclude that there are several private-sector companies globally with the relevant expertise and appetite to provide energy services through P3 arrangements. In Kenya, for a private-sector company to engage in selling energy services, it needs to obtain the relevant permits from the Kenyan authorities, namely a licence or permit for power generation, distribution and supply.[16] As detailed in the Energy Act 2006, installed capacities of less than 3 MW require a permit, while those above 3 MW require a licence; the permit is cheaper and quicker to obtain. In addition, land in the camps in Kenya is managed and allocated by the Refugee Affairs Secretariat (RAS) working with UNHCR.

Several of the companies interviewed have already approached humanitarian agencies and engaged in detailed discussions, provided energy audits and initial costing, often at their own expense. However, very few of their efforts have resulted in humanitarian agencies engaging in P3 agreements – there are some examples of DBOM agreements having been established, but none was identified where the private sector has signed a contract to provide energy as a service to humanitarian agencies. Some of the reasons cited by the private sector for this are given below, alongside some of the mechanisms that could be used to encourage agencies to engage in such agreements:

- Most P3 agreements require a minimum three- to five-year contract period, with others stipulating 10 to 15 years. Procurement processes often restrict humanitarian agencies from committing to long contract periods, since agencies typically operate on funding cycles of one to two years. Some companies are exploring offtake agreements based on kWh instead of a given time period, to get around procurement limitations on long-term contracting. The availability of short-term funds encourages agencies to procure energy infrastructure outright (through DB agreements) with limited provision for long-term O&M.
- In addition, agencies' responsibilities within a camp can change. For example, an agency's role as lead provider of healthcare services may be given to another agency after a number of years.
- In both of the above cases, offering donor-funded mechanisms to compensate the company or its funder(s) in the event of early contract termination could be a way to address concerns. However, humanitarian agencies would still need to demonstrate long-term commitment to P3 projects and not simply see these mechanisms as an easy way to mitigate future payment obligations.
- Humanitarian agencies are reluctant to erect permanent structures for energy infrastructure in temporary settings, instead favouring standalone diesel assets that can more easily be redeployed elsewhere. That said, even in temporary settings the building of permanent structures is often unavoidable and is already happening.
- P3 agreements can result in higher costs for power during the first few years, as investors and private-sector companies need to recover their capital investment, particularly in agreements in which they are providing financing for the system. However, appropriate

[16] For further details, see The German Climate Technology Initiative, GIZ Promotion of Solar-Hybrid Mini-Grids Project (2015), *How do we license it? A guide to licensing a mini-grid energy service company in Kenya*, https://www.giz.de/en/downloads/GIZ2015-ProSolar-Licensing-Guidebook.pdf (accessed 27 Feb. 2019).

structuring of capital funding through concessional loans or loan guarantees could be used to reduce the upfront burden on humanitarian organizations.

- Companies have also cited humanitarian agencies' long procurement processes as a hindrance to developing contracts.

Box 2: Case study – Kube Energy

Kube Energy, a Norwegian renewable-energy services company, powers non-profits currently reliant on diesel generators in displacement settings, with a particular focus on Somalia and South Sudan. To date, the business has financed projects through internal and partner resources. Kube cites the following as major hurdles to non-profits adopting solar power in emergency settings: the high upfront costs of solar systems, a lack of pressing practical need to replace diesel with an alternative fuel source, non-profits' lack of experience in tendering under PPA structures, and non-profits' limited operating expertise. Kube has had to spend time and resources educating the market, and this has led to long lead times to reach project implementation stages. The key to success in this space is to deliver immediate cost savings and improved reliability, thereby reducing operating risk for humanitarian agencies.

Nonetheless, the company has recently won a tender to sell power under a PPA contract to a major international development organization's facility in a refugee camp in South Sudan. The solution provided will run on solar power and battery with diesel as a back-up, targeting 85 per cent to 90 per cent up time for the solar/battery system. With the PPA model, the non-profit ends up paying more for power than if the system were financed in cash upfront. However, it transfers all of the financial and operating risk to Kube Energy. This mitigates the development organization's lack of technical design and operating expertise.

Locating the facility on the site of the non-profit affords the same level of security for the installation as for other infrastructure owned by the non-profit. The model could be further developed by securing land independently of the non-profit and then selling power to multiple development organizations within the displacement setting, as well as to local community facilities. With an anchor tenant for a mini-grid secured, there might be scope to connect households as well, using results-based financing mechanisms for example.

The risks of operating in this environment – the most important being 'longevity risk', which can affect long-term purchase/leasing agreements – highlight the need for small-ticket insurance and investment guarantee products to support commercial capital that is willing to finance the projects on a technical and credit-risk basis.

To prove the concept, Kube Energy and its partner, Scatec Solar, have been obliged to finance this project with internal equity and have picked the strongest prospect site. To extend the model to smaller sites and/or sites with longer payback periods, Kube Energy will require blended finance. Once it has a track record, the model should attract project financing from lenders in the space, such as SunFunder and Cross Boundary Energy. A guarantee mechanism could help to attract lenders at an earlier stage, and at any rate may allow Kube Energy to expand its model faster by accessing more capital.[17]

[17] Cohen, Y. and Patel, L. (2019), *Innovative Financing for Humanitarian Energy Interventions*, Research Paper for the Moving Energy Initiative, London: Royal Institute of International Affairs, https://mei.chathamhouse.org/resources/reports.

4. Kalobeyei and Kakuma – Evaluating Energy Infrastructure Management Options

The MEI began working in the Kakuma camp and Kalobeyei settlement in August 2016, completing assessments of refugees' energy use and priorities before embarking on several interventions to test new approaches to energy management and provision. These interventions have focused on engaging the private sector through funding low-carbon projects and market development activities. The MEI also completed feasibility work into the options for infrastructure management at the camps, including whether the camps could be suited to P3-type agreements.

Review of existing energy infrastructure

Currently UNHCR and its partner agencies are using diesel generators to supply electricity at the majority of their facilities in Kakuma camp. There have been efforts to supplement diesel electricity with solar PV generation coupled with battery storage at some sites, and also to provide dedicated clean energy at others. However, most of these efforts have been unsuccessful, mainly due to a lack of proper O&M and budgetary allocation, often on the part of the agencies. This has led to several cases of premature battery failures.

In February 2018, Kakuma town received power from an REA-constructed,[18] Kenya Power-operated diesel mini-grid, which runs on two 500 kilo-volt-ampere (kVA) diesel generators. As of June 2018, the system was underused and there remained room (and a business case) for adding connections and building up demand. Majority state-owned Kenya Power[19] intends to extend distribution to other nearby villages, including Kalobeyei. This would require upgrading the transformer. Kenya Power has also indicated that it may consider supplying larger buildings and businesses in Kakuma camp; indeed, observations on the ground suggest that this is already being piloted. However, as the camp is not under government mandate, supplying it more broadly with state-generated power may be politically sensitive.

Offices and staff residences at the UNHCR compound in Kakuma are served by five generators that are powered at different intervals depending on prevailing load and weather conditions, with a total capacity of 2,050 kVA. At a power factor of 0.8, the installed capacity of these generators is equivalent to approximately 1,640 kW. To meet fluctuating power demand at the compound, the generators become operational as needed and collectively consume around 1,000 litres of diesel in a 24-hour period. Given that UNHCR pays approximately $1 per litre for diesel, this represents an annual fuel cost of around $365,000 to provide power to the UNHCR compound. Observations indicate that the five diesel generators available to UNHCR are likely to be underused.

[18] Rural Electrification Authority.

[19] Kenya Power owns and operates most of the electricity transmission and distribution systems in Kenya. The government has a controlling stake of 50.1 per cent, with private investors owning 49.9 per cent. For further details, see Kenya Power (undated), 'Who we are', http://kplc.co.ke/content/item/14/who-we-are'.

A 16-kilowatt peak (kWp) solar PV system, consisting of 84 panels of 190 watts each, with battery storage was installed at the UNHCR compound in 2010 to supplement power generation from the diesel generators. The purpose of the system was to provide electricity for security lights during the night; it was designed and built through grant funding provided by EDP, a Portuguese company. However, the batteries failed in less than two years, primarily due to high temperatures at their storage location and lack of maintenance.[20] Some of the solar panels remain functional, nonetheless, and should work well during daytime to supplement diesel generation. The PV system itself has now been turned off. Similar examples of solar PV systems that are not functioning to their full capacity were observed at other sites within Kakuma camp.

There is a clear commercial opportunity for hybridization, given that agencies spend a significant share of their budgets on diesel and that the private sector could be engaged to provide energy as a service – potentially financing the equipment if the agencies sign long-term agreements.

These observations highlight two areas where the private sector could be engaged in managing the existing energy infrastructure at Kakuma camp:

1. A private firm could be contracted to manage the current diesel generator infrastructure at the Kakuma compound, with UNHCR negotiating a monthly fee for the service. Bonus payments could also be negotiated, with both the contractor and UNHCR sharing the savings in the event that diesel consumption is reduced. This would provide incentive for both parties to implement energy-saving measures and maximize the efficiency of the equipment.
2. The private sector could be contracted to recommission and maximize the existing solar infrastructure in the camp. Such an arrangement could be combined with management of the existing diesel assets, as suggested above, or with development of new hybrid/ renewable assets.

In addition to the UNHCR compound, there are various other compounds in Kakuma, operated by the World Food Programme (WFP), Norwegian Refugee Council (NRC), Lutheran World Foundation (LWF) and National Council of Churches in Kenya (NCCK) respectively. Electricity to these compounds is supplied by each agency's own diesel generators. Given the large anchor loads, there is an opportunity to install solar or hybrid systems directly at these compound sites so that they become self-reliant. Alternatively, if the compound sites could be combined, they could make a good location for a larger solar generation site, the excess electricity from which could be sold to and used by others. Using compound land would also mitigate the challenge of land acquisition, which is a key factor that delayed the Kenya Power mini-grid from becoming operational in Kakuma town. There is a clear commercial opportunity for hybridization, given that agencies spend a significant share of their budgets on diesel and that the private sector could be engaged to provide energy as a service – potentially financing the equipment if the agencies sign long-term agreements.

[20] Such batteries should last maintenance-free for approximately five years before they need replacing. However, the high temperatures and dusty environment experienced in Kakuma can contribute to premature failures.

Since the Kenya Power mini-grid in Kakuma was commissioned, several of the agencies have expressed interest in connecting to it – partly to support the government's efforts to expand electricity supply infrastructure. A private mini-grid operator would not be able to match the tariff offered by Kenya Power without an ongoing public subsidy. It is therefore unlikely that the agencies will enter into long-term contracts with the private sector for managing existing diesel infrastructure or developing renewable-energy infrastructure at the Kakuma compounds. Hybridization of the Kenya Power mini-grid may be the best option for these compounds to access cleaner energy.

Box 3: Lutheran World Foundation compound energy usage

The compound in Kakuma refugee camp managed by the Lutheran World Foundation (LWF) hosts 19 agencies. It has two diesel generators (300 kVA and 250 kVA), one which operates in the daytime and the other at night. Currently LWF pays around KES 2,000,000 ($19,820) per month for fuel. This represents approximately 45 per cent of the agency's annual operating budget for the Kakuma compound, and reducing this cost is a priority for LWF. As Kenya Power is now providing power in Kakuma town, LWF discussed the possibility of connecting to the Kenya Power diesel mini-grid. Quotations indicated an estimated equivalent cost of KES 350,000 ($3,468) each month; this would represent a saving of around 80 per cent each month.

Energy infrastructure options for the Kalobeyei settlement

Following the review of existing energy infrastructure, the feasibility work focused on the Kalobeyei settlement, with surveys conducted from 31 January to 8 February 2017 to assess the site's requirements and suitability for any new energy infrastructure. Kalobeyei was chosen instead of Kakuma camp as the focus of the feasibility work because it is further away from the Kenya Power diesel mini-grid, which at the time of the surveys was still under construction and seemed unlikely to be extended in the foreseeable future.[21] In addition, the Kalobeyei settlement was at the early stages of development at the time of the site surveys and there was a strong focus on using sustainable energy sources – providing an opportunity to integrate innovative management arrangements from the outset.

The plans for the Kalobeyei settlement, at that time, envisaged that it would house UNHCR and partner agencies' offices, a hospital (with a clinic and maternity ward), police posts, a community recreation centre, a business park, a central market place, a firewood/cooking stove production centre, primary and secondary schools, a nutrition centre, distinct family compounds and neighbourhoods, a social services centre, neighbourhood markets, a playground and a sports field.

Total electricity demand for the first year of the site was forecast at 350 kWp, including potential demand from refugee households and the surrounding community. It was estimated

[21] There are now indications that the mini-grid may be extended to Kalobeyei, although this would require upgrading the transformers. However, firm verification of such a plan, or of any timeline for it, could not be obtained.

that demand could exceed 1 MW by the time all the facilities were built after 10 years.[22] The demand sites were spread over an area of approximately 3.8 km^2 within the camp;[23] Kalobeyei village is approximately 2.5 km away from the main camp buildings. The refugee and local households were not wired for electricity service, nor did any distribution network exist. At the time, the households represented more than 80 per cent of the potential energy demand. However, this figure does not necessarily translate directly into a commensurate willingness on the part of residents to pay for the service. It should be noted that a number of informally run diesel mini-grids are in operation within Kakuma camp, and that households and businesses pay a relatively high tariff to connect to them. This indicates that some households and businesses are able to pay for power in neighbouring Kakuma; however, the extent of this market in Kalobeyei is yet to be determined.

Providing power to refugee households and businesses (either for free or for a fee) does not fall under the current mandate of UNHCR or any other humanitarian agency. It is likely that such an initiative would need to be led by the private sector. However, the private sector would need to see that managing connections for businesses and households would make commercial sense. This is a challenge with mini-grids in any off-grid locations, heightened in refugee settings by the fact that the economic activity of refugees is limited and data regarding energy usage are sparse. Managing individual payments to enable households to pay for an electricity service could be time-consuming; significant investment would be required to build the necessary distribution network and metering facilities. In this context, for Kalobeyei it was proposed that a power supply system be developed using the camp services and administration as the anchor client, but with the capacity to deliver power to refugee households and the surrounding community should the proposed grid be expanded in future phases.

To reduce costs and environmental impact, a system of end-user incentives could be put in place to manage demand, which could be done through a metering system. Once meters are in place, excessively heavy users could be identified and energy-saving initiatives implemented. Smart metering could also provide an opportunity to manage peaks in demand via load shedding,[24] or by restricting total demand from any one building. A system of metering could also help with providing power to refugee households, perhaps using a ‘pay as you go’ system through mobile phone payments to manage customer payments.

Options for the provision of power in Kalobeyei

A number of scenarios were mapped out to understand the potential capital and operating expenditures of different energy infrastructure options. For these analyses, the total base load was calculated by estimating electricity demand from one building of each type (one police post, one hospital, one UNHCR office, etc.). This base load would need approximately 1,037 kWh of power per day. Cost estimates did not cover the cost of connecting households, but any system could be expanded and include such costs at a later stage.

[22] Electricity needs for surveyed and planned facilities were estimated using a number of potential fixtures and appliances and their power requirements (watts) at each site. For buildings that were planned or under construction, comparable facilities and available information were used to estimate electricity needs.

[23] Estimated area of Phase 1 of Kalobeyei taken from the Kalobeyei Master Plan map.

[24] ‘Load shedding’ is the deliberate shutdown of electric power in a part or parts of a power-distribution system, generally to prevent the failure of the entire system when demand strains capacity.

The following scenarios (each of which would provide around 1,037 kWh per day) were considered:

1. Distributed generation using individual diesel generators for each of the major buildings (the typical power provision system). This would have a cumulative capacity of 164.5 kVA, with each individual system using a small battery bank[25] for overnight lighting needs.
2. A mini-grid system using diesel generation with a total capacity of 210 kVA.[26,27]
3. A mini-grid system using 110-kVA diesel generation, a 75-kWp solar PV installation and a 24-V, 1,500-ampere hour (Ah) battery.
4. A mini-grid system using 100-kVA diesel generation, a 75-kWp solar PV installation and a 24-V, 4,000-Ah battery installation.
5. A mini-grid system using 60-kVA diesel generation, a 150-kWp solar PV installation and a 24-V, 5,000-Ah battery installation.

Wind generation is also a technology option for the Kalobeyei settlement and could be considered for some projects. However, to date most renewable installations in the camp have used solar technology, which agencies seem more familiar with.

All the above solutions apart from Option 2 use battery storage to provide power when diesel or solar output is reduced or unavailable. Options 4 and 5 have larger battery installations to maximize the use of solar power and provide better grid stability. The more batteries a system has, the less diesel it will use, since the solar-charged batteries will provide power when solar radiation is not sufficient. However, this increases the capital expenditure of the system, and such options have higher battery replacement costs. Standard batteries have a short life, six years at most, even if well maintained and protected from high temperatures. Unprotected from high temperatures, batteries can last as little as two years. The above appraisal assumes a battery life of five years.

Table 3: Financial analysis of electricity supply options

Option	Capital cost, $	O&M costs, $/yr	NPV, $	Additional cost payback – years
1. Baseline – diesel generators	62,200	75,213	-639,390	n.a.
2. Mini-grid, diesel	91,000	68,100	-600,701	4.0
3. Mini-grid, solar/diesel/batteries	235,000	29,775	-448,159	3.8
4. Mini-grid, solar/diesel/batteries	243,000	25,395	-434,194	3.6
5. Mini-grid, solar/diesel/batteries	367,000	17,730	-492,647	5.3

Notes: NPV refers to 'net present value'. n.a. = not applicable.
Source: Table developed by the authors.

[25] In the distributed-generation option, the overnight load for each institution is too small to efficiently run a diesel generator, so small battery banks are included. In Option 2, since generation and distribution are shared through a network, the diesel generator set can efficiently cater for the cumulative overnight demand from all these institutions.
[26] A combination of smaller diesel generators would be used to allow for them to be staged as demand fluctuates.
[27] When combining loads into a single generation system, it is not just a case of adding the standalone generation capacities, since the combined system must account for starting currents and demand spikes.

The following assumptions were used for this analysis:

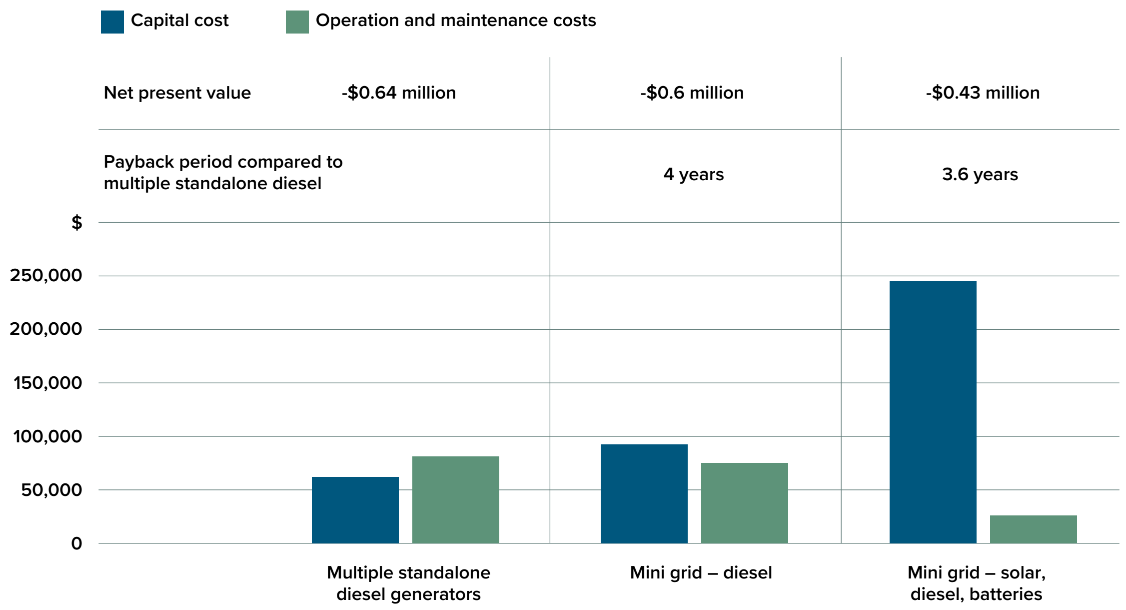
1. Capital costs are preliminary estimates, which would have to be further validated in conjunction with suppliers. Project costs are discounted over a projected 15-year service life. The PV array and diesel generators are assumed to have a service life longer than this period. The batteries are assumed to be replaced in year five and year 10. The cost estimates for the mini-grid systems include a 5-km distribution system (total length of cables, not radius of network) to connect the institutional loads.
2. O&M costs – diesel is assumed to cost $1 per litre. For Option 1 (a large number of distributed generators), it is assumed that three operators are employed. For the other options, the use of two operators is assumed. The plant suppliers will require ongoing maintenance to enforce warranties. The cost of this maintenance is assumed to be covered by the labour cost.
3. Financial appraisal is done using a discounted cashflow model. Table 3 shows the net present value (NPV) of each option, with a discount rate of 10 per cent used. Current prices at the time of writing are used; no provision has been made to adjust for the possible disproportionate inflation of diesel costs, or for likely falls in battery costs. No adjustment has been made for possible tax or grant impacts. The appraisal also assumes a flat level of demand per annum, with zero growth. Because the incremental cost per kWh of additional supply is greater for diesel than for solar systems, this assumption will tend to underestimate the relative attractiveness of solar power.

Design details of these options and their appraisal are given in Annex 3.

From Table 3, it can be seen that Option 4 has the best NPV. Therefore, a mini-grid system using diesel generation, a 75-kWp solar PV installation and a 24-V, 4,000-Ah battery system was recommended as the best solution that could meet the institutional base load scenario formulated for the settlement. The initial capital investment was estimated at $243,000, with an operating cost of $25,400 per annum. While this solution is initially more expensive than multiple standalone diesel generators (which require an estimated upfront investment of $62,200), annual savings on operating costs are estimated at $49,800; this means that the additional investment would be repaid within 3.6 years. This option also both offers a more reliable supply (since it is not reliant on one generation type or fuel source) and reduces greenhouse gas emissions.

The comparison between Options 1 and 2 shows that mini-grids are more economical to run than multiple standalone generators even when both options are based on the use of diesel generators. This indicates that the status quo electricity supply in the majority of refugee camps is inefficient and expensive. Furthermore, solar-diesel hybrid solutions are more economical than diesel alone, although they require higher upfront investment.

Figure 2: Comparison of main electricity supply options with potential for Kalobeyei (Options 1, 2 and 4)[28]



Source: Developed by the authors.

To fully understand the cost saving that could be achieved from switching to renewable sources, it is necessary to consider how the capital and operational costs of a system will be paid. UNHCR works with a range of implementing partners, to which it assigns budgets to provide certain services in the Kakuma camp and Kalobeyei settlement through project partnerships. Implementing partners may also secure funds directly from a donor to implement certain projects or activities within the camp complex. For example, the International Rescue Committee (IRC) provides healthcare services in Kakuma camp, and the NRC provides services relating to water, sanitation and hygiene (WASH). Under current practice, it is the responsibility of the IRC to provide power to the hospitals and clinics, and the responsibility of the NRC to provide power to water-pumping facilities. The two agencies finance these activities either through the budget assigned from UNHCR or through funds from other donors – though in some cases UNHCR will directly fund an energy installation. However, if a mini-grid system were to provide power to facilities operated by different agencies, an arrangement would have to be made to allocate costs between them.

Under these circumstances, any new arrangement needs to ensure a good alignment of incentives between the various parties, such that all parties realize an economic benefit. This means that whichever party funds the capital cost of the installation will need to realize a revenue stream or operational cost saving that justifies that investment. Equally, whichever party realizes the gain from reduced diesel consumption should also be the party that either directly or indirectly (via offtake payments or monthly fees) funds the investment cost. Clearly, this will require UNHCR to play a leading role in implementing any mini-grid, and in coordinating the allocation of associated payment and supply responsibilities.

[28] Operation and maintenance costs are expressed per year.

Box 4: Case study – providing solar power to IRC health clinics in Kakuma

In early 2018, through funding from the MEI, Kube Energy installed solar systems at Clinics 5 (3 kW) and 6 (36 kW) run by the International Rescue Committee (IRC) within Kakuma refugee camp in Kenya. Both systems include battery storage and are designed to provide 85–100 per cent of the clinics' power needs. The IRC will sign a one-year O&M contract with PowerGen, a Kenyan-based renewable-energy company, to manage both systems, with the option to renew the contract each year. A DBOM-type agreement was used for the solar systems, with capital expenditure funded through an MEI grant. Kube Energy led the overall development and management of the project; PowerGen implemented the EPC[29] work; and the University of California, Berkeley provided support in monitoring and evaluation (M&E). UNHCR will ultimately own the system, while the IRC will use the power it provides.

Total energy cost savings from the system at Clinic 6 amount to $1,834 per month or $22,008 per year. This is equivalent to a 79 per cent reduction in total energy costs. The project has also reduced CO_2 emissions by 4.136 tonnes per month or 49.63 tonnes per year. Prior to the initiation of the project, the IRC had planned to install a diesel generator to provide basic power at Clinic 5. This generator would have cost $10,000 to install and would have consumed approximately 450 litres of fuel per month. With the installation of the solar system, the IRC will not need a diesel generator at the clinic.

During the proposal stage, the IRC had agreed to invest at least 80 per cent of the energy cost savings in purchasing new medical equipment and improving healthcare provision at Clinics 5 and 6. It had also agreed to contribute funds to design and install two larger systems at the clinics. The IRC planned to use the energy cost savings to make these investments by pulling funds from its diesel fuel budget. In 2017, UNHCR made a policy change to remove the IRC's funding for fuel and to consolidate procurement of fuel for all NGO partners in Kakuma through UNHCR. This policy change meant that the IRC now receives diesel in kind and does not realize any cost savings from the system. As such, it was not able to contribute funding either to the system or for new medical equipment, and two smaller systems were redesigned. The project and the MEI approached UNHCR to explore whether it would be willing to allocate the cost savings from the solar systems to improving healthcare provision at Clinics 5 and 6, but UNHCR was not able to make this commitment at the time due to its own funding shortfalls.

During the proposal and design stage, the IRC indicated that it was planning to scale up operations at Clinic 6 and purchase additional equipment for Clinic 5. The solar systems were designed to accommodate the projected increase in energy usage at both clinics. However, the IRC has not been able to make these investments because of budget cuts, and both facilities are currently using significantly less energy than the systems were designed for.

One possibility is for UNHCR to bear the cost of building and operating the system, either directly or via monthly payments to a separately funded project company. UNHCR would no longer provide individual allocations for diesel to implementing partners, but instead would provide

[29] Engineering, procurement and construction.

the power directly to partner facilities. This way UNHCR would directly realize the cost savings from introducing renewable-energy technologies. To some extent, this model would retain the problem of the status quo in providing the implementing partners with no incentive to be energy-efficient. A refinement of this approach could be to allocate more budget responsibility for power purchases to the implementing partners. However, such arrangements would require a shift in policy and a new approach to procurement, which may take time to implement.

Developments in Kalobeyei's energy infrastructure

Since the site assessments and analysis were completed, a number of additional developments beyond the MEI project have influenced the evolution of energy infrastructure in the Kalobeyei settlement. These include the following.

- The German development agency GIZ,[30] through its Energising Development (EnDev) results-based finance (RBF) programme, will fund two mini-grids in Kalobeyei settlement (one in the settlement's market and one in the host community). The programme will offer up to 50 per cent of the capital expenditure funding required and an additional RBF subsidy for household connections. UNHCR is supporting this project, which was tendered in July 2018 for commissioning by June 2019 with the intention that one developer would construct both mini-grids. The selected developer will design, build, own and operate these mini-grids. No offtake agreements are being guaranteed as part of the project, and it will be up to the selected developer to secure these commitments. It is predicted that the majority of demand for the power generated by the mini-grids will come from local businesses. Households and some institutions will also be connected, but no single anchor client has been identified. Pre-feasibility work completed by GIZ showed that 34 per cent of the population in Kalobeyei settlement can pay KES 1,500 ($15) or more per month for electricity. This means that 66 per cent of the population is unable to afford this amount; GIZ therefore recommends that some form of subsidy will be required.
- GIZ originally proposed a 170-kWp system with battery storage and diesel generator back-up for Kalobeyei Settlement Village 1, with 60 kWp of capacity implemented in the first phase. For the Kalobeyei host-community mini-grid, the required system size is estimated to be 20 kWp. GIZ may consider subsidizing the end-user tariff further for these sites and expanding the grid capacity, if additional funds can be secured. UNHCR will work closely with GIZ and the selected contractor on this. Although no humanitarian agency has been identified as an anchor client, the mini-grids will go some way to improving the provision of electricity in Kalobeyei and testing the ability of the private sector to operate energy infrastructure on a commercial basis (albeit with an ongoing subsidy).
- In July 2018, UNHCR installed a 55-kW solar hybrid system in the main hospital in Kalobeyei The system was designed and built by the private sector. It will be operated and maintained by trained staff of the Red Cross who manage the hospital, with a one-year warranty provided by the supplier. No O&M contract has been signed with the private sector, and instead the system will be managed in-house. This removes the potential anchor client that the MEI had proposed to form a project that UNHCR could tender for an infrastructure management contract with the private sector.

[30] Gesellschaft für Internationale Zusammenarbeit.

- Plans for a separate UNHCR compound at the Kalobeyei site have been put on hold. Instead, the agency will manage its operations from its Kakuma sub-office, relying on a field post in Kalobeyei. This also removes significant demand that had been forecast in our analysis (around 63 kWp by year three).

As a result of these developments and the possibility of agencies in Kakuma connecting to the Kenya Power mini-grid, there was limited appetite by agencies to engage in P3-type agreements providing energy as a service for the main humanitarian operations in Kakuma or Kalobeyei.[31] However, opportunities still exist to engage the private sector in operating and maintaining the energy infrastructure that is being developed. There is potential to explore camp-wide O&M contracts with the private sector to ensure the continued and effective operation of both solar and diesel infrastructure (beyond the main compounds that may connect to Kenya Power). For this to make sense, it is likely that UNHCR, as the party that realizes the cost savings from reduced diesel consumption, will need to play a leading role in managing these contracts, potentially with support from an implementing partner.

Incorrectly sized generators and the tendency of agencies to run their own individual generators (even when adjacent to each other) mean that large cost savings can be made when establishing grids that connect agency compounds.

While P3 agreements providing energy as a service may not be taken up in Kalobeyei, they are still a viable option in many displacement settings. As outlined elsewhere in this paper, they hold many advantages compared to in-house management of infrastructure. In particular, P3 contracts are likely to make the most economic sense in settings where the cost of diesel for humanitarian agencies is high,[32] where the availability of local or in-house technical expertise is limited, where there is currently no use of renewable energy, and where no stable government power provision is likely in the medium term. Furthermore, incorrectly sized generators and the tendency of agencies to run their own individual generators (even when adjacent to each other) mean that large cost savings can be made when establishing grids that connect agency compounds. It is likely that such contracts will be more feasible in displacement settings of a protracted nature, where a minimum project size is available to make the investment attractive to the private sector. In settings of an emergency nature, or within areas of high conflict, the ability and appetite of the private sector to operate may be less. In such cases, further structuring of partnerships may be needed before it is possible to ascertain what role the private sector can play and the risks associated with its involvement.

While provisions can be made for the technical and financial aspects of P3 agreements, the main hurdle to their use remains the fact that institutional barriers within humanitarian organizations are preventing better alignment of incentives and engagement in longer-term contracts.

[31] There are some additional potential anchor clients that could be sounded out inside the main camps, including the IRC-run main hospital (Clinic 1).
[32] The cost of diesel is particularly high in areas where fuel has to be flown in, such as Malakal in South Sudan (priced at around $2.6/litre).

5. Conclusions and Recommendations

Building and maintaining electricity infrastructure to power offices, businesses, households and other operations in refugee camps and other displacement settings is difficult. It is especially challenging for UNHCR and its partner agencies, because supplying electricity is not their core mandate or activity. Management of energy infrastructure in such settings is mostly done in-house by humanitarian agencies. This can lead to cases of premature failure of infrastructure due to a lack of technical expertise or budgetary ownership. A number of options exist to use the expertise of the private sector through P3 agreements. These include engaging the private sector to design and build systems; and offering 'energy as a service' through PPA agreements.

P3 agreements can draw on private-sector expertise and promote more efficient management of infrastructure, as well as providing options for private capital in project development. In particular, agreements in which the private sector provides energy as a service have the potential to transfer more of the operational risk to the private-sector party, thus relieving each humanitarian agency of the responsibility to operate and maintain energy infrastructure and allowing it instead to focus on its core activities.

The optimum arrangement for humanitarian agencies will depend on the specific context of the site: for example, whether it is an emergency or protracted setting; the availability of technical expertise; and the availability of upfront financing.

The MEI has developed a toolkit[33] in conjunction with Kube Energy to guide humanitarian organizations that are interested in transitioning to solar-powered energy. The toolkit considers four different options for this transition, the pros, cons and economic analysis for each option, and the best practice for organizations to start on this journey.

This research paper has presented work by the MEI to investigate the options for setting up infrastructure management contracts, with a focus on the development of energy infrastructure in the Kalobeyei settlement. The MEI was ultimately unable to support the establishment of an infrastructure management contract at Kalobeyei within the desired time frame,[34] due to a number of external factors. However, the following conclusions can be drawn from this work to inform future efforts:

- Private-sector companies exist that are willing and able to develop infrastructure management contracts to provide energy as a service. Where a sufficient offtake can be guaranteed, the private sector can also finance the energy infrastructure. However, institutional barriers constrain humanitarian agencies from entering into the sorts of long-term service agreements required by private-sector firms.
- Humanitarian agencies' reliance on short-term donor funding incentivizes short-term procurement, rather than longer-term agreements that may prove more cost-effective and efficient in the medium to long term.

[33] MEI and Kube Energy (2018), *The Solar Energy Handbook*.
[34] The second phase of MEI ran from June 2016 to November 2018.

- Humanitarian agencies need to be willing to change their procurement policies to accommodate long-term service agreements. Alternatively (or, more likely, in conjunction with this option), financial mechanisms such as partial risk guarantees need to be developed to offset the risks involved. It is likely that high-level support in humanitarian and donor agencies will be required to allow for the necessary changes to test contracts and financial mechanisms.
- Humanitarian operations are vulnerable to sudden changes (whether political or operational) in the donor funding landscape. This makes it very difficult for agencies, and as a result the private sector, to plan for the long-term energy needs of operations in displacement settings, which in turn makes it challenging to develop infrastructure management contracts.[35] Again, innovative financial mechanisms could help to mitigate these risks, as could donors taking a more long-term strategy (where feasible) towards funding humanitarian operations.
- For infrastructure management contracts to make economic sense, financial incentives need to be aligned to ensure that whichever party holds the contract will realize a revenue stream or operating cost saving that justifies the investment involved. Within a displacement setting in which several agencies play a role in operations, this would likely require UNHCR to take a leading role in implementing any agreements, and in coordinating the allocation of associated payment and supply responsibilities.

A number of measures can be recommended to support greater adoption of such contracts:

- Further exploration of financial mechanisms such as partial risk guarantees is needed. Such mechanisms could mitigate the risk of early contract termination and the inability of humanitarian agencies to enter into long-term agreements.
- Humanitarian agency policies should be reviewed to determine how they can be made more conducive to ‘energy as a service’-type agreements, both through incentives for humanitarian partners to enter into P3 agreements and through changes in procurement that could facilitate longer-term arrangements.
- Donors should review how they provide funding for energy infrastructure in displacement settings, to ensure that the conditions necessary for continued sustainability – either funding for long-term O&M or efforts to incentivize long-term partnerships with the private sector – are considered.

Once the first infrastructure management contracts can be tested in displacement locations (through the use of donor funding or otherwise) and associated data collected, this will ease the way for future investments in these types of projects.

[35] The risk of overspecifying the output is normally borne by the public agency, which will end up paying for more power than it actually requires.

Annex 1: Outlining P3 Projects

After a project has been identifed that could be suitable for a public–private partnership (P3) arrangement, and the decision made to pursue it further, various steps need to be worked through to design and structure a suitable contract. Figure 3 provides an outline of the typical stages that a P3 project would go through in development and implementation.

The development of a P3 project often requires a public agency to hire an experienced consultant to prepare terms of reference, request proposals, conduct bidding, evaluate proposals and negotiate final terms and conditions. This may be an area where programmes such as the MEI can offer technical assistance to the humanitarian sector.

Figure 3: Summary of key steps involved in designing and contracting a P3-type agreement

In-house preparatory arrangements

- Conceptual project structure
- Institutional due diligence (legal and regulatory framework, government policy, involvement of other departments, in-house capacity, etc.)
- Project implementation strategy
- Setting of project committee(s)
- Government approval if needed

In-house preparatory arrangements

- Project planning and feasibility
- Risk analysis for project
- Assessing financing options and value for money
- Development of project business model
- Securing necessary government support and approval
- Service and output specifications
- Defining basic terms of contract
- Developing a preliminary financing plan

Implementation arrangement and pre-procurement

- Outlining of implementation arrangement
- Preparation of bidding documents
- Drafting of contract
- Consideration of special issues (land acquisition, foreign exchange, investment promotion, etc.)
- Establishment of bid evaluation criteria and committee
- Any government approval

Procurement

- Market sounding
- Pre-qualification of bidders
- Release of RfP – finalization of service and output specifications
- Final tender for contract
- Bid evaluation and selection
- Final approvals

Contract award and management

- Contract award, financial close and contract signing
- Service delivery management
- Monitoring of contract compliance
- Relationship management
- Renegotiation (when needed)
- Establishment of a process and a dispute resolution team

Source: Developed by the authors.

The MEI worked with Herbert Smith Freehills (HSF), a law firm, to look at general issues and considerations in developing contracts and running procurement processes that may be relevant to tendering an infrastructure management contract. A summary of these considerations is provided below.

General procurement processes

The following sets out a list of preliminary issues to be considered during the procurement process for an infrastructure management contract:

UNHCR policy and procuring entity – If involved, UNHCR (or any other humanitarian agency) will likely follow its *Procurement Practitioner's Handbook*[36] or equivalent documentation (note that each UN organization has its own rules and regulations, although these are based on common *Handbook* guidelines). The most recent versions of these documents should be requested and reviewed. Alternatively, a third party can enter into a 'Procurement Partner' contract[37] with UNHCR and run the procurement process on its behalf.

Other procurement rules – Relevant local laws may apply to the sourcing of materials, labour and so on. For instance, in many countries there are restrictions on the employment of refugees. Additionally, local regulations may apply to generating or selling power and will need to be considered.

A donor agency providing funds for the project may wish to apply additional policies and procedures relating to tax compliance, bribery prevention, corporate social responsibility, etc. These should be reviewed to assess how they align with those of UNHCR/others.

Market testing – Some initial pre-feasibility market testing (such as that completed under the MEI for Kalobeyei) should be conducted to establish the extent and condition of the existing infrastructure and the potential demand for electricity, as well as to establish potential solutions among suppliers. The outcome of this will help to determine the information required for tendering and budgeting. The UNHCR *Handbook* has further guidance on the tendering process.[38]

Budget – The *Handbook* notes that no tender documentation should be issued without an approved and budgeted requisition. At this stage it needs to be clear which party will 'own' the procurement and funding of the project. Ideally, the budget would come directly from the humanitarian operator that will be paying for the operating costs of the system. If this is not possible, donor funding could be considered for a demonstration project to show viability.

Shortlisting, registration of bidders and pre-qualification – The UN approach is to identify a shortlist of bidders to tender, though inclusion/exclusion criteria are undefined. One common approach is to publicize a pre-qualification questionnaire (PQQ). Those that respond and meet the minimum criteria are shortlisted for full tender submission. The PQQ pass criteria for the project would need to be defined.

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[36] UN (2006), *UN Procurement Practitioner's Handbook*, updated September 2012, https://www.ungm.org/Areas/Public/pph/.
[37] UNHCR (2014), *Implementing Partnership Management Guidance Note No. 4: Procurement by Partners with UNHCR Funds*, November 2014, https://www.unhcr.org/3c458f992.pdf.
[38] UN (2006), *UN Procurement Practitioner's Handbook*, updated September 2012.

Types of competition – Three main types of competition can be used for a procurement:

- **Request for proposal (RfP)** – typically used where the requirement cannot be fully defined at issue, and the supplier's innovation and expertise are sought to negotiate an agreed solution.
- **Invitation to bid (ItB)** – typically used where there is a fully specified technical requirement; bids are assessed (in both technical and commercial terms) on a pass/fail basis.
- **Request for quotation** – typically used where the requirement (for products or services) can be clearly defined at the outset; common for low-value purchases.

Overall, it is expected that the RfP process should apply to an infrastructure management contract.

Scope of requirements, terms of reference and scope of works – To produce the procurement documents and draft contract documents, the following points need to be defined and described:

- **Scope of requirements (SoR)** – Focuses on the physical products required. There are three types of specification that can be combined for the SoR:
  1. **Functional characteristics** – What does the product need to do?
  2. **Performance characteristics** – What does the product need to achieve?
  3. **Technical** – Physical attributes, either absolute or a range of working methods.
- The UN *Handbook* contains a useful range of typical inclusions for SoR.[39]
- **Terms of reference (ToR)** – Focuses on the scope of work required and responsibilities for service provision.
- **Scope of work (SoW)** – Focuses on the works to be completed (civil, mechanical, electrical, engineering and installation), including the supply of related materials. There is useful detail on SoW in the *Handbook*.[40]

It is expected that much of the SoR, ToR and SoW detail will come from the market testing stage.

Procurement document – This is made up of several elements under the umbrella of an RfP (or ItB). The document should set out the headline scope of the procurement and any relevant context, the SoR, ToR, SoW, submission details and expected response format (in line with the evaluation criteria). To aid bidders, a pre-bid site visit and Q&A process should be considered.

Evaluation of tenders – Typically, RfPs are first technically evaluated, with those that are acceptable then financially evaluated by a separate team. Also, given the humanitarian context, legal and contractual issues should be evaluated. Contracts are likely to have weighted criteria (against a scale). Criteria and weightings will be based largely on the SoR, ToR and SoW to be developed.

Negotiation/best and final offers (BAFO) – It can be useful to provide for a period of negotiation to follow the initial receipt and evaluation of tenders. This process seeks to clarify aspects of the bid, such as resolving ambiguities and correcting mistakes/deficiencies, with the aim of improving the tender quality and price certainty.

[39] Ibid.
[40] Ibid.

Form of contract – The form of contract (including terms and conditions) often accompanies the tender documents. Comments on the draft contract may be sought and may form part of the evaluation process.

Contract award – Once the final form of contract is agreed with the winning bidder, the contract will be awarded. There is often a debrief for unsuccessful bidders.

Considerations for contracting

The following issues may be observed in an infrastructure management-type contract:

Cost structure – Three basic cost structures can be adopted:

1. **Cost plus** – Covers reasonable incurred costs by the contractor plus a mark-up to cover overheads or provide a profit. This requires proactive management by the procuring party to track the budget or programme, but allows flexibility for unforeseen issues to be covered.

2. **Bonus/penalty** – The contractor is given incentives to maximize output and minimize operational costs. In the case of deficient performance, the contractor is likely to resist penalties linked to external factors (e.g. road access issues, camp emergency issues). The procuring party should assess how dynamic the local environment is likely to be.

3. **Fixed price** – A set value is given for a fixed scope of work/responsibilities. If comprehensive, this ensures costs are capped. However, the contractor will factor higher contingency costs into its proposed financial terms.

Each of these cost structures represents a trade-off between risk allocation and price. The more risk the contracted party is expected to take on, the more contingencies are likely to be factored in, resulting in greater price uncertainty or an increased overall price. One additional risk factor in the humanitarian context is the involvement of local entrepreneurs or refugees, who are typically seen as transient residents.

Level of service – Consideration should be given to the level of service and managing structure desired. Options include:

- **Full labour service contract** – The procuring party purchases all equipment, parts and spares. The contractor provides the labour to manage the O&M of the equipment. Overall, the contractor is less incentivized to keep equipment costs down.

- **Full-coverage service contract** – The contractor purchases and maintains all equipment. It is in the contractor's interest to install good-quality equipment and perform preventive maintenance, as it will likely have to pay liquidated damages on equipment/service failure.

- **Hybrid service contract** – The provision of labour, parts, materials and emergency services is divided between the contractor and local entrepreneurs/individuals in the refugee camp. This requires greater detail to be developed in the allocation of services/ownership; however, if managed correctly, this option could increase community buy-in and make it easier to manage costs.

Other key terms:

- **Design, build, test and commission** – Minimum standards and milestones to be outlined.
- **Services: scheduled and unscheduled maintenance** – To avoid uncertainty and disputes, clear scope and processes should be defined at the beginning for both types of maintenance.
- **Warranty for services and parts** – 'End of term' warranties for parts installed could help to ensure they last until the next scheduled maintenance event. The logistics of remote locations should also be considered when enforcing warranties.
- **Handover and termination assistance** – In the event of poor performance, end of contract or the replacement of contractors, a clear handover or decommissioning plan should be outlined.
- **Provisions for renewal** – Linking key milestones with a right to renewal would be beneficial if longer-term funding could be secured to increase the incentive for the private sector to invest.
- **Payment** – Clear payment terms should be laid out. This could include deductions for poor performance, interest on default payments, discounts for early payment, etc.
- **Access** – Each site will have different access rights, security requirements, working hours, work areas, etc. These points will need to be reflected in the contract.
- **Warranties** – In addition to technical warranties, criteria such as compliance with anti-corruption policies, safeguards against the use of slave labour etc., and other UNHCR requirements may be included.
- **Breach** – Failure to meet requirements or adhere to policies set out should result in clearly stated consequences such as termination, penalties, obligations to replace/repair, etc.
- **Indemnities** – Consideration should be given to the extent of indemnities required, such as environmental indemnities and indemnities for harm (including loss of life) suffered by refugees or others.
- **Insurance provisions** – Responsibility for insurance needs to be set out and further consideration given to the context of refugee camps, e.g. employee liability, construction etc.
- **Force majeure** – Given the stability concerns associated with displacement settings, it will be necessary to consider what is included under this provision and which party takes on the risk. For instance, do acts of war apply in conflict zones?
- **Consent/approvals** – Any required licences, approvals and so on should be outlined, along with who is responsible for obtaining them.
- **Governance** – The governing law or set of guidelines (e.g. UNHCR policy, country law) should be outlined for operation, transparency (audit requirements) and dispute resolution. If such law is not relevant or sufficiently developed, an internationally recognized forum should be selected for neutrality. Local counsel should be engaged early on.

Annex 2: Summary of Estimated Electricity Demand at Kalobeyei Settlement

Table 4 provides a summary of estimated electricity demand, both existing and future, at the Kalobeyei settlement at the time of the MEI's site surveys in January–February 2017. Electricity needs for surveyed and planned facilities were estimated using the number of potential fixtures and appliances and their power requirements (watts) at each site. For planned buildings and those under construction, comparable facilities and available information were used to estimate electricity needs.

Table 4: Summary of estimated demand from planned sites at Kalobeyei settlement, kWp

Site/year	1	2	3	4	5	6	7	8	9	10
UNHCR[41]	0	25	63	100	138	175	188	188	188	188
Police post and residences	1	4	6	6	6	6	6	6	6	6
Clinic and maternity ward	37	37	37	37	37	37	37	37	37	37
Field post	0	14	14	14	14	14	14	14	14	14
Primary schools	3	5	8	10	10	10	10	10	10	10
Market	0	0	27	27	27	27	27	27	27	27
Secondary schools	3	6	10	13	16	19	19	19	19	19
Reception centre	0	2	2	2	2	2	2	2	2	2
Nutrition centre	0	0	4	4	4	4	4	4	4	4
Vocational centre (assumed)	0	0	0	30	30	45	45	60	60	60
Refugee households	146	160	176	194	213	234	258	284	312	343
Kalobeyei village	141	148	155	163	171	180	189	198	208	219
10% safety margin	33	40	50	60	67	75	80	85	89	93
Total yearly demand, kWp[42]	365	442	552	659	734	829	878	933	975	1,021

[41] Updated information as of February 2018 indicates that plans for the UNHCR compound in Kalobeyei have been put on hold. Demand in this table is based on the original plans for the compound as of February 2017.
[42] Totals reflect a simplified assumption that the loads are additive – in reality, the peak loads would not occur at the same time.

Annex 3: Details of Option Design and Appraisal

The following options have been appraised. Diesel has been priced at $1 per litre and labour at $100 per month. For the mini-grid systems, it is assumed that a distribution system of 5 km is provided and is AC-based. The distribution system would be designed to meet anticipated demand.

1. Distributed generation

Separate generator systems have been estimated for UNHCR offices, police posts, the hospital, the post office, primary and secondary schools, the market centre, the vocational centre, the reception centre and the nutrition centre. Details of assumptions on the use of generators and the hours of operation are given below. It is assumed that the generators will be run and maintained by three operators.

Table 5: Summary of cost calculations for distributed-generation option

UNHCR				
Capital costs		Running costs		
Item	**Cost, $**	**Hours run/day**	**Diesel, l/hr**	**$/yr**
15-kVA DG set	4,125	6	2	4,380
5-kVA DG set	1,375	8	0.8	2,336
Battery bank	1,500			
Other costs (wiring, etc.)	500			
Total	7,500			6,716

Hospital				
Capital costs		Running costs		
Item	**Cost, $**	**Hours run/day**	**Diesel, l/hr**	**$/yr**
15-kVA DG set	4,125	8	2	5,840
25-kVA DG set	6,875	7	3	7,665
5-kVA DG set	1,375	8	0.8	2,336
Battery bank	1,250			
Other costs (wiring, etc.)	500			
Total	14,125			15,841

Primary school				
Capital costs		Running costs		
Item	**Cost, $**	**Hours run/day**	**Diesel, l/hr**	**$/yr**
2-kVA DG set	600	6	2	4,380
Other costs (wiring, etc.)	300			
Total	900			4,380

Secondary schools				
Capital costs		Running costs		
Item	**Cost, $**	**Hours run/day**	**Diesel, l/ hr**	**$/yr**
2-kVA DG set	600	6	0.3	657
3-kVA DG set	900	8	0.4	1,168
Battery bank	1,200			
Other costs (wiring, etc.)	300			
Total	3,000			1,825

Reception centre				
Capital costs		Running costs		
Item	**Cost, $**	**Hours run/day**	**Diesel, l/hr**	**$/yr**
2-kVA DG set	600	6	0.3	657
1-kVA DG set	400	8	0.25	730
Battery bank	1,000			
Other costs (wiring, etc.)	300			
Total	2,300			1,387

Police station				
Capital costs		Running costs		
Item	**Cost, $**	**Hours run/day**	**Diesel, l/ hr**	**$/yr**
2-kVA DG set	600	12	0.3	1,314
Battery bank	750			
Other costs (wiring, etc.)	400			
Total	1,750			1,314

Field post office				
Capital costs		Running costs		
Item	**Cost, $**	**Hours run/day**	**Diesel, l/hr**	**$/yr**
15-kVA DG set	4,125	6	2	4,380
2-kVA DG set	600	8	3	8,760
Battery bank	1,000			
Other costs (wiring, etc.)	500			
Total	6,225			13,140

Market centre				
Capital costs		Running costs		
Item	**Cost, $**	**Hours run/day**	**Diesel, l/hr**	**$/yr**
20-kVA DG set	6,000	6	2.5	5,475
20-kVA DG set	6,000	8	2.5	7,300
Battery bank	4,000			
Other costs (wiring, etc.)	500			
Total	16,500			12,775

Vocational centre				
Capital costs		Running costs		
Item	**Cost, $**	**Hours run/day**	**Diesel, l/hr**	**$/yr**
30-kVA DG set	9,000	6	4	8,760
Other costs (wiring, etc.)	500			
Total	9,500			8,760

Nutrician centre				
Capital costs		Running costs		
Item	**Cost, $**	**Hours run/day**	**Diesel, l/hr**	**$/yr**
0.5-kVA DG set	200	10	1.5	5,475
Other costs (wiring, etc.)	200			
Total	400			5,475

2. A mini-grid system using diesel generation

Design details and running assumptions are given below. It is assumed that the system will be run by two operators.

Table 6: Summary of cost calculations for the option of a mini-grid system using diesel generation

Capital costs		Running costs		
Item	Cost, $	Hours run/day	Diesel, l/hr	$/yr
100-kVA DG set	30,000	8	9	26,280
50-kVA DG set	18,000	8	6	17,520
50-kVA DG set	18,000	8	6	17,520
10-kVA DG set	4,000	8	1.5	4,380
Other costs (panels, powerhouse wiring, breakers, etc.)	1,000			
Distribution network	20,000			
Total capital cost	91,000	Total annual diesel cost		65,700
		Total annual labour cost		2,400

3. A mini-grid system using diesel generation and 75-kWp solar PV installation

Design details and running assumptions are given below. It is assumed that the system will be run by two operators.

Table 7: Summary of cost calculations for the option of a mini-grid system using diesel generation and 75-kWp solar PV installation

Capital costs		Running costs		
Item	Cost, $	Hours run/day	Diesel, l/hr	$/yr
100-kVA DG set	30,000	7	9	22,995
10-kVA DG set	4,000	8	1.5	4,380
Solar panels + structure	120,000			
PCU	25,000			
Inverter	25,000			
Battery bank	8,000			
Other costs (panels, powerhouse wiring, breakers, etc.)	3,000	Total annual diesel cost		27,375
Distribution network	20,000			
Total capital cost	235,000	Total annual labour cost		2,400

Note: PCU refers to power control unit. An inverter is an electronic device or circuitry that changes direct current to alternating current.

4. A mini-grid system using diesel generation, a 75-kWp solar PV installation and a 24-V, 4,000-Ah battery installation

Design details and running assumptions are given below. It is assumed that the system will be run by two operators.

Table 8: Summary of cost calculations for the option of a mini-grid system using diesel generation, a 75-kWp solar PV installation and a 24-V, 4,000-Ah battery installation

Capital costs		Running costs		
Item	Cost, $	Hours run/day	Diesel, l/hr	$/yr
100-kVA DG set	30,000	7	9	22,995
Solar panels + structure	120,000			
PCU	25,000			
Inverter	25,000			
Battery bank	20,000			
Other costs (panels, powerhouse wiring, breakers, etc.)	3,000			
Distribution network	20,000	Total annual diesel cost		22,995
Total	243,000			
		Total annual labour cost		2,400

5. A mini-grid system using diesel generation, a 150-kWp solar PV installation and a 24-V, 5,000-Ah battery installation

Design details and running assumptions are given below. It is assumed that the system will be run by two operators.

Table 9: Summary of cost calculations for the option of a mini-grid system using diesel generation, a 150-kWp solar PV installation and a 24-V, 5,000-Ah battery installation

Capital costs		Running costs		
Item	Cost, $	Hours run/day	Diesel, l/hr	$/yr
60-kVA DG set	25,000	7	6	15,330
Solar panels + structure	225,000			
PCU	35,000			
Inverter	35,000			
Battery bank	24,000			
Other costs (panels, powerhouse wiring, breakers, etc.)	3,000			
Distribution network	20,000	Total annual diesel cost		15,330
Total	367,000			
		Total annual labour cost		2,400

Financial appraisal

Financial appraisal has been carried out using a discounted cashflow model, with a discount rate of 10 per cent. Current prices at the time of writing are used, and no provision has been made to adjust for the possible disproportionate inflation of energy costs. The appraisal also assumes a flat level of demand, with zero growth year on year. No adjustment has been made for possible tax or grant impacts. The model results are given below.

Table 10: Summary of the payback period for each design option

Payback (yrs), mini-grid vs distributed generation			
Mini-grid system – diesel generation		Distributed-generation opex	Opex of each mini-grid option
Additional capital cost	28,880		
Reduction in revenue/yr	7,113	75,213	68,100
Payback yrs	4.0		
Mini-grid system – diesel and solar PV			
Additional capital cost	172,800		
Reduction in revenue/yr	45,438	75,213	29,775
Payback yrs	3.8		
Mini-grid system – using diesel, solar PV and batteries: Option 1			
Additional capital cost	180,800		
Reduction in revenue/yr	49,818	75,213	25,395
Payback yrs	3.6		
Mini-grid system – using diesel, solar PV and batteries: Option 2			
Additional capital cost	304,800		
Reduction in revenue/yr	57,483	75,213	17,730
Payback yrs	5.3		

Table 11: Summary of the financial appraisal for each design option

Option	NPV (10%)	Cashflows														
		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yr 11	Yr 12	Yr 13	Yr 14	Yr 15
1. Distributed generation																
Initial capital cost		-62,200														
Replacement of batteries						-10,700					-10,700					
Diesel cost		-71,613	-71,613	-71,613	-71,613	-71,613	-71,613	-71,613	-71,613	-71,613	-71,613	-71,613	-71,613	-71,613	-71,613	-71,613
Labour		-3,600	-3,600	-3,600	-3,600	-3,600	-3,600	-3,600	-3,600	-3,600	-3,600	-3,600	-3,600	-3,600	-3,600	-3,600
Total	-639,391	-137,413	-75,213	-75,213	-75,213	-85,913	-75,213	-75,213	-75,213	-75,213	-85,913	-75,213	-75,213	-75,213	-75,213	-75,213
2. Mini-grid system – diesel generation																
Initial capital cost		-91,000														
Diesel cost		-65,700	-65,700	-65,700	-65,700	-65,700	-65,700	-65,700	-65,700	-65,700	-65,700	-65,700	-65,700	-65,700	-65,700	-65,700
Labour		-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400
Total	-600,701	-159,100	-68,100	-68,100	-68,100	-68,100	-68,100	-68,100	-68,100	-68,100	-68,100	-68,100	-68,100	-68,100	-68,100	-68,100
3. Mini-grid system – diesel and solar PV																
Initial capital cost		-235,000														
Replacement of batteries						-8,000					-8,000					
Diesel cost		-27,375	-27,375	-27,375	-27,375	-27,375	-27,375	-27,375	-27,375	-27,375	-27,375	-27,375	-27,375	-27,375	-27,375	-27,375

Option	NPV (10%)	Cashflows														
		Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yr 11	Yr 12	Yr 13	Yr 14	Yr 15
3. Mini-grid system – diesel and solar PV																
Labour		-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400
Total	-448,159	-264,775	-29,775	-29,775	-29,775	-37,775	-29,775	-29,775	-29,775	-29,775	-37,775	-29,775	-29,775	-29,775	-29,775	-29,775
4. Mini-grid system – using diesel, solar PV and batteries: Option 1																
Initial capital cost		-243,000														
Replacement of batteries						-20,000					-20,000					
Diesel cost		-22,995	-22,995	-22,995	-22,995	-22,995	-22,995	-22,995	-22,995	-22,995	-22,995	-22,995	-22,995	-22,995	-22,995	-22,995
Labour		-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400
Total	-434,195	-268,395	-25,395	-25,395	-25,395	-45,395	-25,395	-25,395	-25,395	-25,395	-45,395	-25,395	-25,395	-25,395	-25,395	-25,395
5. Mini-grid system – using diesel, solar PV and batteries: Option 2																
Initial capital cost		-367,000														
Replacement of batteries						-24,000					-24,000					
Diesel cost		-15,330	-15,330	-15,330	-15,330	-15,330	-15,330	-15,330	-15,330	-15,330	-15,330	-15,330	-15,330	-15,330	-15,330	-15,330
Labour		-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400	-2,400
Total	-492,647	-384,730	-17,730	-17,730	-17,730	-41,730	-17,730	-17,730	-17,730	-17,730	-41,730	-17,730	-17,730	-17,730	-17,730	-17,730

About the Authors

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Cover image: A solar array installed for International Rescue Committee health clinics in Kakuma refugee camp, Kenya.

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