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Energy services for refugees and displaced people

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ABSTRACT

The current literature on energy access highlights energy deprivation on a regional or country basis, but frequently neglects those outside of national energy agendas such as refugees and displaced people. To fill this gap and to help inform future analysis, this paper presents an end-use accounting model for energy consumption for cooking and lighting by displaced populations. We present initial estimates for the overall scale of energy poverty and three high-level scenarios for improving access to energy for cooking and lighting. Key findings suggest that as many as 7 million displaced people in camps have access to electricity for less than 4 h a day and that the widespread introduction of improved cookstoves and basic solar lanterns could save $303 million a year in fuel costs after an initial capital investment of $334 million. We conclude that there is a strong human, economic, and environmental case to be made for improving energy access for refugees and displaced people, and for recognising energy as a core concern within humanitarian relief efforts.

1. Introduction

With the adoption of Sustainable Development Goal (SDG) 7 in September 2015,[1] the international community has, for the first time, established energy as a fundamental pillar of development in its own right [1]. Yet, there has been relatively little focus on energy poverty as an area of concern within the 'humanitarian sphere' [2]. In the context of the UNGA High-Level Meeting on Refugees and Migrants and the Leaders' Summit on Refugees in September 2016, this paper sets out the overall scale of energy poverty among forcibly displaced people and presents the costs of different interventions to improve access. With the number of people displaced by conflict now exceeding 65 million, we estimate that the vast majority lack access to clean, safe and secure energy services and are reliant on biomass for cooking.

Although energy services underpin many of the needs of those forcibly displaced by emergency situations, from cooking and heating to medical care and communication, the humanitarian agencies designated to care for them are ill equipped to meet these needs [3]. In contrast other basic needs, such as food, water, sanitation, shelter and health, have been the focus of both concerted action and research [4–7]. In part this is due to a lack of funding available for energy services [8]. Energy infrastructure tends to be seen as a long-term investment and thus inappropriate in the context of immediate emergency relief [2]. As such, energy is seen as a core concern from a long-term development perspective but frequently falls outside the remit of interim humanitarian responses.

This approach is, however, only sustainable in cases where humanitarian responses really do remain short-term. Roughly 6.4 million refugees are to be found in protracted displacement situations[2] [9] and such situations are fast becoming the norm with relatively few being resolved quickly [10]. Inadequate energy supply measures introduced as interim stopgaps in emergency circumstances can, over time, entrench expensive, unhealthy and inefficient processes.

A detailed consideration of energy use by the forcibly displaced is required to help inform policy-makers and improve the current system. The Moving Energy Initiative (MEI)[3] was formed in 2015 as

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[1] SDG 7 states that we must 'ensure access to affordable, reliable, sustainable and modern energy for all'.

[2] A protracted situation is one in which 25,000 or more refugees of the same nationality have been in exile for five years of longer in a given asylum country.

[3] The MEI is a consortium made up of Energy 4 Impact, Chatham House, Practical Action, Norwegian Refugee Council and UNHCR. For more information: https://www.chathamhouse.org/about/structure/eer-department/moving-energy-initiative-Project.

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a means of establishing this agenda. Drawing heavily on Lahn and Grafham [3], research conducted by Chatham House for the initiative, this paper sets out estimates for the overall scale of energy poverty among the forcibly displaced and several high-level scenarios for improving energy access for cooking and lighting.

Throughout this paper the terms 'displaced' and 'forcibly displaced' are used to encompass both refugees and internally displaced persons (IDPs) following UNHRC definitions for both terms.[4] Our model, however, draws on UNHCR data on persons of concern, a general term used to describe all people whose protection and assistance needs are of interest to UNHCR, as such it also includes asylum seekers, stateless persons and returnees.

The rest of this paper is structured as follows: Section 2 outlines the methodology. Section 3 presents our estimates for current energy use among the forcibly displaced. Section 4 outlines our cost estimates for three high-level scenarios for improving energy access. Section 5 concludes.

2. Method

A number of different methods exist for modelling energy demand [11]. Based on the nature and availability of the underlying data we choose to model energy demand with an end-use accounting approach, arriving at global demand estimates by scaling up from data on energy use patterns at the household level.

It is important to note that there is a paucity of good quality data on energy use patterns of refugees and displaced people. There is no centralised system for gathering data on this issue and few existing studies that gather data beyond single cases. The main focus of research so far has tended to be on the impact of improved cookstoves on fuel wood use [12–15]. While limited, the existing literature on non-cookstove interventions in displacement settings covers a broad range of alternative and renewable energy solutions. Nerini et al. [16], for example, study the potential for a portable module to sustainably meet the energy and water needs of displaced populations in protracted emergency settings. Micangeli, Michelangeli and Naso [17] study the effect of solar thermal collectors during the post-emergency phase after the Abruzzi earthquake. A few recent unpublished studies analyse a broader range of energy needs and uses among the displaced but again only gather data on a single case [18,19]. There are many more studies on the potential benefits of different energy solutions in non-displacement settings [20].

To approximate energy patterns at the household level we draw on primary data gathered from interviews, field surveys conducted by partner organisations, research on individual camps and proxies based on national data for non-displaced populations. It is also important to note that heating is not considered explicitly in the model. As many displaced people rely exclusively on the warmth of cooking fires for heating,[5] the use of fuel for heating is considered to be largely synonymous with the use of fuel for cooking. Until more comprehensive data is made available, therefore, the model should be seen as a highly stylized indication of the overall scale of the problem and the effort required in intervening rather than a descriptive analysis.

2.1. Data

Table A.1 in Annex A sets out the sources for data included in our model, distinguishing between population data, fuel and stove data and energy consumption data.

2.1.1. Population data

The size and location of displaced populations is drawn from UNHCR data for 2014. Preliminary research suggests that displaced household energy use differs considerably between camp and non-camp settings [21]. We therefore separate camp and non-camp populations and treat each category differently in the model.[6] Research on energy-use in urban, peri-urban and rural settings suggests further variation between household energy use patterns in these different contexts [22]. The non-camp population is, therefore, split again, distinguishing between households in urban, rural and slum settings. Global Tracking Framework (GTF), UNHCR and Millennium Development Goal Indicator data is used to proportionally assign the non-camp population to the respective categories [9,23,24].

2.1.2. Fuel and stove data

Data on the cost of fuel and of providing equipment is drawn from Demierre et al. [25] and Vianello [26] respectively and checked against our interview data and by experts at the Global Alliance for Clean Cookstoves (GACC) and SolarAid. The specific costs and technical assumptions used in our model are reported in Annex A Tables A2–A3. For displaced households outside of camps and connected to the grid we assume a constant electricity cost of \$0.25/kWh across countries. For displaced households outside of camps and with access to non-solid fuel we assume they use LPG and calculate their expenditure using the same LPG cost as used for camp households. In accordance with existing studies on tier-level energy access [27,28], technology and fuel efficiency figures follow the World Bank and SE4All Multi-tier Framework (MTF) (see Annex D for further details). This ranges from tier level 0 (low or no access to energy) to tier level 5 (affordable, reliable, modern and sustainable energy access).

2.1.3. Energy consumption and access data

2.1.3.1. Camp populations. To gather data on energy use patterns in camps we conducted 24 semi-structured 1-h phone interviews with UNHCR country office staff in 19 countries.[7] Three further countries were covered in face-to-face interviews: UNHCR-administered camps in Jordan and Tanzania during field research, and an interview in London with the Border Consortium. 17 of the interviewees were located in Sub-Saharan Africa. A more representative sample was not possible as our choice of locations was constrained by where we had access to contacts able to answer questions about energy and environmental concerns.

[4] A refugee is a person who 'owing to a well-founded fear of being persecuted for reasons of race, religion, nationality, membership of a particular social group or political opinion, is outside the country of his nationality and is unable to, or owing to such fear, is unwilling to avail himself of the protection of that country.' (UN General Assembly 1950); Internally displaced persons (IDPs) are persons or groups of persons who have been forced or obliged to flee or leave their homes or places of habitual residence, in particular as a result of or in order to avoid the effects of armed conflict, situations of generalized violence, violations of human rights or natural or human-made disasters, and who have not crosses and internationally recognized state border. (OCHA 2001).

[5] Gunning (2014) finds that the baseline situation for heating is "either there is no heating, or where heating is provided, it is by cooking stoves, fire or heating stoves fuelled by coal, charcoal or fuelwood".

[6] This distinction was made on the basis of UNHCR settlement categories. Populations assigned to collective centres, reception/transit camps, self-settled camps and planned/managed camps were all included under our camp population. Populations assigned to individual accommodation and undefined/unknown were designated non-camp population. Based on this distinction, the camp population comes to 8,696,922 and the non-camp population comes to 40,356,952 of the 49,053,874 total displaced population.

[7] While the majority of the interviews were conducted with UNHCR staff, we also conducted interviews with staff from the Border Consortium, the World Food Programme (WFP) and UNICEF.

While these interviews provided insights, they also revealed large gaps in the information available. Each interviewee was asked to give details on energy use by households and operations in their camp (see Annex B for the interview questions). The degree of specificity with which they were able to answer the questions varied considerably. Figures for firewood consumption were, for example, only available in nine instances. In cases where other fuels were used the data is even patchier. As specific figures on average household fuel use were typically unavailable we relied on approximate estimates of proportional expenditure on fuel. After each interview we wrote up our findings and our rough estimate of the fuel mix for the camp and fed these back to the interviewees for adjustments and comments.

The data on camp operations was so fragmented that a global projection of the additional energy required for camp infrastructure and services was not possible. Our estimates are, therefore, limited to household demand.

The interviews were supplemented by two field surveys conducted by Practical Action and Energy 4 Impact in Goudoubo camp in Burkina Faso and Dadaab camps in Kenya respectively.[8]

$$consumption\ \ of\ \ fuel_k = \frac{proportion\ household_j\ spends\ on\ fuel_k\ \times\ e_{j\ total}}{p_k}$$

2.1.3.2. Non-camp populations.

For non-camp displaced populations we assume that their access and consumption patterns broadly follow those of non-displaced populations in the respective urban, slum and rural setting. National GTF data on non-displaced populations is used to proxy levels of access to solid and non-solid cooking fuels and to grid connections. As GTF data does not distinguish between slum and urban populations, we take a simple average of the urban and rural ratios for access to grid connections as a proxy for slum access. For access to non-solid fuels we use the same rate as that of urban populations. Using urban and rural data as a proxy for slum data will suffice in some cases but will not adequately reflect the variation we can expect in slum settings. Research on slum households more generally suggests that energy use patterns in peri-urban settings varies considerably by country [29]. In Thailand, for example, Shrestha et al. find that almost 100% of households are grid connected and a high percentage use LPG for cooking [30].

2.2. Cooking and lighting typologies

Based on the survey and interview data, we establish a typology for cooking and lighting energy use patterns of displaced households (Tables C1 and C3 in *Annex C*). This allows the diverse energy situation of displaced households to be grouped into a manageable number of camp 'types' to make the analysis more tractable.

For cooking, the camp types are 'Firewood dependent', 'Firewood mix', 'Kerosene dependent', 'LPG fuelled', and 'Alternative biomass.' For lighting, the types are 'Torch dependent', 'Kerosene dependent', 'Electricity dependent' and 'Solar dependent.' While each type tends to have a dominant fuel, other fuels are included to account for the wider set of households in the camp. For example, for cooking the majority of camps fall into the 'Firewood dependent' type, which based on our interview data signifies 5% of household energy expenditure spent on charcoal, 88% on firewood, plus small amounts on kerosene and LPG. For lighting, the percentage breakdown between energy sources is based on numbers of households rather than expenditure, as this data was more readily available.

For cooking, the typology specifies the efficiency with which each fuel is used, based on the tier level of cookstoves generally used in camps, defined according to the World Bank and SE4All Multi-tier Framework (MTF). For lighting, the MTF is also used to define the baseline tier level of access that households currently have.

To calculate average figures for energy consumption for each type, we take the simple average of the data available on household-level firewood use. This gives us a value of 131 kg/HH/month. This is assumed to be the total primary energy baseline for 'Firewood dependent' camps (52.25 in kgoe/HH/month). To scale the firewood use figure down for 'Firewood dependent' camps to reflect the assumption that firewood only accounts for 88% of expenditure, with the difference made up by other fuels, we use the two equations below:

where $e_{j\ total}$ is the total monthly energy expenditure by a household in camp type j and p_k is the price of fuel k.

$$primary\ energy\ baseline = \sum \frac{c_k \times\ h_k}{(1 - L_k) \times f}$$

where c_k is the consumption of fuel k, h is the heating value for fuel type k, L is the energy losses in production for fuel type k[9] and f is the conversion factor for kcal to kgoe.

With the data we have on fuel prices and the proportional household expenditure on respective fuels set out in the typology, we can solve for total monthly energy expenditure for 'Firewood dependent' camps. Once calculated, this gives us a scaled down firewood consumption figure of 108 kg/HH/month for 'Firewood dependent' camps. With the consumption figures for each fuel we can calculate the 'useful energy demand' taking into account the efficiency of fuels used in the 'Firewood dependent' camps:

$$useful\ energy\ demand = \sum c_k \times h_k \times\ \eta_{kl}$$

where η_{kl} is the efficiency of the stove used to burn fuel k at tier l.

The average useful energy demand at the household level is assumed to be the same for all camp types across tier levels. Final energy consumption for the other camp types is then calculated based on this useful energy demand and based on the MTF fuel efficiency figures discussed above (see Table C.2 in Annex C for the consumption figures for all camp types).

Average figures for energy costs, CO_2 emissions[10] and capital

[8] The results of these surveys are available on the Moving Energy Initiative website: https://mei.chathamhouse.org.

[9] Energy losses in production are only calculated for charcoal and for processed solid fuel. $l_{charcoal} = 1 - \left(Carbonisation\ rate\ \times\ \frac{h_{charcoal}}{h_{firewood}}\right)$; $l_{PSF} = 1 - \frac{net\ h}{gross\ h}$.

[10] The conversion factors used are for CO_2 and do not account for other Kyoto gases or non-Kyoto climate forcing pollutants. We do not account for the share of renewable versus non-renewable share of biomass extraction.

value are calculated for each baseline and target type by multiplying the consumption figures by fuel costs, CO_2 conversion factors and stove costs (see the equations in Appendix A for further details). For lighting, CO_2 emissions are made up of indirect emissions from on-grid and off-grid electricity as well as direct emissions from fuel combustion in the household.

2.3. Scaling up

In order to scale up the camp level energy patterns to global estimates of use, emissions and capital costs, we link the real world populations to the camp types set out above.

2.3.1. Camp populations

Each camp in the UNHRC dataset with a population above 20,000 is assigned a baseline camp type for cooking and for lighting, based on the interview data, field and desk research. Smaller camps were not assessed individually; their populations were allocated to types based on the characteristics of the larger camps in their region.[11] For both cooking and lighting, firewood-dependent and torch-dependent respectively are the most prevalent types in the model. Having assigned each camp a camp type, we scale up to a global figure of fuel expenditure by aggregating each camp's fuel spend:

$$Total\ Fuel\ Spend = \sum \frac{n_i}{5} \times e_{ij}$$

where n is the population of camp i, each household is assumed to be made up of five people and e is the household expenditure on fuel for camp i based on its camp type j. Global figures for emissions and capital value are calculated in the same way.

2.3.2. Non-camp populations

For households with access to non-solid cooking fuels for cooking, LPG is assumed to be the fuel burnt, with IEA country data used to calculate household LPG consumption [31,32]. For households without access to non-solid fuels, we revert to the camp baseline household types.[12]

For non-camp cooking, therefore, the equation to scale up is:

$$Total\ Fuel\ Spend = \sum \frac{n_{i\ with}}{5} \times c_{i\ NSF} \times p_{NSF} + \frac{n_{i\ without}}{5} \times e_{ij}$$

Where $n_{i\ with}$ is the population in country i with access to non-solid fuel for cooking, $c_{i\ NSF}$ is consumption of non-solid fuel in country i, p_{NSF} is the price of non solid fuel, $n_{i\ without}$ is the population in country i without access to non-solid fuel for cooking, and e_{ij} is the expenditure on fuel for cooking of camp type j assigned to country i.

For households connected to the grid, IEA country-level consumption data are used to calculate consumption [31,32]. All non-camp populations without grid connection are assigned to the torch-dependent baseline lighting type.

For non-camp lighting, therefore, the equation to scale up is:

[11] For example, if 80% of larger camps in Subsaharan Africa were camp type 1 (Firewood Dependent), then 80% of the population from smaller camps was allocated to type 1. Regions in our model included Subsaharan Africa, Middle East and North Africa, Central Asia, Asia, South America, Europe, North America.

[12] Firewood-charcoal mix for urban populations; firewood-dependent for slum and rural populations.

$$Total\ Fuel\ Spend = \sum \frac{n_{i\ on\ grid}}{5} \times c_{i\ grid\ elect} \times p_{grid\ elect} + \frac{n_{i\ off\ grid}}{5} \times e_{ij}$$

where $n_{i\ on\ grid}$ is the population in country i with grid access, $c_{i\ grid\ elect}$ is the household electricity consumption in country i, $p_{grid\ elect}$ is the price of grid electricity, $n_{i\ off\ grid}$ is the population in country i without access to grid electricity and e_{ij} is the expenditure on fuel for lighting of camp type j assigned to country i.

2.4. Scenarios

Target types of energy use patterns for camps are established alongside the baseline types (see Tables C2 and C3 in Annex C). These set out an improved pattern of energy use in terms of 'tier level' access and fuel use and are utilised in our projections for the three high-level scenarios for improving access. For cooking, this implies moving towards higher tier levels, with more efficient and cleaner cookstoves. The useful energy demand for cooking is assumed to remain unchanged as households move up tier levels, resulting in lower fuel use for cooking due to improved end-use efficiency. For lighting, higher tier access generally implies greater levels of lighting (and improved reliability), so the final consumption tends to be higher (see Table A.4. in Annex A for our assumptions on electricity consumption at different tiers). For each target cooking and lighting type consumption, emissions and capital value are calculated in the same way as set out above for the baseline types.

Under each of our three scenarios, described in more detail below, each baseline camp type moves to a specific target type, which represents an improvement in fuel use and tier access level (see Table C.4 in Annex C for shifts from baseline to target type). In this way, the impact on energy consumption, expenditure and emissions of moving from baseline to target fuels and technologies can be estimated.

2.5. Limitations

This is a simplified model of a highly complex system. It, therefore, has a number of limitations:

Our baseline and target types do not fully cover what is in reality a vast array of different patterns of energy use. Energy use by displaced households varies both within and between camps, but our model only takes the latter into account. Moreover, 17 of the 24 interviews were conducted with staff located in Sub-Saharan Africa. Average energy use figures derived from this sample are, therefore, more likely to reflect patterns in that region.

The data used in the model both for assigning types and for assumptions on cost and consumption are highly stylized averages. Use, costs and emissions may in reality vary considerably between different contexts. Variations in the type of wood, stove and the humidity of the climate mean that firewood use can vary between 0.7 and 3 kg per person per day [8]. In remote locations, moreover, fuel costs can be considerably higher than those faced by the general population [33]. The cost of firewood, in particular, is difficult to capture, as it is often collected for 'free.' The opportunity cost in terms of productive time lost while collecting firewood is difficult to assess with the activity itself resulting in non-financial costs in terms of risks to personal safety.

In terms of the scenario analysis, the model does not account for the costs of training, distribution, service and maintenance that would be required to make the three scenarios considered viable propositions. Nor does it account for less than 100% adoption of new technologies within one year of implementation. There is,

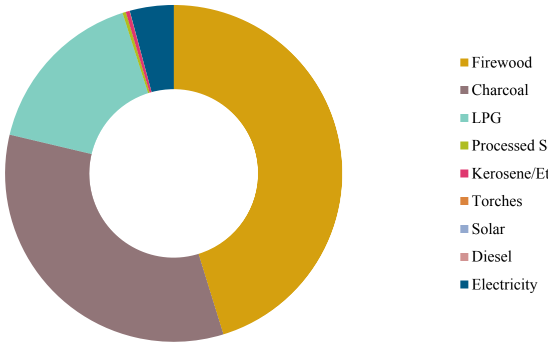

Fig. 1. Energy sources used by forcibly displaced households in 2014.

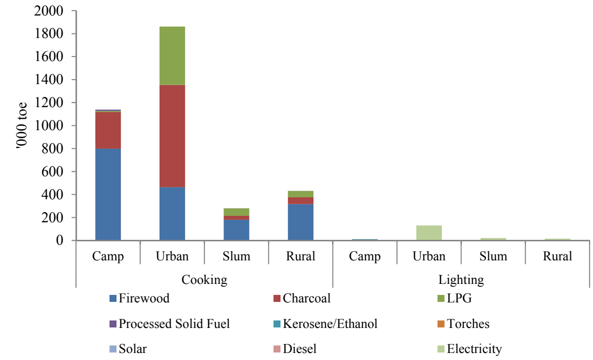

Fig. 2. Annual energy consumption by displaced populations in different settings, 2014.

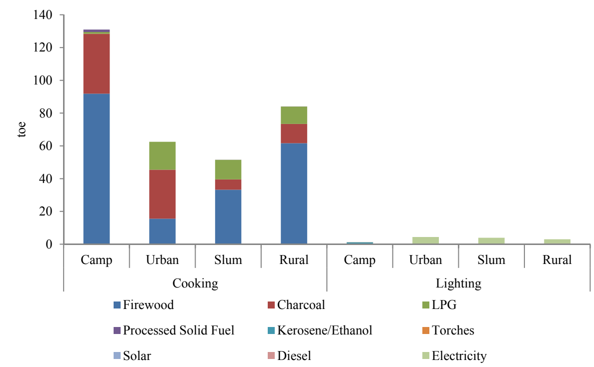

Fig. 3. Per capita annual energy consumption by displaced populations in different settings, 2014.

moreover, limited evidence to support the assumption that useful energy demand for cooking is constant as households move up tiers in the different scenarios. Research suggests that energy use would change as supply improved [34]. Finally, the model does not take into account the co-benefits associated with each scenario. The rising economic costs associated with a shift to LNG and solar do not adequately reflect the potential gains in improved livelihood possibilities, health benefits and security. Properly considering these factors is critical to the success of any energy intervention.

The model thus gives only an indication of the scale of the issue and should not be viewed as a comprehensive picture of energy use for cooking and lighting among forcibly displaced people. The estimates for the scenarios set out in section 4 should be read as rough approximations of the type of costs and savings involved.

3. Current energy demand and costs to displaced people

We estimate that a majority of displaced people do not have access to enough energy to cover their basic needs. This is particularly the case in camps where an estimated 89% only have tier 0 lighting and an estimated 77% only have tier 0 cooking facilities. This suggests that as many as 7 million displaced people in camps have access to electricity for less than 4 h and inadequate access to non-electric energy every day. In urban, slum and rural settings the distribution of those with tier 0 access is not quite as extreme.[13] An estimated 14% of urban displaced people have tier 0 lighting and an estimated 9% have tier 0 cooking facilities. As the urban population makes up the majority of the dataset, however, these lower proportions still represent around 4 and 2.6 million displaced people for lighting and cooking respectively.

According to our estimates energy use by the forcibly displaced resulted in around 3.9 million tonnes of oil equivalent (toe) being burnt in 2014. As can be seen from the estimates in Fig. 1 this mostly took the form of firewood and charcoal.

Figs. 2 and 3 highlight the variation in energy use among displaced people in different settings in aggregate and per capita terms. In absolute terms energy consumption for cooking is highest in urban settings. Factoring in the much higher urban displaced population, however, the volume of per capita energy used for cooking is estimated to be over twice as high (0.13 tonnes of oil equivalent (toe)) in camps than in urban settings (0.06 toe). This reflects the relative inefficiency of cooking technology in camps relative to urban settings. Conversely, displaced people in camps are estimated to use considerably less energy for lighting than displaced people in urban, slum and rural settings as they often lack access to any form of lighting.

We estimate that expenditure on energy could be at least $200 per year per family of five. This works out at a global total cost of $2.1 billion in 2014.[14] A cost that is primarily carried by displaced households.

Figs. 4 and 5 highlight the variation in energy expenditure on fuels among displaced people in different settings in absolute and per capita terms.[15] Spending on cooking fuel in both aggregate and per capita terms is estimated to be comparatively low in camp settings. While the figures above suggest that displaced people in urban settings may use proportionately less fuel than those in camps, they spend far more on that fuel, which takes the form of costlier LPG in our model.

These energy use and expenditure estimates highlight a divergence between use and costs for cooking and lighting. Cooking tends to be more fuel-intensive than lighting, although fuel-intensity will vary depending on equipment type. According to Gunning [8], displaced households still extensively cook on 'three

[13] In slum settings an estimated 20% (around 1 million) and 29% (around 1.6 million) of displaced people have access to Tier 0 lighting and cooking facilities respectively. In rural settings these same proportions are 42% (2.1 million) and 53% (2.7 million) respectively.

[14] For global level fuel spend figures, the number of displaced households in a camp (or in a country, for non-camp populations) is multiplied by the average annual household fuel spend for its respective baseline type or national displacement context. Thus, for example, the number of households categorized as firewood dependent is multiplied by the average fuel spend for a firewood-dependent household. By adding up each camp's annual fuel spend and (for non-camp settings) each country's fuel spend, we are able to estimate global energy costs in forced displacement situations. A similar method was used to calculate global estimates for energy consumption and emissions.

[15] This refers to spending on fuels only and does not include estimates of the capital costs associated with energy end-using equipment.

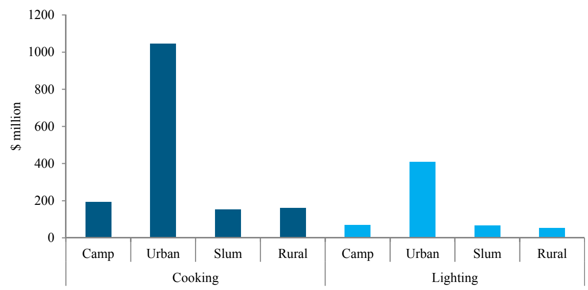

Fig. 4. Annual spending on energy by the forcibly displaced in different settings, 2014.

stone fires,' a highly firewood intensive method. Although surveys suggest that displaced people view lighting as a priority, in some cases topping better access to fuel for cooking [35], our estimates for expenditure do not reflect this preference. Displaced families are often unable to afford lighting as the majority of their expenditure on energy goes to purchasing cooking fuel. In Dadaab camps in Kenya, for example, 61% of households rely on no more than a torch for lighting [36].

The interviews conducted suggest that displaced people themselves are generally responsible for meeting their own household energy needs, while a number of different groups - local authorities, responsible IOs and NGOs, the government - bear some aspect of the cost of energy for operations and the running of a camp.

Our field surveys give us a more fine-grained view of household energy spending in Dadaab camps in Kenya and Goudoubo camp in Burkina Faso. The Dadaab survey suggests that average monthly household spending on energy comes to $17.20, amounting to around 24% of household incomes [35]. As a point of comparison the average rural Kenyan household spends around 5% of its income on energy [37]. In Goudoubo camp average monthly household spending on energy comes to $10.65, accounting for between 5 and 7% of individual income [38]. This lower expenditure may, in part, be linked to the fact that 60% of households in the camp are using donated solar lamps, lowering their expenditure on lighting.

The limited access to expensive but low quality energy outlined above has serious health, safety and environmental impacts beyond the financial toll. Surveys indicate negative coping mechanisms by displaced households in the face of inadequate energy provision. Households report skipping and undercooking meals and selling food rations to buy fuel [18,39,40]. Inadequate heating poses a risk in countries with cold winters [41]. Reliance on biomass for cooking fuel presents health risks in the form of indoor air pollution [42]. Our estimates suggest that as many as 14.6 million displaced people may be reliant on firewood for cooking and may therefore be exposed to dangerous levels of indoor air pollution. Open fires, candles and illegal electricity connections can present a fire hazard.

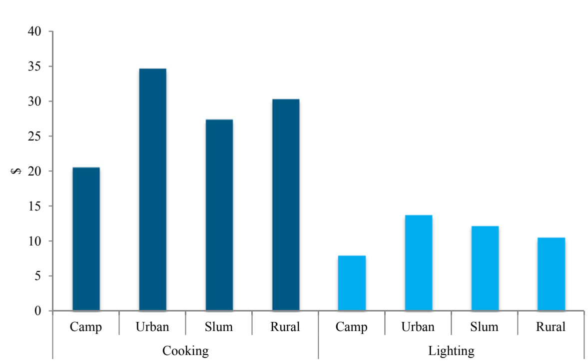

Fig. 5. Per capita annual spending on energy by the forcibly displaced in different settings, 2014.

A number of studies, moreover, document the sexual and gender-based violence faced by women when venturing outside camps to collect firewood [35,43–46].

In terms of environmental impact, our model estimates that energy use by displaced households emitted around 14.3 million tonnes of CO_2 in 2014. This is comparable to levels emitted by Sri Lanka (15.23 million tonnes) and Lithuania (13.74 million tonnes) in 2011 [47]. While this is very small proportion of global emissions, it is a high figure relative to the amount of energy consumed.

A further environmental cost is the deforestation caused by current patterns of energy consumption by displaced people. Based on data on household firewood consumption in camps used in our model and our estimates of the number of displaced households in camps reliant on firewood for fuel, we estimate that around 65,000 acres of forest may be used each year to produce energy for refugee camps.[16] This estimate should be taken as an extreme upper bound as it assumes that all fuel wood collected comes from forest sources when it may in fact be collected from non-forested common lands and hedges. Although refugee impact on deforestation is minor compared to the impact of illegal logging and agricultural development in many host countries, in contexts where local firewood is scarce perceptions of competition for resources can cause resentment [48].

4. Results

The scale of the problem outlined above suggests that by managing energy provision differently we may have the opportunity to improve the lives of displaced people in a number of ways. Using our energy model we estimate the fuel costs, capital costs and emissions associated with three potential scenarios for improving energy access.

4.1. The incremental change scenario

In the first scenario we have all displaced households retain their baseline patterns of energy use for cooking but move up to a minimum tier access level of 3. In other words, they continue to consume the mix of fuel they had consumed previously but they do so more efficiently. A firewood-dependent household will consume the same proportion of firewood to other fuel types but will consume less of that fuel: 38.08 kg per month rather than 108.81 kg or a 65% reduction. As the majority of households in the model are dependent on firewood, this scenario entails the widespread adoption of improved cookstoves, which have been shown to reduce firewood consumption by 30–70% [49]. For lighting we have those households that were previously dependent on torches and kerosene adopt basic solar lanterns and household diesel generators to meet lighting needs at a tier access level of 1.[17]

We estimate that under this scenario displaced people could save $303 million each year on fuel costs after an initial capital investment of $334 million (see Fig. 6). The total capital cost of equipment would, therefore, be offset in just over a year.[18] It is

[16] The average household firewood consumption figure for firewood-dependent households (119.16 kg per household per month) derived from the interviews conducted, was scaled up to the total population of concern to the UNHCR living in firewood dependent camps (6,644,004 people). On this basis we calculate a total consumption figure of 1.9 million tonnes a year. This figure is then converted via cords to acres of forest.

[17] Households that previously had a large degree of grid connectivity move to 100% of their lighting needs fulfilled by the grid and households that already used solar to fulfil their lighting needs move to a 50/50 split between mini-grid and solar use at tier 1 access.

[18] This simple payback calculation takes the additional capital cost/annual savings on fuel expenditure. It does not take equipment lifetime and discount rates into account.

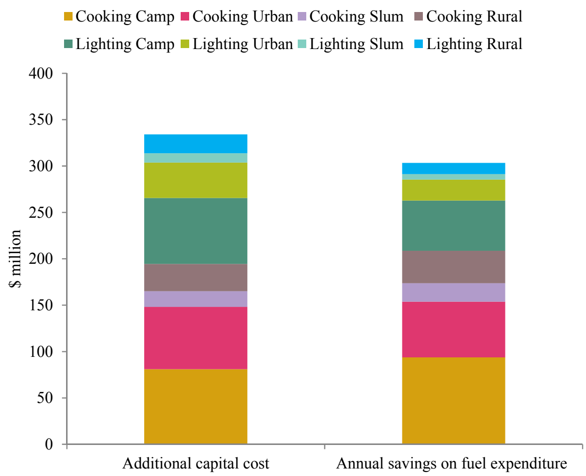

Fig. 6. Potential savings and capital costs – widespread introduction of clean cookstoves and basic solar lanterns.

important to note that this is not a direct payback. The considerable initial capital investment required would need to be covered by IOs and any relevant public-private partnerships. The annual fuel savings would, however, largely accrue to displaced households.

These estimates highlight clear financial incentives for undertaking such an intervention at scale. A shift from tier 0 to tier 3 access would, moreover, mark a considerable improvement in energy access for cooking and the efficiency gains in terms of reduced fuelwood consumption could translate into less time spent collecting firewood [50].

This first scenario is, however, the least ambitious of the three and does not adequately mitigate the costs to health from indoor air pollution. WHO guidelines on household fuel suggest that a move away from solid biomass for cooking is the only path towards globally acceptable standards of safety [26]. In terms of lighting, moreover, a shift from tier 0 to tier 1 access would only translate into minimal gains, i.e. very low power available 4 h a day.

4.2. The alternative energy scenario

In the second scenario we have households that were previously dependent on solid biomass for cooking[19] shift two-thirds of their fuel consumption to biomass briquettes. As in the first scenario this marks an improvement in tier access levels for cooking energy from tier 0 to a minimum tier 3 access level. In terms of lighting, households that were previously dependent on torches and kerosene adopt a 50/50 split between mini-grids and solar lanterns at a minimum tier 1 access level.[20]

Our estimates suggest that if implemented globally this intervention would involve an additional capital investment of $768 million and would generate fuel savings of $166 million annually (see Fig. 7). The costs of the capital investment for this scenario would be recovered in under five years but again the savings would accrue to displaced households rather than the NGOs or IOs covering the capital costs. The leap in capital costs arises from the more advanced lighting solutions which would entail an additional capital cost of $574 million but would generate annual savings of $117 million. Switching to briquette fuel for cooking would

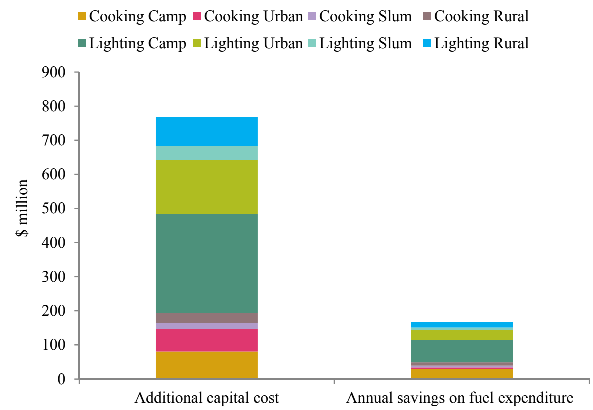

Fig. 7. Potential capital cost and savings – widespread introduction of biomass briquettes and solar and mini-grid lighting solutions.

decrease the fuel costs but only by $49 million a year. In the context of the high initial capital investment biomass briquette programmes are only likely to be viable with subsidies in place.

We chose to include a briquette scenario as briquette interventions were quite common in the refugee camps we interviewed and we wanted to test the economic and social rationale behind these projects. While the financial case is less convincing and the access levels would not improve beyond what is outlined under the first scenario, the environmental and livelihoods benefits are higher. The shift to biomass briquettes would lower firewood consumption easing pressure on local forests. Briquette interventions are often implemented in conjunction with programmes to train and employ refugees to make briquettes and sell them [51]. Once again, however, briquettes do not meet WHO safety guidelines on indoor air pollution. Previous briquette interventions, moreover, suggest that the quality of briquettes manufactured can decline if the manufacturing process is not well designed and managed.

4.3. The fundamental change scenario

In the third scenario we have all displaced households adopt LPG as their main cooking fuel. LPG is highly efficient relative to firewood, charcoal and biomass briquettes and fulfils the WHO standards on safety, offering considerable benefits in terms of lowered risks of acute respiratory infections. In terms of lighting the majority of households again adopt a 50/50 split between solar and mini-grid solutions but in this scenario the households shift to tier 3 level access for lighting, which signifies at least 8 h of energy for lighting during the day and at least 2 h after dark.[21] This scenario, therefore, represents a fundamental shift to a modern energy supply for displaced people.

Meeting this high level of ambition would, however, require a very substantial additional investment of $1.6 billion and an additional annual fuel cost of $614 million (see Fig. 8). Introducing LPG across all displacement contexts is unlikely to be practical. The fuel itself is costly and requires consolidated supply chains and additional infrastructure which both take time and additional finances. In some contexts, for example, where LPG is locally produced or where other fuels are more expensive the business case will be clearer [52]. Subsidies and market development strategies would thus be essential for the introduction of LPG solutions in certain contexts.

[19] These are households that fall under our firewood-dependent and firewood/charcoal mix types for cooking. Liquid fuel, LPG and Alternative biomass types all retain their original fuel mixes but at a tier 3 access level as in the first scenario.

[20] As in the first scenario grid-connected households maintain that energy mix but at a minimum tier access level of 1.

[21] Grid connected households again adopt 100% grid connection but at a minimum tier 3 level access as opposed to 1 in scenarios 1 and 2.

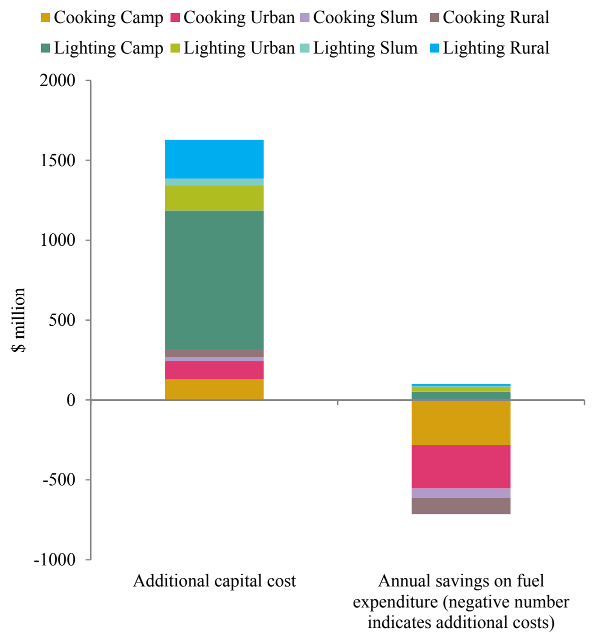

Fig. 8. Potential savings and capital cost – widespread introduction of LPG and solar and mini-grid lighting solutions.

4.4. Comparing the three scenarios

Fig. 9 compares the three scenarios on the basis of capital cost, fuel spend and emissions, which are represented by bubble size. Scenario one is the easiest to achieve as the upfront costs of the technology are relatively low and the annual fuel savings for displaced people would be considerable. Scenario two would generate similar gains in lower emissions but would cost more both in terms of capital and fuel costs. Scenario three is the most expensive but would yield huge potential benefits in terms of safety, health, protection and market generation.

This is far from an exhaustive representation of possible energy interventions. There are on-going trials studying the benefits from solar cooking, communal cooking and ethanol stoves among other things [49,53,54]. Renewable energy is rapidly becoming more cost-effective relative to traditional technologies and may in many cases be the preferred choice for off-grid areas where transportation of fuels and extending existing grids can be prohibitively expensive [55]. Energy solutions need to be implemented on a case-by-case basis, taking existing local supply chains, climate, culture and social behaviour into account.

5. Conclusions and policy implications

The SDGs call on us to 'leave no one behind.' In terms of energy access, however, our findings suggest that refugees and the displaced are some of the furthest behind. This paper has set out initial estimates for the overall scale of energy poverty among the forcibly displaced and has presented three high-level scenarios for improving energy access. While our estimates for current energy poverty and the costs accrued highlight the scale of the problem, the incremental change scenario presented above indicates that simple and cost-effective solutions, while not necessarily adequate from a health and social perspective, are within our grasp. If we are to ensure that refugees and displaced people catch up we need to move towards a recognition of energy as a key component of humanitarian relief efforts.

To that end, possible approaches include:

- First, ensuring that energy is incorporated as a key consideration at each stage of a humanitarian response. Planning for energy provision should be a feature of the immediate emergency response and then be revisited and updated as the situation develops.
- Second, there needs to be a systematic approach to collecting and reporting data on fuel use, energy practices and costs. The

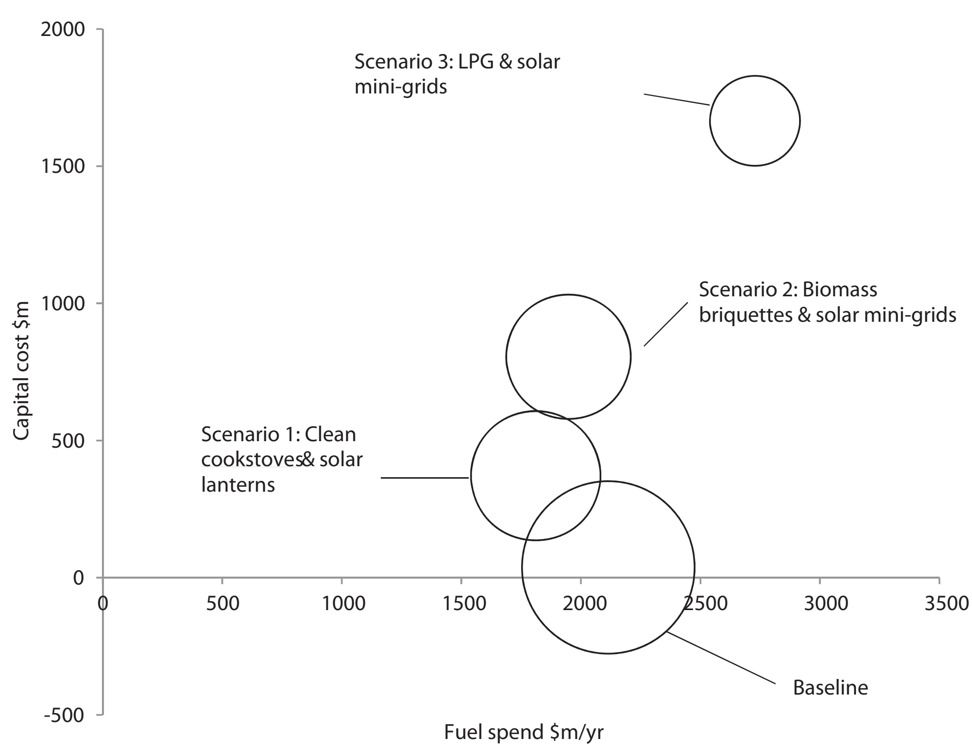

Fig. 9. The three scenarios compared (bubble size = CO_2 emissions).

paucity of data confronted when conducting our interviews highlights the huge gap in this area.

- Third, agencies should explore new and longer-term funding and delivery models for humanitarian relief [3]. The current short-term funding model does not lend itself to investments in alternative energy solutions where the savings, as indicated by our scenario analysis, are only likely to accrue after a number of years.

5.1. Extensions

We have set out a simple model of energy use by the forcibly displaced. The simplified methodology used is intended to give a sense of the scale of the problem, to provide a context for, and help guide policy-making. However, if any scenario for improving energy access for displaced people is to be workable it will necessitate more fine-grained and context-driven analysis. This paper, therefore, presents a basis for more detailed research that lends itself to more specific policy recommendations.

Further research on the range of displacement contexts and the concomitant impact of these on the distribution of energy use, costs and practices would be valuable. Similarly, a better understanding of the particular energy needs of refugees and displaced people as opposed to the energy poor in general would be worthwhile. With better data the model could be relied upon to provide a more fine-grained and descriptive rather than indicative projection of the problem.

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Annex A

Table A.1
Data sources.

Data	Source
Displaced population data	
Displaced population in camps	UNHCR, 2014 data [56]
Displaced population not in camps	UNHCR, 2014 data [55]
Urban ratio for non-displaced population	Global Tracking Framework, 2014 data [23]
Urban ratio for displaced population	UNHCR, 2014 data [55]
Slum ratio for non-displaced population	Millennium Development Goal Indicators, 2014 data [24]
Fuel and stove data	
Fuel prices	Demierre et al. [25]
Stove prices	Vianello, Practical Action Toolkit [26]
Heating values	
Charcoal	FAO [57]
Firewood	FAO [56]
Processed solid fuel	Biomass Energy Centre [58]
Biogas	Baltic Biogas Bus [59]
LPG	Engineering ToolBox [60]
Kerosene	Biomass Energy Centre [61]
CO_2 conversion factors	Fachbuch Regenerative Energiesysteme, UBA [62]
Stove efficiency ratings	Review of ISO International Workshop [63]
Tier definitions	Global Tracking Framework [64]
Energy consumption and access data	
Household energy consumption	Interviews with camp staff, field surveys, desk research
Consumption non-solid fuel (country level)	International Energy Agency, 2014 data [31,32]
Population access to non-solid fuel	Global Tracking Framework, 2010 data [23]
Consumption grid electricity (country level)	International Tracking Framework, 2010 data [31,32]
Population access to grid electricity	Global Tracking Framework, 2010 data [23]

Table A.2
Cost assumptions.

Prices for cooking fuels	$/kg
Charcoal	0.18
Firewood	0.07
Processes solid fuel	0.18
Biogas	0.00
LPG	1.80
Kerosene	1.28
Biomass briquettes	0.23
Electricity unit costs for lighting fuels	
Torches	$4/month
Kerosene	$1.5/litre
Electricity	$0.3/kWh[a]
Mini-grid 1	$0.1/kWh[b]
Mini-grid 2	$0.3/kWh[b]
Diesel generator	$0.5/kWh
Solar	$0.00
Stove costs	$/stove
tier 0	0

Table A.2 (*continued*)

tier 1	5
tier 2	10
tier 3	50
tier 4	80

[a] Includes capital costs.
[b] Running costs only.

Table A.3
Stove efficiency ratings.

Tier	Illustrative stove type	Efficiency
0	3-stone fire	14%
1	ICS	19%
2	Rocket stove	30%
3	Forced draft	40%
4	LPG	50%

Table A.4
Mapping of tiers of electricity consumption.

Tier	Consumption kWh per household per year
0	3
1	35
2	194
3	820
4	1720

A. Equations

Expenditure on fuel for cooking for camp ***i*** type ***j***:

$$e_{ij} = \sum c_k \times p_k$$

where c_k is the consumption by of fuel k and p_k is the price of fuel k.

Expenditure on fuel for lighting for camp ***i*** type ***j***:

$$e_{ij} = \sum p_k \times \ \mathit{share\ of\ population\ using\ fuel}_k$$

where p_k is the price of fuel k.

CO_2 emissions from energy use camp *i* type *j*:

$$\mathit{emissions}_{ij} = \sum c_k \times \ \mathit{emissions}_k$$

where c_k is the consumption by of fuel k and $\mathit{emissions}_k$ is the emissions generated by burning fuel k.

Capital value of energy equipment camp ***i*** type ***j***:

$$\mathit{capital\ value}_{ij} = \sum p_{kl} \times \ \frac{\mathit{useful\ energy\ demand}_k}{\mathit{useful\ energy\ demand}_{j\ total}}$$

where p_{kl} is the price of stove for burning fuel k at tier l, $\mathit{useful\ energy\ demand}_k$ is the useful energy demand of fuel k, and $\mathit{useful\ energy\ demand}_{j\ total}$ is total useful energy demand for a household in camp type j.

Annex B. Interview questions for camp operators and in-country experts

The following questions are generic. We will ask them during the interview, perhaps with some amendment given your particular country situation. If answers are not known, don't worry, we know there will be some gaps in information but are looking for information to the best of your knowledge. If there are any existing materials or reports giving any data on these issues, these would also be much appreciated. If you wish to send some answers ahead of the interview, you are most welcome to write into this document and return to us with the details below.

Name:
Country:
Name of camps/centres covered:
No of displaced people served:
Date:

20 Questions

1. What types of energy are used for a) camp operations and b) refugee households
2. What is the average household size?
3. Do refugees have access to electricity? (in what form? Who has access? What uses?)
4. Are there any renewable energy applications? Are any renewable energy applications planned? If so, when and by whom? And how will they be paid for?
5. What are the main technologies/equipment for using energy in a) camp operations b) households (e.g. main type of cooking equipment, type of generators, water pumping, water heating, milling, lighting, mobile phone charging, refrigeration)
6. Where does cooking take place? If inside, is there a chimney?
7. Types of shelter (these need to be roughly divided into categories from tents to permanent structures) and materials used
8. Annual climate in vicinity of camp, are there extremes of temperature, heavy rains, snow?
9. Are types of shelter suited to climate and weather? If not, what are main problems?
10. Has any attempt been made to weatherize/refit/insulate homes? When? Effects? Is any retrofitting planned? When?
11. Longevity of camps (when built, how long expected to last?)
12. Proximity of camps to local populations
13. Energy provision and trade – how much is provided e.g. by UNHCR or other agency
14. How much is bought by refugees themselves/collected? Which family members tend to engage in this activity most?
15. How much do households use of each type of energy; and how much do they pay for it? e.g. per week or month (e.g. incl size of LPG canisters, litres of kerosene, weight of wood/biomass, charcoal)
16. How much does the UNHCR (or other organization/host government) pay for fuels and electricity? E.g. per camp per year. Does UNHCR hold this data?
17. Do refugees sell energy (firewood, own generated electricity, stolen electricity, oil fuels …)? To what extent?
18. Do refugees sell energy using equipment? To what extent?
19. Any findings from studies on health impacts of energy related conditions (cooking/temperature/lighting)? Any collection of data on premature deaths from lung, respiratory and related diseases?
20. How frequent are case of burns/hospitalization/house fires caused by energy use (e.g. stoves, candles, bad electrical connections)?

Annex C. Cooking and lighting typologies

Table C.1
Cooking: Baseline energy types and targets (% of monthly household expenditure on fuel).

Type		Minimum tier	Description	Charcoal	Firewood	Processed solid fuel	Biogas	LPG	Kerosene/other
Baseline	1	0	Firewood-dependent	5%	88%	0%	0%	2%	5%
	2	0	Firewood mix	35%	60%	0%	0%	5%	0%
	3	0	Kerosene dependent	2%	13%	0%	0%	20%	65%
	4	0	LPG fuelled	15%	15%	0%	0%	70%	0%
	5	0	Alternative biomass	0%	30%	70%	0%	0%	0%
Target	1	3	Firewood-dependent	9%	76%	0%	0%	5%	9%
	2	3	Firewood mix	50%	40%	0%	0%	10%	0%
	3	3	Kerosene dependent	2%	6%	0%	0%	27%	65%
	4	3	LPG fuelled	13%	6%	0%	0%	81%	0%
	5	3	Alternative biomass	0%	24%	76%	0%	0%	0%
	6	3	Biomass briquettes	0%	24%	74%	0%	0%	2%
	7	3	LPG II	0%	0%	0%	0%	100%	0%

Table C.2
Cooking: Baseline energy use types and targets (kg consumed per household per month).

Type		Minimum tier	Description	Charcoal	Firewood	Processed solid fuel	Biogas	LPG	Kerosene/other
Baseline	1	0	Firewood-dependent	2.28	108.81	0.04	0.00	0.09	0.32
	2	0	Firewood/charcoal mix	13.54	64.30	0.00	0.00	0.19	0.00
	3	0	Liquid	2.13	38.34	0.00	0.00	2.13	9.70
	4	0	LPG	10.69	28.95	0.00	0.00	4.96	0.00
	5	0	Alternative biomass	0.00	64.14	53.76	0.00	0.00	0.00
Target	1	3	Firewood-dependent	1.71	38.08	0.02	0.00	0.09	0.24
	2	3	Firewood/charcoal mix	10.16	22.50	0.00	0.00	0.19	0.00
	3	3	Liquid	1.60	13.42	0.00	0.00	2.13	7.28
	4	3	LPG I	8.02	10.13	0.00	0.00	4.96	0.00
	5	3	Alternative biomass	0.00	22.45	25.54	0.00	0.00	0.00
	6	3	Biomass briquettes	0.00	24.73	22.30	0.00	0.00	0.09
	7	3	LPG II	0.00	0.00	0.00	0.00	12.26	0.00

Table C.3
Lighting: Baseline types and targets (% of population in camp using fuel type).

Types		Minimum tier	Description	No access	Torches	Kerosene	Grid electricity	Mini-grid 1	Mini-grid 2	Household diesel generator	Solar
Baseline	1	0	Torch-dependent	18%	61%	4%	0%	0%	0%	10%	7%
	2	0	Kerosene-dependent	5%	20%	60%	5%	0%	0%	0%	10%
	3	0	Electricity-dependent	0%	5%	5%	90%	0%	0%	0%	0%
	4	0	Solar-dependent	5%	10%	20%	0%	0%	0%	0%	65%
Targets	1	1	Solar/diesel	0%	0%	0%	0%	0%	0%	50%	50%
	2	1	Grid	0%	0%	0%	100%	0%	0%	0%	0%
	3	1	Solar/mini-grid	0%	0%	0%	0%	50%	0%	0%	50%
	4	3	Grid	0%	0%	0%	100%	0%	0%	0%	0%
	5	3	Solar/mini-grid	0%	0%	0%	0%	50%	0%	0%	50%

Table C.4
Shifts from type to target under three scenarios.

Baseline			Scenario		
Baseline type		Description	Incremental change	Alternative energy	Fundamental change
			Target	Target	Target
Cooking	1	Firewood-dependent	1	6	7
	2	Firewood/charcoal mix	2	6	7
	3	Liquid fuel	3	3	7
	4	LPG	4	4	7
	5	Alternative biomass	5	5	7
Lighting	1	Torch-dependent	1	3	5
	2	Kerosene-dependent	1	3	5
	3	Electricity-dependent	2	2	4
	4	Solar-dependent	3	3	5

Annex D. Simplified multi-tier matrix of energy access

Table D.1
Simplified multi-tier matrix of energy access.

Attributes of energy supply			Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Capacity	Household electricity		No electricity[a]	Very low power	Low power	Medium power	High power	
	Household cooking		Inadequate capacity of primary cooking solution				Adequate capacity of primary cooking solution	
Duration and availability	Household electricity		<4 h	4–8 h		8–16 h	16–22 h	>22 h
	Household cooking		Inadequate availability of primary cooking solution				Adequate availability of primary cooking solution	
Reliability	Household electricity		Unreliable energy supply				Reliable energy supply	
Quality	Household electricity/cooking		Poor-quality energy supply			Good-quality energy supply		
Affordability	Household electricity		Unaffordable energy supply		Affordable energy supply			
	Household cooking		Unaffordable energy supply				Affordable energy supply	
Legality	Household electricity		Illegal energy supply			Legal energy supply		
Convenience	Household cooking		Time and effort spent sourcing energy cause inconvenience			Time and effort spent sourcing energy do not cause inconvenience		
Health and safety	Household electricity		Unhealthy and unsafe energy system				Healthy and safe energy system	
	Household cooking[b]	Use of fuels (BLEENS)			Use of non-BLEENS solutions (if any) for cooking		Use of BLEENS or equivalent solutions only (if any)	
		Performance of cookstove	Level 0	Level 1	Level 2	Level 3	Level 4	Level 5

Note: BLEENS = biogas, liquid petroleum gas, ethanol, electricity, natural gas and solar.
Source: Adapted from World Bank/ESMAP [65,66].
[a] The detailed multi-tier matrix for household electricity considers a continuous variable between tier 0 and tier 1 for basic lighting services so as to capture the contribution of solar lamps that do not reach the minimum output threshold required for tier 1 access but are highly affordable and enable households to reduce or eliminate the use of kerosene for lighting.
[b] Levels are defined based on the technical performance of the cookstove (for example, in terms of efficiency, pollution, and safety), kitchen ventilation, and conformity of usage (use of required accessories, regular cleaning, and so on.).

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