Humanitarian Engineering and Energy for Displacement (HEED)

Humanitarian energy interventions: the need and opportunities for systematic decision-making

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Acknowledgements

The authors would like to acknowledge the financial support of the Engineering and Physical Science Research Council (EPSRC) for funding the Humanitarian Engineering and Energy for Displacement (HEED) project as part of the Global Challenges Research Fund (EP/P029531/1). The authors would like to acknowledge and thank project delivery partners Practical Action and Scene Connect for their significant role in co-ordinating in-camp activities and providing technical inputs and tools. We would also like to recognise the support of MIDIMAR (Ministry of Disaster Management and Refugees) and UNHCR (United Nations High Commissioner for Refugees) and the contributions of the Global Plan of Action, Chatham House, and the RE4R (Renewable Energy for Refugees) Project (a partnership between Practical Action and UNHCR, supported by the IKEA Foundation). We would also like to acknowledge Tamunosa Jamaica contributions to the literature review and give particular thanks to Rembrandt Koppelaar for developing the RERT tool.

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More details on the HEED project can found at http://heed-refugee.coventry.ac.uk

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This report should be referenced as:

Jonathan Daniel Nixon, J.D., Koppelaar, R.H.E.M., Robinson, S. and Crawley, H. 2021. Humanitarian energy interventions: the need and opportunities for systematic decision-making. Humanitarian Engineering and Energy for Displacement (HEED) Project, Coventry University. DOI: 10.18552/HEED/2021/0001

1. Access to energy in contexts of displacement

Access to energy is vital in enabling refugees to achieve economic self-sufficiency and social integration (Lahn, and Grafham, 2015). In the context of displacement, access to energy delivers multiple benefits: it saves lives, protects vulnerable groups and promotes human dignity, all of which are core ethical elements of the Humanitarian assistance and Spheres Standards (Lahn, and Grafham, 2015). In addition to enhancing the quality of everyday life, access to energy improves refugees and other displaced populations wellbeing through powering infrastructure services (medical and educational facilities), treating water and providing light. Indeed access to energy underpins all but the most rudimentary ventures that allow people to survive in context of displacements (Trace, 2019).

Despite this, access to energy has typically been neglected by international and humanitarian organisations responsible for emergency provision and long-term support to refugees (Rosenberg-Jansen et al., 2018). This is partly a result of the emphasis on meeting immediate emergency needs, but also reflects difficulties associated with longer-term planning within the humanitarian sector, much of which is focused on immediate humanitarian needs including protection, housing, water, food and health (Lahn, 2019). This has led to the neglect of energy as a strategic priority area, restricting funding opportunities, and impairing energy programme prioritization and coordination (Lahn, and Grafham, 2015). Critically there is a need for research to inform and guide decision-making, as there is a lack of data and evidence to inform practitioners (Rosenberg-Jansen, 2020, Grafham and Sandwell, 2019).

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2. Energy decision making in refugee camps

Improved decision making in the energy sector has become an important and widely researched area to future-proof and ensure sustainable operations and developments. There are now a plethora of examples of analytical decision tools and methods being developed and applied for suitable project planning, informing investments and policy, operating networks, site and technology selection and system design and integration (Kumar et al., 2017). However, research and applications of energy decision making in the context of protracted and displaced settlements remains almost completely unexplored (Nixon and Gaura, 2019)

Energy decision-making involves evaluating numerous social, technical, environmental and economic criteria. There may not be good information available regarding the energy needs, interests and aspirations of different communities. Different stakeholders and decision makers can sometimes have conflicting objectives, which need to be considered and balanced. In the context of energy planning and decision making in refugee camps, there are additional complexities and challenges that have to be taken into account including a reluctance on the part of policy makers and others (for example, neighbouring communities) in some contexts to acknowledge the permanency of camps or settlements hosing refugees or other displaced populations. This further increases the difficulty of managing and making appropriate long-term decisions. In this context, decision support tools can provide a more systematic method to decision making which allows a more objective assessment of the factors that should inform energy provision in contexts of displacement.

The need for greater objectivity and transparency in relation to energy provision for those living in camps is reflected, and reinforced by, changes in the use of data in displacement contexts. The humanitarian sector is going through a major shift in the way that it treats data, with a greater focus on the collection, management, analysis and sharing of data to inform collective responses in humanitarian settings (Grafham and Sandwell, 2019). Significant actors within the humanitarian sector around the world (e.g., UNHCR, Red Cross, Ikea Foundation) have argued for consistent approaches to energy interventions. In this context the need for systematic tools for energy decision-making in refugee camps is particularly strong (UNITAR, 2018).

This briefing paper highlights the potential benefits of humanitarian decision-making tools through the application of a decision support tool developed as part of the EPSRC-funded Humanitarian Engineering and Energy for Displacement (HEED) project led by Coventry University in partnership with Practical Action and Scene Connect. HEED draws upon social science and engineering expertise to better understand energy needs and identify solutions that produce socio-technical systems that encourage community resilience and capacity building. The project focuses on the energy experiences, needs and aspirations of Congolese refugees living for protracted periods of time in Rwanda and internally displaced persons (IDPs) forced to leave their homes as a result of the 2015 earthquake in Nepal.[1]

1 More information at the HEED website

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3. The Renewable Energy Recommendation Tool

The Renewable Energy Recommendation (RERT) tool was built by Scene Connect, with support from Coventry University and Practical Action between June 2018 and April 2019. The aim was to provide technology recommendations based on different criteria selection targets to increase energy access in refugee camps and improve sustainability for:

1. Cooking energy
2. Household lighting and electricity
3. Camp/communal lighting and electricity

Users of the tool engage with an Excel-based spreadsheet model and answer questions to describe the situation of a refugee camp (e.g. location, population, infrastructure, etc.) and levels of energy access. Within the tool, users can then specify performance targets and a desired energy access level based on the World Bank's Multi-tier Framework for assessing levels of energy access for household electricity, cooking, heating and community facilities (Bhatia and Angelou, 2015). There are advanced options within the tool to enable specific technical data to be modified for a wide range of alternative renewable energy options. RERT then scores and ranks alternative technologies based on how they perform against a number of techno-economic performance criteria. The RERT's intended use is for "non-emergency" humanitarian situations, including:

- Recently established refugee camps (after 6 months – 1 year) to assess early options for energy infrastructure improvements
- Long established camps (over 1 year) to address existing camp energy infrastructure and design long-term, economically viable and impactful energy interventions
- Within other humanitarian settings (e.g. IDPs within a specific area but not considered a refugee camp) or within host community settlements

The RERT tool is freely available.

A user guide can be found on Github.

4. Application

The application and functionality of the RERT tool is demonstrated for two cookstove selection case studies in: i) Kigeme refugee camp, Rwanda, and ii) Kebribeyah refugee camp, Ethiopia. The camps are introduced along with the RERT input data. The criteria that the tool considers for cookstove selection are outlined and the current baseline energy access cooking situation is established for each camp. A number of technology alternatives are proposed and the RERT tool considers the performance of each against selection criteria to arrive at recommended alternatives for a specific energy access target.

4.1 Decision criteria

Cooking solutions involve a combination of a cookstove technology and a fuel type. Cookstove selection problems typically focus around evaluating technological performance and usability criteria; potential criteria to consider when selecting a cookstove for an energy intervention are summarised in Table 1. The RERT tool considers ten performance criteria and the energy access tier (see Table 2).

Table 1: Potential criteria to consider when selecting a cookstove for an energy intervention (Vaccari et al., 2017,Soomroa et al., 2016)

Criteria	Sub-criteria
Economic	Cooking energy expenditure (includes fuel cost, useful life, energy conversion efficiency), investment cost, operating and maintenance cost, available subsidy, interest rate, energy conservation cost, carbon dioxide (CO2) and black carbon abatement cost
Technical/Commercial	Fuel consumption, cooking time, efficiency, quality, sophistication level, size/weight, durability, need for tracking, nutrition value of the food, improvement in models, spares and after-sales service, distribution network, market research, need for user training, installation and adoption efficiency
Environmental	CO2 emissions, fossil fuel depletion and other hazardous environmental impacts

Table 2: RERT selection criteria for cookstove selection

Cookstove selection criteria	Unit
Energy access tier [a]	–
Camp – Investment cost for cooking intervention	US$
Camp – Total cooking fuel cost	US$
Camp – Carbon dioxide emissions per year	Tonnes
Camp – Annual area at risk from deforestation for wood fuel use	km^2
Camp – Area used for providing wood fuel from plantations	km^2
Household – Affordability of cooking fuel	Very low to Very high
Household – Monthly cooking fuel cost	US$
Household – Cost of purchasing cooking stove	US$
Household – Carbon dioxide emissions per family per year	Tonnes
Household – Health risk associated with cooking	Very low to Very high
a Global Tracking Multi-tier Framework for energy access (Bhatia and Angelou, 2015)	

To achieve a specific energy access tier, a combined cookstove and fuel type cannot exceed certain threshold performance values for fuel acquisition, meal preparation, PM emissions and CO exposure. These threshold values specified in Table 3 are drawn from the Multi-tier Framework for energy access (Bhatia and Angelou, 2015) and Clean Cooking Alliance (2018) hosted ISO-International Workshop Agreement (ISO-IWA) on cookstove performance targets.

Table 3: Energy access tier requirement for cooking set in RERT

Energy Tier	Fuel acquisition and preparation time (hours per week)	Stove preparation time per meal (min)	PM 2.5 (µg/m³)	CO exposure (mg/m³)	Efficiency (%)
Tier 1	< 7	< 15	⇠ 800	⇠ 35	<15
Tier 2	< 4	< 10	⇠ 400	⇠ 25	<25
Tier 3	< 1.5	< 5	⇠ 170	⇠ 18	<35

4.2 Cookstove technology alternatives

Tier 2 and 3 cooking solutions considered by the RERT tool are shown in Figure 1 and performance specifications are provided in Table 4.

Figure 1: Alternative cookstove options modelled by the RERT tool

Metal ICS side-feeder (charcoal)

Ceramic cookstove (firewood / charcoal)

Metal ICS batch-loaded (firewood / charcoal)

Kerosene stove

Gasifier stove (Mimi Moto)

Ethanol stove

LPG / Biogas stove

Electric cookstove

Table 4: Cookstove performance specifications
(Barbieri et al., 2017; CleanCookingAlliance, 2021; Still et al., 2015; MacCarty et al., 2010; Johnson and Chiang, 2015; Ruiz-Mercado et al., 2012; Bentson et al., 2013; Pillarisetti et al., 2014)

Stove	Fuel	Eff.	Indoor emissions CO (g/min)	Indoor emissions PM2.5 (mg/min)	Utilisation rate	Average daily stove use (hours)
Improve stove from metal fuelled with side feeder	Wood	18%	0.795	28.50	0.80	2.50
Improve stove from metal fuelled with side feeder	Charcoal	18%	0.795	28.50	0.80	2.50
Improve stove from metal that is batch loaded	Wood	25%	0.58	35.00	0.80	2.50
Improve stove from metal that is batch loaded	Charcoal	40%	0.455	5	0.80	2.50
Gasifier Stove built for burning pellets	Pellets	40%	0.455	5	0.80	2.50
Cook stove for ethanol / kerosene combustion	Ethanol	45%	0.35	1	0.80	2.50
Cook stove for ethanol / kerosene combustion	Kerosene	45%	0.35	1	0.80	2.50
Cook stove burnt for gas burning (LPG, biogas)	LPG	35%	0.48	7	0.80	2.50
Cook stove burnt for gas burning (LPG, biogas)	Biogas	35%	0.48	7	0.80	2.50
Modern Cook Stoves – Induction Electric Cooker	Electricity	73%	0.00	0	0.80	2.50

5. Case studies

5.1 Case study 1: Cookstove selection in Kigeme refugee camp, Rwanda

Kigeme refugee camp is in Nyamagabe district, Rwanda, and is home to over 21,000 residents. A number of programmes to improve energy access have been recently undertaken in Kigeme. One of these programmes involved the introduction of improved cookstoves, with refugees having the option to buy fuel (pellets) using their cash allowance. The improved cookstove solution scheme was delivered in the camp by a Rwandan private sector social enterprise, Inyenyeri, who produce environmentally sustainable fuel burning pellets and lease clean and highly efficient cook stoves to residents. Model input data was collected in 2018/19 from camp officials, United Nations Humanitarian staff and members of the community via surveys (Gaura, 2020) (see Table 5).

Figure 2: Charcoal selling, Rwanda, 2019, and charcoal burning cookstove, Kigeme Camp, Rwanda, 2019. HEED/Edoardo Santangelo

Table 5: RERT questionnaire input data for Kigeme refugee camp

Camp geography and demographics		
Camp population	21,000	-
Number of families	4000	-
% of HH operating business from home	8%	%
Distance between HH	6–12	m
Camp area per person	30–34	m^2
Vacant space inside camp for energy installations	100	Family HH equivalent
Primary source for wood fuel	Forest	
Topography	Hilly	
Vacant space outside camp for energy installations	Little space	
Household cooking		
Use of traditional 3-stone cookstove	4/10	Families
• Firewood fuel	9/10	Families
• Charcoal fuel	1/10	Families
Use of clay cookstoves	2/10	Families
• Firewood fuel	6/10	Families
• Charcoal fuel	4/10	Families
Use of efficient cookstoves	4/10	Families
• Pellets	10/10	Families
Income		
Population in low income bracket (approx. US$26/month)	70	%
Population in low income bracket (approx. US$66/month)	20	%
Population in low income bracket (approx. US$178/month)	10	%

5.1.1 Baseline

For cooking, the RERT tool establishes the current baseline situation. The monthly total fuel expenditure for cooking in Kigeme was estimated to be around 1.7 million RWF (~1,700 USD). The annual CO2 emissions for the camp were estimated to be 6,939 tonnes for cooking. The utilisation of wood-fuel without provisioning of such fuels in a sustainable manner is evaluated by RERT to be associated with a forest area of 0.23 km2 that is at annual risk of deforestation, given biomass needs to supply cooking fuels for all the 4,000 families in the camp.

Finally, health risks due to stove usage are still high given the prominence of three-stone cookstoves and, to a lesser extent, fired clay (ceramic) stoves.

5.1.2 Results

The RERT tool assessed sixteen different cooking solutions to identify the best options to achieve tier 3 for cookstove energy access in Kigeme refugee camp. Three high performing cookstoves to increase energy access for cooking to tier 3 are cookstoves using either LPG, biogas or ethanol (see Table 6).

Table 6: Top performing cookstoves for Kigeme refugee camp to achieve tier 3 energy access for cooking

Indicator	Unit	Current Situation	Cookstove with LPG supply	Cookstove with biogas supply	Cookstove with ethanol
Camp – Investment cost for cooking interventions	Franc (RWF)	5,463,808	10,383,965	10,383,965	15,324,723
Camp – Total Cooking Fuel Cost	Franc (RWF)	1,708,855	8,457,777	0	1,179,384
Camp – Carbon Dioxide emissions per year	tonnes	6,939	1,632	2,462	1,502
Camp – Annual area at risk from deforestation for wood fuel use	km^2	0.232	0.00	0.00	0.00
Camp – Area used for providing wood fuel from plantations	km^2	0.005	0.00	0.00	0.00
Household – Affordability of Cooking Fuel	Very low to Very high	Very low	Very low	Very low	Very low
Household – Monthly Cooking Fuel Cost	Franc (RWF)	427	2,114	0	295
Household – Cost of purchasing cooking stove	Franc (RWF)	1,366	2,596	2,596	3,831
Household – Carbon Dioxide emissions per family per year	tonnes	2.01	0.41	0.62	0.38
Household – Health risk associated with cooking	Very low to Very high	High	Low	Low	Very low

Whilst the results are highly dependent on the model inputs and assumptions, such as fuel cost and availability, the performance of all cookstove options can be easily compared. The tool thus allows decision makers to assess acceptable costs directly alongside potential social and environmental impacts. To arrive at more suitable recommendations, targets need to be specified in RERT, e.g. to avoid a solution being recommended that is too expensive or unavailable.

5.2 Case study 2: Kebribeyah refugee camp, Ethiopia

Kebribeyah camp was established in 1991 for Somali refugees fleeing the civil war in their country and currently has a population of 14,685 displaced people (UNHCR, 2018). The camp is not organized, and the refugee housing is mixed with that of the host community. Since the refugee households are located along with those of the host communities, individuals of the host community extend their grid lines and provide electricity supply for a fee. Households cook using a three-stone fire or a traditional charcoal stove. Table 7 shows the RERT model input data, which was provided by MercyCorp, an NGO that that carried out an energy access assessment of refugee camps in Jijiga, Ethiopia, in 2020. This information is not currently publicly available; more details on MercyCorp's work in humanitarian energy can be found here (MercyCorp, 2021).

Table 7: RERT questionnaire input data for Kebri Beyah Refugee Camp

Camp geography and demographics		
Camp population	14685	–
Number of families	7769	–
% of HH operating business from home	5	%
Distance between HH	6–12	m
Camp area per person	35–44	m^2
Vacant space inside camp for energy installations	None	Family HH equivalent
Primary source for wood fuel/land outside camp	Shrubland	
Topography	Flat	
Vacant space outside camp for energy installations	Lots of space	
Household cooking		
Use of traditional 3-stone cookstove	7	Families
• Firewood fuel	7	Families
• Charcoal fuel	3	Families

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Household cooking		
Use of clay cookstoves	3	Families
• Firewood fuel	0	Families
• Charcoal fuel	10	Families
Use of efficient cookstoves	0	Families
• Pellets	–	Families
Income		
Population in low income bracket (approx. US$26/month)		10%
Population in low income bracket (approx. US$66/month)		70%
Population in low income bracket (approx. US$178/month)		20%

5.2.1 Energy access targets

Using the scenario builder functionality within the RERT tool, energy access targets can be specified. The current baseline situation and the desired situation for Kebribeyah Refugee Camp is shown in Table 8. The current cooking energy access tier in Kebribeyah was determined to between tier 0 and 1, with most of camp residents surveyed using firewood or charcoal in basic 3-stone fires and charcoal stoves. Only 4% of residents used kerosene stoves for cooking.

Table 8: Baseline and selection criteria targets for cooking in Kebribeyah Refugee Camp

Decision criteria		Target	Current situation
Energy Access Tier	–	2	0.3
Camp – Investment cost for cooking interventions (max threshold)	ETB	101,710	10,687
Camp – Total Cooking Fuel Cost (max threshold)	ETB/month	20,342	68,181
Camp – Carbon Dioxide emissions per year (max threshold)	tonnes/year	3,500	16,129
Camp – Annual area at risk from deforestation for woodfuel use (max threshold)	km^2/year	1	7.273
Camp – Area used for providing woodfuel from plantations (max threshold)	km^2	0.02	0.010
Household – Affordability of Cooking Fuel	–	Medium	Very low

Decision criteria		Target	Current situation
Household – Monthly Cooking Fuel Cost (max threshold)	ETB/month	15	9
Household – Cost of purchasing cooking stove (max threshold)	ETB	50	1
Household – Carbon Dioxide emissions per family per year (max threshold)	tonnes/year	2.00	2.21
Household – Health risk associated with cooking	–	Medium	Very high

5.2.2 Results

To achieve energy access tier 2, the RERT recommends fired clay wood/charcoal stoves or, with significantly more investment, improved wood fuel stoves. The top 3 solutions based on the number of targets met and achieving tier 2 are shown in Table 9.

A fire clay stove would achieve five out of ten targets whereas wood fuel stoves would only meet three. Implementation of fired clay stoves would reduce monthly cooking costs (51–66% across the camp), carbon emissions (53–67%) and health risks from very high to high. Improved cookstoves offer similar benefits at a much higher investment cost and lower household affordability. The implementation of improved cookstoves would be dependent on the final product specification and support (i.e. funding, grants) available for implementation. The RERT tool could not find a technology alternative that would fulfil all the criteria selection targets (see tables 2 and 3).

Table 9: Top performing cookstoves for Kebribeyah refugee camp to achieve tier 2 energy access for cooking based on specific criteria selection targets

Indicator	Unit	Fire clay cookstove (ceramic) with woodfuel	Fire clay cookstove (ceramic) with charcoal	Improved metal batch loaded stove with woodfuel
Camp – Investment cost for cooking interventions	birr (ETB)	42,780	42,780	395,092
Camp – Total cooking fuel cost	birr (ETB)	23,434	33,494	23,434
Camp – Carbon dioxide emissions per year	tonnes	7,656	5,269	7,656
Camp – Annual area at risk from deforestation for wood fuel use	km2	2.49	7.11	2.49

Indicator	Unit	Fire clay cookstove (ceramic) with woodfuel	Fire clay cookstove (ceramic) with charcoal	Improved metal batch loaded stove with woodfuel
Camp – Area used for providing wood fuel from plantations	km2	0.00	0.00	0.00
Household – Affordability of cooking fuel	Very low to Very high	Very low	Very low	Very low
Household – Monthly cooking fuel cost	birr (ETB)	3	4	3
Household – Cost of purchasing cooking stove	birr (ETB)	6	6	51
Household – Carbon dioxide emissions per family per year	tonnes	0.99	0.68	0.99
Household – Health risk associated with cooking	Very low to Very High	High	High	High

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6. Discussion

The RERT tool demonstrates how technology alternatives can be quickly compared for humanitarian applications by considering a range of different techno-socioeconomic criteria and the level of energy access that could be achieved. Different criteria selection targets and energy access levels can be easily chosen to evaluate a range of different scenarios for specific refugee camps. However, the RERT tool is currently limited to ten criteria and there are many more that could have been included (e.g. maintenance cost, ease of use, adaptability to cooking practices), which may have changed the recommendations. The inclusion or exclusion of relevant and irrelevant criteria, and the impact on recommendations made or ranking of alternatives is a well-known problem in decision-making. There are also many interdependencies between selection criteria that could affect the decisions being made. This is a particular problem in complex humanitarian settings. These factors, therefore, need to be carefully considered when researching, developing and applying humanitarian decision-making tools.

The RERT tool only shows the deviation from criteria selection targets and ranks alternatives based on how many targets have been met. Multi-criteria decision-making techniques could be implemented as the next step to provide a systematic method to ranking the performance of technological alternatives. For example, methods such as the Analytical Hierarchy Process rank the alternatives based on criteria weightings, whereas Topsis ranks alternatives based on the criteria deviations from an ideal solution. Further research would be needed to investigate how different stakeholder criteria weightings and ranking methods could change the recommendations being made for improving energy access in humanitarian settings.

It is important to note that the tool is designed as a first high-level feasibility assessment, often using data which has already been collected (e.g., through research projects or by camp authorities). The tool would be utilised by in-country/in-camp energy advisors, providing a first step towards supporting humanitarian energy decision-making for cooking and electricity interventions. Whilst decision-making tools, like RERT, may not be enough for arriving at successful and sustainable energy interventions, they will help users to understand locally relevant and appropriate technologies, which will lead to better designed feasibility studies and, in turn, more impactful energy interventions.

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References

Barbieri, J., Riva, F. & Colombo, E. 2017. Cooking in refugee camps and informal settlements: A review of available technologies and impacts on the socio-economic and environmental perspective. Sustainable Energy Technologies and Assessments 22, 194–207. doi: 10.1016/j.seta.2017.02.007

Bentson, S., Still, D., Thompson, R. & Grabow, K. 2013. The influence of initial fuel load on Fuel to Cook for batch loaded charcoal cookstoves. Energy for sustainable development 17: 153–157. doi: 10.1016/j.esd.2012.10.011

Bhatia, M. & Angelou, N. 2015. Beyond connections: Energy access redefined. Washington: World Bank.

CleanCookingAlliance, 2021. The clean cooking catalog, product and performance data for the clean cooking sector.

CleanCookingAlliance, 2018. Voluntary performance targets.

Gaura, E. 2020. Surveys, The Humanitarian Engineering and Energy for Displacement (HEED) project Data Portal.

Grafham, O. & Sandwell, P. 2019. Harness better data to improve provision of humanitarian energy. Nature Energy, 4: 993–996. doi: 10.1038/s41560-019-0518-8

Johnson, M.A. & Chiang, R.A. 2015. Quantitative guidance for stove usage and performance to achieve health and environmental targets. Environmental Health Perspectives, 123: 820-826. doi: 10.1289/ehp.1408681

Kumar, A., Sah, B., Singh, A.R., Deng, Y., He, X., Kumar, P. & Bansal, R. 2017. A review of multi criteria decision making (MCDM) towards sustainable renewable energy development. Renewable and Sustainable Energy Reviews, 69: 596–609. doi: 10.1016/j.rser.2016.11.191

Lahn, G. 2019. Energy insight: Thinking differently about energy access in displacement situations. Applied Research Programme on Energy and Economic Growth. London: Chatham House.

Lahn, G. & Grafham, O. 2015. Heat, light and power for refugees, saving lives, reducing costs.

MacCarty, N., Still, D. & Ogle, D. 2010. Fuel use and emissions performance of fifty cooking stoves in the laboratory and related benchmarks of performance. Energy for Sustainable Development, 14: 161–171. doi: 10.1016/j.esd.2010.06.002

MercyCorp, 2021. Inclusive energy access 101.

Nixon, J.D. & Gaura, E. 2019. Chapter 10: Remote sensing technologies and energy applications in refugee camps. In: Energy Access and Forced Migration, Grafham, O. [ed]. doi: 10.4324/9781351006941

Pillarisetti, A., Vaswani, M., Jack, D., Balakrishnan, K., Bates, M.N., Arora, N.K. & Smith, K.R. 2014. Patterns of stove usage after introduction of an advanced cookstove: the long-term application of household sensors. Environmental Science & Technology, 48: 14525–14533. doi: 10.1021/es504624c

Rosenberg-Jansen, S. 2020. Rethinking energy economies for refugees. Oxford Department of International Development.

Rosenberg-Jansen, S., Barlow, M., Peisch, S., Ponnan, N. & Rathi, P. 2018. Sustainable humanitarian energy services: Inclusive participation, lessons learnt, and paths forward. Practical Action, United Kingdom. doi: 10.3362/9781780446806.001

Ruiz-Mercado, I., Canuz, E. & Smith, K.R. 2012. Temperature dataloggers as stove use monitors (SUMs): field methods and signal analysis. Biomass Bioenergy, 47, 459–468. doi: 10.1016/j.biombioe.2012.09.003

Soomroa, H., Shaha, S.F., Nixon, J.D., Harijanc, K. & Mirjatd, N.H. 2016. Development of AHP model for ranking of cook stove technologies for Sindh Province, Pakistan. 4th International Conference on Energy, Environment and Sustainable Development 2016 (EESD 2016).

Still, D., Bentson, S. & Li, H. 2015. Results of laboratory testing of 15 cookstove designs in accordance with the ISO/IWA tiers of performance. EcoHealth, 12, 12–24. doi: 10.1007/s10393-014-0955-6

Trace, S. 2019. It's time to talk about improving energy access for displaced people. Oxford Policy Management.

UNHCR, 2018. Kebribeyah Camp profile.

UNITAR, 2018. The global plan of action for sustainable energy solutions in situations of displacement – framework for action. Geneva: UNITAR.

Vaccari, M., Vitali, F. & Tudor, T. 2017. Multi-criteria assessment of the appropriateness of a cooking technology: A case study of the Logone Valley. Energy Policy, 109, 66–75. doi: 10.1016/j.enpol.2017.06.052

Humanitarian Engineering and Energy for Displacement (HEED)

Since the introduction of the UNCHR global strategy on Safe Access to Fuels and Energy (SAFE) in 2014, humanitarian responses to refugees and internally displaced people (IDPs) have sought to deliver safe and sustainable energy provision. By focusing on the lived experiences of refugees and IDPs in Nepal and Rwanda to understand energy usage in refugee camps and settlements, the HEED project will develop, and contribute to, innovative responses which address demands for improved energy services.

Our research, led by key experts in the fields of engineering and social science, is looking for solutions that will provide crucial guidance on creative approaches and technologies to clean or fuel-efficient cookers, alternative and sustainable fuels, and solar-powered lighting, which will build the resilience of refugee communities.

Our partners

The HEED project, is led by an interdisciplinary team based at Coventry University, in partnership with the international development charity, Practical Action, and Scene Connect, a social enterprise strengthening communities through the development of ICT products.

Contact us

www.heed-refugee.coventry.ac.uk

This research has been funded by the EPSRC Global Challenges Research Fund (Grant N° EP/P029531/1).

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