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Energy Delivery Models for Humanitarian Assistance: the Case of Lebanon

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1 Background

There are 65.3 million forcibly displaced people across the globe[1], an unprecedented number of displaced populations.

Despite its small size, Lebanon ranks third in the top hosting countries with 1.1 million Syrian refugees according to UNHCR data (the number climbs to 1.5 million according to the Lebanese Government data), and yet comes first when refugee population is related to local population, with almost one in four people being a refugee. Additionally, Lebanon, although 99% electrified, suffers from an electricity supply shortage that has been aggravated by the Syrian refugees' influx. In 2009, the average production capacity was 1,500 MW while the average demand was around 2,000-2,100 MW. The instantaneous peak demand in the summer was estimated at 2,450 MW[2]. The Syrian refugees influx resulted in an additional demand of 486 MW caused by the direct and indirect additional power consumption[3].

This results in a national electricity black-out of up to 12 hours in some regions, and presents an uncommon energy poverty situation where limited access to energy is an issue not limited to refugees, but widely shared among the host communities, especially the most vulnerable ones equivalent to 1.03 million Lebanese[4] or one fourth of the population. In order to overcome the energy gap, energy delivery models have to meet the basic needs of the most vulnerable populations -the host communities and the displaced individuals- while being easy to deploy and waiving unnecessary policies and frameworks.

This exchange discusses the energy delivery models, the UNDP customized model in the case of Lebanon, and the potential of modular units in meeting the energy needs in the cases of humanitarian aid.

1: UNHCR data, April 2017

2: MEW. «Policy Paper for the Electricity Sector, Beirut: Ministry of Energy and Water». June 2010.p.3

3: UNDP. «The Impact of the Syrian Crisis on the Lebanese Power Sector and Priority Recommendations». Januray 2017. p.64.

4: Lebanon Crisis Response Plan 2017 - 2020. Government of Lebanon and United Nations. january 2017. p.10.

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Overview of Energy Models

When a refugee crisis emerges, humanitarian aid agencies are often focused on providing life-saving services and components, while other important basic rights and needs such as energy become secondary issues.

Moreover, although the refugees are naturally the primary focus of the different stakeholders dealing with the crisis, there is a common understanding and subsequent action plans to focus also on the host communities in order to avoid friction between host communities and refugees, and between local communities and international aid organizations. Building resilience and empowering the host communities plays a vital role in their ability to respond to the crisis and alleviate its impact.

Thus, providing energy access and building energy resilience for both the refugees and host communities is essential. Models that can meet both population groups are optimum, especially when the refugees are mostly located in informal settlements and/or hosted in private local households; similar to the case of Lebanon.

In order to build energy resilience, different energy models combining technological and financial schemes, as well as policy and legal frameworks are sought after. Ideally, the first step in building such models is the mapping of the beneficiaries' needs. Yet, in most emergency responses, the resources and time needed to perform such a baseline task are difficult if not unattainable, which in many cases results in providing services and products that do not meet, optimally, the needs or requirements of the beneficiaries.

In the absence of reliable and continuous electricity from the grid side, alternatives are considered.

Within these alternatives, decentralized renewable energy systems are among the easiest to deploy. There are different energy delivery models providing access through decentralized, renewable models, yet mini-grids have emerged as a cost-effective and sustainable solution[5].

Implementing mini-grids however requires an enabling environment comprising financing and tariff schemes, a thorough regulatory framework[6], the availability and development of technical capacity[7] and maintenance support, and the mitigation of the governance barriers. In most countries, an additional key factor in mini-grids implementation is the political will; so often governments and donors are reluctant to admit that a refugee crisis is not a short-term emergency[8]. In the case of energy delivery models for humanitarian purposes, where fast responses and interventions are needed; the above mentioned requirements form a barrier to the rapid deployment of mini-grids, hence hindering the ability of these systems in creating a viable, efficient solution for providing fast access to energy for host communities and displaced individuals.

Mini-grids are therefore optimal solutions for long-term energy planning and investing. In the displaced populations' case, mini-grids are only feasible in locations where there's a consensus that the crisis is a long-term one, where there are clusters of refugees; such as formal settlements, in proximity to distribution lines, when the intervening humanitarian agencies have a strong technical team with extensive expertise in the field, and when a solid monitoring and maintenance program is put in place. In this

5: Pugazenthi D, Sarangi Gopal, et al. "Replication and scaling-up of isolated mini-grid type of off-grid interventions in India". AIMS Energy, p.223.
6: Subhes Bhattacharyya & Debajit Palit. "Mini-grid based off-grid electrification to enhance electricity access in developing countries: What policies may be required". Energy Policy. 2016 (94). p. 169.
7: USAID. "Hybrid Mini-Grids for Rural Electrification. Lessons Learned". 2011. p.6.
8: Owen Grafham, Glada Lahn, & Johanna Lehne. "Energy solutions with both humanitarian and development pay-offs". Forced Migration Review, May 2016. P. 47.

scenario, when the crisis ends and displaced populations return to their homeland, the mini-grid systems will remain an asset to the host communities and will contribute to their energy mix, forming a win-win situation for both the host communities and the refugees.

In Lebanon, the government policy remains to reject formal camps for the 1.5 million Syrian refugees, claiming that such settlement arrangements would encourage refugees to stay in the host country (something similar to the case of the Palestinian refugees in Lebanon), thus most of the Syrian refugees reside in rented accommodation, while the rest are located in exposed places such as unfinished buildings and informal camps[9].

The fact that the refugees are spread all over the country and dispersed over 1,298 locations[10] escalates the challenge for securing the needed resources to meet their basic needs, also for mitigating the impact of this crisis on the already vulnerable host community.

From a technology perspective, this situation presents however an opportunity for innovation, consisting of customized energy delivery models.

The UNDP-Lebanon Model

The energy sector strategy of the Lebanon Crisis Response Plan -LCRP-, published in 2017, has as objective to improve access to energy at minimum standards to the households affected by the Syrian crisis[11], a target that UNDP Lebanon has been working on since the start of the Syrian refugees' influx.

Facing the crisis and the need to deliver urgent and basic energy for lighting at the household level, UNDP Lebanon aimed at supplying and installing lighting kits which would meet different targets:

• Meeting the basic electricity needs of the host communities and displaced individuals
• Meeting the basic illumination level needs of the households
• Ensuring continuous, uninterrupted lighting at different times of the day
• Ensuring the equipment is user-friendly and is easily and rapidly installed

There are various lighting kits models on the global market. Market research shows that standard lighting kits comprise one to two lighting points, of up to 3W in general, and providing up to 350 lumens per room, which is lower than the illuminance levels required to reach a satisfactory level of lighting in a typical Lebanese household.

In order to meet the minimum standard illuminance required per room, customized Photovoltaic Lighting Kits –PLK- were designed and implemented.

The PLK consists of a small photovoltaic generator, lamps, battery, and an integrated battery PV charge controller. The rating capacity of the main components could be fulfilled by the capacity of each unit or by a modular arrangement of several compatible components in parallel.

9: Venetia Rainey. "Lebanon: No formal refugee camps for Syrians. 11 March 2015". Al Jazeera.
10: UNHCR. "Number of Syrian Refugee Families and Individuals per Cadastral in Lebanon". CAS
11: Lebanon Crisis Response Plan 2017-2020. Government of Lebanon and United Nations. January 2017. p.62.

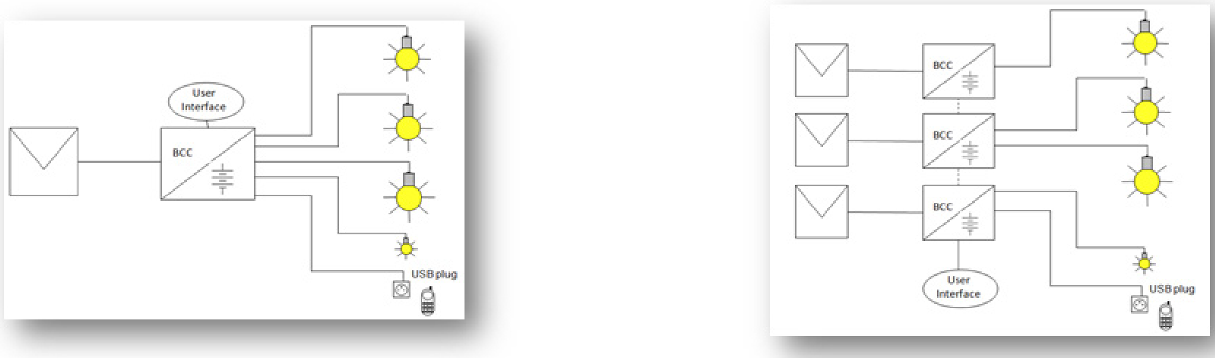

Figure 1: Potential General Layouts of the PLK

Figure 2: Components of the implemented model (to the left: lighting kit, to the right: PV panel)

The PLK design was based on providing a minimum illuminance level of 700 lumens per room (which could be accomplished with one lamp or 2 smaller lamp units), for three rooms per household, in addition to one small courtesy lamp of 150 lumens, for a total of seven hours per day. Thus, the minimum total lumen requirement is 15,750 lm x hours per day. The PLK also includes a mobile phone charger.

The size of the required PV generator is dependent on the efficiency of the lamps and the performance ratio (PR) of the PLK's components. A reference solar radiation of 4.0 kWh/m2/day is used for typical winter conditions in Lebanon. The PV panels are of crystalline silicon type, installed at a tilt angle of 45 degrees, and at true south orientation, also optimized for winter conditions. The PR takes into account the match between components and the type of charge controller. Thus, the reference PR is 0.7 for systems without MPPT, and 0.75 for systems with MPPT.

The battery is 12V lithium ion phosphate deep discharge type with a permissible repeated deep discharge without damage capacity, with a lifecycle of 1,500 full cycles, and sized to account for 1.5 days autonomy. The final battery capacity is dependent on the efficiency of the lamps, the battery duty cycle efficiency and the allowable depth of discharge.

The lamp is defined of LED type, warm white, given that warm white color is more attune to residential requirements of lighting comfort. The lamp requirements were set with efficiencies higher than 75 Lm/Watt. As a result, and depending on the lamp efficiency (which could range between 75 lm to 100 lm), the permissible PV capacity ranges between 56 Wp to 75 Wp. Accordingly, the required battery capacity ranges between 21.9 Ah and 29.2 Ah.

The charge controllers control the following functions: charging of the battery, load control, protection and includes a user interface.

The PV modules charge the batteries during the day and provide energy to any functioning lamp concurrently, once the batteries are fully charged, the controller curtails any additional / extra PV generation, which is indicated to the user on the interface. This curtailing period represents the best time for the user to make use of the charger outlet for their phones / cameras / MP3s, etc…

In the evening, when the sun is no longer available for the PV modules to produce energy, the batteries supply the lamps / charger with the required energy to function. The user interface is simple and indicates the status and the remaining capacity of the batteries. If the batteries are too low, the system shuts down, and when the batteries are recharged, the system resumes normal function.

Since one product that meets these specifications isn't commonly available on the market, the PLK unit installed in each household consists of a mix and match of a several components and equipment already available on the market and tested for optimum performance. The currently installed PLKs within the UNDP Lebanon- host community projects are thus a combination of two to three lighting kits per household, depending on the product's specifications.

A Design Targeting the Most Vulnerable

The main objective behind the PLK system design and of the LCRP energy strategy is to meet the basic energy needs of the most vulnerable population. The major requirements of an energy delivery model that meets the needs of vulnerable populations are as follows[12]:

- A design that has a positive human development impact
- Technologically capable of meeting the energy needs
- Environmentally sustainable
- Replicable and scalable
- Simple to operate and maintain

The PLK design meets all these requirements in addition to the speed of installation, and bypassing the government and legal barriers necessary for the implementation of other energy delivery models such as the mini-grids.

The PLK units were implemented in some of the most vulnerable households within several most vulnerable villages of Lebanon, impacted by the Syrian crisis.

According to a nationwide survey conducted by the EU-funded CEDRO project, supported by other integral donors such as the UK Department for International Development, the German Cooperation, the Kingdom of Saudi Arabia and the Kingdom of the Netherlands, and based on households that have received PLK units already and those that may be PLK recipients in the near future, it was found that 90% of these households suffer from electricity black-outs of more than 12 hours per day, and have rated the electricity situation in Lebanon to be very poor (UNDP, forthcoming - 2017).

12: Raffaella Bellanca & Ben Garside. “An Approach to Designing Energy Delivery Models That Work for People Living in Poverty”. IIED. CAFOD. 2013. p.10.

The average income of these households is 342$ per month, thus, 83% cannot afford a secondary power source, and use either a small UPS or candles during black-outs.

Approximately 83% of respondents have classified the implemented PLK units to be useful or very useful.
The PLK therefore changes the energy situation and the everyday life of these families, which are on average 6.5 persons per household; enabling women to pursue their household activities and the children to complete their schools' homework. As such, overcoming the energy gap also enables creating a better environment for women and children.

Although 92% of the surveyed households stated lighting as a primary electricity need, the need to power a fridge came second with 78%, followed by the need for electricity for television use.

These needs of these households reflect the global needs of electricity usage, and although the implemented PLK doesn't generate power to run neither a fridge nor a TV, it creates a potential for further innovation, mainly through modular units.

Modular Units

In order to supply the three main electricity needs of households; lighting, fridge and television, bigger system's capacities are needed. Yet, increasing a solar photovoltaic -PV- system is often equivalent to increasing its complexity, and in turn, the qualified technical team and related costs. Additionally, having to size the system for each household is not practical for fast deployment over a large number of households, especially in emergency and humanitarian responses.

Hence, modular units present an opportunity to increase a PV system's capacity and power additional appliances, while maintaining the simplicity of a PLK unit.

Modular lighting units are pre-engineered; enabling a high quality material with reduced installation time, and have pre-set slightly larger capacities than the standard lighting kits, and power DC light bulbs and appliances. Units are produced in "modules" that can be combined on the site location to achieve a desired capacity allowing the addition of a small fridge or television. The modular units shall thus comprise manuals specifying the needed capacity and number of modules to power a specific appliance. Spare parts of the light bulbs and appliances should also be available at sale points, permitting a higher lifetime of the overall system usage.

The modular units also enable increasing the system's capacity following initial installation of one or more modules, thus, allowing the end-users to invest at their own pace in the system's expansion and upgrade.

Adding a "build-your-own" feature with detailed installation guidelines would also alleviate the need for installation technicians and team, resulting in a reduced cost and implementation time.

Conclusion

In emergencies and refugee crisis, humanitarian aid agencies should not overlook the need for energy, being a primary basic right, and should equally focus on the host communities and the displaced populations.

For this purpose, different energy delivery models are available. Mini-grids are optimal solutions for long-term energy planning and investment. Yet, since they face many barriers; technological (presence of a qualified technical team), legal and governance barriers, in the case of crisis, mini-grids are only feasible in locations where there the displaced population is clustered in centralized areas, and when there's a clear government's will and acceptance that the crisis is not short-term.

Customized lighting kits are models that target the most vulnerable, provide the required illuminance levels for households and meet the primary electricity need of people; lighting. They thus serve as a good energy delivery model for humanitarian assistance in terms of providing basic access to energy, being easy and fast to implement, as well as being sustainable and environmentally-friendly.

Modular pre-engineered units, that can be combined for optimum capacities, take lighting kits a step further by meeting the secondary and tertiary electricity needs: powering a fridge and a television, and have a high potential in tackling the energy poverty issue, especially for displaced populations and the host communities.

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