Estimating the use of diesel generators in displacement settings

Preliminary results and recommendations for a solarisation programme

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Summary

The GPA Coordination Unit conducted a survey among energy experts in the humanitarian system to estimate the number of diesel and petrol generators[1] that are used to produce electricity in humanitarian operations, with a view to establishing the opportunities to transition to integrate solar solutions.

Based on feedback from six UN organisations and ICRC[2] we estimate that there are currently **11,365 generators** in use. Our initial conservative estimates are that humanitarian agencies spend **$108 million** on fuel per year, emitting **194,000 tCO_2**. In addition, we have also estimated that a total investment of **$236 million** would be necessary to solarise viable systems, saving $70 million in fuel costs and 126,000 tCO_2 per year.

Figure 1: *A generator in Markazi settlement, Djibouti.*

Introduction

Diesel generators are commonly used by humanitarian agencies in displacement settings to produce electricity for critical services for populations of concern, as well as in national and regional offices where grid power is unreliable or not available. Despite their widespread use, the impacts of diesel generators – such as the number of units in operation, their fuel consumption, and other related costs, such as those associated with maintenance – are not well documented and the potential benefits of decarbonising these systems are similarly uncertain.

To begin to quantify these issues we developed a model which uses Monte Carlo methods (described below) to estimate the global-level impacts of diesel generators in displacement settings and the opportunities for solar to decarbonise these systems. These are **initial order-of-magnitude estimations** to investigate the validity of this process, explore what information it can provide, and develop a foundation for further analysis in support of scaling up efforts to decarbonise energy systems.

Impacts of diesel generation

The GPA Coordination Unit reached out to six UN humanitarian agencies and ICRC to estimate the number of diesel generators currently being used by their operations. Estimates varied in scale and certainty, with a cumulative total of **11,365 generators** currently in use. Respondents highlighted that this number has increased in recent years, as a result of increasing numbers of displaced people.

Our model accounts for the number of diesel

[1] For readability we refer to these hereafter as either “diesel generators” or "generators" only.

[2] The authors are grateful for the participation of the following UN organisations: FAO, IOM, UNDP, UNHCR, UNICEF, WFP and ICRC.

This is a working paper outlining the initial results of our analysis. The assumptions and methods will be further refined which will impact the estimations presented here, as well as provide new insights into other topics.

generators, their typical daily usage, fuel consumption and other factors to calculate their overall global impact. We estimate that agencies spend **$108 million (± $8.3 million)** on diesel per year[3] in supplying power for their operations. This emits an estimated **194,000 tonnes of CO_2 (± 15,000 tCO_2)**.

Opportunities for solar

For each system we estimate the amount of diesel generation that could be offset by solar power, the solar capacity required, and the costs and benefits of each system and cumulatively. We estimate that solar could reduce fuel expenditure by two thirds or **$70 million (± $5 million) per year** and CO_2 emissions by **126,000 tCO_2 (± 10,000 tCO_2)**.

We estimate that **118 MW (± 9 MW)** of solar capacity would need to be installed worldwide at a total cost of **$236 million (± $18 million)**[4]. This would be a direct substitution of solar in place of diesel; ideally any solarisation program would, in the first instance, seek to reduce total energy demand through energy efficiency measures. This would reduce the required solar capacity and subsequent costs.

Furthermore, decarbonising diesel systems could result in an estimated **$2.8 million (± $0.2 million)** from carbon credits and potentially **$7.0 million (± $0.5 million)** from P-RECs every year.

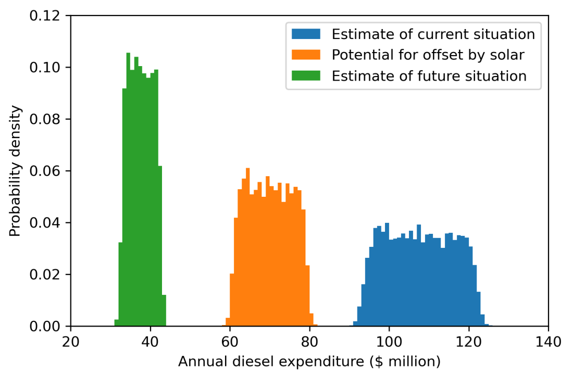

Figure 2: *Estimates of present global fuel expenditure (blue), those could be offset by solar (orange), and future expenditure after solarisation (green).*

[3]This is most likely a conservative estimation and does not include maintenance, spare parts or CAPEX for new units.

[4]This is an indicative value, not including expenditure relating to human resources, administration, consultant fees or other associated costs.

Methods

Overview We use a Monte Carlo analysis to account for the uncertainties around the input parameters shown in Table 1. To calculate the impact of a single diesel generator system, we select values for each of the parameters from a uniform distribution between the low and high estimates. We then consider 11,365 such systems and calculate their cumulative impacts, recording the results. We repeated this process 10,000 times to find the average of the estimates of all of the cumulative impacts, expressed here as this average value ± standard deviation.

Limitations We aim to use a bottom-up method to calculate global-level impacts which is inherently highly dependent on the input values. Changing these could significantly impact the overall results. In reality parameters would not be uniformly distributed and likely would be linked, rather than independent as assumed here. This analysis can provide initial order-of-magnitude estimates but more development of the model is required to provide results with more confidence.

Further developments We are working with partners to refine our input data, assumptions and modelling process, including the addition of gensets from other humanitarian actors. We will include and quantify the impacts of other relevant topics, such as energy efficiency measures, which could reduce diesel usage and require less solar capacity to achieve the same benefits.

Table 1: *Parameters used in the Monte Carlo analysis. Random values are drawn from a uniform distribution.*

Parameter	Low	High	Units
Generator size	5	50	kW
Capacity factor	30	60	%
Usage hours	2	18	hrs/day
Usage days	180	365	days/yr
Fuel use	0.25	0.35	L/kW
Fuel cost	0.50	2.00	US$/L
Fuel GHGs	2.0	2.5	$kgCO_2/L$
Diesel reduction	30	100	%
Daily solar resource	3.0	6.0	kWh/kW
Solar price	1000	3000	US$/kW
Carbon credit price	3	42	US$/$tCO_2$
P-REC price	30	45	US$/MWh