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Created on: 8 Oct 2014
Last Updated: 8 Oct 2014
ISO 9001 Approved for Release by: Gerald Demeules, Global ICT Advisor

Solar Panel Solution for COs Affected by Ebola

Costs, Technical solution and Business Case

1. Cost and Return on Investment (RoI) = 1.13 year[1]

	1	2	3
	Items	**Lead Time (weeks)**	**Unit Cost USD**
A	40 kW Solar Power kit: Equipment , Power Management Unit assembly and configuration at the contractor facilities	3	$71.2k
B	Shipping by sea	5	$2.8k
C	Installation	1	$15.1k
D	One year Monitoring and Management		$1.8k
E	**Total per kit**		**$91k**
F	**Grand Total for 6 Kits**		**$546k**

Table 1: Cost of complete Solar Solution.

	1		2	3
	Country Office	**Annual Usage of Diesel (litre)**	**Annual Cost of Diesel**	**RoI (year)**
A	Guinea	44,092	$47,192	**1.93**
B	Liberia	157,019	$151,874	**0.6**
C	Sierra Leone	126,742	$105,507	**0.86**
D	**Average**			**1.13**

Table 2: Return on Investment (ROI).

- *Liberia & Sierra Leone CO Diesel usage is derived from the UNDP Global GHG Inventory. Guinea's consumption is an estimated based on a single 40 kW generator running 8 hours a day.*
- *Calculation based on Pump price of diesel fuel per litre from the World Bank*
- *The Solar System is fully able to substitute all electricity from generators.*

[1] Link to calculations and Diesel/GHG inventory
ROI is based on the assumption that a solar system would completely offset the Diesel usage. It will not be able to do this if CO continues to utilize Air-conditioning at the current rates. It will however offset every cost related to general IT and lightning. Hence ROI will be increased to a more long term return. Reducing annual costs on avg. in each CO by 53.258USD

2. Business case

Why would UNDP CO offices benefit from solar power supply? Countries using diesel generators are greatly dependent on diesel prices, switching to solar power will reduce volatility towards fluctuation in diesel prices and diesel shortages. The abundant hours of sun in e.g. African countries allow max utilization of the solar power system and ensure that COs will continue to have electricity in emergency situations. On organization wide level it fits with The Delivering as One strategy seeking to implement corporate goals from each programme into one plan. The solar system will allow UNDP offices to incorporate UNEP commitments towards sustainability into UNDP practices and reduce CO2 emission.

2.1 Direct Cost of Diesel Generators versus Solar Power

Besides high fuel prices, other direct cost associated with fuel power are high transport and storage costs of fuel. In general, the riskier the political situation of a country the higher the fuel costs, transportation and storage costs. In figure one (below) incurred cost for a diesel generator and solar power, as well as value depreciation are compared. The solar off grid solution has a lifespan of 20 years and a high initial cost, but no further operating cost. An average diesel generator is estimated to cost US$6000 but has high operating cost. The average diesel costs of a diesel generator, operating eight hours a day, are US$150 a day. Comparing the diesel generator to the solar solution, after approximately four years the residual value of the solar solution will be equal to the incurred operating cost of the diesel generator. Starting from year four there will be **yearly cost savings equal to the operating cost of the diesel generator minus the depreciation value of the solar power stationary kit, over a lifespan of 20 years.** Moreover, the total cost of ownership (below) show high operating cost compared to solar power. For example, in Nigeria ''Power from private **[diesel] generators costs US$0.35 per kilowatt-**hour or more, ten times more than electricity from the grid in most other countries'' (The economist, 2014). In comparison, the **solar power solution costs US$0.25** per kilowatt-hour for a lifespan of 20 years. ''Given the high cost of power from diesel generators in Africa, renewable energy can be an attractive alternative'' (The economist, 2014). Considering the reduction to zero CO2 emission, solar power is an efficient and a sustainable solution to power supply.

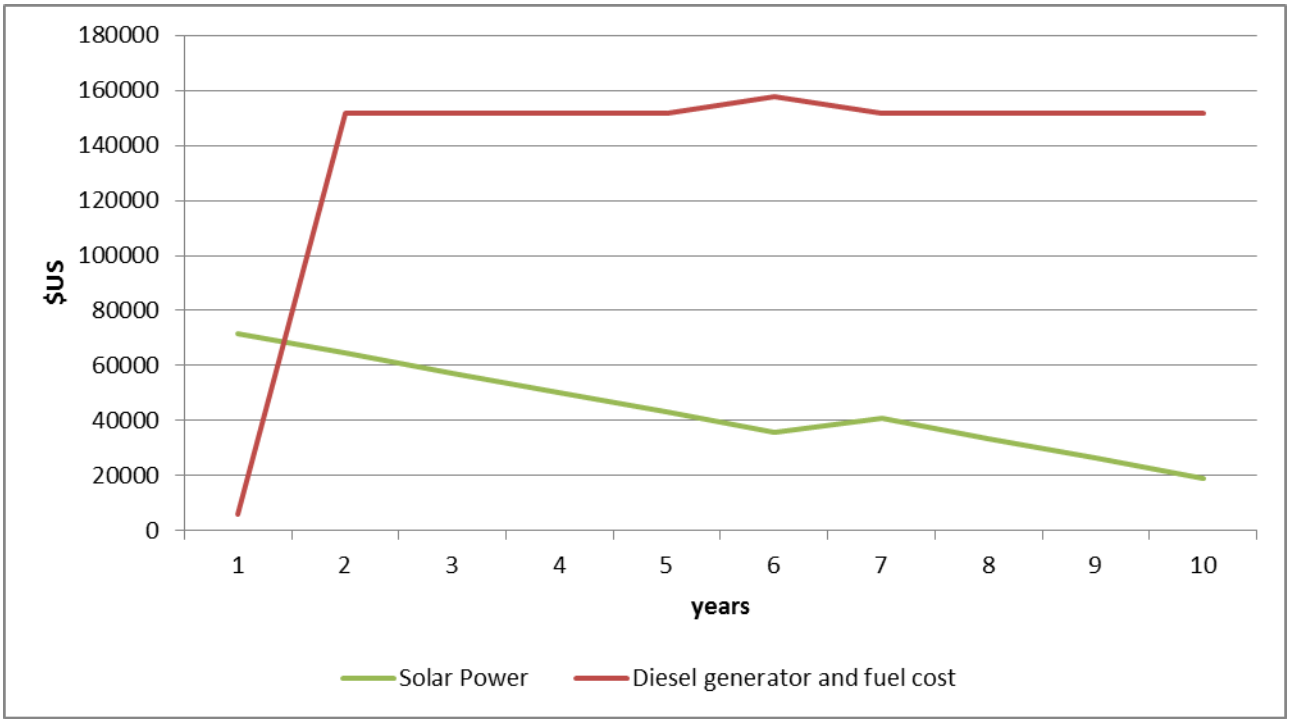
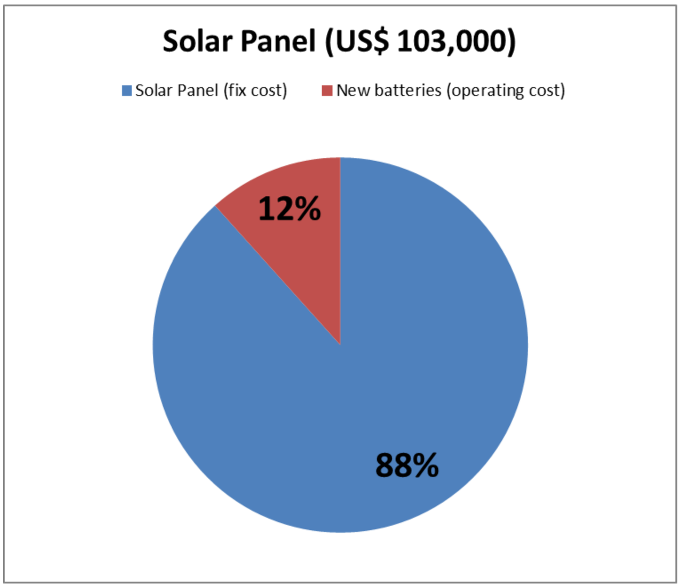


Figure 1: Incurred cost (US$) for diesel generator and value depreciation for solar power panels over 10 years (Example Liberia).
***Without installation cost for solar power and diesel generator.**



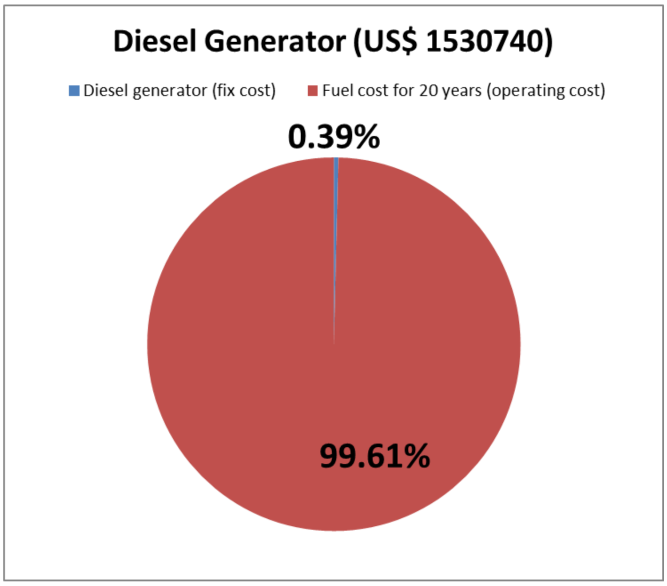
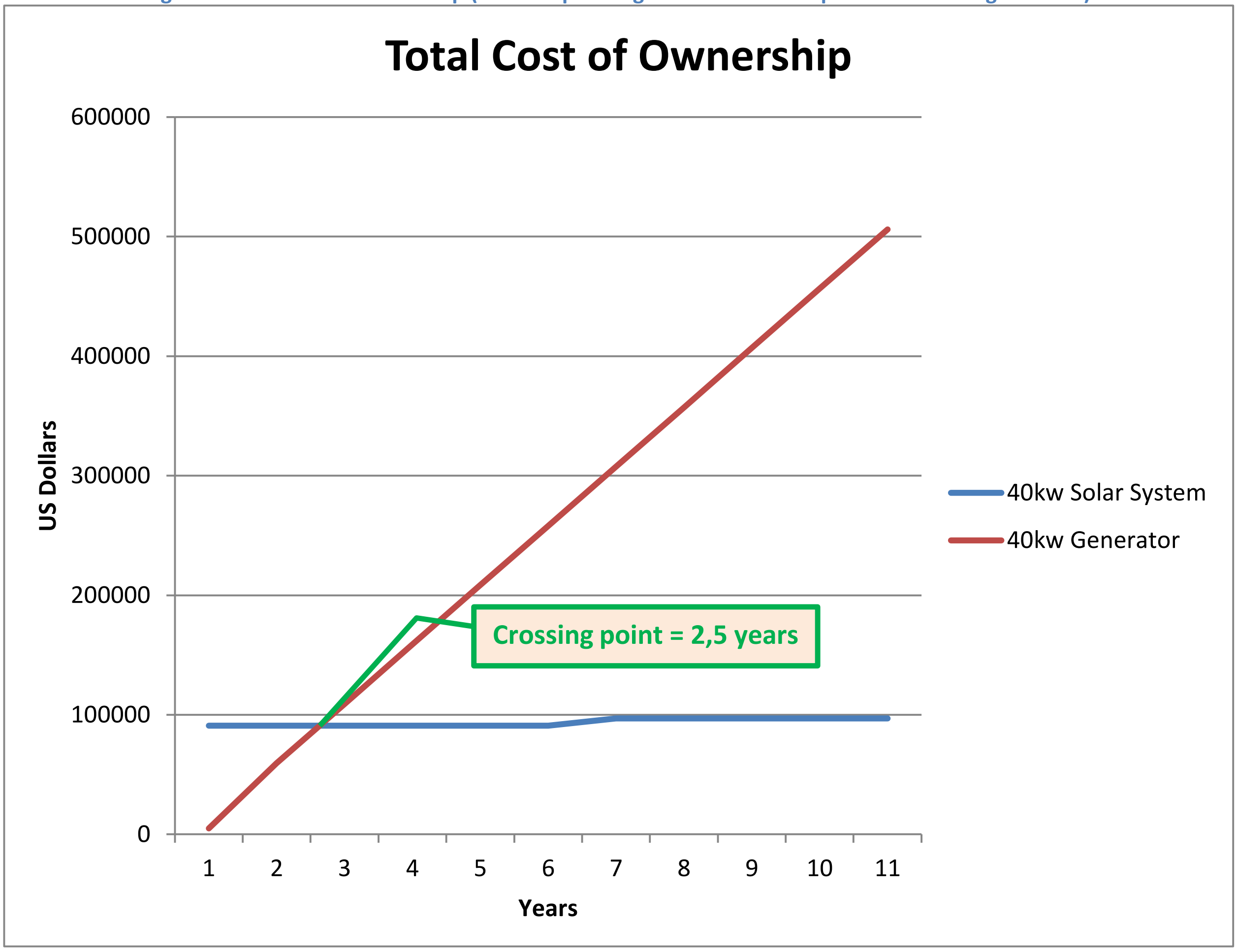


Figure 2: Total cost of ownership (fix and operating cost for the solar panel and diesel generator).



2.2 Indirect cost associated with Diesel Generators

There are immense security costs incurred throughout the transportation process of fuel. Incidents of burglary of fuel lead to high construction cost in the CO, and subsequently being cut off from fuel power impedes efficiency of the CO and hence productivity decreases. Moreover, there have been accidents resulting from old generators not functioning probably. Most important, being dependent on fuel power and being not able to communicate in times of emergencies can in risks lives and might lead to losing lives.

3. Technical solution

Solar Panel

- 96 panels each 1.6 sqm, peak power output 250 Wp
- Total capacity is up to 24 kW
- Total area 185 sqm on roof top, parking shade, etc.

Batteries

- 32 batteries, each 48v/1760AH
- Total capacity of 42 kWh at 50% discharge
- Room size 15 to 20 sqm

Smart Power Management

- Reduce generator utilization to minimum, or
- Increase resiliency to maximum
- Adaptive charging cycle to prolonge baterie life (4 step)

The Solar power solution will be supplied by GSOL and consists out of **96 solar panels** (one panel: 100cm*1650cm, 19kg), **3 KVA inverter** and **32 battery banks** (48V/ 1760 Ah= 42 kWh at 50% discharge). The inverter can be connected to two independent alternating current sources, for example shore-side power and a generator, or two generators. The inverter will automatically connect to the active source. The inverters can auto-start a generator and/or allow national grid to enter the system. This happens so fast (less than 20 milliseconds) that computers and other electronic equipment will continue to operate without disruption. By entering the system, grid or generator can both assist in handling high load and assist in charging batteries. The limit for a 10 KVA inverter in terms of generator assist power is 100A = 23kW. In case the battery is only charged 50% the diesel generator will automatically kick in and compensate for the lack of solar power. When the load reduces, the spare power is used to recharge the battery.
This system can support an entire office: IT infrastructure, lights and air condition.

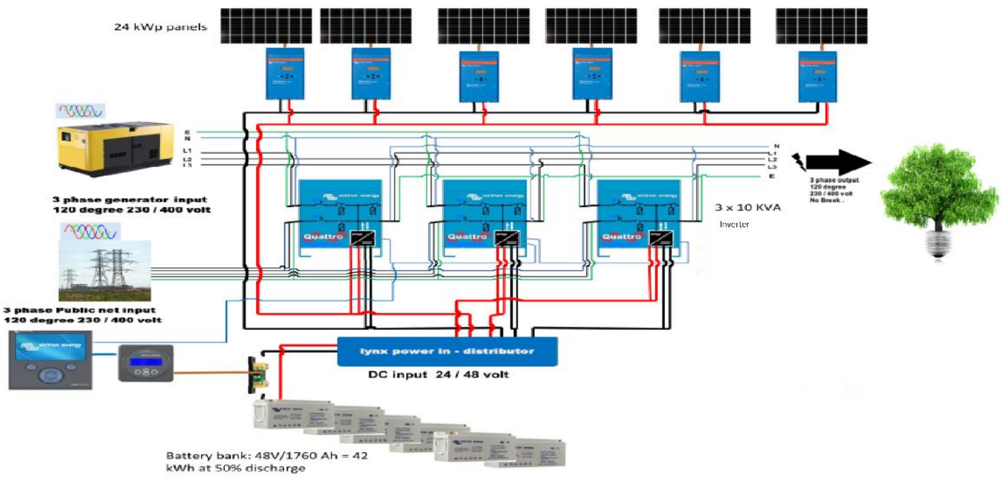


Figure 3: Off Grid PV System - Solution for West Africa.

In case of insufficient solar power supply (e.g. weather conditions or similar) there are three options:
1) The diesel generator will automatically start
2) Or the batteries discharge more than 50%
3) Turn off Air condition and/or lights

GSOL provides a plug and play solution, which means that GSOL does 85% of the work in Denmark and only the final installation will take place in Sierra Leone, Liberia and Guinea. The installation of the solar panels is conducted by local workers hired by GSOL. The technical installation and connection of cables, chargers, inverters and batteries are done by GSOL engineers that will be deployed on site in Liberia, Guinea and Sierra Leone. All configurations and systems settings are done by GSOL staff from Denmark. During the installation process local labour will be engaged and there will be a strong focus on local capacity building. GSOL staff will coach local UN staff and teach locals about solar power, as well as handling the technical equipment. In order to assure efficient running of the solar panels, there will be a monitoring process coordinated by GSOL running for one year. GSOL is available for supervision around the clock and there will be monthly reports, with future design possibilities and optimization. In case of system failure GSOL will provide a local service person.
Including the assembling process of equipment and the shipping time, the equipment is expected to arrive in Sierra Leone, Liberia and Guinea during the first week of December.

4. Risks

	A	B	C	D	F
	Risks	**Like-lihood**	**Impact**		**Mitigation**
1	**Improper technical Installation** Wrong assembly and wiring at the site could fry the inverters and batteries making the system unusable	low	High		1. Delivered as plug and play solution (power management part assembled and configured at vendor facilities) with few cables to be connected between the units; 2. Vendor engineer travel at the site for QA, installation oversight and commissioning;
3	**Damage from Natural Disasters** West Africa prone to **lightening**. Season storm and may damage panels or reduce their efficiency from flying objects, requiring replacement.	Medium	High		3. Ensure redundant and best of breed **lightening protection**; 4. Implement in situ preventive maintenance plan; 5. Plan for 5% panel replacement per year;
4	**Weather conditions** Weather conditions may change from day to day and year reducing the output.	Medium	Medium		6. Maintain a generator backup with sufficient fuel storage;
5	**Compromising Building Integrity** Roof needs to be able to hold the panels including the wind load. The building structure extra weight and roof perforation without causing water leaks could compromise the integrity of the roof.	Medium	High		7. **Site survey** and the building engineer must review site preparation and civil work plan; 8. Bracket of the panels must be solidly anchored to the roof while not compromising its integrity and causing water leaks;
6	**Faulty utilization of system** The CO is forced or by faulty utilization of the Solar system to discharge the battery below 50% of capacity, reducing the longevity of batteries which will increase the cost of the system.	Medium	Low		9. Add batteries to avoid discharging below 50%; 10. Replace batteries sooner than 10 years; 11. Implement proper monitoring and alarm systems;
7	**Improper Space for Solar Panel** Lack of space with proper sun exposition.	Medium	High		12. Conduct a thorough **site survey**; 13. Accept lower performance;
8	**Improper Battery Room** Battery room too hot and subject to flooding and other environmental hazards.	Medium	High		14. Accept lower batteries performance; 15. Choose a dry and well ventilated room;

9	**Improper Power Load Assessment** Under estimate power load required for normal utilization and pick.	Low	Medium		16. Conduct through **site survey** and evaluation of current electrical set-up and generator; 17. Use the grid or generator to fill the gap;
10	**Lack of Users Expertise** Regular maintenance not done properly and safety measures not implemented.	Medium	Medium		18. Training will be given to the CO staff; 19. **Local partner** will be on standby; 20. **Preventive plan and safety plan** will be maintained 21. Implement remote monitoring and alarm systems done by experts (vendors);

Table 3: Risk Assessment.

3 area to focus to reduce risks:

i. **Site Survey;**
ii. **Reliable local partners, sound preventive maintenance;**
iii. **Good lightening protection and safety measures and training plan;**

5. Implementation Plan

The project is broken-down into multiple phases to reduce the risks:

1. Site Survey: on-going in collaboration between the vendor and the CO
2. Delivery of equipment , Power Management Unit assembly and configuration at the vendor facilities– lead time 3 weeks; $427k
3. Packing and shipping by sea– lead time 5 weeks: $18.6k
4. Installation – 1 week: $90.6k
5. One year monitoring and maintenance: $10.3k

Total: $546k

6. Designed Challenges

Given the urgency, the system was designed with limited information, leading to the following challenges:

1. ***Sites***: There are two 40 Kw kits per CO but only one site identified so far for installation, that is the CO itself. Clarification on where the 2nd kit will be installed is needed;
2. ***Solar Panel location***: The CO compound is still being surveyed, space and optimal location for the 96 solar panels might be a problem; (for roof pictures see **Annex** A)
3. ***Battery Room***: The CO compound is still being surveyed, space and optimal location for the room that will house the 32 battery banks, chargers, power distribution switches and inverters. A 15 to 20 sqm room must be identified;
4. ***System Capacity***: Although the design should support the CO, no power load assessment has been done. Hence there is a risk that the designed solution may still need a generator to complement the solar panels and batteries;

6. Monitoring and Maintenance

GSOL will be available to monitor the solar system on individual buildings from a distance for different periods. This well help to ensure the proper usage of the system and configuration of the system. If faulty units are realized they can be replaced. The monitoring process is at the moment not part of any LTA and thus is optional and will come at a cost.

With relevance for product replacement the GSOL manufacturers give 10 year product warranty and 25 year power warranty on solar modules. Product warranty guarantees that the product is free from defects for 10 years. Any defective components will be replaced free of charge. Performance warranty guarantees that solar panels provide a minimum 90% after 10 years of operation and a minimum of 80% after 25 years of operation

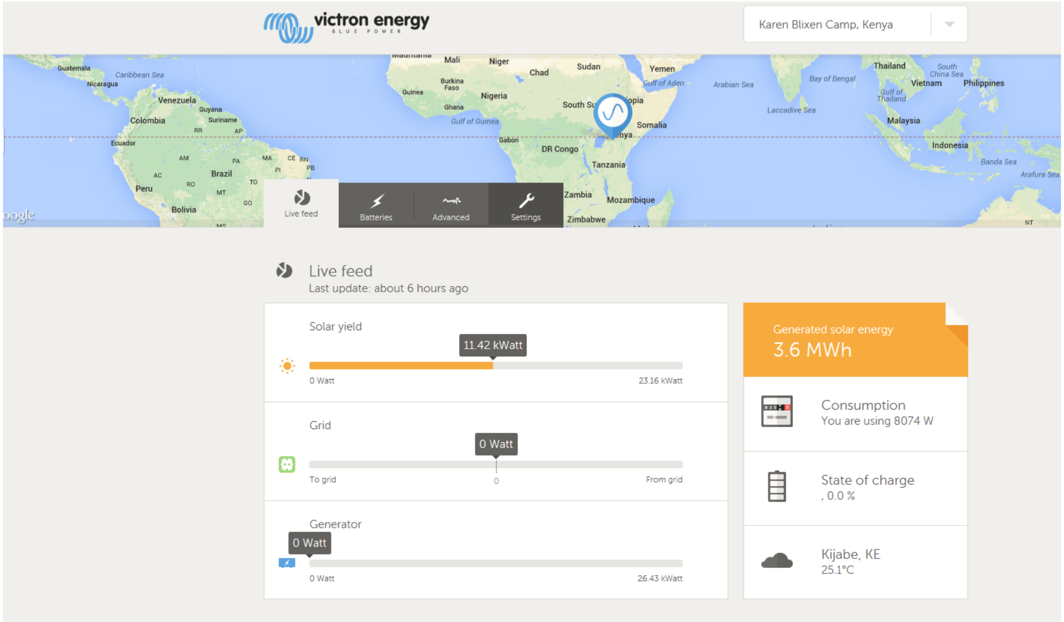


Figure 4: Victron solar survey mobile application.[2]

The Victron application for efficiency optimization and global remote monitoring. The app allows for remote monitoring so tech engineers can survey the solar system both on-site and on distance. It is a simple app that shows through live feeds the output of the solar system; solar yield, consumption, battery capacity and low battery loads. With knowledge of the solar system and local weather conditions it allows for simple assessment of the Solar system and the need for a potential check-up.

- ***See a live system*** at https://vrm.victronenergy.com/user/login/invitekey/7dd9790bba0066342c08c2fce0a937e1
- Username: nora.thommessen@undp.org
- Password: uncity123

7. Selection of the Vendor

GSOL was selected as vendor to due to the win of an open bidding for solar system with the most reliable equipment at best prices.

GSOL are under the frame agreement FA/2014/pmcs/goods/004 with UN. Among other they have been the supplier to UNCHR in Niger for solar panels of 117.075 USD “PO GP600129-2”, camps in Africa, to Danish state projects and the Danish military with portable solar kits. So far GSOL supplied the UN 3 solar panel systems and have supplied 20 large solar projects worldwide up to 436 kWp. UNDP OIST have worked closely with Gsol during the Ebola emergency were GSOL have shown both capacity and flexibility under the current circumstances.

For the signed agreement and complete set of contractual documents see UNHCR GSOL .

[2] https://vrm.victronenergy.com/user/login/invitekey/7dd9790bba0066342c08c2fce0a937e1
Username: nora.thommessen@undp.org
Password: uncity123

7. Two Success Stories

7.1 Solar power in CO in Eritrea

Figure 5: CO in Eritrea.

In 2013, the CO in Eritrea is one of UNDP offices that adopted a solar system solution to sustain the local energy consumption. The CO formerly ran on diesel generator and was continuously faced with diesel shortages and large expenditures from diesel consumption. The installed solar system is supporting the whole office and reduced CO2 emissions to zero and costs significantly. It has only taken close to two years for the office to recover the initial cost of the solar panel system and so far the local electricity grid and diesel generator is only running as a backup. Previous to implementing the solar system, the Eritrea CO was regularly faced with disruptions in it workflow resulting from the diesel shortages and inconsistent grid support. The solar system has made the former occasional shortages which impeded daily work a problem of the past. The UNDP Resident Representative also added that the new system has improved work life balance, as solar systems are a considerable noise reduction compared to diesel generators. The adoption of a solar system at the CO will create awareness of this sustainable solution whereof many more institutions could benefit from. The capacity developed at the CO can be a benefit to and develop the local society.

7.2 GSOL Installation at the Karen Blixen Camp in Kenya

Figure 6: Installation of PV in Kenya (GSOL).

GSOL, a Danish company on LTA with UNDP, is to install the solar system in the Ebola affected countries. GSOL have among other supported solar solutions to the Karen Blixen camp where a 9Kw output solar system supports the whole camp including water pump, industrial kitchen, lights and electronic communication equipment. The payback of the system have been 3 years and reduced the daily running hours of the diesel generator to 2 hours. So far it **has reduced Annual CO2 by 7.65 tonnes**. Karen Blixen camp has been satisfied with the GSOL product to the extent that they initiated new projects with GSOL.

Annex A

Sierra Leone

Sierra Leone

Sierra Leone

Guinea

Guinea

Liberia

GSOL Sustainable Energy

REFERENCE LIST – Shortlist

CASES IN DENMARK

Case	**location**	**specification**
Odense Municipality	Schaksgade	School- 49 kWp
Silkeborg Municipality	Balleskolen Virklund skole Mosaikken Sorring skole Voel skole Vestre skole	School- 93 KWp School- 48 kWp School- 51 kWp School- 28 kWp School- 30 kWp School- 30 kWp
Sydfyn's Business Preschool	Sydfyns Erhvervsforskole	School – 130 kWp ground mounted
Aarhus State Library	Aarhus Statsbibliotek	Public Building – 137 kWp
Lighthouse Tommerup	Fyrtårn Tommerup	Public Building – 120 kWp
Køge Municipality	Holmebækskolen Ellemarksskolen Ejby skole	School- 40 kWp School- 50 kWp School- 60 kWp
Fisher Danmark A/S	Fisher A/S, Køge	46 kWp
Agricultural enterprise	Glamsbjerg, Fyn	436 kWp – roof mounted
Assens Municipality	Aarup skole Assens skole Haarby skole Skallebølle skole Tommerup Skole	School- 72 kWp School- 67 kWp School- 50 kWp School- School-
Faaborg-Midtfyn Municipality	Noragerskolen Kværndrup Autismecenter	School- 54 kWp Autism care facilities
Svendborg Minicipality	Vindeby Plejecenter Nymarkskolen Thurø plejecenter Grønnemoseværkstederne Tåsingekolen	Elderly care facilities - 18 kWp- building integrated. School- 90 kWp Elderly care facilities - 45 kWp Sheltered workshop- 45 kWp School- 40 kWp

GSOL· Nordre Ringvej 121 · DK-5700 Svendborg · Tel: +45 82 30 30 60 · www.gsol.dk · info@gsol.dk

Copenhagen construction Management	Københavns byggestyrelse, Hvidovre	45 kWp- building integrated
CC Jensen A/S	CC Jensen, Svendborg	30 kWp
Nyborg Municipality	Lilleskov	80 kWp
Copenhagen Municipality	Langhuset, Rødovre	Public building- 50 kWp
St. Ajstrup Køkken- og hvidevarebrugsen	St. Ajstrup, Nibe	213 Kwp
Johannes Fog A/S	Nordsjælland, Denmark	A distributor of Gsol PV systems - Gsol supplies and installs
Harald Nyborg A/S	Denmark	A distributor of Gsol PV systems - Gsol supplies and installs
Davidsen A/S	Denmark	A distributor of Gsol PV systems - Gsol supplies and installs
Bauhaus A/S	Denmark, Sweden	A distributor of Gsol PV products
Domestic housing	Denmark	Supply and installation of over 6 MW PV systems to domestic housing in Denmark

CASES IN SWEDEN

Aktiv Sol	Växsjö, Sweden	Roof mounted PV system

CASES IN AFRICA

Karen Blixen Camp	Kenya	Supply and installation of off-grid system and battery bank
Ullicon ApS	South Africa	Supply and installation of off-grid system and battery bank
Diana Conservation	South Africa	Supply and installation of off-grid system and battery bank
Karen Blixen Camp	Kenya	Expansion of Off-grid system
UNDP	Niger	21 off grid systems
UNDP	Burundi	Supply of batteries and inverters
UNDP	Mali	100W PV systems

LTA

UNDP		Solar lantern
UNDP		100W PV system
UNDP		300W PV system
UNHCR		20kW PV system
UNHCR		40kW PV system

ANNEX 3 Solar Irradiation Africa