SOLAR POWER SOLUTIONS – BUSINESS CASE

Niger UNDP Country Office

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OFFICE OF INFORMATION AND SYSTEM TECHNOLOGY (OIST)
GLOBAL ICT ADVISORY (GIA) UNIT

Contents

Current Energy situation

- Expensive national grid
- 21 power shortages per month
- Gas generator used as backup: polluting, expensive
- Impedes Business continuity (15% working hours loss/month)

Our Solar Solution

- $51K saved per year
- 241 tonnes of CO_2 saved per year
- Improves stability and reliability
- Employees' wellbeing is better off
- Smoothens business continuity

The Economics

- Payback: **9 years**
- 10 years TCO of Generator/Grid: **$905K**
- 10 years TCO of Solar Energy: **$441K**
- Solar Energy Investment: **$441K**
- RoI: **134%**

1. Introduction

Why would UNDP Country Offices (COs) benefit from solar power supply? Countries such as Niger have limited access to electricity, and thus also rely on diesel generators. As they 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 maximum utilization of the solar power system and ensure that COs smoothen their business continuity and have electricity in emergency situations. At an organization wide level it fits with The Delivering as One Strategy seeking to implement corporate goals from each program into one plan. The solar system will allow UNDP offices to incorporate UNEP commitments towards sustainability into UNDP practices and reduce CO2 emission.

2. Technical solution

The solution proposed is a hybrid solar installation i.e. grid interactive/ grid-tie with power backup. This reduces the reliance on NIGELEC i.e. the Niger electricity company. Consequently, more of the energy will be produced in an environmentally efficient way. The solar system will be able to deliver 54.41% of energy needs on sunny days. In case of power cuts on clouded days the system will have a battery backup that will assist the office to run on necessary equipment. Generators will be turned on as a last resort if the grid fails on continuous clouded days. The hybrid system works best in climates where peak demand for electricity from the grid often coincides with the sun shining, due to high power demand of the air conditioning units.[1]

Solar Panels

- 650 panels each 1.6 sqm, peak power output 250 Wp
- Total capacity is up to 162.5 kWp
- Total area 1040 m2 on roof top, parking shades, ground, etc

Batteries

- 36 batteries, each 48v/1760AH
- Total capacity of 350000
- Room size 3x7

Smart Power Management

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

3. Purpose

The UNDP/GIA staff has been implementing solar power energy in Guinea, Sierra Leone and Liberia in the end of 2014 in order to cope with the Ebola crisis. In such emergencies the need for fast ICT responsiveness is even more crucial, while energy supply in these places is often undermined by shortages. Around the same time, the Senegal CO and DLO as well as Niger CO expressed a need for greener, reliable, sustainable and cheaper energy alternative. The request from Niger includes *UNDP CO, UNFPA and UNECA (Economic Commission for Africa*) offices, as they are all based in the same building. In contrast to Liberia, Guinea and Sierra Leone, these country offices are mainly running on grids which are available but unreliable. As a result, the offices also rely on diesel/gasoline generators, but these are expensive, polluting and unstable.

[1] Solar Electricity Handbook, Michael Boxwell

Despite the fact that solar electricity is promising and effective, the major barrier to its utilization is the high initial cost of investment. However, the higher the initial investment, the higher the annual saving, and hence faster payback. As our business case aims at installing a partial solar coverage, we also need to estimate a percentage of solar coverage.

3.1 Indirect cost from power outages

Out of 189 countries, **Niger is ranked 165th for getting electricity**, according to the World Bank's Doing Business 2015 report. Accordingly, access to and availability of electricity is a major barrier for organizations to do business in Niger.[2] On average, Niger witnessed **21 shortages per month** in 2009 while the sub-Saharan countries' average was 11.[3] Production cost of electricity in Niger by its national grid company, NIGELEC, is one of the most expensive of the West African economies, USD 0.16/kWh as of 2009[4] (e.g. see below table 2 and 3.) Due to shortages, Niger is estimated to lose 13% of annual working hours[5], an important invisible cost. It is one of the most affected countries by outages, which have a large impact on the delivery of UN offices when exposed. Since VOLL[6] analysis is not applicable in the case of Niger, a direct cost cannot be incorporated in ROI. However, not quantifiable power outages should not be neglected as they force delays in operation, not only within the UN but also with partners awaiting communication. This, in turn, creates delayed feedback mechanisms.

- **Less Output due to 10-15% Working Hour Loss**
- **Negative Working Environment**
- **Bad Project Implementation**

The inability to perform duties and daily routines will also put considerable strain and stress on UN officers, which will lower the output of UN offices further. The psychological impact of unreliable power supply on the motivation to perform vital tasks should not be underestimated and can have a very negative impact on project and day to day operations.

3.2 Costs associated with Diesel Generators

Besides high fuel prices, other direct costs associated with fuel power are high transportation and storage costs of fuel. 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. In Niger, 216 liters of gas is burnt every day, which translates into a daily $200 fee. In addition, there are immense security costs incurred throughout the transportation process of fuel. Moreover, there have been accidents resulting from old generators not functioning probably Most importantly, when dependent on fuel power there is a risk of being unable to communicate in times of emergencies. This can be a severe risk to lives.

"There are long periods of shortages during hot season (April to July), which can last from a week up to a month. Meanwhile, the generator cannot support continuously these electric loads, and has to cool down for 1 to 2h every 5 working hours. During these times, UNDP Niger operations are dramastically slowed. Besdies, the budget for energy is seriously affected as fuel price remains very high ($1 on average)."
Niandou Habibou, ICT Analyst, UNDP Niger

[2] Doing Business 2015 data for Senegal, http://www.doingbusiness.org/data/exploreeconomies/senegal
[3] http://siteresources.worldbank.org/NIGERINFRENCHEXT/Resources/AICD-Niger_Country_Report_Fr.pdf
[4] http://siteresources.worldbank.org/NIGERINFRENCHEXT/Resources/AICD-Niger_Country_Report_Fr.pdf
[5] *The Africa Competitiveness Report 2009 © 2009 World Economic Forum, the World Bank and the African Development Bank*
[6] *(value of lost load analysis)*

Figure 1: Average number of power outages per month, World Bank data

Figure 2: Access to Electricity, World Bank data 2015

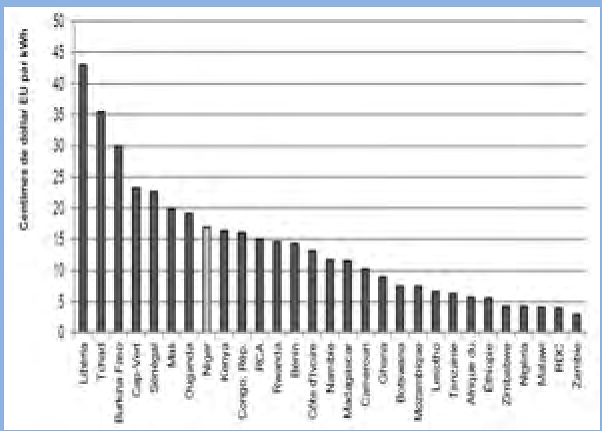


Table 2: Electricity prices in US Dollar per kWh, Africa infrastructure country diagnostic, World Bank data 2011

Pays	Coûts de la production d'électricité (dollars EU/kWh)	Prix du carburant (cents de dollar EU/litre)		
		2004	2006	2008
Burkina Faso	0,39	94	112	133
Mali	0,39	90	104	110
Niger	0,16	94	111	97
Nigeria	0,15	45	66	113
Ghana	0,12	43	84	90
Côte d'Ivoire	0,11	95	106	120

Figure 4: Production cost of electricity USD & fuel price, Africa infrastructure country diagnostic, World Bank data 2011

3.3 Sustainability

The 7th Millennium Development Goal (MDG) is to "*integrate the principles of sustainable development into country policies and programs*". Most electricity generated to UNDP from Nigelec is acquired through polluting sources – coal, diesel and a lesser part from hydroelectricity. Consequently, UNDP Niger's use of these materials is contradicting the organizations overall goals. The proposed solar system will align the offices with the MDG goals on;

1. Short term: it allows for a cost neutral sustainable energy solution
2. Long term: it releases funds and allows them to be placed at the CO's disposal

Overall the system will, over its lifetime reduce the amount of GHG pollutants from its annual production by[7]:

- For 350 mWh

241 tonnes of Carbon dioxide

- Annual reduction of emissions over 1 year

- Equivalent to

Trees planted:
6188

Cars taken off the road for a year:
50

Tonnes waste recycled instead of landfilled
86.5

Tanker trucks of gasoline not burned
3

Apart from reducing the amount of pollutants recognized by the IPCC the implementation of solar energy will also reduce if not eliminate local diesel generators use which is responsible for considerable noise pollution and therefore create a healthier work environment for the UNDP offices.

3.4 Diffusion of Knowledge and Capacity Building

The Economist in a recent article called solar systems one of the most promising energy sources for the development of Africa, due to high sun exposure and an unstable conventional energy supply.[8] A good example is Kenya that stands out as one of the pioneers of the solar revolution. The Kenyan project roused interest and contributed to the development of a private solar market. Locals who had worked on these large scale projects where educated by some of the head engineers and in the aftermath many

[7] http://www.epa.gov/cleanenergy/energy-resources/calculator.html#results

[8] http://www.economist.com/news/special-report/21639014-thanks-better-technology-and-improved-efficiency-energy-becoming-cleaner-and-more

of these locals have become solar system stakeholders in Kenya. Looking forward, the country is projected to produce half of its energy through solar systems by 2016.[9]

As the example from Kenya shows investing in solar panels can also be a solution to Niger's numerous energy shortages for which the UNDP CO can become a leading example. In addition to sustainable, green energy, the solar project can benefit the whole Nigerien economy if managed properly. UNDP can help create awareness and stakeholders, essential to diffuse knowledge and build capacity at local scale.

4. Costs and Return on Investment (RoI)

Inputs

Installed capacity	162.5	kWp
Storage capacity	720	kWh
Lifetime of solar panel	20	Years
Lifetime of battery pack	15	Years
Cost of battery	300	$/kWh
Grid capacity	148	kW
Cost of grid power	14	¢/kWh
Cost of generator power	18	¢/kWh
Feed-in tariff	0	¢/kWh
Office time	8	h/day

Outputs

Annual solar output	250,000	kWh
Total annual consumption	502,029	kWh
Solar usage	42	%
Grid usage	51	%
Generator usage	7	%
Annual solar surplus	32,934	kWh
Annual cost of power	41,967	$
Total system cost per year	68,420	$
Unit cost of power	8.4	¢/kWh
Net savings	277,282	$

Business Case

Solar CapEx	440,875	$
Solar OpEx	4,409	$/year
Convetional OpEx	82,284	$/year
Simple payback period	12.3	Years

	1	2	3		4	5	7	6
	Country Office	**Annual Usage of Diesel (liter)**	**Annual Cost of Diesel (USD)**	**Annual Generator Output(kWh)**	**Annual Usage of Grid (kWh)**	**Annual Cost of Grid (USD)**	**Total electricity consumed (kWh)**	**Total Cost (USD)**
A	Niger CO	12,931	12,000	66,565	502028.571	70,284	568,594	82,284

Table 1: Energy consumption and costs 2014[10]

[9] http://www.theguardian.com/environment/2014/jan/17/kenya-solar-power-plants

[10] *Grid documentation from 2014; 216 liters of diesel are consumed every day; Niger unit cost of Grid = 0.14 USD*

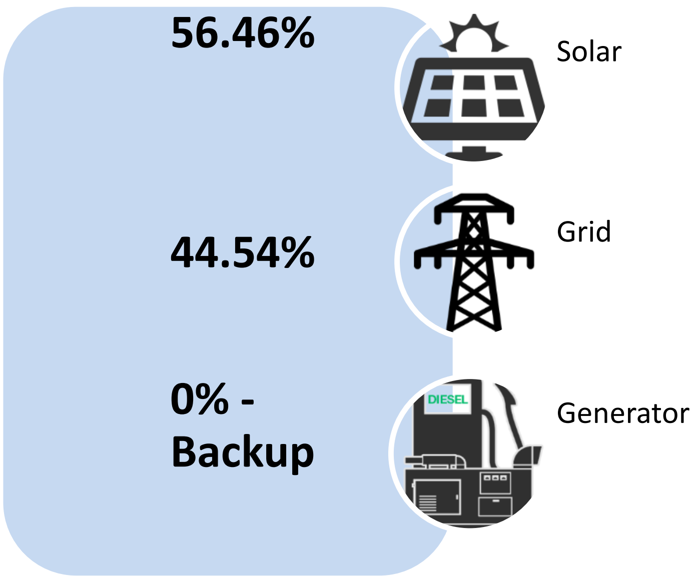
	1	2	3	4	5
	Max solar output	**Generator production**	**Solar surplus**	**Uncovered grid kWh**	**% covered of grid**
A	350000	66,565	283,435	218,594	**56.46%**

Table 3: Estimates of solar power output and percentage of solar reliance[11]

	1	2	3	4
	Country Office	**Total cost of PV installation (USD)**	**Energy cost saved per year (USD)**	**RoI**
A	Niger CO	**440,874.89**	51,680.9	**134.45%**

Table 4: Return on Investment[12]

Estimates % of Utilization



- **Capacity of Solar Panel: 250Wp**
- **Total Capacity: 162.5 kWp**
- **Batteries: 20 kWh**
- **Total Daily Consumption: 2,218kWh**

➔ During the investment period, there is a **134% return on the PV system.**

[11] Estimates are based on Photovoltaic Geographical Information System; http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php?map=africa

[12] Energy cost saved per year is based on the percentage of estimated PV electricity production; Calculated over a period of 20 year; Depreciation of the solar equipment is not comprised

- ➔ The estimated payback period is 9 years.
- ➔ The Solar System includes investment cost plus yearly maintenance costs of 3,500 USD.

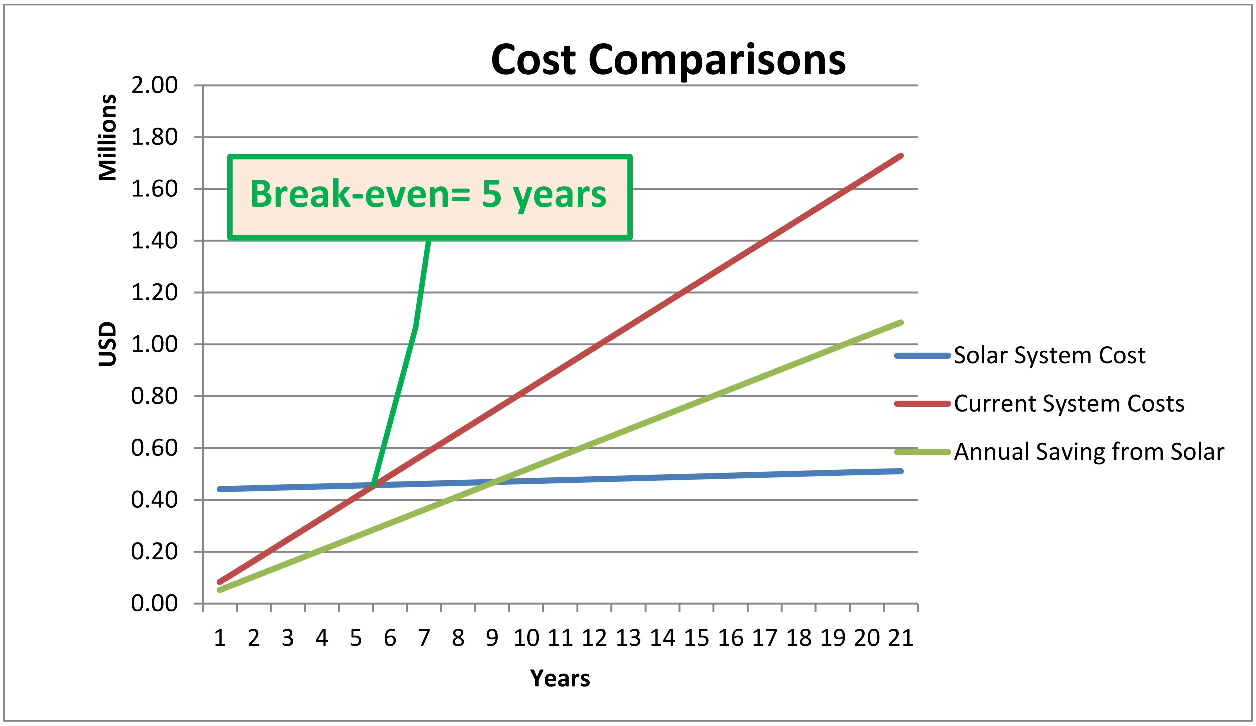


Figure 4: Total cost of ownership for DLO (fix and operating cost for the solar panel and grid/generator)

5. 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;
2	**Unstable Grid** Unstable grid may cause an on-grid solar system to shut off and should do so on in some cases. However some inverters may not be able to handle grid conditions in developing countries	Low	High		3. Request capacity of inverters from contractor and get guarantees
3	**Damage from Natural Disasters** West Africa prone to lightening. Season storm may damage panels or reduce their efficiency from flying objects, requiring replacement.	Medium	High		4. Ensure redundant and best of breed **lightening protection**; 5. Implement a preventive maintenance plan; 6. Plan for 5% panel replacement per year;
4	**Weather Conditions**	Medium	Medium		7. Maintain a generator backup with sufficient fuel storage;

	Weather conditions may change from day to day and year reducing the output.				
5	**Compromising Building Integrity** Roof needs to be able to hold the panels including the wind load.	Medium	High		8. **Site survey** and the building engineer must review site preparation and civil work plan; 9. 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 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		10. Add batteries to avoid discharging below 50%; 11. Replace batteries sooner than 10 years; 12. Implement proper monitoring and alarm systems;
7	**Improper Space for Solar Panel** Lack of space with proper sun exposition.	Medium	High		13. Conduct a thorough **site survey**; 14. Accept lower performance;
8	**Improper Battery Room** Battery room too hot and subject to flooding and other environmental hazards.	Medium	High		15. Accept lower batteries performance; 16. Choose a dry and well ventilated room;
9	**Improper Power Load Assessment** Under estimate power load required for normal utilization and peaks.	Low	Medium		17. Conduct through **site survey** and evaluation of current electrical set-up and generator; 18. 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		19. Training will be given to the CO staff; 20. **Local partner** will be on standby; 21. **Preventive plan and safety plan** will be maintained 22. Implement remote monitoring and alarm systems done by experts (vendors);

Table 1: Risk Assessment.

3 major areas 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;**

In order to reduce the risks, the project is broken-down into multiple phases handled by UNDP OIST GIA and the contractor. This will include:

- Logistics
- Site Survey and Assessment
- Design and Cost proposal
- Installation
- Monitoring
- Assistance with Maintenance Support

7. Conclusion

UNDP Niger, UNFPA and UNECA have expressed a need of a more reliable, greener and sustainable energy alternative to the unstable, polluting and expensive combination of national grid and fuel generators. The solution proposed by OIST/GIA office is to install a PV system that would replace the entire generator production and half of the consumption from the national grid. As

[13] UNDP Terms of Reference for solar and wind power system suppliers. IK/2014-01-27

a result, over the total estimated period, a 134% return on investment is expected, with a payback period estimated to be of 9 years after installation.

Annex A: Project Initial Investment Costs

No	Item Description	Qty	Unit price	Total
1	Solar Panels for Niger (include controller)	650	$228.18	$148,317.00
2	Batteries 20 kW-hr	36	$432.08	$15,554.88
3	Inverters	13	$3,206.77	$41,688.01
4	Ancillaries, Cables, Monitoring Systems	1	$60,993.00	$60,993.00
5	Power Management Unit and Assembly	1	$2,847.00	$2,847.00
6	Site Survey and Design	1	$5,113.00	$5,113.00
7	Site Preparation, Civil Work and Installation	1	$139,048.00	$139,048.00
8	Internal Power Distribution Panel and internal building cabling	1	$3,910.00	$3,910.00
9	One year Monitoring, Maintenance and Support 1 year	1	$3,500.00	$3,500.00
10	Shipping and Insurance	1	$19,904.00	$19,904.00
	Total Cost, USD for Site 1.1			**$440,874.89**

Table 3: Cost of Solar Solution[14]

Annex B - PV as a Service[15]

In order to reduce the risks, the project is broken-down into multiple phases;

7.2 Assessment, Per-Site survey and Business Case

Logistics:

a. International transportation, insurance, customs clearance
b. Organization of local transport

7.3 Site Survey

This should be an on-going collaboration between the vendor and the offices, in the course of these steps;

a. Formal Site Survey Report (by vendor of appointed vendor partner)
b. Identify solar panel install location(s)
c. Identify possible location of battery bank (inside or outdoor in weatherproof enclosure)
d. Identify best available climatic data to be used in system sizing (at least monthly values of solar irradiance and temperature)

[14] Solar Panel Solution Scoping Costing and Bill of Material Tool

[15] UNDP Terms of Reference for solar and wind power system suppliers. IK/2014-01-27

e. Photo documentation and assessment of any shading objects (by Google earth or local staff)
f. Review and calculation of consumption profile given by the client (appliances and daily use, including surge loads)
g. Inspection of roof load bearing capacity in case of roof mounted PV system (by local)
h. Selection of a suitable mounting system that do not compromise the roof tightness

7.4 Design and Cost Proposal

a. Site specific optimization of PV and battery size (3 days of autonomy if no other specified)
b. Sizing cable lengths and dimensions for maximum 2% voltage loss at nominal load
c. Sizing inverter(s) for the necessary surge load capacity
d. Wiring diagram of the entire installation

7.5 Build (installation)

a. Civil work and Site Preparation;
b. Electrical Work;
i. PV array mounting and cabling with weather proof connectors
ii. Battery mounting in a ventilated compartment or container. Optional air condition in hot climates and with temperature sensitive battery type.
iii. Cabling from inverter to new AC switchboard with two outlets (critical and non-critical loads)
iv. Lightning protection
v. Pre-assembling and wiring: mounting of inverters, controllers and the likes done as much as possible in a factory/lab environment
vi. Configuration for Smart Power Management, including automatic start of generator or load shedding scheme;
vii. Overvoltage and surge protection
viii. Option: New electrical switchboard panel 20-600A

7.6 Post installation optimization, 24/7 monitoring, reporting and operation & maintenance.

1- System commissioning,
    i. User acceptance test
    i. Training
    ii. Commissioning report (measurements and visual inspection)
    iii. Full technical documentation package in English or local language, warranty certificates and contact information
2. System Monitoring
    i. WEB based monitoring and graphic display of daily PV production, battery SOC and daily consumption, as well as weather/solar monitoring
    ii. Automatic alarm via email/SMS by system malfunction
3. Maintenance and Support;
    a. Continous management yearly reporting inclusive of guidance on opportunities to further optimize and enhance the system based on actual usage data (considering consumption, generation and solar system).
    b. Service contract
4. Technical Specifications;
    a. Provide schedule with main components and their technical specifications

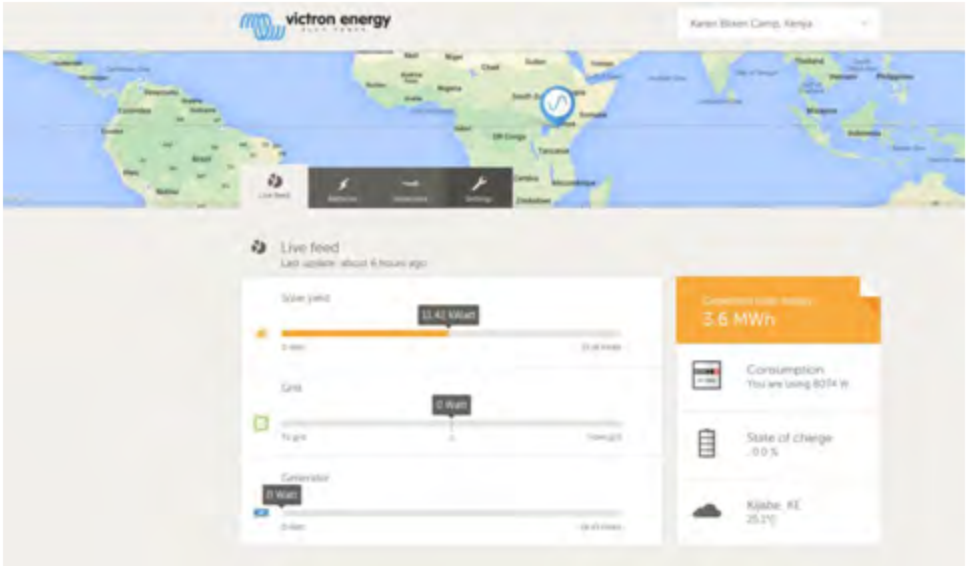


Figure 1: Victron [solar survey mobile application](https://vrm.victronenergy.com/user/login/invitekey/7dd9790bba0066342c08c2fce0a937e1).[16]

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:
- Password:

[16] https://vrm.victronenergy.com/user/login/invitekey/7dd9790bba0066342c08c2fce0a937e1

8. Success Stories

8.1 Solar power in CO in Eritrea

Figure 2: CO in Eritrea.

The CO in Eritrea is one of UNDP offices that adopted a solar system solution to sustain the local energy consumption in 2013 The CO formerly ran on diesel generators 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.

Annex C: Pictures


Free space, rooftop


Some panels are already installed


Building, south part


East part, Parking

Map of UNDP Niger Country Office

Annex D: Bill of Material of a Potential Vendor

GSOL

UN reference number: UNDP/PSO GP600186
GSOL bid number: 3069

Niger location

Bill of Material as per section 1. Solar Panels in price schedule

Item		Description	Qty.	Units
1,1	Solar Panels	Victron BlueSolar MPPT 150/70 charge controller	19,00	pcs.
1,2	Solar Panels	Solar panels, 250W	300,00	pcs.
1,3	Solar Panels	Connector box, SOL	19,00	pcs.
1,4	Solar Panels	MC4 connectors	150,00	pcs.
1,5	Solar Panels	MC4 Y-connectors	38,00	pcs.
1,6	Solar Panels	Solar panels, 250W	350,00	pcs.

Bill of Material as per section 2. Batteries in price schedule

Item		Description	Qty.	Units
2,1	Batteries	Victron 12V/220Ah AGM Deep Cycle	36,00	pcs.
2,2	Batteries	Battery rack	2,00	pcs.

Bill of Material as per section 3. Inveters in price schedule

Item		Description	Qty.	Units
3,1	Inveters	Victron Quattro 10000 Quattro inverter / charger, 10 kVA	9,00	pcs.
3,2	Inveters	Fronius Symo 20 inverter	4,00	pcs.

Bill of Material as per section 4. Ancillaries, cables, monitoring systems in price schedule

Item		Description	Qty.	Units
4,1	Ancillaries, cables, monitoring systems	Combiner box for DC positive	1,00	pcs.
4,2	Ancillaries, cables, monitoring systems	Combiner box for DC negative	1,00	pcs.
4,3	Ancillaries, cables, monitoring systems	4 mm2 cable	1.500,00	mtr.
4,4	Ancillaries, cables, monitoring systems	16 mm2 cable Sol -> CC	1.900,00	mtr.
4,5	Ancillaries, cables, monitoring systems	16 mm2 cable for CC	380,00	mtr.
4,6	Ancillaries, cables, monitoring systems	Cable lugs for 16 mm2	38,00	pcs.
4,7	Ancillaries, cables, monitoring systems	35 mm2 cable for Inv	360,00	mtr.
4,8	Ancillaries, cables, monitoring systems	Cable lugs for 35mm2	72,00	pcs.
4,9	Ancillaries, cables, monitoring systems	50 mm2 battericable	198,00	mtr.
4,10	Ancillaries, cables, monitoring systems	Cable lugs for 50 mm2	108,00	pcs.
4,11	Ancillaries, cables, monitoring systems	AC cable, 50mm2	180,00	mtr.
4,12	Ancillaries, cables, monitoring systems	AC power-in cable	180,00	mtr.
4,13	Ancillaries, cables, monitoring systems	AC connection box	2,00	pcs.
4,14	Ancillaries, cables, monitoring systems	AC cable 4x95 mm2	20,00	mtr.
4,15	Ancillaries, cables, monitoring systems	6mm2 ground cable, DIN-rail, Cable lugs	1,00	pcs.
4,16	Ancillaries, cables, monitoring systems	Lightning protection, AC	1,00	pcs.
4,17	Ancillaries, cables, monitoring systems	Lightning protection, DC	19,00	pcs.
4,18	Ancillaries, cables, monitoring systems	Mounting and various (DIN)	2,00	pcs.
4,19	Ancillaries, cables, monitoring systems	4 mm2 solar cables	1.050,00	mtr.
4,20	Ancillaries, cables, monitoring systems	Connectors	2,00	Pcs.
4,21	Ancillaries, cables, monitoring systems	4x25 mm2 AC cable	200,00	mtr.

Bill of Material as per section 5. Power Management Unit and assembly in price schedule

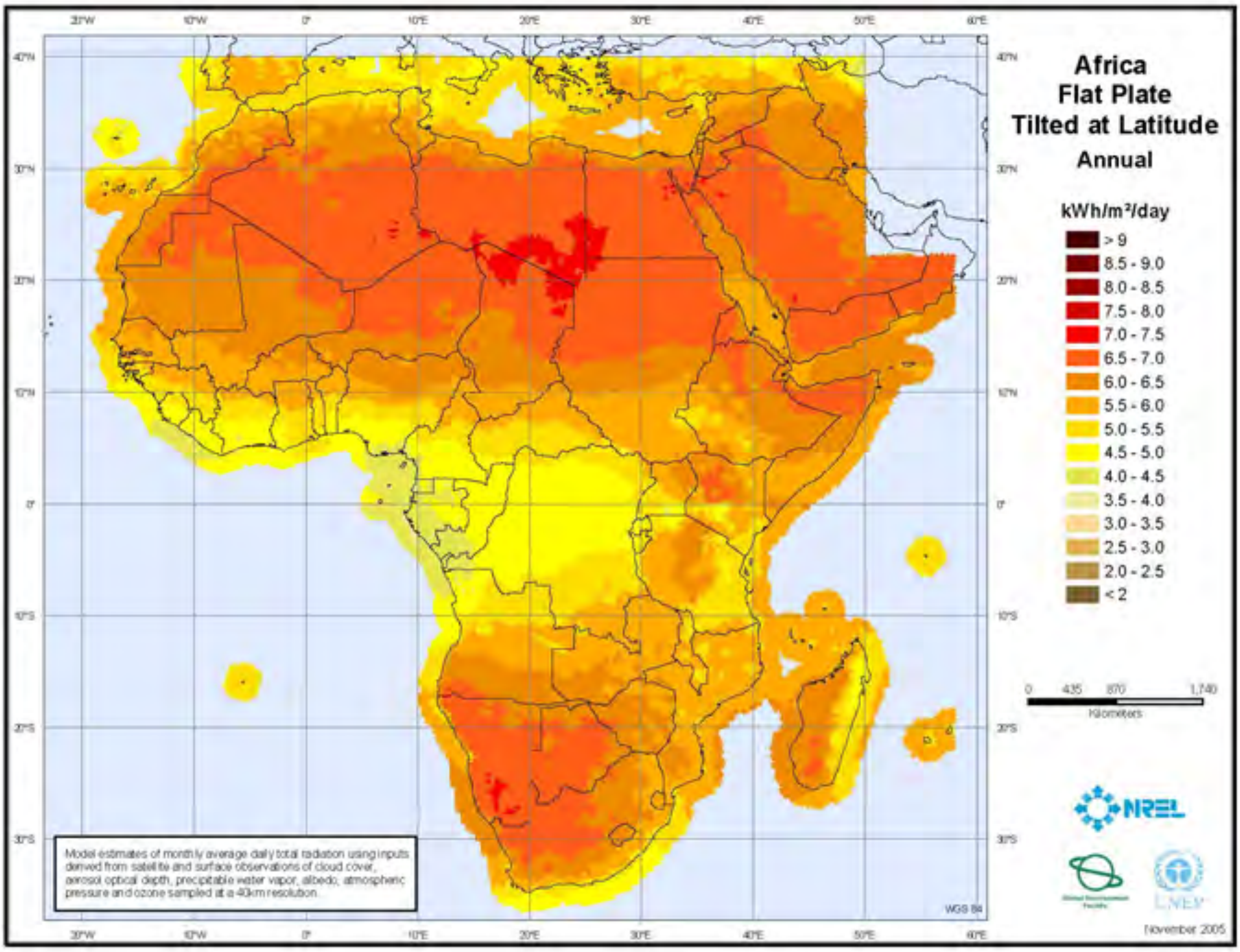
Item		Description	Qty.	Units
5,1	Power Management Unit and assembly	Generator autostart cable	100,00	mtr.
5,2	Power Management Unit and assembly	BMV 702 inc.l temp sensor	1,00	pcs
5,3	Power Management Unit and assembly	Color Control GX	1,00	pcs
5,4	Power Management Unit and assembly	LAN cables	31,00	pcs
5,5	Power Management Unit and assembly	Mounting and various	2,00	pcs

Bill of Material as per section 7. Site preparation, civil work and installation in price schedule

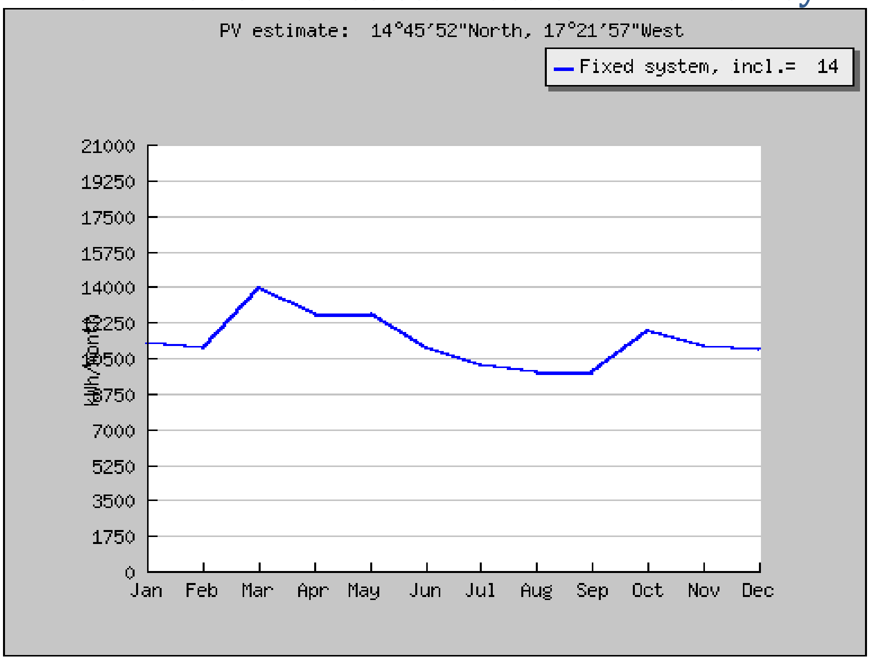
Item		Description	Qty.	Units
7.1	Site preparation, civil work and installation	Mounting system, roof offgrid	75,00	pcs.
7.2	Site preparation, civil work and installation	Various (strips, screews, tape, exstra cable lugs etc.)	3,00	pcs.
7.3	Site preparation, civil work and installation	Mounting plate	3,00	pcs.
7.4	Site preparation, civil work and installation	Preassembly	3,00	pcs.
7.5	Site preparation, civil work and installation	Cable tray	26,10	mtr.
7.6	Site preparation, civil work and installation	Mounting parking system - on-gird	50,00	pcs.
7.7	Site preparation, civil work and installation	Concrete blocks	20,00	pcs.
7.8	Site preparation, civil work and installation	Mounting ground system	25,00	pcs.
7.9	Site preparation, civil work and installation	Mounting wall system	13,00	pcs.
7.10	Site preparation, civil work and installation	Local installation	1,00	pcs.

TOTAL MATERIEL - END Niger

Annex E: Solar Irradiation Africa

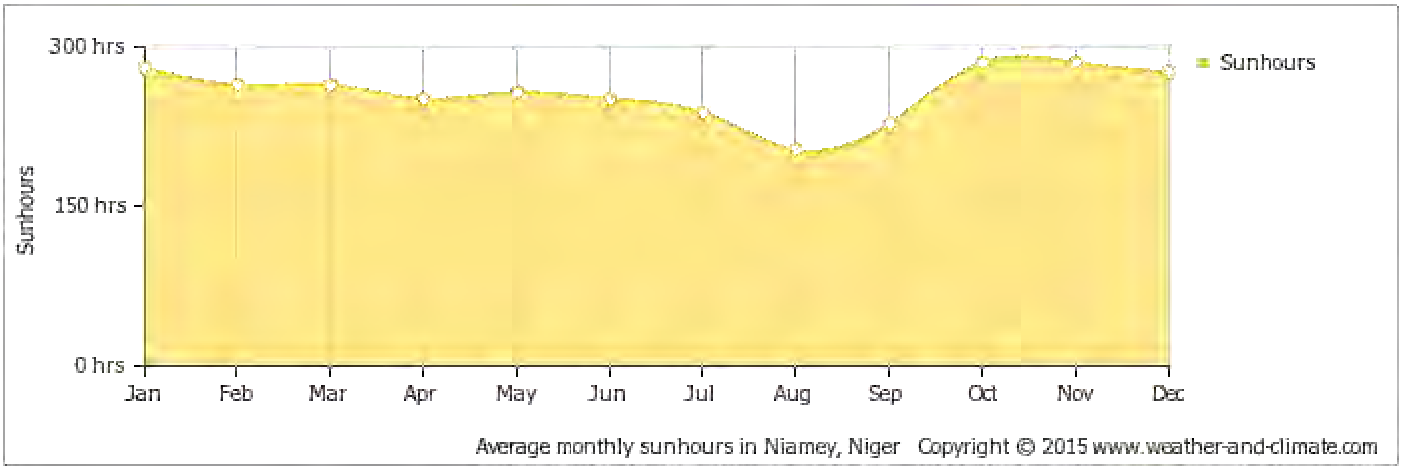


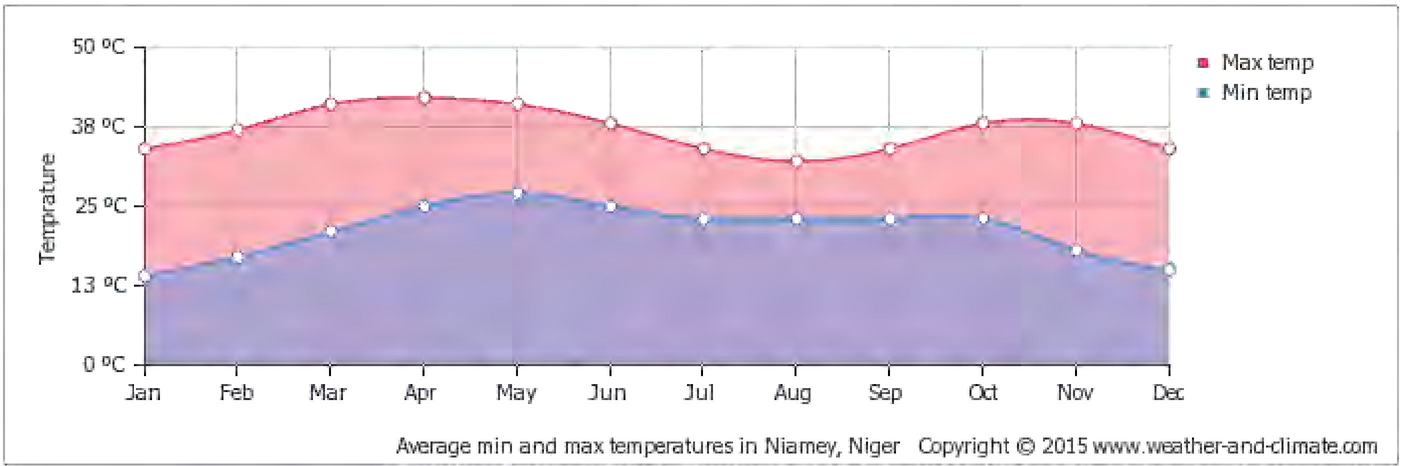
Annex F: Performance estimate of PV in Niamey [17]

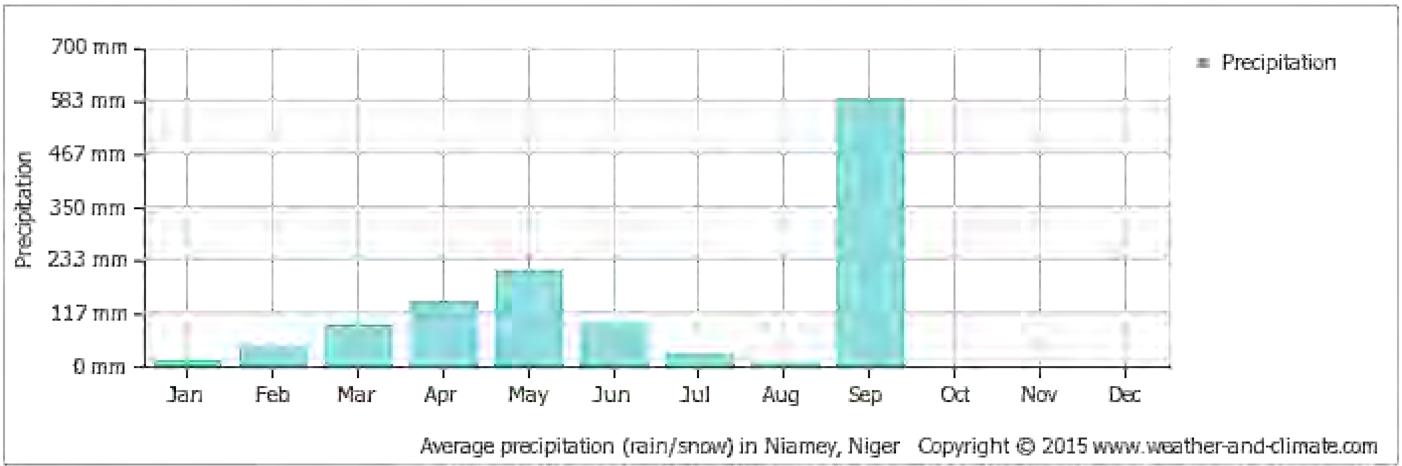


[17] PV Estimation, http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php?map=africa#

Annex E: Weather and Climate Figures [18]







[18] http://www.weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine,Niamey,Niger