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Resilient nations

SOLAR POWER SOLUTIONS – BUSINESS CASE

Senegal Country Office and Regional Hub

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

Contents

Current Energy situation

- **Expensive national grid**
- **12 power shortages per month**
- **Gas generator used as backup: polluting, loud, expensive**
- **Impedes Business continuity (12% working hours loss/month)**

Our Solar Solutions

- **Saves $47K per year**
- **Prevents 160 tonnes of CO2 emissions per year**
- **Improves stability and reliability**
- **Smoothens business continuity and improves employees' wellbeing**

The Economics[1]

Dakar Country Office

- Payback: **10 years**
- Solar Energy Investment: **$266K**

- 10 years TCO of Generator & Grid: **$303K**
- 10 years TCO of Solar Energy: **$266K**

- RoI: **107%**

Dakar Regional Office

- Payback: **9 years**
- Solar Energy Investment: **$208K**

- 10 years TCO of Generator & Grid: **$213K**
- 10 years TCO of Solar Energy: **$207K**

- RoI: **86%**

[1] Link to Excel file with the economics

1. Introduction

Why would UNDP Country Offices (COs) benefit from solar power supply? Countries such as Senegal have limited access to electricity due to shortages, and thus also rely on diesel generators. As they are greatly dependent on diesel prices, switching to solar power will reduce dependence on fluctuating diesel prices and supply.. 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 SENELEC i.e. the Senegalese electricity company. Consequently, more of the energy will be produced in an environmentally efficient way. This hybrid system works best in sunny climates, where peak demand for electricity from the grid often coincides with the sun shining, due to the high power demand of the air conditioning units.[2]

Country office

- 350 panels of 1.6 sqm each, peak power output 250 Wp
- Total capacity is up to 87.5 kWp
- Total area 900 sqm on roof top

Regional Hub Office

- 250 panels of 1.6 sqm each, peak power output 250 Wp
- Total capacity is up to 62.5 kWp
- Total area 200 sqm on roof top

Smart Power Management

- Reduce generator utilization to minimum, or
- Increase resilience to maximum

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 is often undermined by shortages. A few weeks later, the Senegal CO and DLO as well as Niger CO expressed a need for greener, reliable, sustainable and cheaper energy alternative. In contrast to Liberia, Guinea and Sierra Leone, these country offices are mainly run on grids which are available but unstable. As a result, they also rely on diesel/gasoline generators that are~~,~~ expensive, polluting and unstable.

To note, 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, hence the faster the payback. As our business case aims at installing a partial solar coverage, we also need to estimate a percentage of solar coverage.

[2] Solar Electricity Handbook, Michael Boxwell

4. Indirect cost from power outages

Out of 189 countries, **Senegal is ranked 183rd for getting electricity**, according to the Doing Business 2015 report. Accordingly, access to and availability of electricity is a major barrier for organizations to conduct business in Senegal.[3] In addition, the World Economic forum notes Senegal **Electricity and Telephony infrastructure ranks 116** out of 144 countries, with an overall grade of 2.7 on a 7 point scale.[4] The highest invisible cost of doing business in Africa is due to power outages. Due to shortages, Senegal is estimated to lose 13% of the annual working hours[5] which has a great impact on productivity. It is one of the countries most affected by outages, which can have a large impact on the delivery of UN office. Since a VOLL[6] analysis is not applicable in the case of Senegal a direct cost cannot be incorporated in ROI – However not quantifiable power outages should not be neglected as they forces delays in operation not only within the UN but also with every partner awaiting communication which in turn will created a delayed feedback mechanism.

- **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.

4.1 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 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.

”We face many difficulties to obtain maintenance contracts for our generator, due to inverters that do not function well. High prices of fuel is another problem, as well as the number of monthly shortages we record. As a consequence, we lose many devices/appliances.”

Yerim Fall, ICT Coordinator RBA, Dakar Regional Office

[3] *Doing Business 2015 data for Senegal, http://www.doingbusiness.org/data/exploreeconomies/senegal*

[4] *Global Competitiveness Report 2014-2015, World Economic Forum, http://reports.weforum.org/global-competitiveness-report-2014-2015/economies/#economy=SEN*

[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

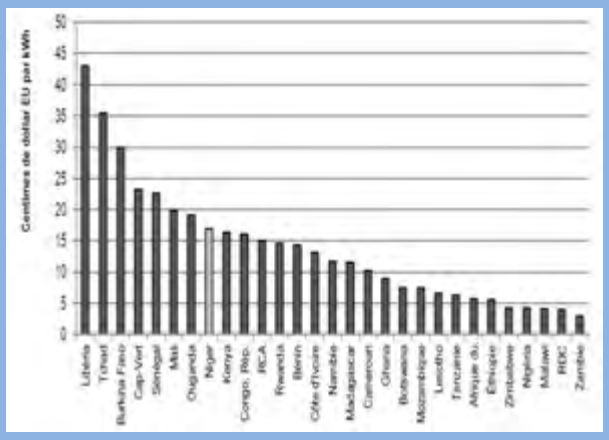


Table 2: Electricity prices in US Dollar per kWh, Africa infrastructure country diagnostic, World Bank data 2011

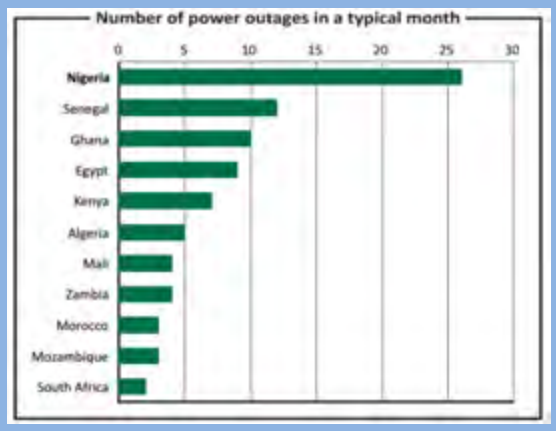


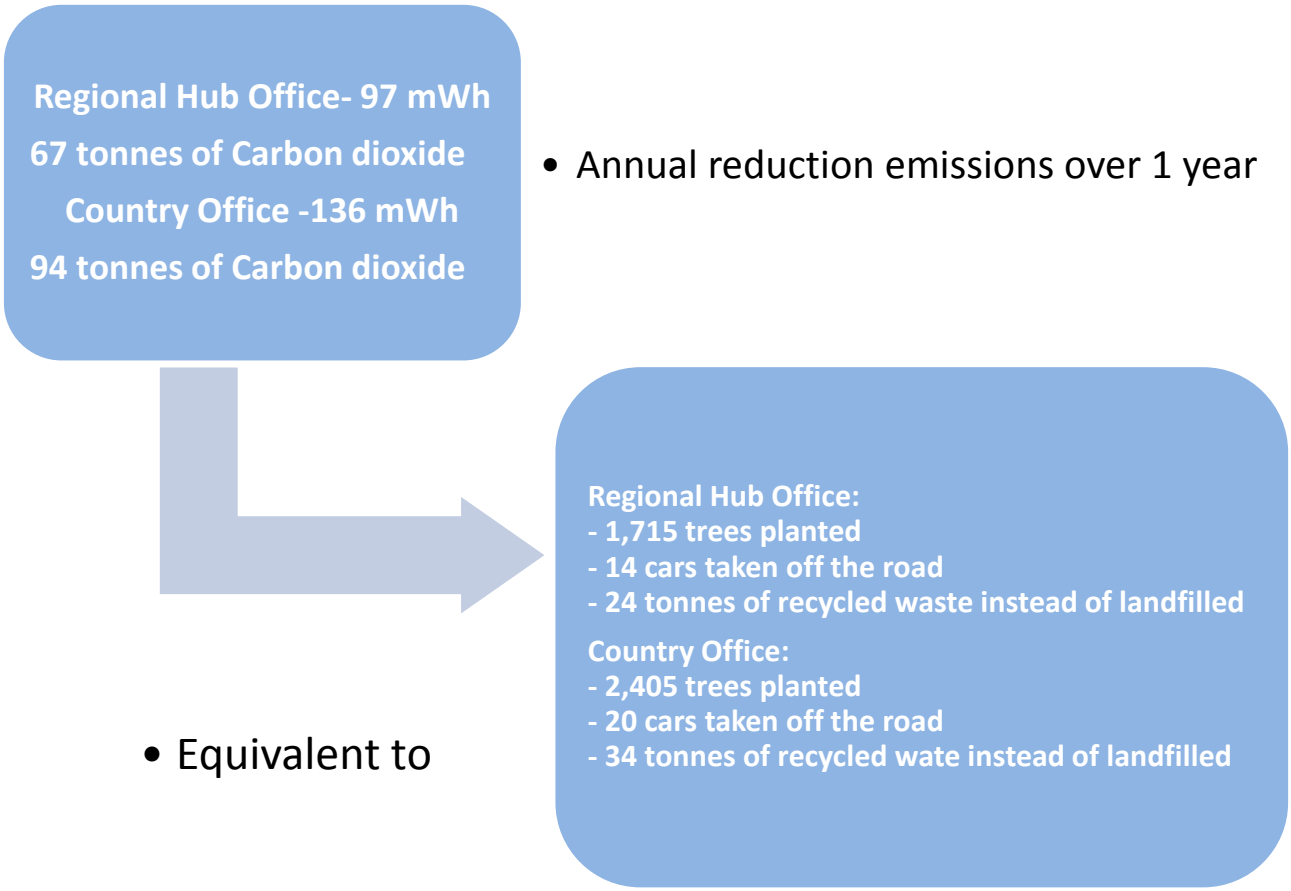
Figure 4: UNDP Dakar Regional

3.1 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 Senelec is acquired through polluting fossil fuels – natural gas, diesel and coal. Thus, UNDP Dakar offices are contradictory with the organization's overall goals. The proposed solar system will align the offices with these goals;

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 by annually: [7]



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. Diffusion of knowledge and Capacity building

A recent special report on energy and technology from the Economist called "Let There be light" stated that the future of Africa is connected to solar systems , since prospects for an expansion and more reliable power grid in Africa are low. Kenya already ventured into the solar revolution years ago, even though solar energy was not as profitable as it is today. This initiative sparked interest and allowed the private market to develop subsequently. Locals who had worked on these large scale projects where educated by some of the head engineers and in the aftermath many of these locals have become solar system stakeholders in Kenya. With these stakeholders available the demand for solar system simply spread by word by mouth.
Besides the sustainable benefits, the amount of energy shortages and its impact on the business life in Senegal is considerable. This solar project can benefit the whole Senegalese economy if managed properly. UNDP can help create awareness and stakeholders, essential to diffuse knowledge and build capacity at local scale.

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

4. Cost, Gain and Return on Investment (ROI)

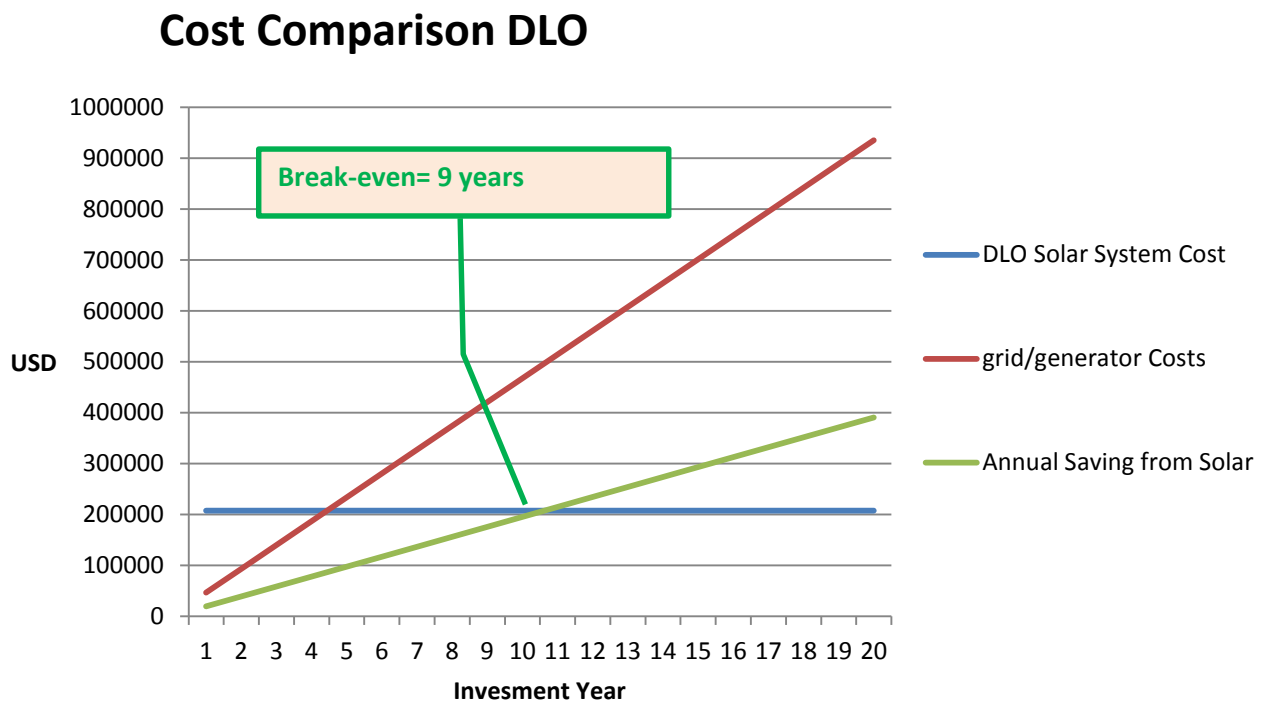


Figure 4: Total cost of ownership for DLO (fixed and operating costs for the solar panel and grid/generator) For a 41.1% solar solution

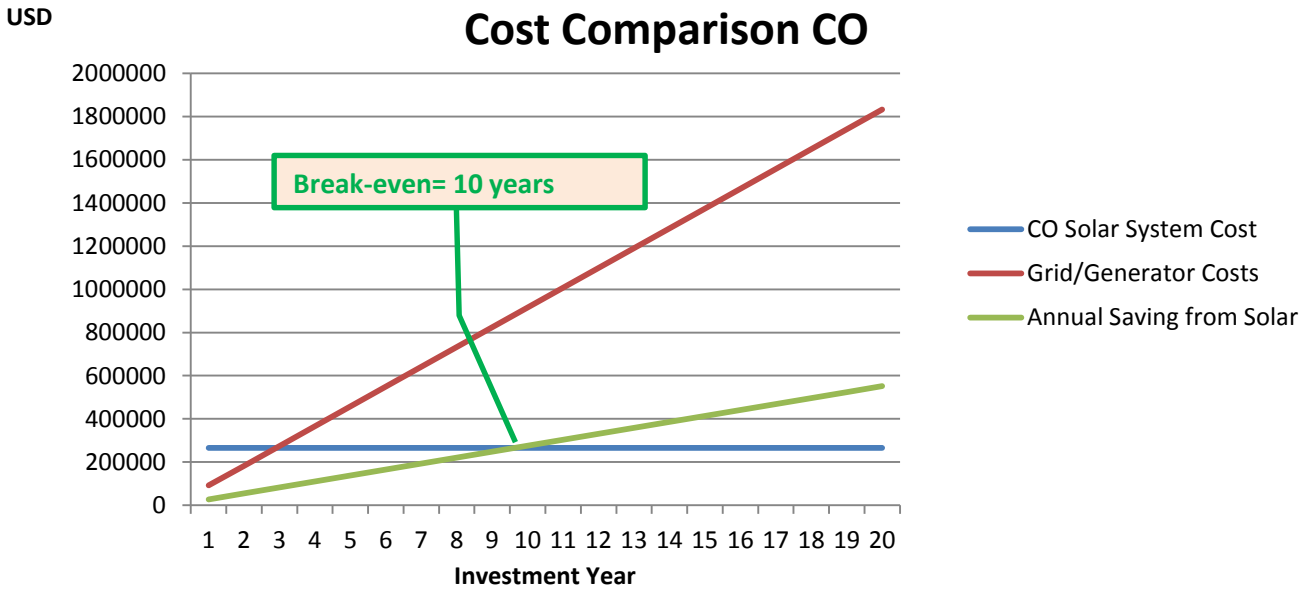


Figure 5: Total cost of ownership for CO (fixed and operating costs for the solar panel and grid/generator) For a 30.1% solar solution

4.2 Current Energy Costs

Country & Regional Hub Office	Annual Usage of Gasoline (litre)	Annual Cost of Gas (USD)[9]	Annual Usage of Grid (kWh)	Cost of Grid USD/ year	Total Energy Usage (kWh)
Dakar DLO	6,066 (55,605 kWh)	10,434	177,164	36,037	232,769
Dakar CO	2,280 (20,900 kWh)	3,921	430,999	87,669	451,899

Table 2: Energy consumption and costs 2014[10]

Country & Regional Hub Office	Total Electricity Consumed (kWh)	Estimate of Annual PV Electricity (kWh)[8]	Total Cost (USD)	Estimate of Solar Power Coverage
Dakar DLO	232,769	97,300	46,471	**41.8%**
Dakar CO	451,899	136,000	91,590	**30.09%**

Table 3: Estimates of solar power output and percentage of solar reliance[1]

Country & Regional Hub Office	Total Cost of PV Installation (USD)	Energy Cost Saved (USD/year)	RoI
Dakar DLO	**207,900**	**19,425**	**0.86**
Dakar CO	**266,150**	**27,559**	**1.07**

Table 4:Return on Investment[11]

DLO:41.8%

During the investment period, there is a **86% RoI** for the Regional Hub Office in Dakar and a **107% return** for the Country Office.

DLO: 58.2%

CO:0% - Backup

DLO: 0% - Backup

Generator

Estimates % of Utilization

Solar Capacity – CO

- **Capacity of Solar Panel: 250Wp**
- **Total Capacity: 87.5 kWp**
- **Total daily consumption: 1255kWh**

5. Risks

	A	B	C		
	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**. Seasonal storms may damage panels or reduce their efficiency, 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;

[8]http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php?map=africa

[9] *Calculation based on Pump price of diesel fuel per litre from the World Bank*

[10] *Senegal unit cost of Grid =0.20341USD*

Dakar offices gasoline usage is derived from the UNDP Global GHG Inventory.

[11] 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

4	**Weather Conditions** Weather conditions may change from day to day and year reducing the output.	Medium	Medium		7. 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		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;**

6. PV as a Service[12]

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

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

- Assistance with maintenance support

6 Conclusion

Senegal offices have expressed their need for a reliable, green and sustainable energy alternative to the current supply through the national grid and generators. The grid supply is expensive and undermined by shortages, and the gas generators that are used as backups incur high indirect and operating costs. The solution proposed by OIST/GIA office is a hybrid/grid connected PV system. This systems should replace parts of the energy mainly purchased through the grid supply. According to the estimates, 42% of the current electricity consumption should be provided by solar power in the DLO and a 30% in the country office. Due to the high initial costs of investment (i.e. estimated at US$210K for DLO and US$265K for CO), the payback of the solar equipment is expected to start around the 9th and 10th year of operation. Over a period of 20 years, this should translate into a strong return on investment around 86% for DLO and 107% for CO.

8. Two Success Stories

7.1 Solar power in CO in Eritrea

Figure 2: 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 3: 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

Solar Power Project Initial Cost Breakdown

	1	2	Senegal CO		Dakar DLO	
	Items	**Unit Price (USD)**	**Quantity**	**Total**	**Quantity**	**Total**
A	Solar Panel 250 Wp, 1.6 m2 (include controller)	300	350	105,000	250	75,000
B	Batteries 24 kW-hr	10,000	0	10,000	0	0
C	Inverters	5,000	18	90,000	13	65,000
D	Ancillaries, cables, monitoring systems	5,000	1	5,000	1	5,000
E	Power Management Unit and assembly	5,000	1	5,000	1	5,000
F	Site Survey and Design	5,000	1	5,000	1	5,000
G	Site Preparation, Civil Work and Installation	15,000	1	15,000	1	15,000
H	Internal Power Distribution Panel and internal building cabling	20,000	1	20,000	1	20,000
I	One year Monitoring, Maintenance and Support 1 year	3,000	1	3,000	1	3,000
L	Shipping	5,000	1	5,000	1	5,000
M	**Total Cost**			**253,000**		**198,000**
N	**UNDP GIA Consultancy and Support (5% total)**			13,150		9,900
	Grand total			**266,150**		**207,900**

Table 3: Cost of Solar Solution[13]

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

Annex B: Pictures of the Rooftops

Regional Hub Office, Dakar, Senegal

Country Office, Dakar, Senegal

Annex C: Bill of Materials for Potential Vendors

GSOL

UN reference number: UNDP/PSO GP500186
GSOL bid number: 3669

Senegal location (Country Office)

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	50,00	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	20,00	pcs.
2.2	Batteries	Battery rack	1,00	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	1,00	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	1.500,00	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 batteriecable	110,00	mtr.
4.10	Ancillaries, cables, monitoring systems	Cable lugs for 50 mm2	60,00	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	150,00	mtr.
4.20	Ancillaries, cables, monitoring systems	Connectors	2,00	Pcs.
4.21	Ancillaries, cables, monitoring systems	4x25 mm2 AC cable	50,00	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.I 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.
7.9	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 SENEGAL (Country Office)

Senegal location (Regional Hub)

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	13,00	pcs.
1.2	Solar Panels	Solar panels, 250W	200,00	pcs.
1.3	Solar Panels	Connector box, SOL	13,00	pcs.
1.4	Solar Panels	MC4 connectors	100,00	pcs.
1.5	Solar Panels	MC4 Y-connectors	25,00	pcs.
1.6	Solar Panels	Solar panels, 250W	50,00	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	20,00	pcs.
2.2	Batteries	Battery rack	1,00	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	1,00	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	1.000,00	mtr.
4.4	Ancillaries, cables, monitoring systems	16 mm2 cable sol -> CC	1.300,00	mtr.
4.5	Ancillaries, cables, monitoring systems	16 mm2 cable for CC	260,00	mtr.
4.6	Ancillaries, cables, monitoring systems	Cable lugs for 16 mm2	26,00	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	110,00	mtr.
4.10	Ancillaries, cables, monitoring systems	Cable lugs for 50 mm2	60,00	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	13,00	pcs.
4.18	Ancillaries, cables, monitoring systems	Mounting and various (DIN)	2,00	pcs.
4.19	Ancillaries, cables, monitoring systems	4 mm2 solar cables	150,00	mtr.
4.20	Ancillaries, cables, monitoring systems	Connectors	2,00	Pcs.
4.21	Ancillaries, cables, monitoring systems	4x25 mm2 AC cable	50,00	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	25,00	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	50,00	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	22,50	mtr.
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 SENEGAL (Regional Hub)

Annex D: Services included

Assessment, Per-Site survey and Business Case

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

6.1 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)
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

6.2 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

6.3 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

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

2. System commissioning,
    a. User acceptance test

   b. Training
   c. Commissioning report (measurements and visual inspection)
   d. Full technical documentation package in English or local language, warranty certificates and contact information
3. System Monitoring
   a. WEB based monitoring and graphic display of daily PV production, battery SOC and daily consumption, as well as weather/solar monitoring
   b. Automatic alarm via email/SMS by system malfunction
4. Maintenance and Support;
   a. Continuous 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
5. Technical Specifications;
   a. Provide schedule with main components and their technical specifications

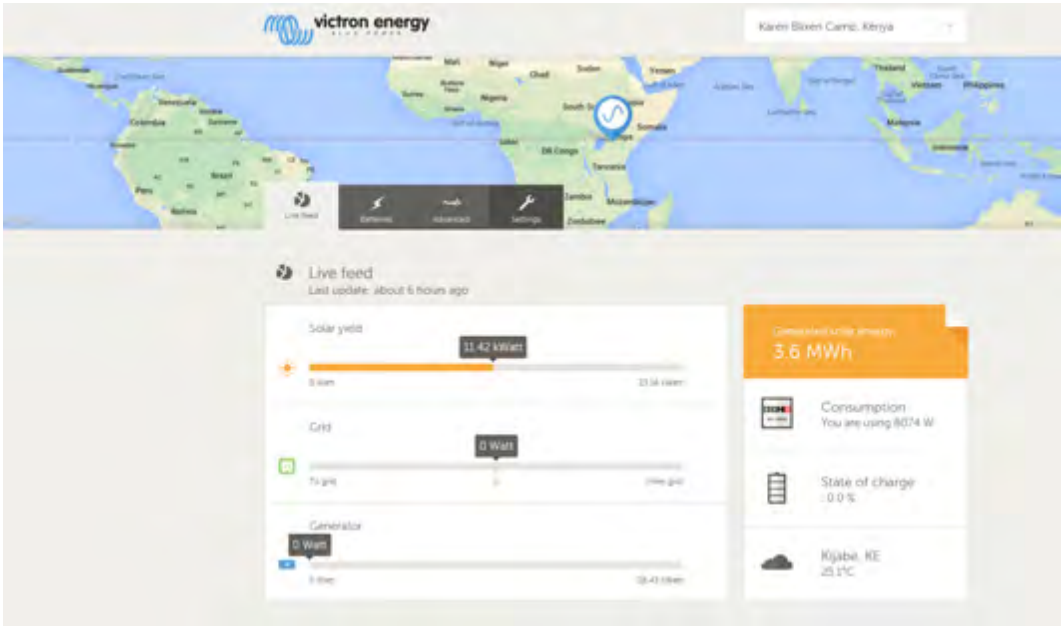


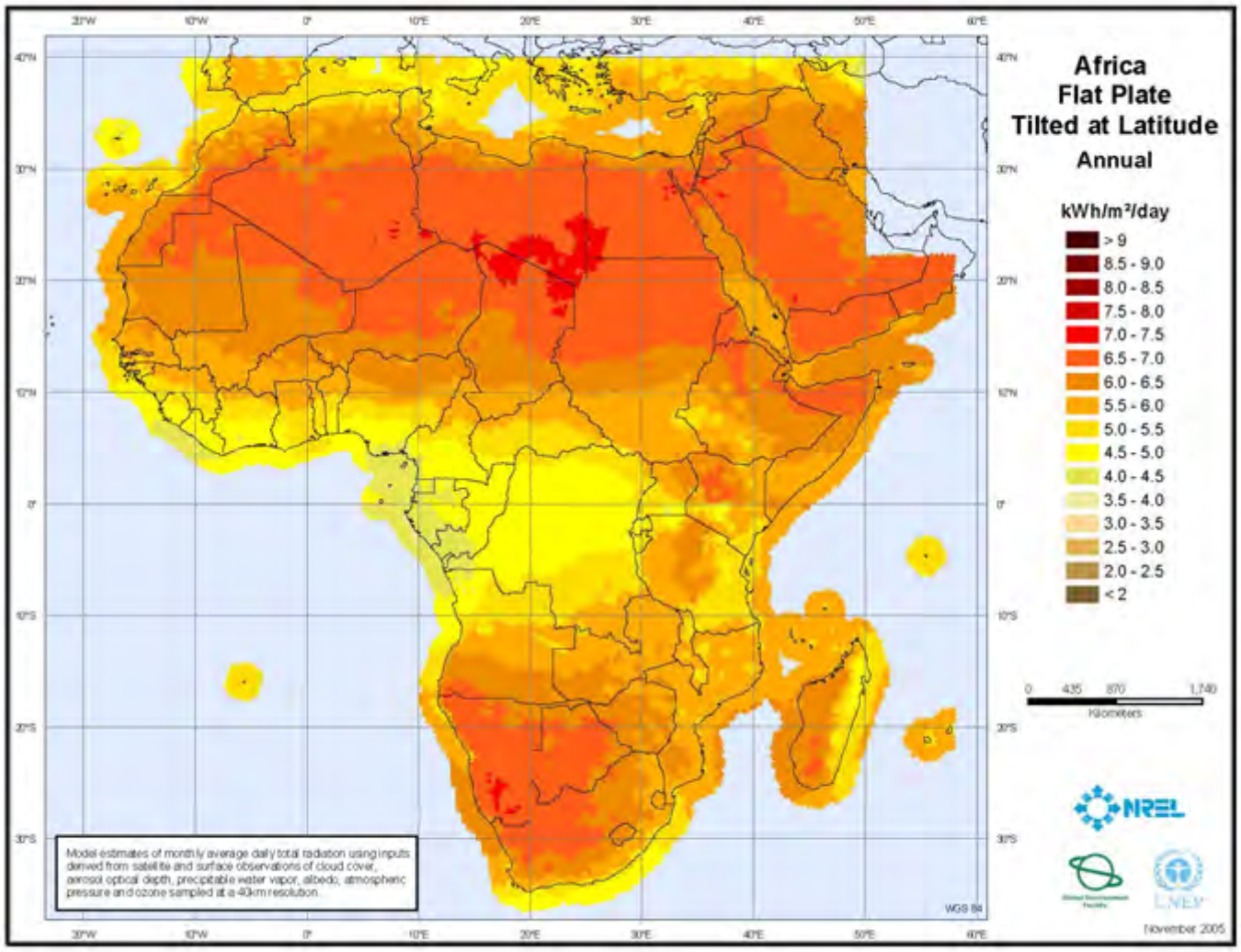
Figure 4: Victron solar survey mobile application.[14]

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.

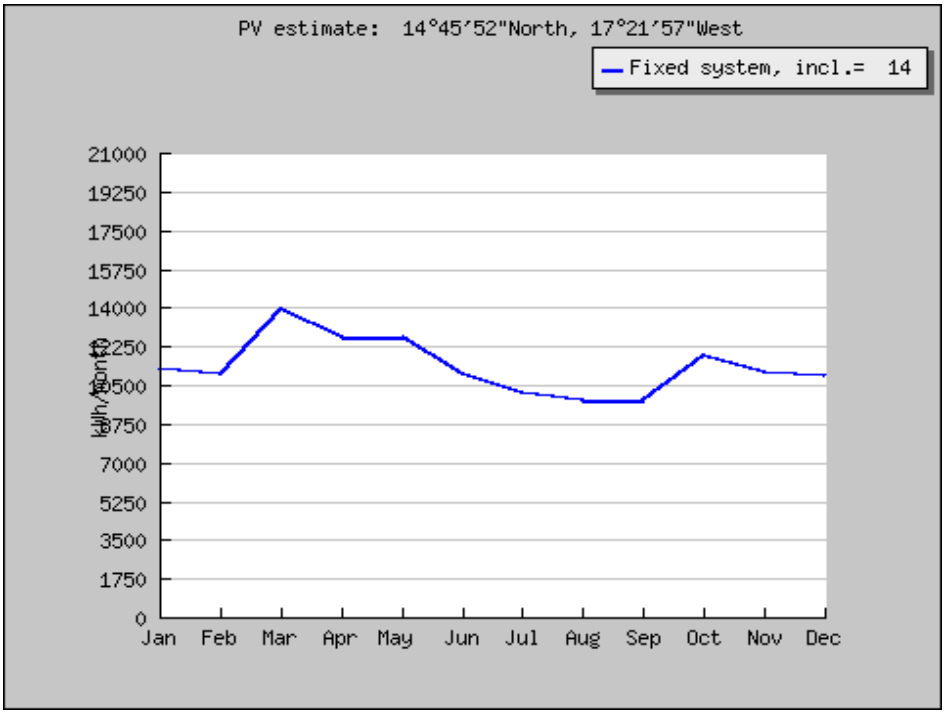
- ***See a live system*** at https://vrm.victronenergy.com/user/login/invitekey/7dd9790bba0066342c08c2fce0a937e1
- Username:
- Password:

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

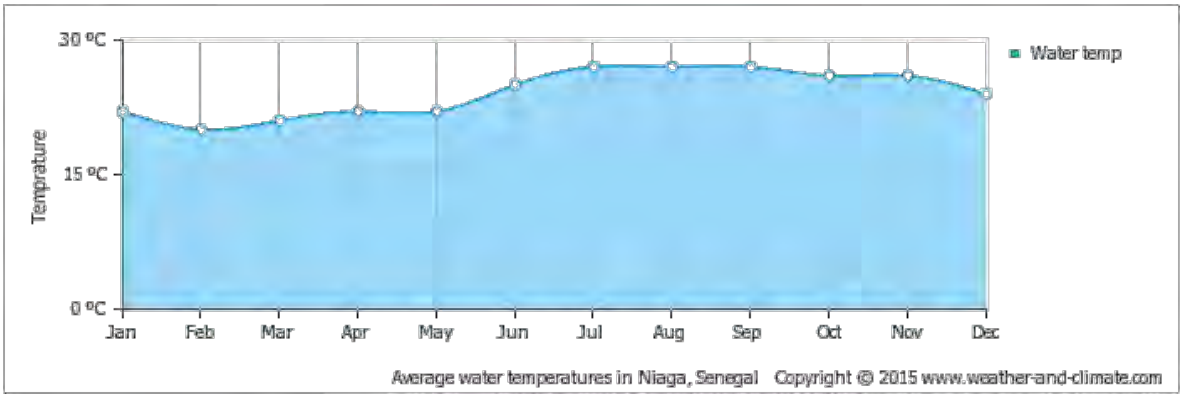
Annex E: Solar Irradiation Africa



Annex F: Performance estimate of PV in Dakar [15]

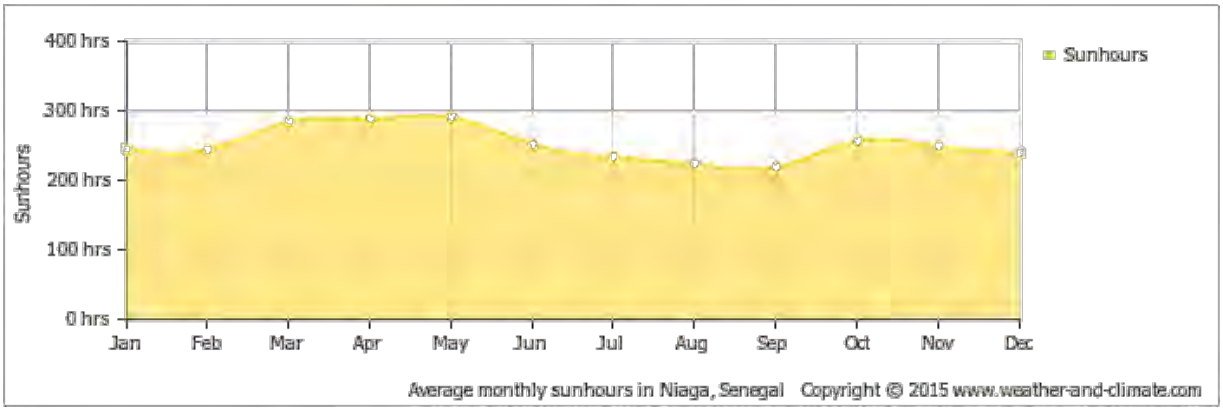


Annex E: Weather and Climate Figures [16]



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

[16] http://www.weather-and-climate.com/average-monthly-min-max-Temperature,niaga,Senegal


400 hrs
300 hrs
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Oct
Nov
Dec
Sunhours
Average monthly sunhours in Niaga, Senegal
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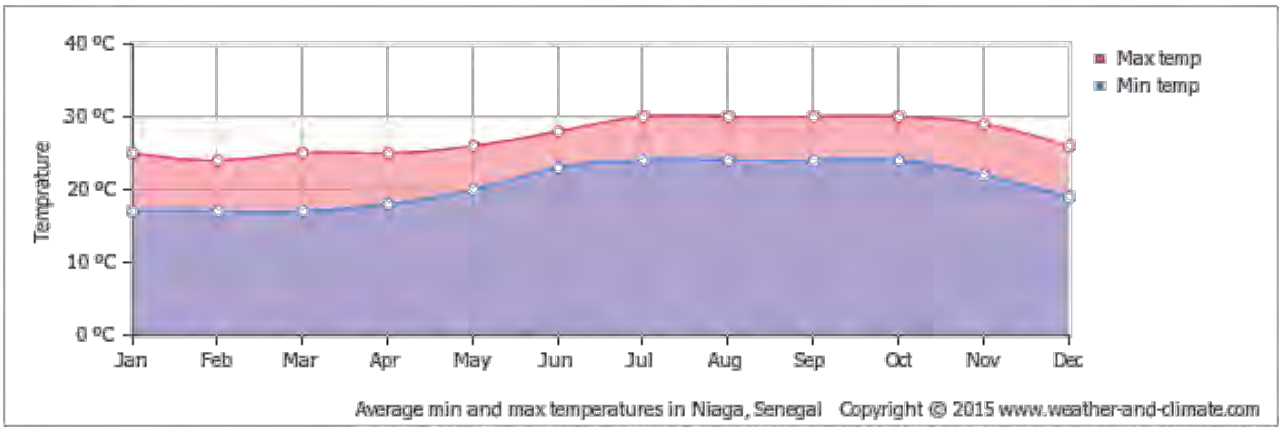
40 °C
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Nov
Dec
Max temp
Min temp
Average min and max temperatures in Niaga, Senegal
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