Decarbonisation of Energy Infrastructure in Displacement Situations

Conducting an Energy Audit and Developing a Value Proposition for Decarbonisation

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Objective of Session

Provide technical input to support practitioners in transitioning to renewable energy sources for facilities and community services

Mark Hankins Introduction

- Thirty years of experience in the field of solar energy and rural electrification as an engineer, trainer, auditor and consultant.
- Specialist in development of off-grid solar markets with understanding of pico-solar, pumping, SHS, productive use, mini-grids, C&I solutions as well as appliances and end-use issues.
- Active advisor in financing of energy access companies and communities
- Has worked on solar PV market development programs for development and humanitarian agencies throughout Africa

Outline of Discussion

- What's different/unique about working in the humanitarian contexts vs. normal RE development
- Making the Transition to Sustainable Energy Sources
- Process of Conducting an Energy Audit and Developing Value Propositions
- Example from experience of solarising humanitarian infrastructure

The Humanitarian Context (vs. normal renewable project development)

The Humanitarian Context 1

Why the Reliance on Unsustainable Generators?

- Grid power unavailable
- Pressure on relief operations to work 24/7
- Large loads demand power supply
  - Air conditioning
- Confidence in generator technology
  - Functionality
  - Infrastructure
  - It just works

- Costly, fuel-hungry
- Dirty, wasteful
- CO^2 emissions
- The **WRONG** message to

The Humanitarian Context 2

Why Relief Agencies don't Integrate Sustainable Power into Operations

- Poor capacity of solar/renewable sector.
- Bad experience with technology
- Procurement approaches
- Solar costs are up front and high
- Confidence in generators

Humanitarian Context 3

The Tools for Transition are Available:
Solar Energy, Efficient Appliances, Storage and Electric Transport

- Solar and electric transport industry are mature
- Regional experience
- Business models available
- Major investment in African solar sector & company appetite
- Large potential to expand solar use to other NGOS, communities and the private sector
- 80% transition is viable and cost-effective

Facilitating shift to renewables in humanitarian operations

How we can assist the transition

- **Learn lessons** from the success of solar for energy access in other countries
- Relief/refugee activities as **anchor loads** which enable solar to serve communities as well as refugee sites
- **Supply companies** encouraged and assisted to move beyond simply supplying relief operations and to develop local markets

Making the Transition to Sustainable Energy Sources

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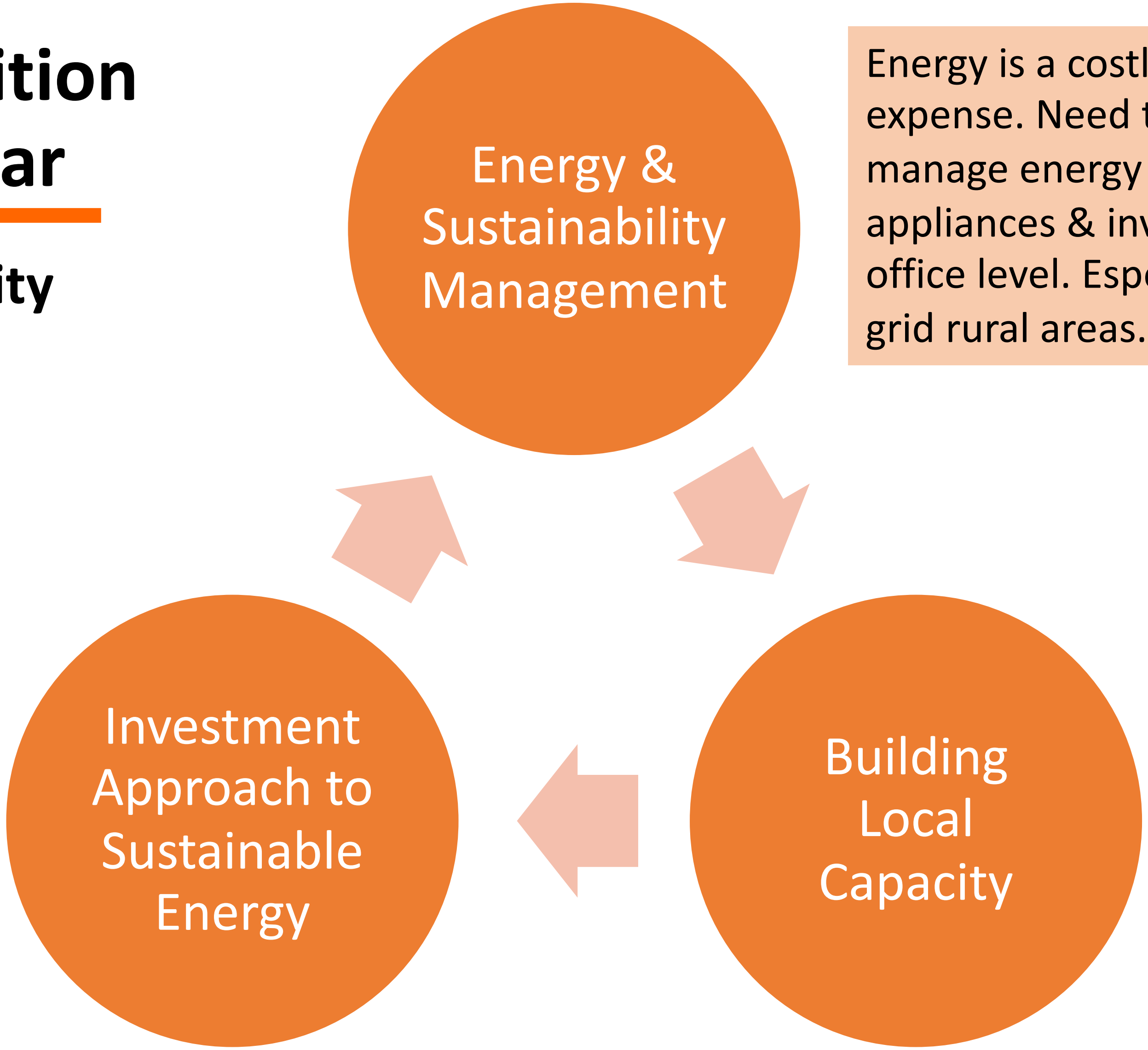
Making the transition from diesel to solar

Investing in sustainability



Energy is a costly operational expense. Need to better manage energy use, appliances & investments, at office level. Especially in off-grid rural areas.

Providers need to stand behind equipment for its operational lifetime and be able to supply services and spare parts.

Energy costs need to be looked at over the long term.

- Investments in solar need to be made per unit of energy.
- Move away from procurement-based approaches.

1 Integrating Better Energy Management

Making the best use of expensive energy sources

- **Business arrangement** of equipment supply (PPA or purchase)
- Make energy a **job responsibility**
- **Better sourcing** of small PV & back-up systems
- **Energy management plan** with achievable targets
- Better **quality** electric system installation
- Keep regular **energy records**
- **Replace** inefficient equipment
- **Investment** in RE and EE

2 Investment Approach to Sustainable Energy

Ensuring Value and Quality over Product Lifetime

- **Standards.** Equipment must be supplied and installed according to recognized standards.
- **PPA Approach:** Suppliers provide services based on kWh supply not only cost of equipment.
- **International/Local Cooperation.** Tender requires strong partnership with local companies.
- **Donor & Community Project Collaboration.** Partnerships between donors enable systems in rural areas to power multiple sites as well as working on key community needs.

3 Building Local Capacity

Working at Multiple Levels to Develop Solar Infrastructure

- **Multi-Level Approach to Solar Development**
- **Include Capacity Building for Standards & Regulation**
- **Incorporate Local Experiences.** There is ample positive experience.
- **Involve Training Institutions.** Vocational and NGO training expertise should be used to build long term skills development.
- **Avoid duplication.** Donors should complement approaches and utilize efforts of partners.

Conducting an energy audit and developing value proposition

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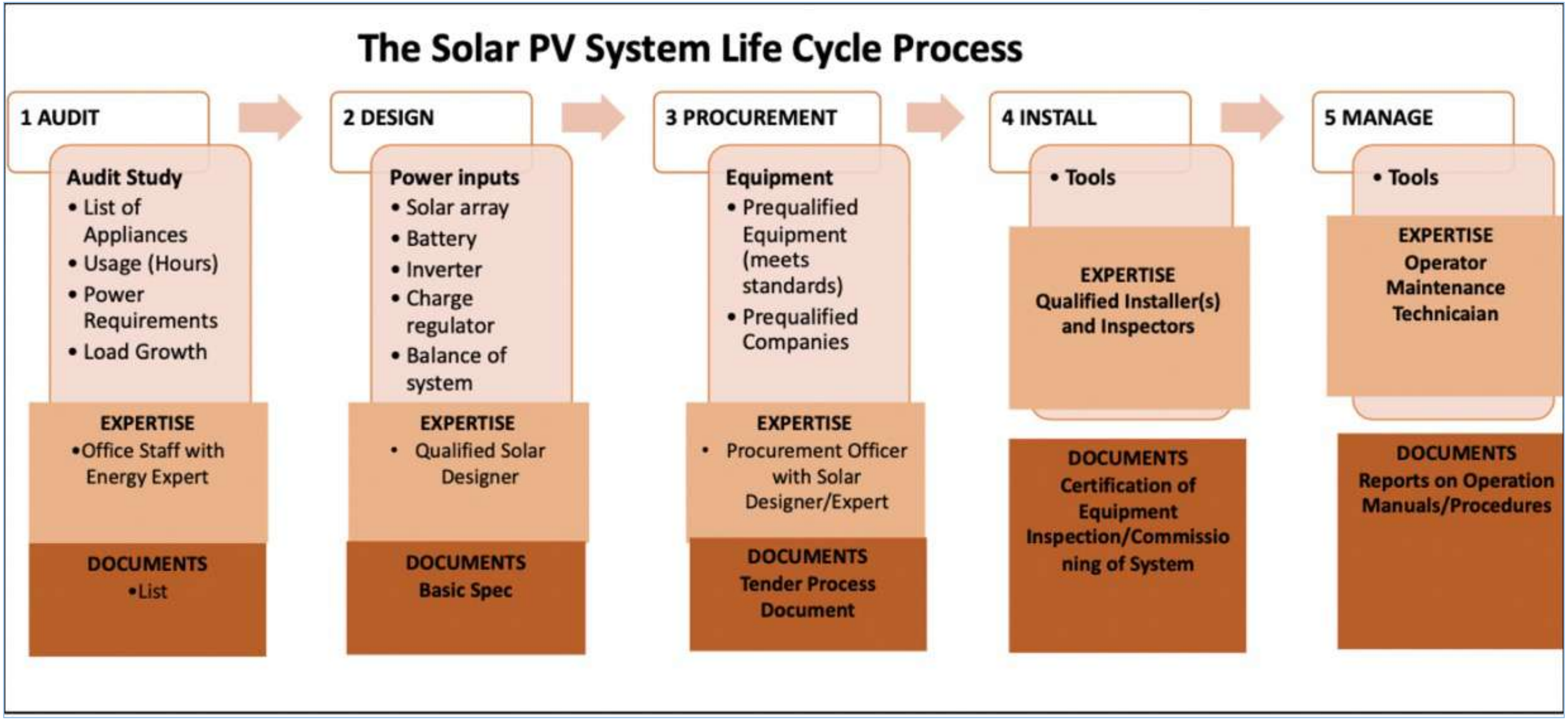
Understand the Organizational Context

- Full buy-in from the agency
- Budgets must be available for all stages of the process
- Expertise and quality equipment are a must

1. Organizational Buy-In, Planning & Budgeting
2. Understanding Technology Situation & Limits
3. Energy & Site Audit, System sizing and Design
4. Financing and procurement
5. After-Service & Management

The Technology Context



Development of energy product supply chain & life cycle support is a long-term process

Audit and Assessment Tools

A number of very good tools are available to conduct audits.

- Tools usually have to be adapted to the specific needs of sites and technology.
- Auditors have to be trained, tooled-up and managed.

- Site information type and specific needs
- Energy systems including electricity and fuels
- Key appliances & energy use
- Qualitative assessment of energy supply including gender issues
- Energy demand profile and growth
- Supply chain & private sector maturity considerations
- End user needs (training, management, financing)

One Size Does Not Fit All

Large systems (commercial/ industrial)

- Carports, rooftop arrays, intelligent inverters and lithium ion storage
- Providers would receive a multi-year power purchase contract
- Tender award based on

a) price per delivered kWh,

b)up-front investment of awardee,

c) technical capacity & experience

Smaller mini-grid/kiosk-type systems

- Providers install solar kiosk/mini-grid solutions that would deliver 240VAC power to offices
- Providers would re-wire the sites (which might be poorly/dangerously wired)
- They would be able to provide power to communities and other NGOs and participate in local capacity building programs.

Program Includes

- Investment
- Capacity Building
- Workable Business Models
- Coordination with other programs

South Sudan NRC Example

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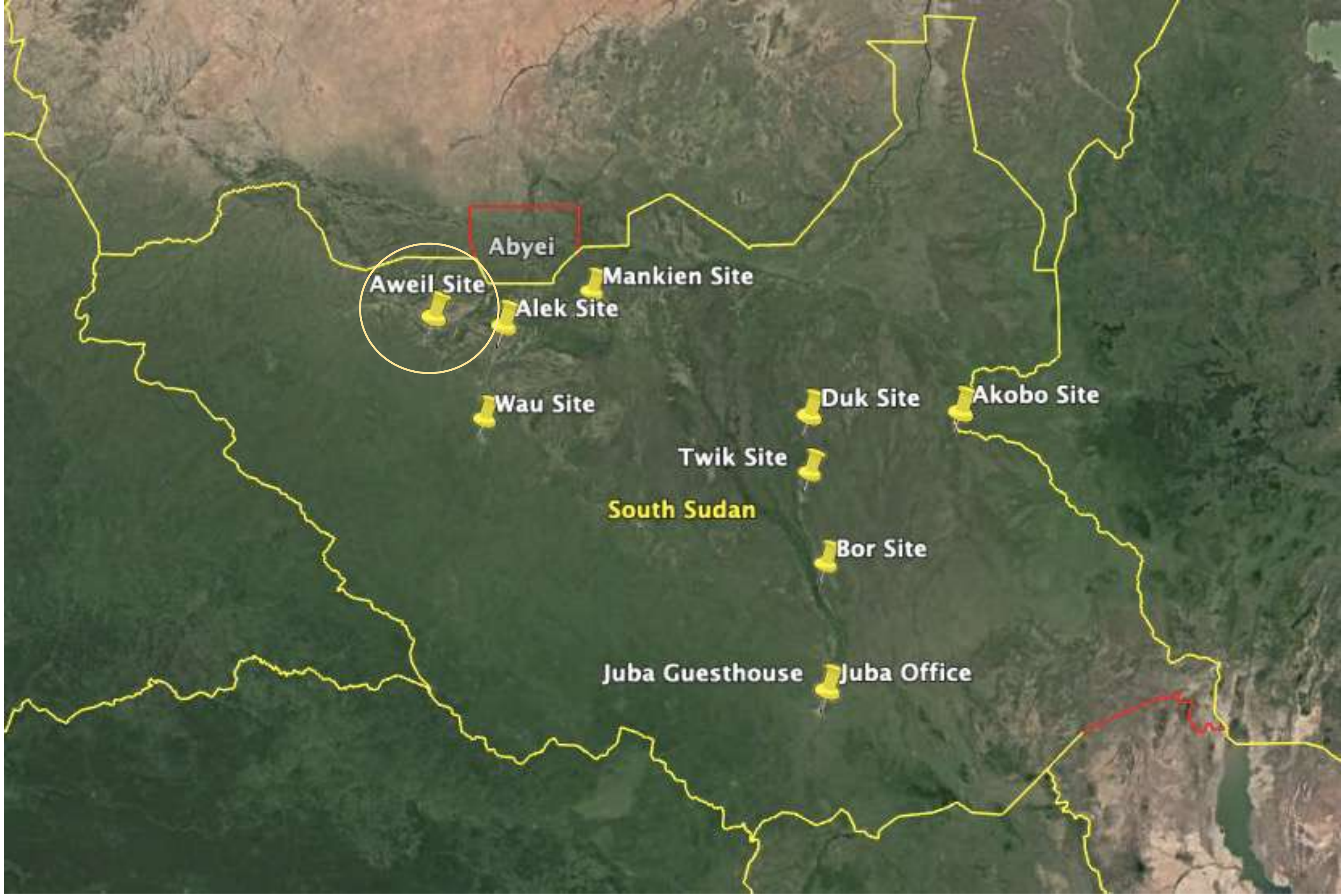
NRC Aweil Office



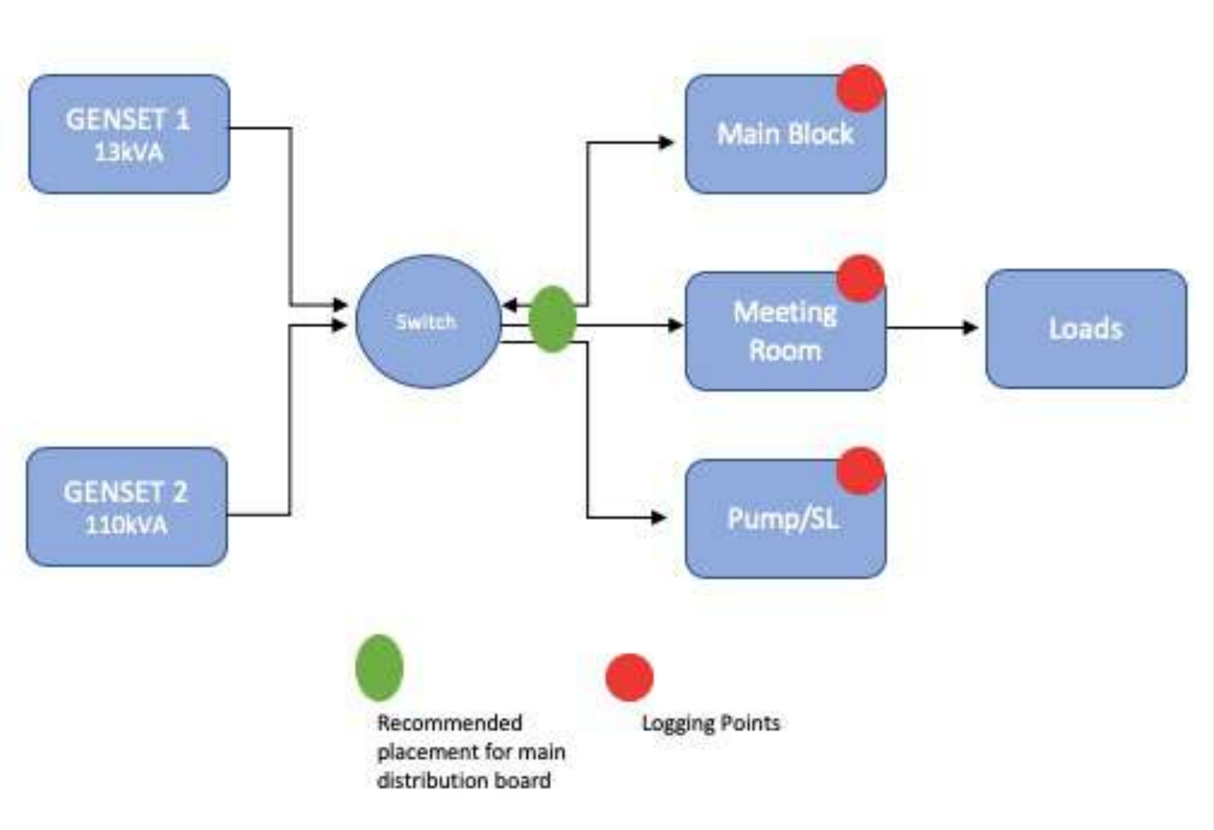
NRC Aweil Overview

Location Coordinates and features	**8°45’55" N, 27°23’40” E The site is low lying and flat in the middle of Aweil town. It is located in Ayuang district and has reasonably good access to other parts of the country.**
Site Operation and Staff Details	Currently, there are 20 NRC staff based in the Aweil office. Mentor Initiative and Safe World NGOs share the office space.
Site Physical Features	NRC Aweil compound has an area of 3880m^2. The compound contains a number of buildings and trees, and has limited available ground space.
Energy costs	In order to run generators on the shared compound, NRC purchased 23,520 liters of diesel over the last year at $1.30/l/. From modeled electricity demand and logged loads, electricity costs are about $0.57/kWh.

NRC Aweil Existing Power System

- Two generators are alternated in use. The smaller one (13 kVA) is used in the morning when air conditioners are not in use, the other (110 kVA) in afternoon and evening during higher use periods.
- Generators are operated for 14 hours/day
- Electric system is 3 phase.
- Both generators are operational.
- A 1100W solar PV system (800Ah batter) provides electricity for critical loads (internet) when the generator is off.
- Offices are poorly insulated and doors are often left open when AC is running.

- System wiring is not clear. There is no proper junction box at the generator and circuits are not well labeled. This prevented proper logging of the entire site.
- The solar PV and generator systems operate independently.



Aweil Generator Arrangement

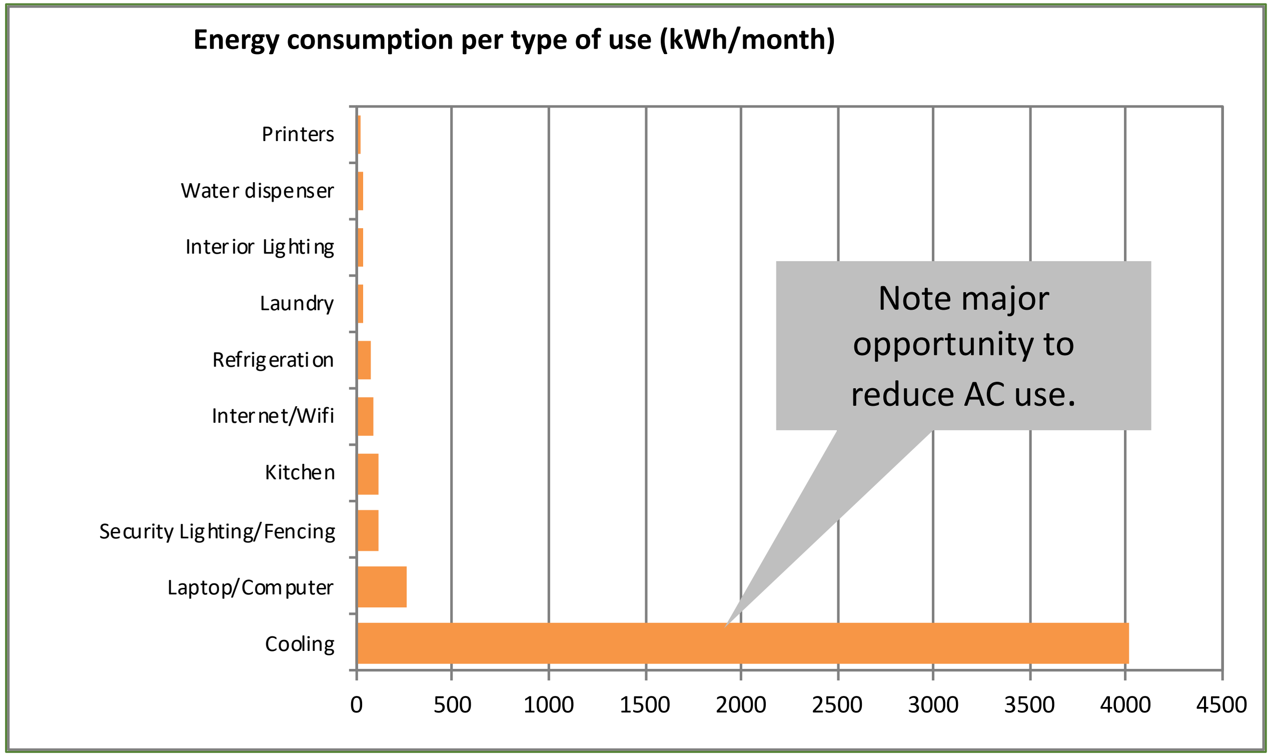
NRC Aweil Electricity Loads

Daily Energy Consumption

Load Category	Maximum Power draw	Adjusted Daily Use of Energy
	kW	kWh
Laptop/Computer	2.41	8.70
Printers	0.34	0.86
Security Lighting/Fencing	0.60	3.70
Interior Lighting	0.53	1.07
TV/Entertainment	0.10	0.69
Cooling	57.95	133.80
Refrigeration	0.33	2.27
Kitchen	17.04	3.69
Pump	2.25	0.56
Internet/Wifi	0.13	3.12
Water dispenser	0.43	0.97
Cell phone charging	0.10	0.13
Laundry	3.10	1.09
Total	**85.30**	**160.60**

NB: Need for extended logging to confirm estimates made from 4 day measurements.

- **Daily Energy Requirement (including losses):**
  177 kWh/day (hot season)
- **Peak demand :**
  > 50 kW (with AC's connected)
- **Major loads:**
  Air conditioning (28 units connected!)
- **Seasonal variance.** Site was audited and logged during cool season most ACs were disconnected.
- System suppliers will be required to propose a system that meets the energy needs of the loads listed.



NRC Aweil System Design 1

Parameter	Required or Recommended Feature of Proposals
Main System Recommendations	• Design based on **5.16 kWh/day** insolation design month (June) • Battery reserve days: **1.5 days**, 50% maximum DoD • System designed to supply load in hot season • Lithium ion system with containerized storage recommended
System voltage	• **48 VDC**
Daily System Charge Requirement	• **3681 Ah per day at 48V**
Minimum solar array design charge output	• **713A at 48V**
Estimated solar array size	• **40 kW**
Module features	• Crystalline modules only • All PV modules Tier 1 type with international certification • Clear labeling modules.
Array mounting	• Roof mounting or carport mounting • Mounting material to use aluminum or metal material coated with viable rust-proofing.
Earthing & lightening protection	• Electrical system, array mounting and equipment housing must be properly earthed

NB: Over 80% of the load is air conditioning. The AC system is quite ”leaky” and inefficient with cool air escaping from poorly fitted windows and doors left open.

Before investing in a large energy system for this site, efforts should be made to improve the management of the AC load, increase the performance of the system and seal leaks in the windows.

Increased efficiency could save money and decrease the size of the required solar PV system.

NRC Aweil System Design 2

Parameter	Required or Recommended Feature of Proposals
Charge regulation requirements	• **48 VDC** rating • Total combined charge control design: **892 A** at **48 VDC** • Charge controllers must have international testing certification, clear labeling/data sheets. • Charge control must feature maximum Power Point Tracking, PWM, reverse polarity protection.
Charge regulation recommendations	• Charge control selection depends on number and type of solar modules, type of coupling (AC or DC) and number of PV sub-arrays. • Suppliers can recommend equipment based on proposed system designs.
Battery bank requirements	• Minimum capacity **11000 Ah at 48V** • Rated battery life at 25% DoD: 3500 cycles • Battery bank includes DC battery fuse, properly sized battery cabling, battery rack.
Battery bank recommendations	• Battery design for 50% DoD maximum • Lithium ion system recommended with cooled containerized storage.

NRC Aweil System Design 3

Parameter	Required or Recommended Feature of Proposals
Inverter charger requirements	• **48 VDC rating** • Pure sine wave • **40 kW** continuous load • **50 kW** surge • Inverter charger with a capacity to connect with a back up generator is required. • Inverters must have international testing certification, clear labeling/data sheets.
Inverter charger recommendations	• To meet the rigorous conditions in remote site, the following top tier brands of inverter chargers are recommended: Outback, Sunny Island (SMA), Victron. • Other suitable types can be proposed with provided that documentation of their viability is provided.
System monitor	• Inverter or system must have on-line monitoring features that enable remote monitoring of daily solar output, battery state of charge and (if possible) load usage

NRC Aweil System Layout: PV size and location

Nominal Size of Array	Area Available	Type	Total Area Required for System and Comments
23kW	Rooftops of Southern buildings (813m²) + middle buildings and carpark (936m²) + green roofed building (295m²) Total area = 2000m²	Rooftops or carport	Several trees on lot shading sections of roofs. Total Power Output = Total Area *Solar Irradiance (1000W/m²) *Conversion Efficiency (0.15) Total Area required = 153m² (15% efficiency)

The system will be installed on the site shown.

- Inverters and battery will ideally be placed in or near the generator room.
- The solar array can be mounted as a car port or on a rooftop near the generator house.
- Installers may be asked to work with the electrical installation at the site.

Final Words

Good news: We know how to make solar PV systems work. PV systems can be more reliable than traditional fuel-based generators. Technology and O&M capabilities are only getting better.

For humanitarian agencies adopt renewables they must observe the same processes they use to make the other technologies work.

- **Independent energy experts** need to be involved in energy auditing and specification of systems. NOT be the company selling the system.
- **Procurement and installation** should be provided with resources and expertise. Agencies should take responsibility and prepare proper tenders and after service arrangements.
- **Providers** should ensure that staff understands the system. Relief organizations should assign responsibility for equipment operation and always include O&M agreements with local providers. Companies should provide on-line system monitoring and management services.
- Those that **manage and provide finance for relief operations** should develop finance models for large *and* small systems. They should use finance tools to broker functionality agreements with system providers.
- **Humanitarian agencies** are critical to the process of building off-grid energy infrastructure. Some of the same people and communities that they serve will be critical links in the infrastructure they are helping to build.

Thank you for your attention

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https://www.linkedin.com/pulse/why-solar-pv-systems-humanitarian-sector-fail-what-players-hankins/

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