SOLAR ENERGY PRODUCTS
APPRECIATION COURSE
APRIL 2019

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Solar Group Manager
SOLAR ENERGY PRINCIPLES

- Energy emitted by the sun
- Measure in watts/m², at standard testing conditions max solar irradiance = 1000w/m²
- Converted to thermal (e.g. solar water heaters) and electrical (e.g. Photovoltaic modules) energy
- Energy optimised by tracking sun’s E-W axis
- Varies throughout day and year
SOLAR ENERGY BASICS

Solar Energy

- Thermal Energy
  - Solar Hot Water Systems

- Electric Energy
  - Solar Power And Lighting Systems
  - Solar Water Pumping Systems
Basic Components of PV System

- Solar Array
- Charge Controller
- Battery
- Inverter
- DC Load
- AC Load
PV APPLICATIONS AND BENEFITS

- **PV applications**
  - Household appliances such as, televisions, radios, laptops, stereos, etc.
  - Water pumping for small-scale remote irrigation, stock watering, residential uses and remote villages.
  - Lighting for residential needs, billboards, security, highway signs, streets and parking lots, pathways, remote villages and schools.
  - Communications by remote relay stations, emergency radios, orbiting satellites, and cellular telephones;
  - Refrigeration for medical and recreational uses;
  - Utility grids that produce utility- or commercial-scale electricity.

- **Benefits of PV:**
  - Portability,
  - Reliability,
  - Low operating costs,
  - Low environmental impact,
  - Stand-alone capability,
  - Modularity
  - Safety
  - Versatility
  - Ease of installation
Types of PV Systems:

1. Direct Current (DC) only System

Diagram of Direct-Current (DC) System:
- PV modules
- Charge controller
- Grounding circuit
- Electric load (DC)
- Battery
Types of PV Systems:

1. Direct Current (DC) only System
Types of PV Systems:

2. Alternating Current (AC) only System

[Diagram of a home solar power system showing components such as Charge Controller, PV Modules, Inverter, Battery, and Electrical Appliance (AC).]
Types of PV Systems:

3. Combined DC & AC System
Types of PV Systems:

4. PV/Generator Hybrid System
Types of PV Systems:

5. Direct PV System
6. GRID CONNECT PV SYSTEMS
GRID TIE SOLUTIONS

Energy system which is formed by combining two or more subsystems that produce the same or similar results.
Photovoltaic Technology

• A technology that converts the radiant energy of sunlight to electricity
• Solar cells are the basic building.
• Solar Cells made of silicon
• Cells are connected together to form modules.
• Modules, in turn, are connected to form arrays

a silicon solar cell
Sunlight falls onto a solar cell.

The solar cell material absorbs some of the light particles (so called photons).

Each photon contains a small amount of energy.

This energy frees some electrons in the material of the solar cell.

Since both sides of a solar cell are electrically connected with a conductor, a current flows.

The solar cell now produces electricity, which can be used instantly or stored in a battery.
SOLAR CELLS

• Voltage generated by a solar cell: ~ 0.5 V
• The current generated depends on its SIZE
• Efficiency: Depends on technology
  (amorphous, multi or mono crystalline)
1. **Monocrystalline**
   - Efficiency: 16%
   - Chemically stable
   - Last long (25-yr warranty)

2. **Multicrystalline**
   - Efficiency: 9-13%
   - Long lifetime (20-yr warranty)
   - Made from different silicon material than mono
   - Have multiple colour tones and patterns

3. **Amorphous**
   - Efficiency: 3-6%
   - Most recent technology
   - Most cheaply produced
   - Don’t use silicon in crystalline form
   - Degrades over time
   - Applications: where space not a limitation; <40W
FROM CELL TO ARRAY
Factors that affect output from a PV module

- Temperature
- Insolation - Strength of irradiation
- Orientation to sun
- Battery voltage
IV Curve 1

Current (amperes) vs. Voltage (volts) for a 20 Wp PV module under Standard Conditions: 1000 W/m², 25°C.

Key Points:
- **Isc**: Maximum Power Point
- **Voc**: Operating Voltage

The graph illustrates the relationship between current and voltage for the PV module.
SOLAR PV CELL PRICING

- Average global PV module price < 1$/Watt in 2014, D&S pricing at KShs115/watt
- Reduction in production costs
- Increased competition & production
- New technologies, growth of production capacity and better production processes
- Improve the cell conversion efficiencies.
- The battery stores electricity for use at night or for meeting loads during the day when the modules are not generating sufficient power to meet load requirements.

- It does this by converting the electrical energy from the panel to chemical energy during storage and converting the chemical energy back to electrical energy during use.

- The capacity of a battery is measured in **amp hours (Ah)**. This indicates the amount of energy that can be drawn from the battery before it is completely discharged. A battery of 100 Ah should ideally give a current of 2 amps for 50 hours (i.e. 2 amps times 50 hours equals 100 amp hours).

- It is **impossible** to remove more energy from the battery than is put in by charging.
Batteries in PV Systems

- The Battery is the heart of a PV System.
- A PV system is as weak/stronger as its battery bank.
- It is the Electricity Storage part of a PV System.
Choosing Batteries

Deep Cycle Batteries
- offers long hours of power.
- Can handle up to 80% DoD

Automotive batteries (SLI)
- are shallow-cycle - not for use in PV system
- designed with only about 20% DoD. Beyond 20% damages battery

Modified automotive batteries (MSLI)
- 35-40% DoD, can be used in PV systems
- Modified SLI have thicker plates and larger acid wells than normal SLI types
Remember....

• Batteries can be connected in Series, parallel or in a parallel/series configuration.

• Always connect batteries of similar capacities, age and states of charge together.

• When installing a Battery in a PV System for its first use ensure that it is Fully Charged before being loaded.

• Batteries surfaces must always be kept clean.
CHAMPION BATTERIES

- Available in 12VDC and 2VDC
  - Higher storage capacity
  - Absorbent Glass Mat (AGM) technology
  - Can be mounted in any orientation
  - Design Life – 20 years
  - Maintenance-free operation
  - Low self discharge

2VDC- 400AH, 800AH, 1200AH, 1500AH
HOPPECKE BATTERIES

OPzV / OPzV solar.power

- Sealed lead-acid battery Single Cell
- electrolyte: fixed as gel with SiO2
- design life time 18 years or 3000 cycles at 50% DoD
- capacity range 200 to 3000Ah
- horizontal position (Option) up to 1500Ah
- excellent cycle stability in PSOC (partial state of charge)

Typical applications
- Village power supplies
- Hybrid systems
A charge controller is the **Regulator** of the flow of electricity from the PV modules to the battery and the load.

It protects the battery from:

- **Over-charging**; Over voltage protection prevents batteries from being over-charged-Useful in unattended systems

- **Deep (over) discharging**; Low Voltage Disconnect lengthens life of battery by disconnecting loads when battery is low.
Basic Features of Charge Controllers....

2. **Indicator** of system performance, thus offering user knowledge of system

3. **Connection point** for the module, battery and load
Other extended features of charge controllers

- Fuses & MCB
- Reverse polarity protection
- Surge & lightening protection
- High temperature disconnect
- Battery type selection
Considerations when Selecting Regulators

- Maximum module current rating
- Maximum load current rating
- System Voltage (12, 24, etc)
- Physical characteristics of charge regulator – IP Rating
D&S CHARGE CONTROLLERS

Apple
- 5A, 10A & 15A, PWM
- 12VDC

Steca,
- 20A, 30A & 40A, PWM
- 12/24 & 48 VDC
- Multi-coloured LCD Display

Opti
- 50A & 80A MPPT
- Gives 20-45% power gain over
- 12/24/48 VDC
- LCD Display
PWM VS MPPT CHARGE CONTROLLER: 75W MODULE

Conventional controller charging at 12V only extracts about 53W.

Solar Boost MPPT controller operates module at its maximum power voltage extracting full 75W.
• Inverters convert Direct Current (DC) to Alternating Current (AC)

• They change the voltage from either 12/24/36/48VDC to 120/240VAC
Why use Inverters??

- They allow battery based systems to run conventional appliances such as TV’s, Videos, computers and fridges.
- They allow the user to run these systems through conventional wiring.
- Suitable for large PV Systems which have long cable runs.
- Useful in modern power back up system applications.
  - Inverter/charger with batteries for emergency power supply.
Categories of Inverters...

- **Square wave Inverters**
  - Old technology, less common and quite inefficient.

- **Modified-Sine Wave**
  - Common & relatively good for domestic non professional applications

- **Pure Sine Wave**
  - Relatively Expensive, ideal for any type of loads within their capacities
There are three levels of power rating:

1. **Continuous rating**: The amount of power the inverter can handle for an indefinite period of hours. This is normally the inverter rating.

2. **Limited-time rating**: The amount of power the inverter can handle for short period of time when an excess load above its continuous power rating is placed on the system. 10 or 20 minutes.
3. **Surge rating**: This is how much the inverter can handle for literally a few seconds while it deals with power spikes caused by the switching ON of equipment such as amps, fans, motors, tv’s etc motors. These are called inductive loads.
Inverter Efficiency

- Inverters are most efficient when the load is operated at about 70-75% of the inverter capacity.
- Inverters consumes power when ON, even with no load connected - idle/standby power.
INVERTER EFFICIENCY

1000 W in → Inverter 80% efficiency → 800 W out

Losses (Heat) 200 W
Considerations when Selecting Inverters

- Power and surge capacity
- Inverter input voltage
- Power quality needs - Either Modified or True sine wave
- Cost
- Consumer
Izzy Inverters
- Inverts DC to AC with special application for solar systems
  - Ranges from 350Watts – 2000Watts
  - Special features include
    - Overload protection &
    - Auto-restart after overload tripping

Vispra Inverter/Chargers
- Pure sine wave output
- Used for Power back-up applications

Opti Inverter/Chargers
- Opti Smart Inverters
  - Pure sine wave output
  - Used for Power back-up applications
- Opti Solar Inverters
  - All-in-one solution for all solar systems applications
  - Pure sine wave output
  - Has a built-in charge controller
  - And is compatible with both inductive and resistive loads
OPTI INITIAL & EFECTO
HYBRID INVERTER/CHARGERS

- Pure sine wave power output
- Less than 10ms transfer time from mains
- Efficiency of 93%
- Generator compatible
- Built in AC charger and PV solar charger suitable charging
- Overload and short circuit protection
- LED monitoring panel and audible alarm
- Remote system monitoring facility with RS232 interface (Efecto only)
- Suitable for parallel connection capability (Efecto only)
VICTRON POWER BACK-UP INVERTER/CHARGERS

- A premium “European Quality” range inverter suitable for off grid applications, for solar systems or for high specification power back-up systems.
- Low frequency super robust Toroid Transformer.
- Fully automatic mains/inverter changeover in less than 5 milliseconds.
- In addition to parallel connection, three units of the same model can be configured for three phase output.
- Available Range 0.8kW – 10kW
System Sizing
Basics of DC Electricity

Basic DC circuit:
- Battery
- 12V DC
- Ammeter
- Fan
- Switch
- Fuse
ELECTRICAL UNITS

Power law and Ohms law

<table>
<thead>
<tr>
<th>ELECTRICAL PROPERTY</th>
<th>ELECTRICAL UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>VOLTAGE (V)</td>
<td>VOLTS (V)</td>
</tr>
<tr>
<td>CURRENT (I)</td>
<td>AMPS (A)</td>
</tr>
<tr>
<td>RESISTANCE (R)</td>
<td>OHMS (Ω)</td>
</tr>
<tr>
<td>POWER (P)</td>
<td>WATTS (W)</td>
</tr>
</tbody>
</table>
Loads connected in series

- In most electrical distribution systems, loads are connected in parallel.
- Neither fan nor light work properly and both have to be switched together

\[ I = I_1 = I_2 \text{ but } V = V_1 + V_2 \]
Loads connected in parallel

• Both fan and light work properly and can be controlled by individual switches
In parallel $I_t = I_1 + I_2$ but $V_t = V_1 = V_2$

$P_{\text{total}} = V \times I$

$P_{\text{fan}} = V \times I_1$

$P_{\text{light}} = V \times I_2$
Calculating Power in Circuits

What is the power used in P1?

What is the power used in P2?

What is the total power consumed?

P_{\text{TOTAL}} = ?

I = 2 A

I_1 = 0.75 A

I_2 = 1.25 A

P_1 = ?

P_2 = ?
Batteries, Solar Modules in Series and Parallel

- Batteries and modules can be connected in series and parallel depending on the required current/voltage output.

**Battery parallel connection**

\[ V = V_1 = V_2 = V_3 \]

**Battery series connection**

\[ V = V_1 + V_2 + V_3 \]
The Sizing Process

STEP 1:
Calculate the Daily Energy Requirement (Wh/day)

STEP 2:
Work out the PV Module Size Wp

STEP 3:
Battery capacity in Ah

STEP 4:
Charge Controller Size in Amperes

STEP 5:
Size cables and other BOS eg Inverters
Calculate the Load Requirement

- Gather data from the customer on the system load and the usage pattern
- Include about 20% to cover on losses and inefficiency and work out the Daily System Energy Requirement
- This will be calculated in watt hours
Step 1: Estimating Energy Consumption

- To size your PV system, you must first know your energy needs, which you figure by listing all your daily loads. A load includes anything that uses electricity from your power source, such as lights, televisions, radios, or phone charger.

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Voltage</th>
<th>Load (W)</th>
<th>Daily hrs of use</th>
<th>Energy Consumption (watt-hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

Total Daily Energy Demand (Wh)
## Estimating Daily Load (2)

<table>
<thead>
<tr>
<th>Appliance</th>
<th>Voltage</th>
<th>Load (W)</th>
<th>Daily hrs of use</th>
<th>Wattage Consumption (watt-hrs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio</td>
<td>9</td>
<td>6</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Lamps (fluorescent)</td>
<td>12</td>
<td>10</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>VCR</td>
<td>12</td>
<td>13</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Color Television</td>
<td>12</td>
<td>75</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Refrigerator</td>
<td>240</td>
<td>120</td>
<td>3</td>
<td></td>
</tr>
</tbody>
</table>

**Total Daily Energy Consumption**
Estimating Daily System Charge Requirement

• If there are AC appliances, they must be calculated separately, as this will contribute to the sizing of the inverter.

• When summing up the total daily load, add 20% to account for losses and inefficiencies.

• The final figure will be the Daily System Power Requirement.
Step 2: Sizing the Solar Module/Array

- The solar module will be the source of all energy in the system.
- Enough solar modules must be installed to provide all of the daily load requirement.
- We use the module charging current to estimate each module output.
Sizing Array

- Modules should be chosen according to the daily energy requirements of the system load.
- Size of array is called System Design power requirement
- This is expressed in Watts.
- Use this number to estimate number of modules

\[
\text{Daily System Energy Requirement (Wh)} \div \text{Design Solar Insolation Value (kWh/m²/day)} = \text{Solar Array System size required (W)}
\]
Sizing Modules

**AP-50 ELECTRICAL/MECHANICAL CHARACTERISTICS**

### Typical Electrical Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Power <em>(Wp)</em></td>
<td>Watts</td>
<td>60</td>
</tr>
<tr>
<td>Open Circuit Voltage <em>(Voc)</em></td>
<td>Volts</td>
<td>21.5</td>
</tr>
<tr>
<td>Max. Power Voltage <em>(Vmp)</em></td>
<td>Volts</td>
<td>16.7</td>
</tr>
<tr>
<td>Short Circuit Current <em>(Is)</em>*</td>
<td>Amps</td>
<td>3.3</td>
</tr>
<tr>
<td>Max. Power Current <em>(Im)</em>*</td>
<td>Amps</td>
<td>3.0</td>
</tr>
<tr>
<td>Short Circuit Temp. Coefficient</td>
<td>mA/°C</td>
<td>+1.5</td>
</tr>
<tr>
<td>Open Circuit Voltage Coefficient</td>
<td>V/°C</td>
<td>-0.09</td>
</tr>
<tr>
<td>Max. Series Fuse</td>
<td>Amps</td>
<td>5</td>
</tr>
</tbody>
</table>

@ Standard Test Conditions (defined as: Irradiance = 1000 W/m²; cell temperature = 25°C; AM 1.5G solar spectrum.)

*Rated power tolerance ±10%

### Typical Operational Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Operating Cell Temp. (NOCT)</td>
<td>45°C</td>
</tr>
<tr>
<td>(Determined under: Irradiance = 800 W/m²; ambient temperature = 20°C; wind speed = 1 m/s)</td>
<td></td>
</tr>
<tr>
<td>Weight (Wind) Bearing Potential</td>
<td>50 lbs/ft² (125 mph equiv.)</td>
</tr>
<tr>
<td>Hallstone Impact Resistance</td>
<td>1” @ 50 mph (25.4 mm @ 80.5 kph)</td>
</tr>
<tr>
<td>Weight</td>
<td>16.6 lbs. (7.5 kg)</td>
</tr>
<tr>
<td>Dimensions</td>
<td>26.0 x 33.8 x 1.4 in.</td>
</tr>
<tr>
<td></td>
<td>(661 x 859 x 35 mm)</td>
</tr>
</tbody>
</table>
Step 3: Battery Sizing (1)

- The battery size is the capacity required to meet all energy storage needs of the system.
- It is based on several factors:
  - Daily System Energy Requirement (Wh)
  - Number of storage days required (days of autonomy)
  - Maximum allowable % Depth of Discharge (DoD)
Battery capacity required

\[
\text{System Battery Capacity (Ah)} = \text{Daily System Energy Requirement (Wh)} \times \text{Number of Storage Days Required (days)} \times \text{Maximum Depth of Discharge (\%)} \times \text{Battery System Voltage (V)}
\]
Step 4: Sizing the Charge Controller

1. Short Circuit Current produced by your solar module. (see module specifications)

2. Get the number of Parallel strings from your solar array

3. Get the total current from each string of the solar array

4. Multiply line 2 by line 3. This equals your total Amps.

5. Choose a charge controller with an Amp rating no lower than Line 3.

6. If the possibility of increasing the overall capacity of your solar system is anticipated install a larger capacity charge controller.
Step 5: Sizing the BOS

1. Map site and estimated cable runs
2. Work out voltage drops and determine wire sizes to use
3. Size fuses
4. Size inverter
Step 5: Sizing the BOS

Sizing the Power Inverter

• Add up all AC loads power ratings to get the instantaneous load size

• Add 25% of this figure to determine the minimum inverter size to use.

• Remember in case of motors loads, use a least factor of two times the motor to determine the inverter size.
PV module mounting options

- Roof top
- Pole mount
- Ground mount
- Tracked mount
SUCCESSFUL PROJECTS

8KW solar lighting system in Turukana
SUCCESSFUL PROJECTS

7 KW solar lighting system in Kapiti
SOLAR HOT WATER SYSTEMS TECHNOLOGY
Operating Principle

A solar collector heats water which is stored in a close coupled tank. Heating process enhanced by ‘thermosyphon principle’ which occurs when there is a temperature differential in the system.
# HOT WATER DEMAND CALCULATIONS

<table>
<thead>
<tr>
<th>Type of Building Premises</th>
<th>Specific Daily Hot Water Demands (DHWD) in Litres per day at 60 ºC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Domestic residential houses</td>
<td>30 per person</td>
</tr>
<tr>
<td>Educational Institutions such as colleges and boarding schools</td>
<td>5 per student</td>
</tr>
<tr>
<td>Health Institutions such as Hospitals, Health Centres, Clinics and similar medical facilities</td>
<td>50 per bed</td>
</tr>
<tr>
<td>Hotels, Hostels, Lodges and similar premises providing boarding services</td>
<td>40 per bed</td>
</tr>
<tr>
<td>Resturants, Cafeterias and similar eating places</td>
<td>5 per meal</td>
</tr>
<tr>
<td>Laundries</td>
<td>5 per kilo of clothe</td>
</tr>
</tbody>
</table>
DIRECT SOLAR SWH SYSTEM

DESIGN FEATURES

- High pressure galvanised steel storage tank with internal piping designed to maximise hot water availability.
- 3kW electric booster heater.
- Outlet piped from hottest area of tank with air bleed and pressure release valve fitted.
- Pure aluminium powder coated frame.
- Multi-layer internal insulation including injected polyurethane base coated with mineral wool and covered with aluminium foil.
- Screwed brass outlets.
- Elegant long life GRP resin insulated tank casing.
- Full area black coated copper absorber sheet ultrasonically welded to the risers to maximise heat transfer.
- Copper riser pipes and manifold tubes.
- High transmittance tempered security glass cover.
- Rigid galvanised rectangular section mounting frame for ease of installation.
INDIRECT SOLAR HOT WATER

Technical information:
- Internal coating: Glazed enamel
- Cathodic protection: By Mg Anode bar
- Insulation: Direct-injected monoblock Polyurethane hard foam.
- Solar heating liquid - Glycol
- Flat Roof or Tiled roof type mounting set

Three different models:
- 150Litres
- 200Litres
- 300Litres
Vacuum Tube SHW systems are the most efficient water heating systems available.

Solar energy is captured in the vacuum sealed glass tube, quickly heating the water in the copper heat pipe.

The heated water rises to the top of the pipe and collects in the tank.

**Capacity:** Hot water 200 litres

**Vacuum tubes:** 20 pieces

**Mounting:** Flat roof mounting set
HEAT PIPE SOLAR HOT WATER

- They are of vacuum glass design and are suitable for pressurized systems
- They feature a series of heat pipes, with purified water, sealed within vacuum glass tube
- Heavy duty stainless steel tank
- Nickel coated silver shinning heat pipe with temperature range of -40°C to 300°C
- Galvanized mounting frame
- Available in 150L, 200L & 300L
VACCUM TUBE Vs HEAT PIPE

- Solar Tank
- Open to air
- PUF Insulation
- Hot Water
- Outer Cladding
- Cold Water
- Working Picture

- Glass tube with high vacuum
- Condenser, heat exchanger
- Heat pipe
- Selectively coated absorber sheet
- Solar cycle heat carrier
COMMERCIAL SOLAR HOT WATER SYSTEMS

Available in:
1,000L
1500L
2000L

Domestic Vertical SWD
Available in:
300L
400L
500L
Electronic Solar Controllers

Main Functions:
- Time and temperature display
- Timing heating at three time sections
- Manual heating activation
- Control thermostat when heating
- Memory protection on power failure
- Trouble indication sensor

STDC Version 1
3 temperature sensor inputs
1 relay output 230VAC (on/off)
TDC CONTROLLER
COMMERCIAL SOLAR HOT WATER

- Long life free standing tanks
- Magnesium anode-rod protection
- High performance circulator pump
- Advanced programmable controller

Commercial Solar Water Heaters
Available in 1,000L, 1500L, 2000L

Domestic Vertical Solar Hot Water Heaters
Available in 150L, 200L, 350L & 500L
ADVANTAGES OF SOLAR HOT WATER SYSTEMS

- Huge Energy Savings – Payback of less than 2 years
- Uses abundant free solar energy
- Abundant Hot Water – 24 hours a day
- Huge Environmental benefits
- Long lifespan – over 20 years
- Maintenance-free System
SUCCESSFUL SWD PROJECTS

Installation of 252 No. 300L Systems

Freedom Heights is a unique and luxurious apartments and mall along Langata Rd opposite carnivore entrance
SUCCESSFUL SWD PROJECTS

Aaran Property: 24No. SWD320L Solar Hot Water Installation in Parklands
SUCCESSFUL SWD PROJECTS

KCB Leadership Center Solar Hot Water Installation
SUCCESSFUL COMMERCIAL SOLAR HOTWATER PROJECTS

6,000Litres Commercial Solar Hot Water System, Human Needs Project, Kibera
SOLAR WATER PUMPING SYSTEMS
SOLAR WATER PUMPING SCHEMATIC
SOLAR WATER PUMPING-
CHEAPER, CLEANER, SUSTAINABLE
SOLAR WATER PUMPING

- With the continued reduction in PV module prices and also advances in solar pumping technology, solar pumping has become the default solution for water supply in rural areas and D&S is the industry leader offering a comprehensive range of products for all solar pumping applications.
ADVANTAGES OF SOLAR PUMPS

Why Solar Pumping?

- Lower Total Cost of Ownership
- Higher reliability & Life expectancy
- Fast & Simple Installation
- Shorter Return of Investment Cycle
- Almost Maintenance Free
- Ecologically Sustainable
- Can be used even in Remote Areas
- Operate Quietly (as compared to diesel generators)
GLOBAL FACTS

- Increased demand for natural resources
- Climate change
- Energy required to access ground water
- Fossil fuels are expensive
- Grid power often not available or not reliable
SOLAR IRRADIATION COMPARISONS

Europe

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Value (kWh/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00</td>
<td>0.03</td>
</tr>
<tr>
<td>9:00</td>
<td>0.09</td>
</tr>
<tr>
<td>12:00</td>
<td>3.6</td>
</tr>
<tr>
<td>15:00</td>
<td>0.41</td>
</tr>
<tr>
<td>18:00</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Africa

<table>
<thead>
<tr>
<th>Time (h)</th>
<th>Value (kWh/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6:00</td>
<td>0.16</td>
</tr>
<tr>
<td>9:00</td>
<td>0.54</td>
</tr>
<tr>
<td>12:00</td>
<td>5.9</td>
</tr>
<tr>
<td>15:00</td>
<td>0.59</td>
</tr>
<tr>
<td>18:00</td>
<td>0.16</td>
</tr>
</tbody>
</table>
Key components

- Pump
- Solar Generator
- Controller
- Water storage
- Water distribution
Basic terms and calculations

Important concepts

- Water per day
  - Total water requirement for the application
  - Pump water during daylight hours

- Store water not electricity
  - Make water available when needed
  - Simple and efficient
SOLAR WATER PUMPING SOLUTIONS
DC- SOLAR PUMPING
DC SOLAR SUBMERSIBLE PUMP

- For Shallow Well Applications
- Rotary screw design, stainless steel with rubber stator
- Features in-built controller
- Motor: Permanent Magnet, oil filled, brushless, DC Motor
- Power by solar array, sized appr. 130% of the rated motor power
- Three Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Input Voltage</th>
<th>Motor Rating (W)</th>
<th>Input Power (W)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D3SOLAR-A 150H</td>
<td>24</td>
<td>150</td>
<td>200</td>
</tr>
<tr>
<td>D3SOLAR-A 270H</td>
<td>36</td>
<td>270</td>
<td>350</td>
</tr>
<tr>
<td>D3SOLAR-A 600H</td>
<td>48</td>
<td>600</td>
<td>780</td>
</tr>
</tbody>
</table>
DC SOLAR SUBMERSIBLE PUMP

- Borehole applications
- Pump are stainless steel, and helical rotor type are supplied with spare rotor
- Features a surface mounted MPPT controller
- Permanent Magnet, brushless high efficiency DC Motor with integrated electronics
- Three Models

<table>
<thead>
<tr>
<th>Model</th>
<th>Type</th>
<th>Power kW</th>
<th>Max Current (A)</th>
<th>Max Voltage (VDC)</th>
<th>Required MPP Voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td>D4SOLARX0600H</td>
<td>Helical Rotor</td>
<td>0.6</td>
<td>15</td>
<td>150</td>
<td>60-120VDC</td>
</tr>
<tr>
<td>D4SOLARX1200H</td>
<td>Helical Rotor</td>
<td>1.2</td>
<td>15</td>
<td>200</td>
<td>120-160VDC</td>
</tr>
<tr>
<td>D4SOLARX1800C</td>
<td>Centrifugal</td>
<td>1.8</td>
<td>15</td>
<td>200</td>
<td>120-160VDC</td>
</tr>
</tbody>
</table>
SUNFLO DC SOLAR SUBMERSIBLE PUMP

- Designed for reliable small-scale water supply from wells or boreholes
- Positive displacement 3-chamber diaphragm design, and can run dry without damage
- Pump components are manufactured from high quality plastics
- Pumps can be installed either with a direct connection to PV module or thro’ charge controller connected to battery for 24hr operation
- Two Models

<table>
<thead>
<tr>
<th>MODEL</th>
<th>Power (W)</th>
<th>Input Power (W)</th>
<th>Voltage (VDC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SUNFLO 150</td>
<td>120</td>
<td>150</td>
<td>24</td>
</tr>
<tr>
<td>SUNFLO 300</td>
<td>300</td>
<td>375</td>
<td>24</td>
</tr>
</tbody>
</table>
GRUNDFOS SQFLEX SOLAR PUMP

- IO 100 – Manual Solar System
- IO 101 – Solar/Generator System
- IO 102 – Wind System
- CU 200 – Solar System with High Level Control and Hybrid System monitoring.
- Input Voltage 96-300V
DC SOLAR PUMP SIZING

- Requirement
  - Use 1.3 Multiplier

- Example
  - D4SOLARX1200H requires 1200W*1.3 = 1560W ≈ 8*195W (two strings in parallel of four panels each)
  - Max voltage = No. of panels in series * V_{oc} = 4*45.4V = 181.6V
  - Input = No. of panels in series * V_{mp} = 4*36.7V = 146.8V

- Max immersion Depth 250m
SF 2 FUTURE PUMP

- SF1 upgraded to SF2
- An innovative solar powered pump specifically designed for small scale agricultural irrigation applications using low pressure sprays and drip
- Positive displacement reciprocating piston type
- The pump includes two components, an 2x40W (80w) solar panel with 6m suction hose and a spares kit.
- Upgradable to 120W
- Pumps up to 20,000l/day at low heads and will lift up to 15m
SUCCESSFUL PROJECTS

Grundfos SQFlex Solar Water Pumping System
SUCCESSFUL PROJECTS

Kapenguria
Solar surface pumps driven by the Grundfos MGFlex motor

- 2-pole motor with integrated variable frequency drive (VFD)
- Enables the motor to run at high frequency in a wide speed range
  - power input (P1) of 70 to 1250 W
  - motor speed range of 1000 to 3400 rpm
  - maximum input current of 5 A
- The motor is suitable for both DC and AC voltage

Control Boxes
IO 50: Manual Solar System
IO 101: Solar/Generator System

– CRFlex Pump ranges:
  - CRFlex 3-9 70m; 6.0 m³/hr
  - CRFlex 5-5 40m; 10.0 m³/hr
  - CRFlex 10-2 25m; 16.0 m³/hr
AC- SOLAR PUMPING
AC 3-PHASE CONTROLLER LAYOUT

Controller layout Schematic
This Shows a Typical Installation Using RSI/Lorentz Inverter, water storage tank and level switch to control start/stop. Equipment with DC disconnect Switch and surge protection
AC PUMP SYSTEMS

- Various sizes of controllers; 1.5kVA – 40kVA
- MPPT technology
- Automatic Digital control, data storage
  - Settable min & max speed
  - Protection for overcurrent, under voltage
d  overspeed, over temp.
  - Inputs for dry running
  - Automatic reset
SUNVETER 2 AC SOLAR PUMP CONTROLLERS

- Sizes, 1 phase 0.75kW – 4kW
- 3 phase 5.5kW – 37kW
- MPPT Voltage: 530-600VDC
- Max DC Input Voltage 750VDC
- Output frequency 0-60Hz.
- Sunverter 2 available with Hybrid Capability and remote monitoring
LORENTZ PSK2

- Suitable for all AC 3 phase motor sizes up to 37kW, suitable for both Grundfos and Dayliff Pumps
- Advanced MPPT capability
- Digital control for fully automatic operation, data storage and protection functions.
- LED display and control panel.
- Smart PSU connection
- Ability to prioritize water delivery or power type in hybrid applications.
- Remote monitoring capability using the Lorentz pump MANAGER
GRUNDFOS RSI

- Sizes 3kW – 22kW, 3phase
- Maximum input DC voltage 800VDC
- Minimum MPPT Voltage: 400VDC
- Output frequency 5-60Hz.
- Digital input for dry running and level switch
Example: Using Dayliff Motor and Lorentz Controller

Pump: Dayliff DS 8-50 (Motor size 7.5KW)
Step 1:
Check a corresponding suitable Lorentz AC Controller, 7.5KW
- MPP Voltage: 500-600VDC
- Max DC Input Voltage: 850VDC

Step 2:
Using a multiplier of 1.3 determine the power requirement.
- Min Power requirement = 1.3*7500 = 9750W
- Chose the desired solar panel size, say Yingli 195W.
- No. of Panels required \( \frac{9750W}{195W} = 50 \) Panels
Step 3:
Using the Max DC input voltage 850VDC, determine the maximum number of panels that can be connected in series.

- Yingli 195W VOC=45.4V, $\frac{850}{45.4} = 18.7 = \text{maximum 18 panels in series}$

Step 4:
Using the MPP voltage range for the controller (500-600VDC), determine the number of panels and arrangement that can give maximum power and that the controller can operate best with.

- Yingli 195W VP=36.7V, $\frac{600}{36.7} = 16.3 = \text{maximum 16 panels in series}$

Step 5:
Determine the total number of panels required. Required number of panels is 50 panels, the panels must be connected in series in multiples of 16. Therefore we will have 3 strings of 16 panels= 48 panels.
Pump controller operation

- Power switch
- Power source is present
- Motor is running
  - RPM indicator by number of flashes
  - Red LED means overload
- Water level is too low – pump stops
  - Restart 20 minutes after recovery
- Tank is full
  - Pump turns off
- Battery voltage is too low
  - Pump turns off
Water level control and sensor

- Low-water probe installed in well
- Dry run protection
  - Stops the pump
  - Restarts automatically (20 min)
  - Flexible installation

- Tank full input can be used to remotely switch off the pump. Typical uses are:
  - Float switch installed in tank
  - Remote pressure switch (distant tank)
  - Sun Switch
Accessories / Ancillaries

- Power Packs for grid / generator connection
- SunSwitch for constant pressure / large pump applications
- Well probe sensors to avoid dry running
- Splice kits for connecting submersible cables
- Float switches for tank full indication when pumping to a storage tank
- Pressure sensors for remote tank switch off
- DC disconnect devices for solar array safety
LORENTZ DATA PORTFOLIO
REMOTE MONITORING

PS Communicator

PS Controller

PS DataModule

PumpScanner

LORENTZ pumpMANAGER

at&t

verizon

T-Mobile

Entel

Telefónica
REMOTE MONITORING

BENEFITS

• 24/7 monitoring
• Completely wireless – anywhere on earth
• Recording of pump parameters - Real time & historical
• Remote configuration & programing – time saving
• Alerts via email and SMS in the event of a system problem - before they threaten production
• Long term measurements
• Improve water availability, delivery, regulation and analysis
• If you can't measure it you can't manage it.
COMPASS

The ultimate sales, sizing and specify tool

- PC based tool to simply specify systems in real time
- Accurate and realistic sizing
  - Over 250,000 Cities
  - 1° grid irradiation database NASA
  - Temperature and precipitation database
- Powerful sales tool
- Fit the right solution first time!!
# COMPASS 3.0

**Data Table:**

<table>
<thead>
<tr>
<th>Pump system</th>
<th>PV generator</th>
<th>Cable</th>
<th>Pipeline</th>
<th>Head</th>
<th>Output</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>PS4000 C-S18-15</td>
<td>2 x 250 Wp (3 x ICL120-22P)</td>
<td>4 mm²</td>
<td>3</td>
<td>30...50 m</td>
<td>86 m³</td>
<td>29 l/Wp</td>
</tr>
<tr>
<td>PS4000 C-S18-15</td>
<td>2 x 250 Wp (3 x ICL120-22P)</td>
<td>4 mm²</td>
<td>3</td>
<td>30...50 m</td>
<td>86 m³</td>
<td>29 l/Wp</td>
</tr>
<tr>
<td>PS4000 C-S17-4</td>
<td>2 x 250 Wp (3 x ICL120-22P)</td>
<td>4 mm²</td>
<td>3</td>
<td>30...50 m</td>
<td>86 m³</td>
<td>29 l/Wp</td>
</tr>
<tr>
<td>PS15C-C52-7</td>
<td>2 x 250 Wp (3 x ICL120-22P)</td>
<td>4 mm²</td>
<td>3</td>
<td>30...50 m</td>
<td>86 m³</td>
<td>29 l/Wp</td>
</tr>
<tr>
<td>PS15C-C52-6</td>
<td>2 x 250 Wp (3 x ICL120-22P)</td>
<td>4 mm²</td>
<td>3</td>
<td>30...50 m</td>
<td>86 m³</td>
<td>29 l/Wp</td>
</tr>
</tbody>
</table>

**Graphs:**

- **Bar Graph:** Water output per day (June to December) and total annual output (31,500 m³).
- **Line Graph:** Solar irradiation and energy output for each month.
Completed Pumping Facility

Guard House

Solar array

Exterior view

Exterior View
Red Cross — Head 32m, flow 32m³/hr

235wx112 No. Solar panels
Community Water Supply, IFO CAMP

D&S designed 5No. LORENTZ PS40K2 systems and 1No. LORENTZ PS21K2 to provide 1,053m³/day
JICA Marsabit Hybrid Water Supply

64no. X 175w solar modules
95m³/day at 100head – 10kw
KRCs – Community Water Supply
GRID CONNECT SOLAR PV SYSTEMS
1. OFF-GRID PV SYSTEM
These systems generate and store energy ensuring continuous supply of energy to loads. Also known as standalone systems.

2. ON-GRID PV SYSTEM
A grid-tied PV power system is an electricity generating solar PV power system that is tied to the utility grid.
OFF GRID PV SYSTEMS

Definition

An off-grid solar PV system is an electricity generator that is deployed to locations not fitted with utility grid distribution system. The system has three main elements:

1. Generation – solar panels
2. Storage - batteries
3. Power inversion – charge controllers, inverters
DC coupled systems

Features
1. The point of connection is on the DC side.
2. The flow path is DC
3. Ideal for small systems
A grid-tied PV power system is an electricity generating solar PV power system that is tied to the utility grid. A grid-tied PV system consists of solar panels, one or several inverters, a power conditioning unit and grid connection equipment.
Grid Tied Solar Electric System

Solar (Photovoltaic or PV) Panels Turns Photons From The Sun Into DC Electricity

AC Power (Out to Utility)

Outdoor AC Power

Outdoor Meter (AC) (spins in both directions)

AC Disconnect

Grid-Tie Inverter

The Inverter Changes DC Current To AC Current That You Can Use In Your Home
OPERATION PRINCIPLE

https://youtu.be/b2MJnh0LAyE
Solar power feeds into the distribution box in the house in series with grid power.

System needs grid power to provide reference voltage for the inverter to start up.

System only works in sunshine.

Solar power is prioritized for consumption by the loads.
Operation principle

The grid inverter works:

- When there is a voltage signal i.e. from the grid. It then produces a similar signal.
- It ramps up the voltage w.r.t. the grid-power from this inverter has higher potential thus utilized first.
ON GRID SYSTEMS

String inverter e.g. “SMA Sunny Boy”

PV

PV

Grid power

AC-bus

AC load
OPERATION PRINCIPLE

https://www.youtube.com/watch?v=gZlZqVKSyzk
D&S 2020 – Resourcing for the Future
AC coupled systems – Grid Connect

Features
1. The point of connection is on the AC side
2. The solar inverter can handle high voltages >600Vdc
3. Very efficient for daytime loads.

D&S 2020 – Resourcing for the Future
OFF GRID PV SYSTEMS

- **PV**
- **PV**
- **AC-bus**
- **AC load**
- **Battery Bank**
- **Bidirectional battery inverter**
  - e.g. “SMA Sunny Island”
- **String inverter**
  - e.g. “SMA Sunny Boy”
- **Back up Generator**
- **Solar battery**
SMA GRID TIED SYSTEM WITH BATTERY BACK-UP
Off grid system animation

Simulation of an off-grid system.
100kW UNHCR KAKUMA PV POWER PLANT
SMA IS THE GLOBAL NUMBER 1 IN SALES FOR THE LAST 2 DECADES

DAVIS & SHIRTLIFF APPOINTED PARTNER OF SMA IN THE REGION IN 2017
SMA HAS A MODERN AND COMPLETE PORTFOLIO FOR ALL SEGMENTS

RESIDENTIAL
- MLPE
- SB 1.5/2.5
- SB 3000-5000
- STP 5000-12000

COMMERCIAL
- STP 20000TL/25000TL
- STP 15000TL
- STP CORE 1
- STP 5000-12000
- STP 75

UTILITY
- SUNNY CENTRAL CP XT
- SUNNY CENTRAL CP JP
- SUNNY CENTRAL 2.2/2.5 MW
- SUNNY CENTRAL STORAGE
- SUNNY TRIPPOWER 75
- SMA Power Plant Controller
- SMA String Combiner/Monitor
- GPM SCADA and Monitoring solutions
- Siemens grid connections on High- and Medium Voltage level

OFF-GRID & STORAGE
- SUNNY BOY STORAGE
- SUNNY HOME MANAGER
- SMA ENERGY METER
- SUNNY ISLAND 6.0/8.0H
- SUNNY ISLAND 3.0/4.4M
- 6/12/36x MULTIYCLUSTER ER-BOX 6/1236
- FUEL SAVING CONTROLLER
- SUNNY CENTRAL STORAGE 500/1000
- SUNNY CENTRAL STORAGE 2200/2500

SERVICE
- Commissioning
- Extended Warranty
- Operation & Maintenance
- Supplementary Services
- Extended Warranty
- Preventive Maintenance
- Commissioning

SMA Company Presentation
Residential hybrid energy solutions for residential consumers with weak or non-existing grid structure

SMA Hybrid Energy Systems

- Residential
  - Sunny Island 6.0H/8.0H
  - Sunny Boy TL-21
  - Sunny Tripower TL-30
  - Multicluster Box

SMA Solar Technology AG
SMA GRID TIED INVERTERS

1. Sunny Boy Series: SB2500 – SB5000 (2.5kW – 5.0kW) – single phase

Features:

- Easy installation
- Easy setup to on/off grid mode
- Multiple MPPT capability (depending on model)
- Plant monitoring capable via RS485/Bluetooth
The New SUNNY BOY Family
small – light - secure

> Ready for **SMART CONNECTED**, the new SMA Service offering
> **Secure** and **Fast installation**, with wireless commissioning and no need to open the inverter lid
> Integrated Webserver for **easy commissioning** and **local monitoring** or via Sunny Places
> Compact and **light weight** design (< 16 kg)
> External **WLAN antenna** for outstanding communication quality
> **5 year warranty** with optional extension to 10 years
> Monitoring Interfaces: WiFi, Ethernet, SMA Speedwire/Webconnect

**Technical Data**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power ($kW_{AC}$)</td>
<td>3.0 – 5.0</td>
</tr>
<tr>
<td>DC-Voltage ($V_{DC}$)</td>
<td>125 - 600</td>
</tr>
<tr>
<td>AC Voltage ($V_{AC}$)</td>
<td>180 – 280 / 50Hz</td>
</tr>
<tr>
<td>MPPT Range ($V_{DC}$)</td>
<td>125 - 500</td>
</tr>
</tbody>
</table>

1 phase, 2x MPP trackers, 2 inputs per tracker,

Features:

- Easy installation
- Easy setup to on/off grid mode
- Multiple MPPT capability (depending on model)
- Plant monitoring capable via RS485/Bluetooth
Summary – Sunny Boy/Tripower

Key Features and Benefits

1. Smaller, Lighter, Lower Cost, More Reliable – World’s most installed inverter with an upgrade!
2. Smart inverter display and monitoring on the customers smartphone
3. Built-in Wifi
4. Built-in Audible Earth Fault Alarm
5. Integrated Zero Export and customer usage data with only SMA Energy Meter
6. Faster and Simpler Installation
7. Better solution than a hybrid inverter, with greater flexibility at no extra cost
8. No adjacent AC isolator required
Industrial hybrid energy solutions for industrial consumers with weak or non-existing grid structure
SMA GRID TIE INVERTERS

Scalability

Low voltage grid
230/400 V
SMA GRID TIE INVERTERS

Scalability

SMA Solar Technology AG

Low voltage grid
230/400 V

SMA Solar Technology AG
Sunny Tripower CORE is the world’s first freestanding PV inverter for decentralized rooftops, covered parking spaces and ground-mount solar projects.

As the 3rd generation of SMA’s industry leading Sunny Tripower product line, the CORE1 revolutionizes the commercial inverter category.

Its innovative engineering approach is built on the foundation that a groundbreaking form factor is combined with an inventive mounting method. The goal is to speed up installation and achieve the most economical return on investment for all parties involved.

The result: Up to 60% faster installation and cost-savings on all levels.
Ideally suited for all commercial applications

- ROOFTOP
- CARPORT
- GROUND MOUNT
A complete power class lineup

POWER:
- 15,000 W
- 20,000 W
- 25,000 W
- 50,000 W

Availability: NOW

Optimum flexibility with improved economics
SMA provides various methods to monitor and control the status of your plant in the comfort of your office/home.

Various equipment for this purpose are:
- SMA Home Manager
- SMA Cluster Controller
HOPPECKE BATTERIES

OPzV / OPzV solar.power

- Sealed lead-acid battery Single Cell
- electrolyte: fixed as gel with SiO2
- design life time 18 years or 3000 cycles at 50% DoD
- capacity range 200 to 3000Ah
- horizontal position (Option) up to 1500Ah
- excellent cycle stability in PSOC (partial state of charge)

Typical applications
- Village power supplies
- Hybrid systems
SOLAR SUPPORT STRUCTURES

Three sources of solar support structure:
- Dayliff Solar Support Structure
- Fujian (Chinese) Solar Support Structures
- Schletter structures from RSA

Design Considerations for Solar Support Structures:
- Load
- Function and Performance
- Safety
- Operating Environment
- Manufacturability
- Installation
- Serviceability
- Durability
- Cost
Sizing grid tied PV systems

Crucial aspects to obtain:
1. Available PV mounting space
2. Facility load assessment
3. Quota of self-sufficiency required
CALCULATING INTERNAL CONSUMPTION

Base load

Solar power must NEVER be greater than load power.

Solar power

Time of day
1. Mounting area

Steps to undertake under this:

1. Measurement of viable mounting area.
2. Determine how many panels can fit in the area.
3. Make sure to allocate spacing for clamping and O&M provisions.
2. Facility load assessment

1. Log data using an energy meter for an adequate period
2. Determine all loads connected to the supply
3. Audit integrity of existing local grid
3. System design

- **AUTOCAD**
  - Site layout plans
  - Solar PV arrangement on available locations

- **SUNNY DESIGN**
  - System sizing
  - Simulation of energy production
  - Financial simulation

**HELIOSCOPE**

*D&S 2020 – Resourcing for the Future*
4. System design

https://www.sunnydesignweb.com
# Standard BOQ

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar panels</td>
<td>Yingli 300W solar panel</td>
</tr>
<tr>
<td>Panel mounting structure</td>
<td>Aluminium roof mount structure</td>
</tr>
<tr>
<td>PV inverter</td>
<td>SMA Tripower 20000TL-30</td>
</tr>
<tr>
<td>AC service box</td>
<td>Dayliff AC switch box</td>
</tr>
<tr>
<td>Solar cables</td>
<td>6sqmm solar cable</td>
</tr>
<tr>
<td>AC cables</td>
<td>5C x 10sqmm flex cable</td>
</tr>
<tr>
<td>Communication cables</td>
<td>Cat 6 ready</td>
</tr>
<tr>
<td>Monitoring system</td>
<td>SMA Home Manager</td>
</tr>
<tr>
<td>Internet connectivity devices</td>
<td>Router/Modem set up</td>
</tr>
<tr>
<td>Installation labour</td>
<td>Mobilization, Installation etc.</td>
</tr>
<tr>
<td>Installation accessories</td>
<td>Conduits, Trays etc.</td>
</tr>
</tbody>
</table>

**D&S 2020 – Resourcing for the Future**
Why Install an Grid tie system

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Client load</td>
<td>100.00kW</td>
</tr>
<tr>
<td>KPLC Rate</td>
<td>21.00KES/kWh</td>
</tr>
<tr>
<td>Monthly consumption</td>
<td>28,800.00kWh</td>
</tr>
<tr>
<td>Monthly bill</td>
<td>604,800.00KES</td>
</tr>
<tr>
<td>On-grid solar generator</td>
<td>60.00kW</td>
</tr>
<tr>
<td>Ballpark cost</td>
<td>8,400,000.00KES</td>
</tr>
<tr>
<td>Units generated</td>
<td>10,750.00kWh</td>
</tr>
<tr>
<td>Monthly savings</td>
<td>225,750.00KES</td>
</tr>
<tr>
<td>% savings</td>
<td>37%</td>
</tr>
<tr>
<td>Payback</td>
<td>37.21 months</td>
</tr>
</tbody>
</table>
Why grid-tied systems?

1. Reduced energy overheads
2. Ensured energy security
3. Easily scalable over time (modular in nature)
4. Increased building/premises value
5. Reduced carbon footprints
6. Will readily adapt into the future grids – distributed generation*
7. Energy influences the status of a nation*
8. Grid parity – solar is becoming a competitive generation resource w.r.t. to the utility grid

* D&S 2020 – Resourcing for the Future
Our holistic strategy

- Turnkey projects
- Products stocks
- Service centre
- Training & support
- Partnerships
Opportunities

1. Industries,
2. Institutions,
3. Office blocks,
4. Service stations,
5. Tourism,
Solarization of Petrol Stations for Total Kenya

- D&S recently contracted by Total Kenya to review solar designs from different market players for the suitability in the installation and solarization of several Total Petrol stations in Nairobi and its environs.
BURHANI MOSQUE 50KW GRID TIE SYSTEM
100kW UNHCR KAKUMA PV POWER PLANT
Questions?