# White Paper Series

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# WHAT TO LOOK OUT FOR WHEN BUYING A SOLAR AND STORAGE SYSTEM (PV) FOR YOUR HOME.

## Introduction

For most homeowners, solar and storage systems are a new technology. Unlike corporations and businesses, who have specialists or employ consultants to guide and perform due diligence on energy solutions, South African homeowners find themselves in the middle of load shedding and not sure which way to turn to find relief.

It is abundantly clear that a solution exists, in the way of solar (PV) panels and battery storage, but with a huge variety of options available, as well as a plethora of installers advertising to do the work or financed options available, how does one know whether their investment is a good one. With the right solution, it will be the best investment made in your property for years to come, however the wrong decision carries a high financial personal risk.

This paper aims to provide the homeowner with some basic information on what a solar (PV) and storage system is, what the key components do, how to work with the installer to correctly size the system, and then what to look out for to reduce as much of the risk as possible from your investment.

This paper does not discuss the political framework, nor feed-in tariffs or Eskom/Municipal regulations, as these are changing rapidly and are different for each.

## *Where to start*

Even before looking for an installer, or choosing what system you want, begin with asking yourself some key questions:

**What is my goal?**

To have backup power?

- How much energy do I use during load shedding/power outages?
- What is important to me to have running during this time?
- Is my distribution board okay for this, or do I need to split it?

To reduce my bill?

- How much energy do I use every day? Do I even know?
- How much usable roof space do I have to use for PV panels?

Or to go off grid altogether?

How will I pay for the system?

- Cash?
- Bond?
- Finance/Rental?

A critical question which most homeowners fail to ask is,
“Have I taken some basic steps to reduce my energy consumption at home, and therefore the amount I will have to spend on solar and storage system?”
Options here include:

- Changing lights out for low energy LED’s (downlights and security lights are easy ways to cut consumption significantly).
- Cooking on gas (or other) instead of electric stoves/ovens.
- Replacing or supplementing hot water geysers with solar (thermal) or heat pumps.

All those changes should be made, either before or during the backup solution installation, and come with significant returns on your investment.

**Once you have these questions answered, then it is a good time to begin looking for someone to consult, design, supply, install and commission your system.**

## *Sizing a residential Solar PV and Storage System*

In order to select the correct system, you should know how much energy you use. Energy is measured and billed in kilowatt-hours (kWh) like water is measured and billed in kilolitres (kL). Below are three (3) ways to do this:

1. The easiest way is to take your electricity bill and *divide the monthly kWh by 30*, for a daily average (note that this may change from Summer to Winter).

2. Every day may not be the same, however, in which case you can *install a power meter to measure your actual profile* (which also tells you what time you use power) for a much more accurate value.

3. Finally, you could do an exercise to *list all of the electrical equipment in the home*, and then multiply the power rating (usually in Watts or kiloWatts) by the number of hours it is used for. This will give a Watt-hours (Wh), or kilowatt-hours (kWh), consumption figure.

Examples of various energy consumers are shown in the table below:

| **Item** | **Quantity** | **Rating** | **Time** | **Energy Used per Day** | |
|---|---|---|---|---|---|
| *units* | | *Watts* | *Hours* | *Wh* | *kWh* |
| Lights | 10 | 50 W | 6h | 3,000 | **3.0** |
| LEDs | 10 | 7 W | 8h | 560 | **0.6** |
| Oven | 1 | 4 kW | 2h | 8,000 | **8.0** |
| Kettle | 1 | 2 kW | 5 min | 167 | **0.2** |
| Fridge | 1 | 100 W | 16h | 1,600 | **1.6** |
| TV | 2 | 165 W | 4h | 1,320 | **1.3** |
| Water Heater | 1 | 4 kW | 1h | 4,000 | **4.0** |
| Pool Pump | 1 | 750 W | 4h | 3,000 | **3.0** |

**Don't forget to consider standby loads of equipment.*

An automated calculator to help with this be downloaded from the Hudaco Energy website (www.HudacoEnergy.co.za).

Once you have noted down your equipment and what those loads will look like, separate them into:

**Essential Loads** – these are the things which you need to run through load shedding and power failures.

- Normally this is lights and plugs in the home (or perhaps only some of the plug circuits if the electrical distribution board (DB) can be easily split).
- This is the primary information used when sizing the battery bank correctly.

**Non-Essential Loads** – these are things which you do not need to run during load shedding.

- Most common items seen here are hot water geysers, pool pumps, ovens/stoves, the heavy users that draw either lots of power or consume lots of energy over time, and it would be extremely expensive to add batteries to carry these loads.

***Congratulations – you've completed one of the most important tasks, and are now ready to think about sizing your system.***

## *Key components of a Solar & Storage System*

The end of this paper contains a technical section which explains more about each of the key components, however below is a brief description about each of the three main components relating to the general design of a residential solar system.

***PhotoVoltaic (PV) Solar Panels*** **produce electrical energy from sunlight.**

- This energy is captured as direct current (DC) and must be used immediately or stored.
- *The size of a PV array (or amount of installed PV panel capacity) is measured in kilowatt-peak, or* ***kWp****.*

***Inverters*** **convert energy from DC to AC (panels and battery to grid), or AC to DC (grid to battery storage).**

- Most residential appliances use alternating current (AC), which is why the inverter is required to convert the direct current (DC) from panels or batteries into usable alternating current.
- Inverters are electrical devices and are required to be installed according to the local wiring codes.
- *The maximum power an inverter can deliver to it's backup loads is measured in kilovoltamps, or* ***kVA***.
    - You could also use just kilowatts, or kW, to describe it but the industry prefers kVA to make it easy to differentiate when talking about panels, inverters and batteries, as well as when considering power factor (something the installer will consider when helping to size the system).

***Batteries*** **store energy for use when grid is present (self-consumption) or when grid is not present (backup mode) due to load shedding for other grid failure.**

- They are normally the most expensive component of a residential system, and also the least understood.
- *Battery capacity is measured in kilowatt-hours, or* ***kWh****, of energy*.

*This section has some space for you to write the information in so that you can share it with your installer and receive the best information possible in order to make a decision on the best solution for your home. Incorrect information may lead to an undersized system, which won't meet your expectations, or an oversized system that costs more than you need to spend.*

**Once you know how much energy you use, you can think about 3 key factors:**

*How much energy do I need to produce in a day to cover my needs?*

- This will help determine the size of your solar array (how much solar power is installed)
- Panels installed are described in kilowatt peak, or kWp.

| **I use _____ kWh per day at home** |
|---|

*How much energy do I need to store in batteries to cover my essential loads during power outages?*

- This will help determine the size of your battery bank (note: how much usable energy I require, not how much capacity I have)
- Battery Capacity is described in kilowatt-hours, or kWh.

As the most expensive part of the system, it is extremely important to understand what factors affect the lifespan of your batteries.

| **I need _____ kWh of *usable* backup energy to get me through each load shedding**. |
|---|

*How much power do I need to pull at any specific time on my backup loads?*

- This will held determine the inverter size, and type, required.
- Inverter sizing is measure in kilovolt-amps, or kVA

| **When in backup mode, I need _____ kVA of peak inverter power.** |
|---|

## What to look for in an installer

Now that you have an idea of what your system might look like, it's time to find a professional to talk through the options, look at your electrical wiring at home, investigate your roof space, and make recommendations on solutions based on meeting your needs, your budget and providing any advice in terms of areas where your initial ideas or expectations can be improved.

Sometimes it simply may not be feasible because of a variety of reasons (roof structure, for example, may not allow the preferred solar panel array size – or perhaps your roof is thatch or asbestos and not allowed to have panels installed directly on to them), but a good installer should then be able to present workable alternatives.

**All new solar installations require the supervision and general control of an Installation Electrician or Master Installation Electrician.**

- No person other than an Installation Electrician (IE) and a Master Installation Electrician (MIE) can issue a Certificate of Compliance on a solar installation.
- No other qualification other than an IE or MIE can qualify a person to so do.
- A Training course or Card/ Certification is good to have for expanded knowledge but is not a qualification to do PV work.

### *At a minimum, the installation company should provide:*

- Proof of Installation Electrician / Master Installation Electrician
- Working at Heights Certificate
- Letter of Good Standing with the Department of Labour
- Liability Insurance
- Installation must be done as per SANS10142-1-3 (-97) and a Certificate of Compliance / Pr. Eng sign off must be given after the job.
- Products should be from a reputable source that can stand behind the warranty.
- Inverters should carry NRS certification (compliance to our local regulations)
- Batteries should not be from some guy that put a plastic kit/box together in their garage – extensive thermal modelling is done on proper battery systems and inverters, and a plastic case with everything enclosed is both a fire risk and likely to shorten battery life significantly.

## *Pitfalls to look for as an owner*

The list of requirements above is by no means exhaustive, but should be an absolute minimum which, if cannot be provided, means that the installer is simply not qualified or compliant.

Below are some key aspects which should be considered as well, and are based upon activities and complaints seen across the market on various social media groups and platforms, as well as feedback from the installers themselves.

- Is the installer competent, do they meet the list of requirements?
- Is the installer likely to be there for any additional support after my installation?
- Does the installer know exactly what they're talking about, and are they helping me to size the system properly, or just selling me something to make a quick buck and pay some bills?
- Will they share 10 happy customers with me that I can contact? Have I checked them out on their website, on Hello Peter etc?
- Are the products themselves reputable with warranties that are actually valid and can be claimed against, should something go wrong?
- Is the manufacturer / importer / distributor willing and able to stand behind the warranties and provide backup support if the installer vanishes?
- Who is the Project/Site Manager for the installation?
- Who is the person who will issue the Certificate of Compliance, and when will they visit the site?

**Some Important Questions:**

| | |
|---|---|
| How long is my warranty on my **inverter** for? | _____ **Years** |
| How many **usable kWh** do I need from my battery? | _____ **kWh usable** |
| How big is my battery's usable capacity (total capacity x DoD %)? | _____ **kWh capacity** |
| How many cycles does the **battery** bank have warrantied? | _____ **cycles** |
| How many years lifespan should that give me?<br>(divide by 365 and then by average number of load sheds per day ) | _____ **years** |

## *Let's get a little more technical*

This section of the paper gives a very brief description of the main components used in a solar (PV) and storage system.

***PhotoVoltaic Solar Panels*** **produce electrical energy from sunlight.**

**This energy is produced in direct current and must be used immediately or stored.**

For the best performance, panels should be mounted facing north (towards the equator) and at a pitch equal to the angle of latitude (e.g. 26$^{o}$ Johannesburg, 33$^{o}$ for Cape Town).

- This is often not an option, and a good option is to mount the panels then at the same angle as the roof, with a small air gap underneath to allow for cooling and water run off.
- Residential roofs are also not always north facing at all, and a good option is to also consider East (morning Sun) and West (afternoon Sun) facing installation – but make sure that they are not then connected to the same MPPT. This is covered more in the section on inverters.

There seems to be a trend to use the largest module size available (often greater than 550Wp or 600Wp). Note that bigger is not always better.

- Even though they can be used on residential systems, the really large modules are actually designed for commercial and industrial applications.
- Residential modules generally range in size from 300 – 500Wp currently, and are easier and safer to carry, and fit well on residential roof spans.

The maximum energy the panels can produce in a day (or week or month or year) can be calculated using specialized software, however a quick rule of thumb is to multiply the installed capacity (in kWp) by a specific factor (often around 4 – 4.5 for Johannesburg, for example).

This factor changes based on installation parameters like:

- Pitch of roof
- Angle of installation
- Products selected (MPPT window)
- Soiling (dust on panels)

I recently saw a company which offers a low monthly payment on systems, but stated on their website that their solution, for a large house, produces 20 – 45kWh per day. I did the calculations and the theoretic (not even actual) maximum achievable is 30kWh, only 66% of the customer's potential expectation.

*It is important to understand approximately how much energy your panels can produce and align your expectations to match.*

*A good supplier/installer will discuss this with you properly and give you a realistic expectation.*

***Inverters*** **converts energy from DC to AC (panels and battery to grid), or AC to DC (grid to battery storage), so that it can be used with your electrical equipment at home.**

Some inverters have a single output that must carry all the loads, others have separate outputs for essential and non-essential loads.

It is important to know which loads you want to have on backup, and consuming battery energy during outages, and which loads you are happy to not have (e.g. water heaters, pool or borehole pumps, oven/stove).

- Inverters should be sized according to the expected load, and electrical architecture (single or three phase).
- Hybrid inverters have MPPT or PWM charge controllers built into them, and can operate in a variety of different modes.
- Some systems require separate MPPT or PWM devices in between the solar panels and the inverter/battery system to manage and control the PV production from the panels.

**Inverters are electrical devices and are required to be installed according to the local wiring codes.**

***Batteries*** **store energy for use when grid is present (self-consumption) or when grid is not present (backup mode) due to load shedding for other grid failure.**

**They are normally the most expensive component of a residential system, and also the**

**least understood.**

Different battery types are available, including lead acid, gel, CNM, Lithium Iron Phosphate (LiFEPO4) and a host of other chemistries. Each battery type has different characteristics and is more applicable for a particular scenario.

Battery lifespan is measured in number of cycles (and not really in years).

**The number of cycles (and therefore battery lifespan) is negatively affected by a variety of factors, including:**

- *Temperature* (high temperatures are bad),
- How much of the battery is used each time it comes into play (a deep D*epth of Discharge* is bad, so be sure to understand the number of cycles warrantied under the chosen/expected DoD),
- *How quickly the battery is charged and discharged* (very fast is bad, unless the batteries are specifically designed for that application, like car batteries for quick starting of a motor).

When it comes to batteries, a 10-year warranty is NOT always a 10-year warranty. **Don't believe the warranty, rather look at the number of cycles at the depth of discharge to determine expected lifespan**.

Below you will see a table which shows the expected lifespan based on number of cycles and load shedding schedule.

| Battery Warranty Cycles | System Cycles per Day | Battery Lifespan in Years |
|---|---|---|
| 1000 | 1.5 | 1.8 |
| 3000 | 1.5 | 5.5 |
| 4000 | 1.5 | 7.3 |
| **6000** | **1.5** | **11.0** |
| | | |
| 1000 | 2 | 1.4 |
| 3000 | 2 | 4.1 |
| 4000 | 2 | 5.4 |
| 6000 | 2 | 8.2 |

- It can be seen that a 4000 cycle battery, with 2 load sheds per day, will last a little over 5 years… nowhere close to the 10-years you might see posted on an advert.

- The only battery which actually does meet the 10 years is a 6000 cycle unit, and assumes only 1.5 load shedding cycles per day.

*A good installer will discuss this with you properly and make sure that you understand the calculations used in determining battery bank sizing and lifespan, as well as how long you can expect to run your required loads for given the size of the battery bank.*

Yes, they are the most expensive part of the system, but also the component which will cost you the most to replace if you install and operate under the wrong conditions.

To learn more about batteries, we have a white paper which can be downloaded from the Hudaco Energy website (www.HudacoEnergy.co.za).

***Balance of Plant*** **refers to the rest of the physical components which are required to complete the system**

Primarily made up of cables and protection equipment such as circuit breakers, surge protection, isolators and fuses, as well as mounting structures for the panels and trunking to keep the cabling neat, tidy and protected from interference or exposure.

It is critical from a safety and compliance perspective that your system has the correct protection included, and that cables are sized correctly for the current they will carry.

***Installation*** **refers to the labour required to install, test, commission and certify the system is working properly and meets standards.**

This cost also sometimes includes travel to and from site.

Note that the installation must be checked by a registered installation electrician (or master installation electrician). These are professionals and it is their duty is to issue the Certificate

of Compliance (CoC), if the system is installed correctly and according to the wiring code, to confirm that your systems meets the national standards and that it has been installed safely for you, your family and your pets.

If the person does not visit the site, they cannot confirm that the work has been correctly, and the home may be at risk.

This CoC should be kept on file or submitted directly to your insurance company to ensure that they have a copy.

**NOTES:**