APOLLO SOLAR

Essentiels de l'ingénierie des systems d'énérgie en site isolé.

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Difference entre PUISSANCE et ENERGIE

1. La puissance est instantanée. Toute la puissance est utilisée maintenant à cet instant.
2. La puissance typique d'un site (puissance necessaire) est de 1KW ou 1000 W. C'est comme 10 lampes de 100W/lampe.
3. Si ces lampes fonctionnent 24h par jour, elles utilisent 24KWh d'énérgie chaque jour.
4. Comprendre et se rappeler la difference est important. On utilize souvent ces mots et une confusion est possible.
5. La puissance c'est simplement Tension x courant (UI) . En Telecom on a 48 volts DC. Avec 1 courant de 25A on a une puissance de 48 x 25 = 1200 watts.
6. **La puissance est exprimée en Watts ou Kwatts et est instantanée.** La lampe de 100 utilise cette puissance seulement quand elle est en marche.
7. **L'Energie c'est la puissance utilisée pendant un temps**. Donc si la lampe marche 1h, elle utilize 100Wh our 0,1KWH en 12h ce sera 100x12=1200Wh.

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How POWER and ENERGY relate to Towers

1. Each mobile phone tower requires a certain amount of Power which is specified in watts or kilowatts.
2. The telecom load is essentially constant with just a 25% increase during heavy calling hours. (The constant load makes our calculations and equipment much easier then if it were changing or unknown which is often the case with village power systems.)
3. If a Tower requires <u>1kW of Power continuously </u>for 24 hours each day, then we need to supply <u>24kWh (kilowatt hours) of Energy every day</u>.
4. The Solar modules are also specified in watts of power and are typically 250 to 350 watts today. But they only produce this much Power when the sun is shinning directly on it - on a clear day - at noon.
5. We store the Energy in batteries. The capacity of the batteries is expressed in Amp-hours. When multiplied by volts gives us kWh of energy storage.

Sources of Electric Energy

The electricity for a tower must be present 100% of the time, 24 hours, every day. When the power stops – the mobile connection is down for every call or data connection using that tower. The Mobile Network Operators do everything they can to prevent down-time.

1. Utility (Grid) power – If it is available and reliable, then it is used. Our systems are used where grid power is not present or reliable.
2. The earliest Off-Grid choice was a diesel generator (DG). They are easily available and well understood, but there are many costs.
3. The first improvement to a simple DG powered site was to add deep cycle batteries. This allowed the DG to be turned off for part of each day and to run more efficiently when it was charging the battery.
4. **Solar Power is relatively new for the Tower market. It offers better reliability, lower costs and it is much better for the Earth. The cost of the PV modules is now low enough to make Solar the first choice. Apollo has 1000 sites running on Pure Solar without any DG backup and they are more reliable than the DG sites.**

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Sources of Electric Energy – Hybrid Sites

1. Adding deep cycle batteries to the DG were called Hybrids. Now to avoid confusion, they are called “DG plus battery.” The DG can be turned off for part of the day to reduce fuel, but the batteries do not last.
2. Tower sites with existing Diesel Generators and Batteries can simply add Solar PV modules which reduces the amount of run time of the DG. There is nothing wrong with this concept and Apollo makes the equipment for any mix of Solar and DG. The question of how much solar is in the hybrid mix is usually determined by the space limitation for the PV array.
3. The spectrum of Solar and DG hybrid percentage can vary. The more solar, the lower the DG run time which cuts maintenance and fuel costs. Apollo Solar supplies any size system to meet the site specific requirements.
4. We like to approach the design of each site by starting with Pure Solar and then add a single DG for back up which will reduce the size of batteries required and can often yield the lowest up front system cost.

Sources of Electric Energy – Diesel Generators

The only good news about diesel generators is that the infrastructure is already in place to keep them running. Here are the reasons whey we like to replace them or minimize their usage:

1. The generator makers require maintenance to change the oil and the oil filter every 250 hours of run time. Note that since the DG is running 24 hours per day, they require a maintenance visit every 10 days!
2. The generator engines should be replaced or rebuilt every 10,000 hours. Running constantly, that goes by in 14 months.
3. In order to supply electricity continuously, each DG site requires 2 generators so one runs while the twin is being serviced.
4. No fossil fuel engine is efficient or clean, but the small diesel engines used on the 12 to 25kW generators at cell towers are very in-efficient.
5. A tower needs about 1kW to 4 kW of power, yet the DG units are 12 to 25kW. It seems that the DG must be large enough so it is difficult to steal. The problem is that a DG running at less than 50% of its maximum power is much less efficient, burning even more fuel.

Solar Panels or Photovoltaic (PV) modules

1. The sun provides 1 kW of Power per square meter at the surface of the earth near the equator. (This is a miracle that should cause us all to pause and appreciate how much it means to us.)
2. Since the atmosphere is not perfectly clear or free of clouds, the actual power varies and it averages less than a full kW per square meter.
3. And since the sun traces a sin curve across the sky, any fixed PV array receives less than about 5 full sun-hours per day.
4. We use tables to look up the average amount of solar IRRADIANCE or INSOLATION at a given location. Data is available for any month of the year expressed in kWh/m2/day. That is the kilowatt hours for every square meter per day. The short term for this is “sun-hours”.
5. The Solar PV modules are currently about 15% efficient, so a 1 sq meter size PV module can produce a maximum of 150 watts on a clear day. You will find that the current popular modules are 2 sq meters and are specified to produce about 300 watts.

Batteries – The tank to store electric Energy

1. Think of the battery as the petrol tank in a car. That tank is large enough to store a certain number of liters of fuel so we can drive around without a pipeline connected to the petrol station.
2. Batteries store electric Energy. The battery must have enough capacity to store the energy that the tower needs when the sun is not shining.
3. The Energy comes from the sun and is converted to electric Power by the PV modules.
4. The instantaneous Power (in kW) from the PV modules is accumulated over time so it is called kWh of Energy in the battery.
5. The capacity of the batteries is expressed in Amp-hours. When multiplied by volts gives us kWh of energy. **Volts X Amps = Watts.**
6. A 48 volt battery with 1000 Amp-hours of capacity can store up to 48,000 watt-hour or 48kWh of Energy.

Batteries – How to keep them alive and well

1. Batteries are an expensive part of any Off-Grid energy system.
2. Every battery has a limited number of charge-discharge cycles.
3. The long-term cost of a system can be driven by battery replacement.
4. Here are the things that shorten the life of lead acid batteries:
   - Leaving them in a discharged state – the plates get covered in sulfate which prevents the battery from working.
   - High temperatures – the sulfate reaction goes faster at high temps.
   - Deep Discharges – We limit the maximum Depth of Discharge to 50%.
5. Our systems do everything possible to extend the life of batteries.
6. We use batteries made from large 2 volt cells which are not useful in cars or motorbikes. They are very heavy so they are hard to steal.
7. Keep terminals clean and tightened to the specified torque.
8. Keep batteries clean, <u>cool</u>, dry and protected from the sun and abuse.
9. Never add new cells or batteries to strings of older batteries.

Batteries – Types used for Off-Grid Energy

1. In all cases these are DEEP CYCLE batteries. The internal construction is much different than a car battery which is designed for short duration, high current output to crank the engine. Car batteries will not work in our deep cycle, energy storage systems.
2. There are several types of Deep cycle Lead-Acid batteries: Flooded, AGM and GEL. The each have strengths, but they all work for us.
3. Flooded Lead Acid or FLA need to have distilled water added periodically. If the plates get dry, the battery is damaged. Flooded batteries will take deep discharges and are the least expensive.
4. GEL batteries use a gelatin consistency electrolyte when does not spill. They do not require maintenance, but they are costly.
5. AGM means Absorbed Glass Mat which describes how the gelled electrolyte is held in place. The are spill proof and maintenance free.
6. GEL and AGM batteries are sometimes called “sealed” but they are not really sealed, they have a valve to allow hydrogen to escape. The correct term is VLRA for Valve Regulated Lead Acid.

Batteries – Wiring in Series and Parallel

1. A battery means a stack of cells.
2. It is the nature of lead-acid batteries to produce 2 volts in each cell.
3. In order to get the 48 volts we wire 24 of the 2 volt cells <u>in series</u>. Positive on one cell connected to Negative on the next cell for the entire series string.
4. And to get the current capacity we need, we can connect 48 volt strings together <u>in parallel</u>. All the positive terminals together and all the negative terminals together. The limit is 4 strings in parallel.
5. Just for a reference, a 12 volt car battery is a package of 6 cells at 2 volts wired in series internally. Again, these are NOT deep cycle and will NOT work for solar storage applications.
6. The storage capacity of the cell is rated in Amp-Hours of energy.

Daily Flow of Energy at a Telecom Tower Site

1. The typical 1kW telecom load will use 1kW constantly from the battery. In 24 hours, it will use 24kWh of energy from the battery. We must size the battery to have at least the capacity for 1 day of energy.
2. We need to replace that energy starting the next morning. The sun only shines for 8 to 12 hours and the energy is minimal at the beginning and end of the day. Every location is different, but an average of 4 full sun-hours is good for an example of a Pure Solar site.
3. If there were no losses and the sun were consistent, one can see that we would need to have 6 times as much Power coming into the battery during those 4 hours as we used for the load in 24 hours. (6 X 4 = 24)
4. Actually, the batteries lose about 20% going in and out, and we need to add a factor to compensate for clouds and haze. We use a factor of 8 to 10 which is called the PV “Array to Load Ratio”, or ALR.
5. <u>So, for a 1kW Load, using the ALR of 8 we will need 8kW of PV array.</u>