Comparison of the Total cost of Ownership Between a Diesel Generator and a Solar/Wind Powered System

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Abstract

The diesel generators and diesel tower lights are ubiquitous on work sites. They are a relatively reliable source of power when grid power is unavailable or too costly. The diesel generator however has a lot of technical drawbacks when it comes to powering a smaller load for extended periods of time - and with minimum human intervention. This is the case for numerous applications; e.g. surveillance, telecommunications, monitoring.

In several cases, the solar and wind powered units can generate substantial savings and benefits.

1 The Influence of Duty Cycle

One of the major differences between a diesel powered solution and a solar/wind powered solution is the ability / requirement of the later to store energy in a battery bank. Since the wind and solar energy can vary by nature, it is necessary for most systems to have batteries absorbing the energy when available, and releasing it when required.

The upside of the battery bank is that if the power requirement is punctual, it is effectively possible to release a much higher output than the rating of the equipment. For example, a 800 W unit, equipped with 8x6d 255Ah batteries, can produce up to 4,000 Watts during a short period of time. Also, contrary to the Diesel generator, no damage or premature wear is induced if the unit supplies lower power than it's nominal specification for a prolonged time.

For example, a typical 4,000 Watts small generator will have a Max AC output of 4,000 Watts, which can be sustained only for a short period. The continuous rated output would be somewhere around 3300 Watts. It is possible to use the generator when less electricity is required, but it will lead to poor efficiency (more fuel being used per kw produced), premature wear, and increased maintenance requirements. Diesel engines are designed to operate with a load and operate more efficiently within the 70 to 80 % range of rated output. When a diesel engine operates for a long period of time below 40 % it begins to over fuel. This happens because the injection tips begins to carbonize and disrupt the fuel spray pattern. The only way to correct a diesel engine that has begun to wet stack is to load the engine for a couple of hours to burn off the excess fuel and clean up the engine.[1]

While sizing a solar and wind powered unit, some critical factors need to be taken into account;

- The availability of raw energy (environmental) - Data is often available from government agencies.
- The capacity of the battery bank - in order to supply energy when load is higher than generated power

- The charging capacity of the solar array and wind turbine systems.
- The maximum charging rate (in amperes) of the battery bank

LYKO has developed software tools to accurately predict the available wind and solar Energy for its wind and solar powered systems at a specified location.[3]

2 Case Study

The calculations in this document are based on a certain number of assumptions regarding fuel cost, hourly rate of maintenance personnel, etc. Please make the necessary adjustments to calculate the best option for your situation.

The following example compares two options to power a small telecommunication load (approximatively 100 W) located in a remote northern location. The first option is using a small diesel generator and the second option is using an array of solar panels and wind turbines.

The generator we chose for the comparison is a 8kW diesel generator. It is oversized for the application, but this is one of the smallest units that provides the required remote monitoring capabilities, cold weather certifications and reliability required by this application.

The alternative is an AMU-800 unit, with a maximum charging capacity of 820 Watts (480 solar + 340 wind) fitted with a 12 kWh absorbed glass matt (AGM) battery bank.

2.1 Initial Purchase and Installation Cost

2.1.1 Diesel Option

Depending on the suppliers and the chosen options, the procurement cost of a diesel unit as specified above varies between $15k and $18k. Most diesel generators nowadays can be left outside and do not require a shelter to protect them from the elements. Most manufacturer will however recommend the generator to be installed on a concrete pad. This is obviously not an issue if one chooses to buy a trailer-mounted generator. But in all case, a secondary containment will likely be required to prevent from potential fuel spills. These are additional costs and considerations to keep in mind.

2.1.2 AMU-800 (Solar / Wind)

Just like for the Diesel option, the procurement cost of a unit can vary depending on the selected options. Let's suppose 45 k$ for the selected unit and option package.

2.2 Fuel Cost

2.2.1 Diesel Option

From the suppliers datasheet we have the following information:
The unit uses 2.8l/h @ 100% speed, and 1.4l/h @ 25%.

We can also assume a fuel cost of about 1.20$ per litre. This would include the cost of the fuel, as well as the cost of having it delivered to the site. This number is conservative. For a remote location - without road access, this amount can easily be multiplied by a factor of 3 or 4 depending on the means of transportation available, and the remoteness of the site.

Considering full time usage - 365 days / year, and 24hr a day:

$365_{(days)} \times 24_{(hr/day)} \times 1.4_{(l/hr)} \times 1.2_{(\$/l)} = \$14,716.8$ per year.

We must also include man-hours for the actual refueling of the unit. The autonomy of diesel generators is usually comprised between 20 to 48 hours - and therefore the need for refueling is about 200 times during the year. We assume that the procedure would take an average of 1 man hour to complete. At a cost of $50 per hour, we have the following:
$200_{(ref/year)} \times 50_{(\$/h)} \times 1_{(h)} = \$10\ k$ per year.

The autonomy and fuel consumption information comes from Kubota's GL Series Brochure. [2]

2.2.2 AMU-800 (Solar / Wind)

The AMU-800 does not require refueling. During heavy ice storms, it is possible (although seldom) that both the wind turbine and solar array require de-icing. Let's assume that this could happen up to twice a year. Using same hourly cost as above, and one hour per visit: $100.

2.3 Service cost

2.3.1 Diesel Option

The procurement of diesel generators used in remote locations typically come with a service agreement for the maintenance. On an annual basis, this service agreement is valued at around $4,500.

Taken individually, each maintenance for a unit is between $500 to $600, plus the traveling cost to the location. The detailed maintenance required can be found in the service manuals in reference, but it mostly consists of oil and filter replacements as well as mechanical troubleshooting and adjustments.

2.3.2 AMU-800 (Solar / Wind)

Because of the few moving parts, AMU-800 require very few maintenances. Maintenance tasks would include ; bearing and brushes replacements in the wind turbine, greasing of wheel bearings and an inspection of the mast lifting mechanism. The batteries are guaranteed 5 years, and are rated for thousand of deep discharge cycles. In most applications - where they remain at full charge almost 100% of the time, we can assume a battery lifetime of more than 10 years. With proper charging, AGM batteries require no maintenance and they do not require addition of water nor do they corrode their surroundings. Therefore, the maintenance costs should be less than $1,000/year.

2.4 Total Cost

2.4.1 Diesel Option

Initial costs:
$\$15,000_{\text{(procurement)}}$

Annual costs (also applies to the first year):
$\$14,716.8_{\text{(fuel)}} + \$4,500_{\text{(maintenance)}} + \$9,000_{\text{(refueling man hours)}} = \$28,216.8/year$

2.5 AMU-800 (Solar / Wind)

Initial costs:
$\$45,000_{\text{(procurement)}}$

Annual costs (also applies to the first year):
$< \$1,000_{\text{(maintenance)}}/year$

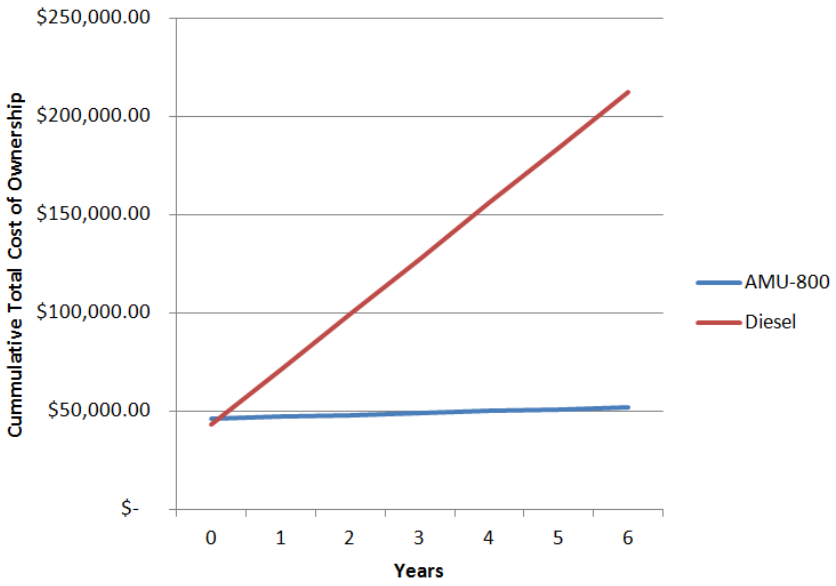

Figure 1: Total Cost of Ownership Comparison

References

[1] Leslie Lamport, *AGI6500DE and AGI6500SDE Operator / Owners Manual Version 11.4.1*. From Aurora Generators website, 2013.

[2] Kubota Engine Corporation America, *Generators - GL Series Brochure*
From `http://generator.kubota.jp/pdf/k-ge_usa.pdf`

[3] Martin Rivard, LYKO Systems, 2013, *Estimating the Available Solar and Eolian Energy to Size an Autonomous Mobile Energy Unit.*