White Paper

"How Do I Know I Can Rely on It?"

The Business and Technical Cases for Solar-Recharged Video Surveillance Systems

MICROPOWER TECHNOLOGIES

Introduction

Remote cameras are a security professional's eyes at the edges of parking lots, ranches, K/12 and university campuses, freight yards and power stations, where property is most vulnerable. The ideal remote camera is:

- solar-recharged – based on renewable energy and independent of the electrical grid
- wireless – flexible enough to place cameras close to target areas of interest, away from the primary source of power
- self-contained – comprising an integrated camera, transmitter, battery and solar panel
- pole-mounted – taking advantage of existing structures and requiring minimal new construction

Any security system is only as strong as its weakest link, and most security professionals are likely to regard a solar-recharged, wireless, pole-mounted, self-contained camera in a distant corner of the property as a probable point of vulnerability. These professionals are trained to look at every component in a system and ask, "How do I know I can rely on it?"

Nevertheless, security professionals in a wide variety of industries rely on solar-recharged, wireless video surveillance systems. They have evaluated the business and technical cases supporting the technology and proved to themselves that these systems are the most cost-effective way to maintain 24/7/365 eyes on their security perimeter.

The Business Case Around Remote Surveillance

Figure 1- Solar rechargeable video surveillance system

Every remote camera must have power and connectivity to deliver video. Consider the constraints on proper installation of remote surveillance cameras:

1. Cameras need to transmit a signal to a central security system. No matter where the camera is placed, its value lies in its ability to connect to and deliver a feed to a video management system (VMS) where that video can be used for situational awareness and upon alarm, situational assessment.

2. Cameras must transmit 24/7/365. Security cannot afford the luxury of downtime. Cameras must have a constant, uninterrupted source of power.

3. Remote cameras should not rely on the power grid. Remote corners of a protected property are not only the most vulnerable points, but they are also the least likely to have or maintain electricity. As security needs change, dependence on the power grid can limit options for relocating cameras.

4. Wired connections are potentially vulnerable and expensive. Cables for both video feed and power are susceptible to cutting, whether deliberate or accidental. Also, laying underground cable requires trenching, planning, permits, inspections, engineering and general facility disruption that can quickly add up to tens of thousands of dollars for average-sized properties.

5. Power consumption must be minimal. An optimally designed remote camera and wireless transmitter can deliver video 24/7/365 with average power consumption of .5-1W, or 12-24W/day.

6. Solar power is the best recharging option. Away from the power grid, a solar-recharged lithium ion battery is the most convenient and economical way of maintaining a constant power supply to the remote camera. Solar energy technologies are mature enough to fully recharge batteries on traffic monitoring systems, in homes and businesses and even on the Mars rovers. Their stable technology and reliable reputation allow banks to offer finance packages recognizing the 20- to 30-year lifespan of solar panels.

Thus, the configuration that best fits the business case is a fully integrated, remote camera that has its own low-power wireless transmitter, rechargeable battery and solar power source, and that is easy to relocate when necessary (see Figure 1).

The Technical Case Around Solar Recharging–"How Do I know I Can Rely on It?"

Still, security professionals focus on the worst-case scenario:
Will there be enough sunlight to recharge a remote, battery-powered camera reliably through a long, dark winter?

Consider the technical case around solar recharging, based on the define-measure-analyze-improve-control approach:

1. Define the Problem of Solar Recharging

Whereas power from the grid is constant, solar energy required to recharge a battery depends on the number of daylight hours per day and the strength of sunlight hitting the solar panel. These factors combined are called insolation, or solar irradiance, and they vary with distance from the equator. They also vary with weather conditions and with the angle of tilt of the solar panel.

Even though the need for 24/7/365 video surveillance is roughly the same in, for example, Phoenix in July as it is in Buffalo in December, the weather conditions are not the same, and it is much easier to rely on a solar panel to keep a battery charged in the former than in the latter. The problem, then, lies in determining whether solar power suffices to keep a battery charged in protracted, sunless conditions where video surveillance is required.

2. Measure Insolation

Although the variables that comprise insolation seem unpredictable and unstable, they are not. The reliability of solar recharging depends on:

a. Mapping insolation anywhere that video surveillance is required.
b. Arriving at a standard unit of measurement for insolation.

Organizations such as NASA, SolarGIS and the National Renewable Energy Laboratory (NREL) collect global insolation data from satellites. The resulting datasets are designed to facilitate the use of solar energy by charting average insolation in a given location in terms of kilowatt-hours per square meter (kWh/m2), a unit of measurement also used in rating solar panels.

For example, the NASA tables show that in Michigan in December, average insolation is 1.41 kWh/m2/day. This means that on an average December day, a 1m2 horizontal solar panel receives 1.41 kWh to convert to electricity for recharging the battery in a remote camera.

Maps illustrating the average insolation, or irradiation, at any point on Earth are available based on up to thirty years of data. These maps (see Figure 2) and their corresponding datasets are designed to depict average sunlight strength for use in solar power projects.

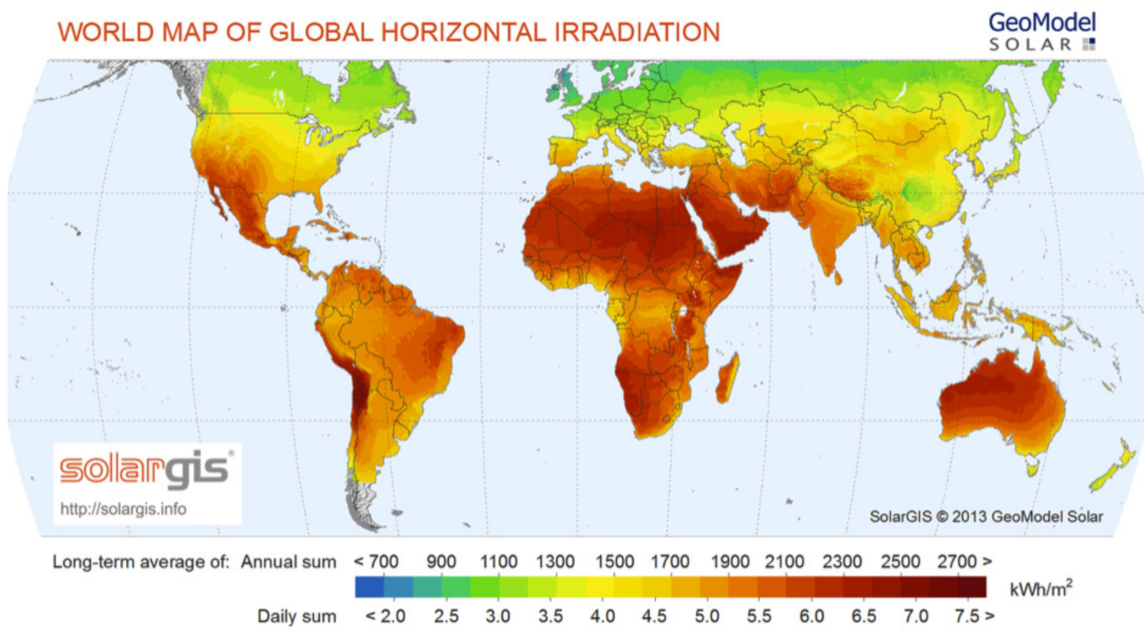

Figure 2 - Global insolation map (Source: SolarGIS)

With a large dataset and a recognized standard of measurement, it is possible to analyze solar recharging.

3. Analyze Worst Case

Given:

- a remote camera and transmitter that consumes 12W per day
- a lithium ion battery with a capacity of 75W
- a solar panel rated at 16 Watts peak (Wp) output

In the very-worst-case scenario, the panel would not recharge the battery at all and the camera would stop functioning after about six days (75W ÷ 12W/day = 6.25 days). However, as long as there is sunlight – that is, as long as the human eye is able to see outdoors without artificial light – the solar panel will charge the battery.

As defined above, the main question is whether solar power will suffice to keep a battery charged in protracted, sunless conditions where video surveillance is required. Security professionals can use a simple model to analyze the power generated and power consumed by the camera.

According to NASA data, a horizontal solar panel in Toronto in December receives 1.24 kWh/m2/day of insolation. Another way of viewing this 1.24 figure is as equivalent peak sun hours, in which solar panels are rated. Therefore, multiplying kWh/m2/day times the solar rating of the panel yields total wattage generated in a day. For example, 1.24 peak sun hours would yield 19.8W over an entire day (16 x 1.24 = 19.8). Since the camera consumes only 12W per day, this calculation shows that, at the time of year when insolation is lowest, the solar panel still recharges 65 percent more (19.8 ÷ 12 = 1.65) in an average day than the camera consumes.

Even more pessimistically, consider that insolation varies from day to day with changes in the weather. Assume a camera with a fully charged battery withstands four days of blizzard or dense fog in Toronto in December, reducing insolation to 15 percent of normal. Day 5 is sunny with 150 percent of normal insolation, followed by four additional gloomy days and another sunny day. As plotted in Figure 3, after a week and a half of improbably bad weather, the battery still holds 38 watts, or enough power for at least three full days of video surveillance

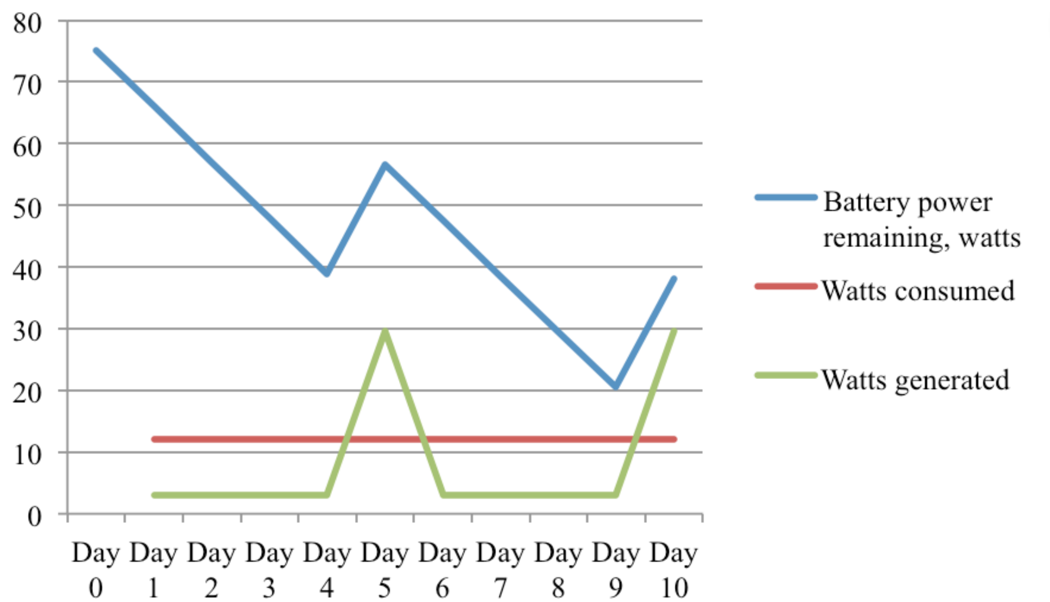

Figure 3 – Solar recharging chart, Toronto example (Solar panel horizontal)

[1]Refer to the Solar Irradiance calculator at http://www.solarelectricityhandbook.com/solar-irradiance.html.

4. Improve effectiveness.

The worst case will not always prevail, of course, and there is ample room to improve on this scenario by adjusting an important variable: the tilt of the solar panel. The sun strikes the surface of the earth at a different angle as the year progresses, so the horizontally mounted solar panel described above is not capturing as much sunlight as it could if mounted at an angle.

The best way to improve the effectiveness of solar recharging is to adjust the tilt of the panel every day to follow the sun, but this is not practical for a pole-mounted remote surveillance camera. The NASA tables include monthly insolation figures adjusted for latitude: best winter tilt, best summer tilt, best tilt for each month and best year-round tilt. If security professionals in Toronto install the solar panels at a 31-degree angle from vertical – the optimal winter angle for that latitude – average insolation in December jumps from 1.24 to 2.27 kWh/m2/day. As charted in Figure 4, after 10 days of improbably bad weather, the battery is fully charged.

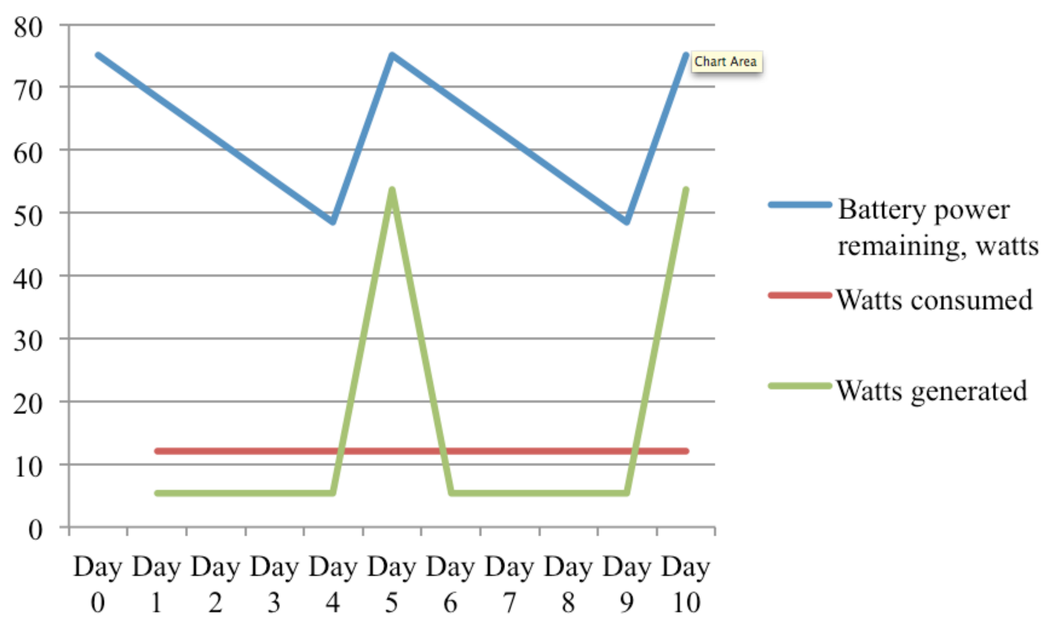

Figure 4 - Solar recharging chart, Toronto example (Solar panel tilted 31°)

Under these conditions the panel is providing an average of over 36W (16W x 2.27 kWh/m2/day = 36.3W) of power per day in the lowest month of the year. Based on this level of power generation, the system generates 200 percent more power than it consumes (36.38 ÷ 12 = 3) in December.

5. Control Efficient Recharging

To maintain recharging efficiency, security professionals should check the physical conditions around the remote cameras and solar panels regularly. Among the factors to control:

- alteration or damage to panel due to nature, weather or vandalism
- placement of the solar panel at the angle for optimal solar generation in winter
- shade from nearby trees or new structures
- optimal balance between location of camera and position of solar panel

Conclusion

Even in high latitudes, at the time of year when days are short and weather conditions are adverse, a 16Wp solar panel sufficiently recharges a 75W lithium ion battery to keep a 12W/day wireless remote video surveillance camera running properly. Using publicly available data, security professionals can perform their own analysis and demonstrate to themselves that they can rely on solar recharging for mission-critical surveillance needs in their own latitudes.