Battery Powered Trackers – The True Cost of Batteries

Executive Summary

Our analysis illustrates that the major cost of replacing batteries in asset tracking tags is the labour cost and not the cost of the battery itself. Employing tags powered by energy harvesting alleviates the need for battery replacement and offers lifetime cost savings, despite the higher initial cost of the tags – if the battery has to be changed at least once, light-powered tags are the more cost-effective choice.

Introduction

The majority of real time location system (RTLS) trackers and tags are currently powered by Li ion coin cell batteries. The lifetime of the batteries is reported to range from a few months to several years, quite a span; but little is discussed about the lifetime cost associated with battery powered tags. In this paper we will look at the total cost of ownership for battery powered tags over their lifetime and compare this to tags powered by battery-less energy harvesting.

There is a growing acceptance of the use of BLE trackers to monitor the location of portable equipment in hospitals, tools on construction sites, goods in warehouses, people moving through transport hubs; the range of applications is very broad. The value of being able to monitor the location of equipment and goods is that it helps to improve efficiency, reduce costs, enhance security and deliver convenience. In an ideal world the tags would be attached to the 'item' being monitored and forgotten about. However, the majority of tags are powered by batteries and as we all know, batteries run out of power at some point depending on how and where they are used.

Although the majority of RTLS tags are currently powered by batteries there are now alternative technologies to power smart trackers, for example harvesting the ambient light using photovoltaic technologies. Due to the advanced technology these trackers come at a price premium. This raises the question, is it more cost effective to pay the additional upfront cost of a battery-less tracker or is it cheaper in the long run to pay for the batteries to be replaced during the lifetime of the tracker? This paper will consider the lifetime costs of replacing batteries in tags and trackers.

In operation battery powered tags can present a number of challenges;

- what happens when the battery runs out of charge and the sensor ceases to function, no longer transmitting location data and the 'goods' position is no longer known?
- not all batteries last exactly the same length of time and so when is the optimum time to change the battery in a tracker? Is it before or after it has lost charge?
- what is the true cost of ownership for battery powered trackers?
- and what is the environmental impact and disposal costs of the millions or in the future billions of batteries that will be required to power these trackers in a connected IoT world?

Battery Lifetime in the Hospital Use Case

One application where there is a significant efficiency gain by adopting trackers is for locating portable medical equipment in hospitals. Hospitals are very busy environments, often working with limited resources and over-demand as indicated by the long waiting times people often experience in Accident and Emergency Departments. There are a significant number of portable medical devices; such as defibrillators, blood pressure monitors, fluid and infusion pumps, vital sign monitors etc. In addition, there are wheel chairs, trolleys and mobile beds that can also be tracked during use. The ability to locate such equipment quickly and easily in a busy hospital improves efficiency and enhances patient experiences and outcomes. Anecdotal evidence suggests that a nurse can spend between 20 – 25% of their shift looking for equipment! Thus, it is accepted that if each piece of portable medical equipment is fitted with a tracker, it will be easy to locate by simply looking at a dashboard showing its location on a map of the hospital. Beyond just locating equipment there are also options to optimise inventories of equipment by tracking usage. Bluetooth trackers are readily available to enable these solutions to be economically delivered. These trackers are currently generally powered by coin cell batteries and available from a number of manufacturers.

The data sheets for such trackers indicate that their lifetime can range from several months to a few years (< 5 years). This lifetime is governed primarily by how long and under what conditions the battery has been stored, the frequency of communication and the operating environment e.g. temperature. In practice many hospitals are reporting a useful battery life of no more than 2 years. The key risk is exceeding the battery's individual lifetime and having the device go dark so the tendency is to err on the side of caution and to change the battery early.

When to change the battery?

In a real-world environment, not all batteries will have the same lifetime. If we assume that the average lifetime for a battery is say 2 years, then a decision needs to be made as to when to replace the batteries, do you:

- replace all batteries in the trackers just before the 2-year lifetime is reached? In some cases, this might be combined with annual equipment servicing so reducing the labour time allocated to retrieving equipment for battery change, but the servicing schedule is unlikely to be optimum for battery lifetime maximisation. If this strategy is adopted there is a high probability that some of the batteries will have already run out of charge and others may have sufficient power to operate successfully for several more months and are being replaced before the end of their useful life.
  or
- replace individual batteries when they are almost depleted (assuming the tags can report on their state of charge) or when they are known to have completely run out of charge, therefore ensuring that each battery is used to its optimum lifetime? This is much less efficient for the person responsible for replacing the batteries and will be more complex to manage and schedule, as this is likely to happen randomly.

When a battery runs out of charge the tracker will cease to send a signal that identifies its location and at this point it is no longer visible on the tracking dashboard. Without location information the whereabouts of the portable equipment is unknown. This means the technician responsible for replacing the battery will first need to find the item and its tracker before the battery can be replaced, not an easy task in a large and busy general hospital. This can be a time-consuming process as the technician has to search for the asset and confirm the identity of the specific piece of equipment and its tag. The scenario is actually worse when you consider that some parts of a hospital may have restricted access and prior approval (paperwork and authorisation) will be required before access is granted.

In summary what appears to be a relatively simple and easy task of taking out an old battery and replacing it with a new one is rarely so straightforward. However, for a business the important consideration is the cost associated with battery replacement, so let us investigate this further.

The Process of Battery Replacement?

Before we dive into the costs of replacing batteries, it is worthwhile to consider the process steps necessary to manage battery powered tags and the actions needed to accomplish a battery change.

A paper by Xidas [*Reference*: Practical Power Solutions for Wireless IoT Xidas_WP.pdf (mouser.com)] comprehensively details their view of the steps required to successfully locate a tag, replace the battery and return it to the tracking system.

For each tag the steps will include:

1. Procuring the replacement batteries, storing them prior to need and for the technician to obtain the batteries from where they are stored
2. For an external technician/engineer there will be travel time to get from home or their workplace to the hospital (if a hospital employee this can be disregarded)
3. Gaining access to the hospital facility (the complexity will depend on whether the battery replacement is made by a hospital employee or an outside contractor)

4. Locating the tag and confirming the status of the battery (if necessary)
5. Replacing the battery (removing the tag from the equipment, opening the battery enclosure, releasing the old battery, installing the new battery and replacing the battery cover and reattaching the tag to the equipment)
6. Confirming the tag is working and that it is visible on the asset tracking platform
7. Disposal of the old battery
8. Logging the date and time that the battery was changed in order to manage future maintenance.

We consider this to be the simplest process flow for replacing a battery.

When considering the total cost of implementing an asset tracking solution, the actual cost of the Li-ion coin cell battery itself is relatively inexpensive. If purchased in volume the cost can be as little as £1/battery and for the sake of this model this is the cost we will assume.

However, when we consider the time and costs associated with steps 1-8 above, the battery cost itself is not the concern. Let us take a conservative view of what the costs could be.

We accept that each case will be different and hence we have made assumptions, as detailed in the table below, if you are considering this for your own circumstances you can replace our values with your own actual amounts.

We consider the cost of a technician to be in the range of £30/hour to £60/hour for a more experienced engineer. As mentioned previously, if the technician is not a hospital employee consideration needs to be made for the travel time to reach the facility.

Activity	Assumptions	Costs	
Materials & admin costs:			
Cost of Battery (purchased in volume)	£1/unit	£1.00	
Cost for an office administer to procure batteries and schedule technician/engineer time, per change campaign	1 hour of administrator time per change campaign. Administrator salary £25,000 pa	£12.00	
Technician labour costs:			
		Labour cost £30/Hr	Labour cost £60/Hr
Travel time (hours), per change campaign	0.5	£15.00	£30.00
Time to locate asset when location known (hours), per tag	0.25	£7.50	£15.00
Time to locate asset when location unknown (hours), per tag	0.5	£15.00	£30.00
Time to replace battery and check performance (hours), per tag	0.1	£3.00	£6.00
Scenario - Batteries in 1,000 Tags to be replaced:			
Materials cost of 1,000 batteries		£1,000	£1,000
Office admin labour cost		£12	£12
Technician labour cost of battery replacement for 1,000 tags	- Number of Tags where location is known and Tag is accessible: 800 - Number of Tags where location is unknown and Tag is inaccessible: 200	£12,015	£24,030
Cost to Dispose of 1,000 batteries = 6.6Kg (at £3/Kg)		£19.80	£19.80
Total Cost to Replace batteries for 1,000 tags		£13,046.80	£25,061.80
Cost per Battery replacement per tag		**£13.05**	**£25.06**

Clearly, we have made a number of assumptions in this lifetime cost model and have only considered the direct costs and not taken any account of the indirect costs associated with the tracker maintenance regime that will need to be added to the costs in the table.

The indirect costs relate to:

- Ordering and arranging shipment of the batteries
- Time to complete paperwork to gain authorisation to access parts of the hospital
- Disruption to the hospital clinical work as areas are out of use whilst the tracker batteries are being changed.

Costs of asset tracking tags vary based on features such as enclosure IP rating, quality, robustness or medical grade quality. However, in any case, the cost calculation clearly illustrates that the lifetime cost of a battery-powered tag is far in excess of that of an energy-harvesting powered tag even for or only one battery replacement cycle.

Some companies or hospitals may elect to purchase the lowest cost tags and change the whole tag rather than replacing the battery, this is an indication of the complexity of managing battery change campaigns and the associated labour costs. However, it comes at an even higher lifetime and sustainability cost.

We would love to hear from any reader on their real cost analysis and if your application has a different use case, please get in contact so that we can consider your specific situation. We are also developing a calculator that will be available soon, please see our website for further news.

Is there an alternative to Battery Powered Trackers?

Energy harvesting covers a number of different technologies, here we will focus on the employment of light energy harvesters for low power Bluetooth enabled trackers. Miniature BLE trackers have been demonstrated in field tests with the NHS and proven to function reliably under the ambient light conditions in a hospital environment. The benefits of PV powered trackers are numerous and include:

1. Reliable performance, even down to very low light conditions
2. Lifetime exceeding 15 years
3. Sustainable with a lower environmental footprint than equivalent battery powered trackers – please get in touch to ask for our sustainability whitepaper and embedded carbon calculator if you would like to know more.
4. The tags can be sealed (enabling a higher IP rating) as there does not need to be a battery compartment that needs to be accessible for battery changes.

5. The tags can be sterilised at high temperature if the application requires this.

Lightricity battery-free asset tracking tag powered by light energy harvesting

In Summary

It is true to say that an energy harvester powered tag comes at a price premium compared to a battery powered tag. However, when one considers the costs associated with changing the batteries on tags, the lifetime costs of a battery powered tag exceeds those of an equivalent light-powered tag.

Given the known variability in battery lifetime and the need to schedule battery-change for lowest risk of failure it is necessary to take a conservative approach to managing battery life resulting in significantly less life than the stated lifetimes often quoted. When it comes to the actual time taken to find a device needing a battery-change and to process that change, the labour costs far outweigh the battery cost. So the lifetime cost of batteries is such that in a typical asset tracking application, if you have to change the battery at least once during the device's lifetime then you would have been financially better off with a battery-free light-powered device. This is before you consider some of the other practical benefits of avoiding batteries e.g. wider temperature range compatibility for sterilisation, smaller size, fit-and-forget operation etc. Finally, the size of battery powered trackers is governed by the size of the battery. However, energy harvester powered tags do not have this restriction and can be miniaturised, thereby making them suitable for attachment to smaller pieces of hospital equipment.

Lightricity PV technology

Our technology is the world's most efficient indoor PV technology (though it works outdoors too). It converts indoor light sources to energy with up to 35% efficiency – a more than six-fold improvement on conventional PV, as validated by the UK's National Physical Laboratory (NPL).

A panel the size of your fingertip will power your IoT device forever. Even in extremely low indoor light. Our technology can be sealed in the device and operate at temperatures from -

40 to +200 degrees, opening possibilities to power devices not previously thought possible with indoor IoT.

We offer two solutions. For those designing new connected devices, our customisable PV panels can be integrated into any low-power IoT device as an alternative to batteries. For IoT systems integrators, we offer off-the-shelf, easy-to-integrate, completely battery-free PV-powered sensors for many common measurement and tracking applications.