# Commercialization of Lithium Titanate Batteries

## Remote, Emergency, and Critical Infrastructure in Cold-Weather Climates

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## Introduction

Battery-operated products are increasing exponentially due to energy transition and improvements in battery technology.

Using safe and efficient batteries with the following characteristic can benefit the environment, economy, and energy sectors.

- Longer lifetime
- Less environmental emissions
- Higher power capacity

Batteries are used in different applications:

- Starter batteries in vehicles
- Backup for renewable energies in a remote, emergency, and critical infrastructure
- Mobile hybrid energy storage

The primary batteries for these applications:

- **Lead-Acid** batteries are **inefficient in cold weather**
  - Low energy density (25–35 Wh/kg)
  - Short lifespan (1,000-1,500 cycles).
- **Lithium-ion batteries (Li-ion) efficiencies are reduced in cold weather** and cannot be charged at temperatures below 0°C.
  - High efficiency (about 99%)
  - High energy density (90-190 Wh/kg)
  - Long cycle-life (2,000-3,000 cycles).
- The **Lithium Titanate Oxide (LTO)** does not suffer from these deficiencies.

## Problem Overview and Methodology

This study's goals are to assess the feasibility of LTO batteries in terms of reliability, effectiveness, the cost, particularly for cold weather applications. The targeted applications are:

1. Energy Storage; Off-grid solar or wind battery backup.
2. Starter-Battery applications: A requirement for emergency-power generation and fleet-vehicle applications.
3. Hybrid-Power Generation: Where battery storage is used in conjunction with conventional gasoline or diesel generators.

To find out if LTO batteries are effective and affordable in freezing weather:

- Compared Lead-acid, Li-ion, and LTO batteries' performance
- Compared batteries' costs
- Calculated leasing option

## The Purpose of the Study

**Environment:**

- Reducing battery waste with higher life cycle batteries
- Use batteries as a backup for sustainable energy sources, to minimize the use of fossil fuels in off-grid infrastructures.
- Reduce electricity use by ending the need for battery heating in cold weather

**Energy:**

LTO battery energy storage and power delivery in chilly weather and the reliability of this battery in remote cold areas.

**Economics:**

Studying the value of using LTO batteries based on the life-cycle cost and the effect of leasing options to make their use economically feasible.

## Findings

### Performance

**Efficiency:**

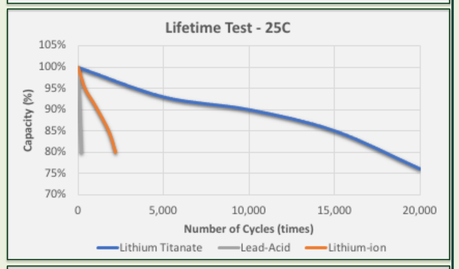
The amount of energy that can be taken from the battery compared to the amount of energy that was charged into the battery beforehand.

**LTO battery efficiency is close to 100%**


**Lifetime:**

The number of discharge times until the battery can store 80% of its original energy capacity.

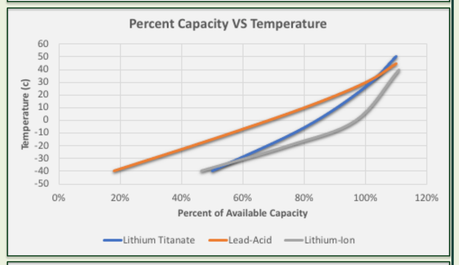
**LTO battery's lifetime is 100 times more than Lead-acid and 8 times more than Li-ion**




**Charging in Cold Weather:**

LTO batteries can perform from -40 to 50℃

**LTO battery's lifetime is 2.5 times more at -40℃ compared to lead-acid.**



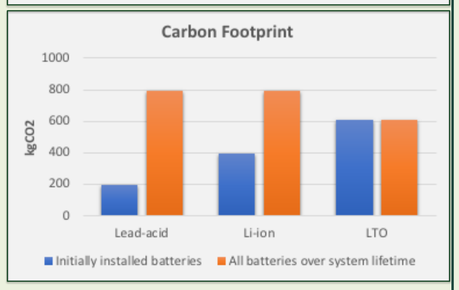

### Sustainability

**Carbon footprint:**

LTO battery's carbon footprint is less than Li-ion and Lead-acid in 20 years

**Battery waste:**

Using LTO batteries can reduce battery waste in long time use.




### Cost

Higher capital is needed to use LTO batteries in the system, but in a long time, it is cheaper.

To Calculate the cost for a 25 kW Power generator following aspects are considered:

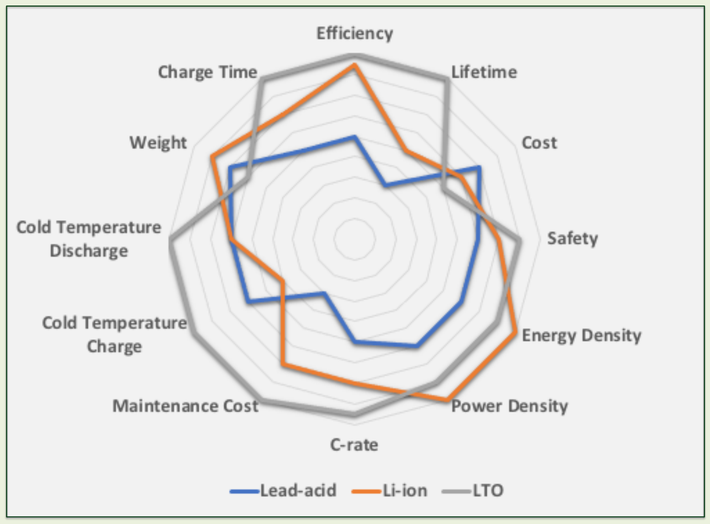
- Battery efficiency
- Battery Depth of Discharge (DOD)
- Number of cycles

| | Battery Price | Without considering cycles | Considering cycles |
|---|---|---|---|
| LTO | $850 | $13,600 | $13,600 |
| Li-ion | $495 | $7,820 | $62,560 |
| Lead-acid | $240 | $43,200 | $345,600 |

Purchasing LTO batteries for less than 10 years is not economical, therefore, the leasing option can help to make LTO batteries affordable for short use.

| Battery box price | Purchase for 10 years |
|---|---|
| LTO | $13,600 |
| Li-ion | $7,820 |
| Lead-acid | $86,400 |

## Conclusion




Advantages and Disadvantages of LTO batteries

| Advantages | Disadvantages |
|---|---|
| Higher efficiency (close to 100%) | Lower energy and power density |
| Perfect performance in cold weather | Higher cost |
| Fast charge (6 min) | Higher weight |
| No maintenance cost | Higher carbon footprint |
| Longer lifetime (about 20,000 cycles) | Hydrogen production |
| Higher current | |
| No safety risks | |
| No battery rooms | |
| Less waste | |

## Recommendations

- Use LTO batteries for remote infrastructures in cold climate areas.
  - LTO battery capacity is 2.5 times more than Lead-acid at -40℃ and performs better in cold climates than Li-ion batteries.
  - LTO batteries do not need to preheat to charge in freezing climates.
  - LTO batteries are more efficient in cold temperatures.
- Using LTO batteries reduces battery waste for a long time.
  - LTO batteries have a longer lifetime compared to Lead-acid and Li-ion batteries.
  - LTO's life cycle is 8 times more than Li-ion batteries and 10 times more than Lead-acid batteries.
  - LTO batteries have the highest efficiency compared to Li-ion and Lead-acid batteries, which can reduce the number of batteries needed for the infrastructure
- Using Lithium to produce more LTO batteries can reduce the use of Lithium which is at risk.
  - Lithium and Graphite are the materials at risk
  - The Titanate element is not at risk.
  - LTO batteries have a longer lifetime and fewer batteries are needed for a system for a long time.
- Considering higher market and investment for LTO batteries, especially in cold climates.
  - The global battery market is predicted to increase by 2030.
  - LTO can help to balance demand and production.
- Use leasing option For less than 15 years of usage of LTO batteries.
  - LTO batteries' cost is one of the main disadvantages.
  - Buying them for less than 15 years is not affordable.