# BATTERIES SELECTION:
# SUSTAINABILITY & LIFE CYCLE COST

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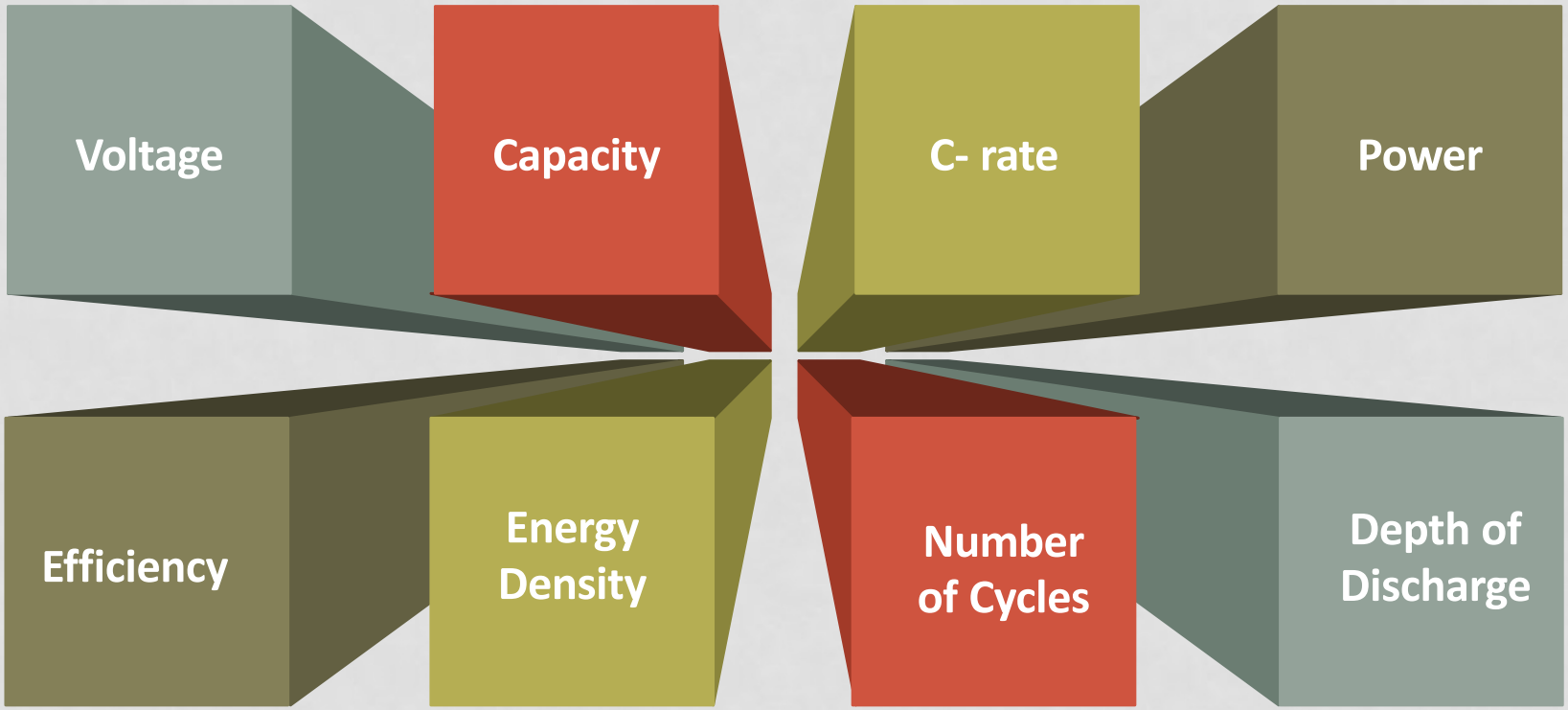
# OUTLINE


1. Battery Characteristics
2. Battery Selection Criteria
3. Battery Types
4. Common Issues
5. Battery Failure
6. Lithium Battery System Configurations
7. High Voltage Battery Systems
8. Cost Benefit Analysis
9. Recommendations for People
10. Recommendations for Municipalities
11. Disposal and Recycling of Batteries

# 1. BATTERY CHARACTERISTICS



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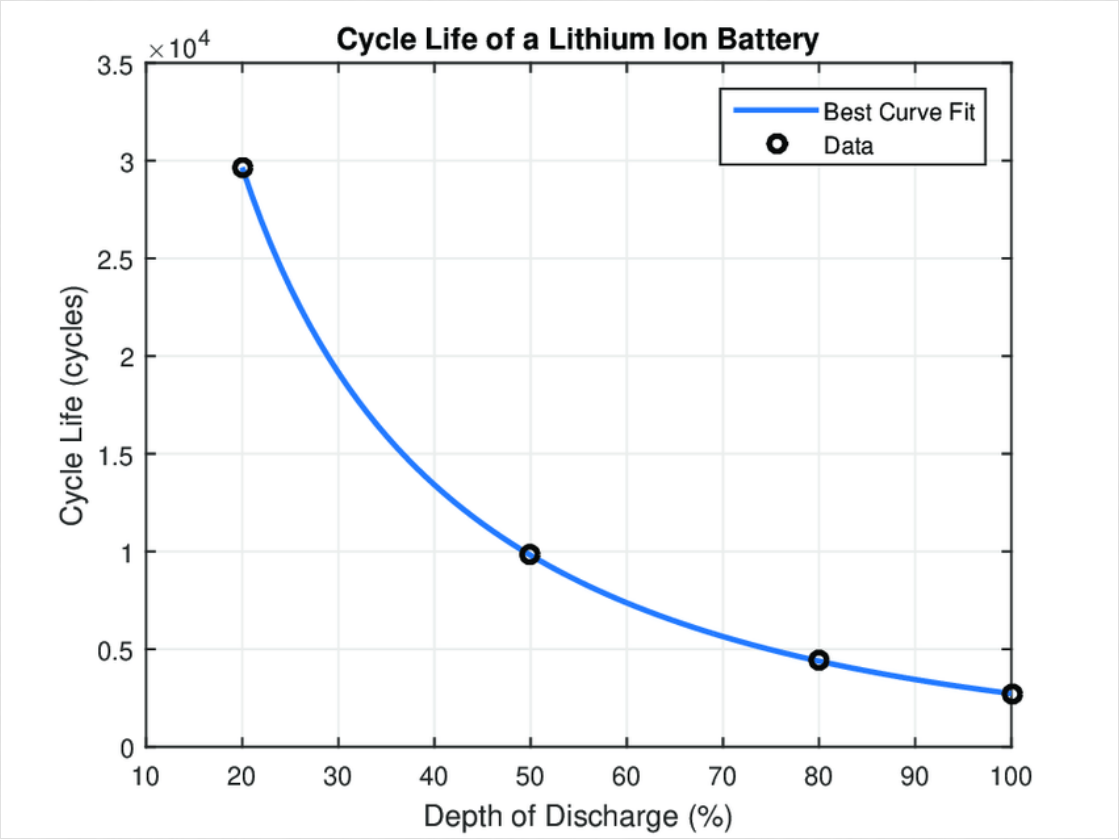
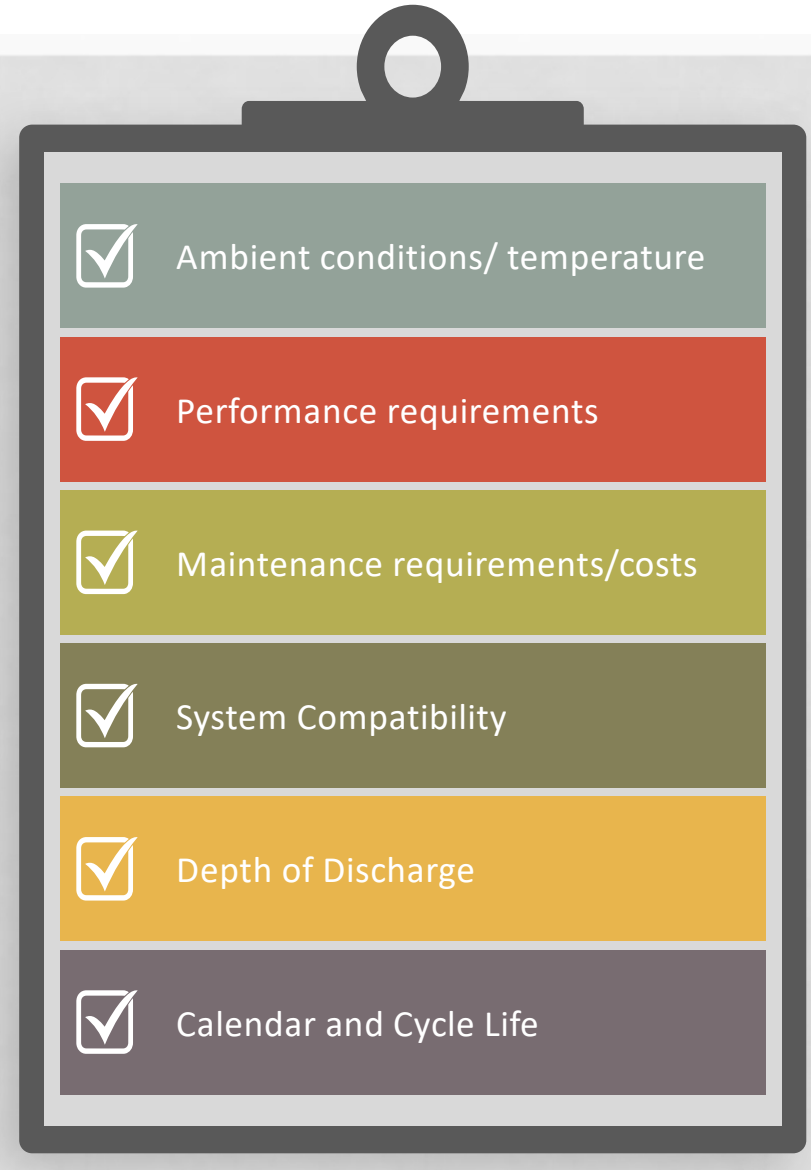
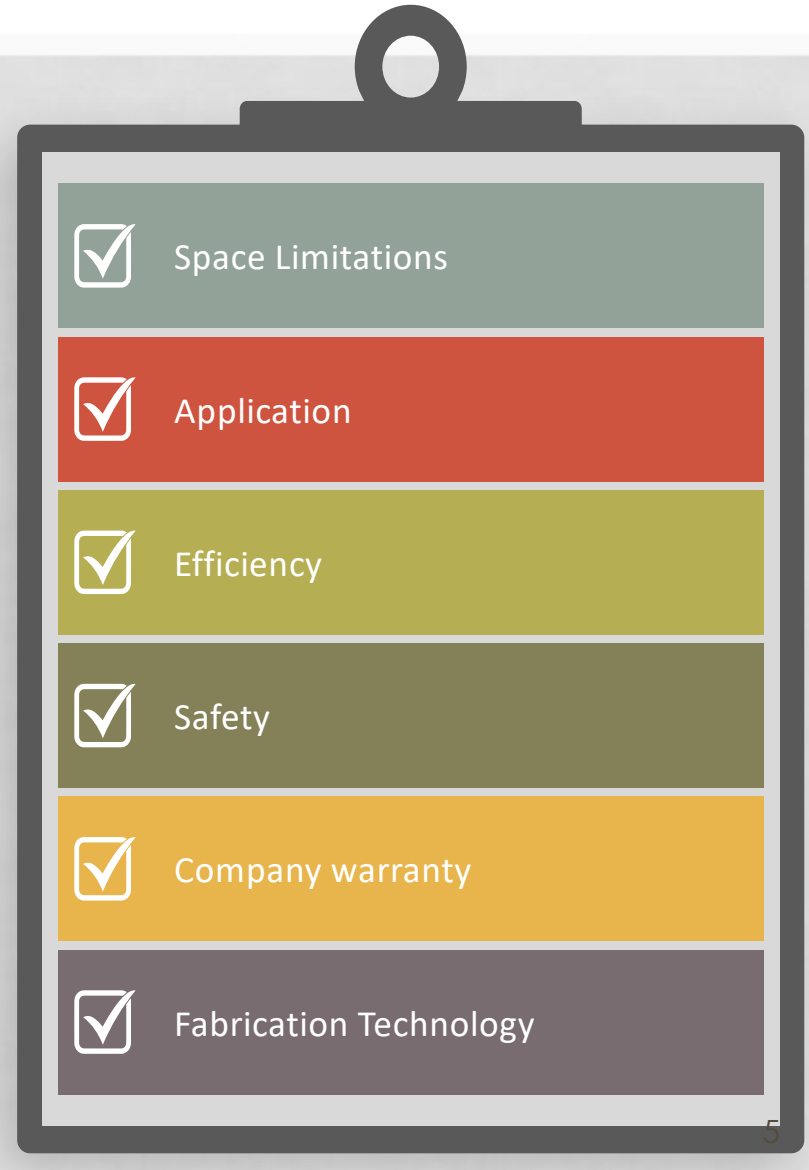



Mallon, K. R., Assadian, F., & Fu, B. (2017). Analysis of on-board photovoltaics for a battery electric bus and their impact on battery lifespan. *Energies*, *10*(7), 943.

# 2. BATTERY SELECTION CRITERIA



# 3. BATTERY TYPES

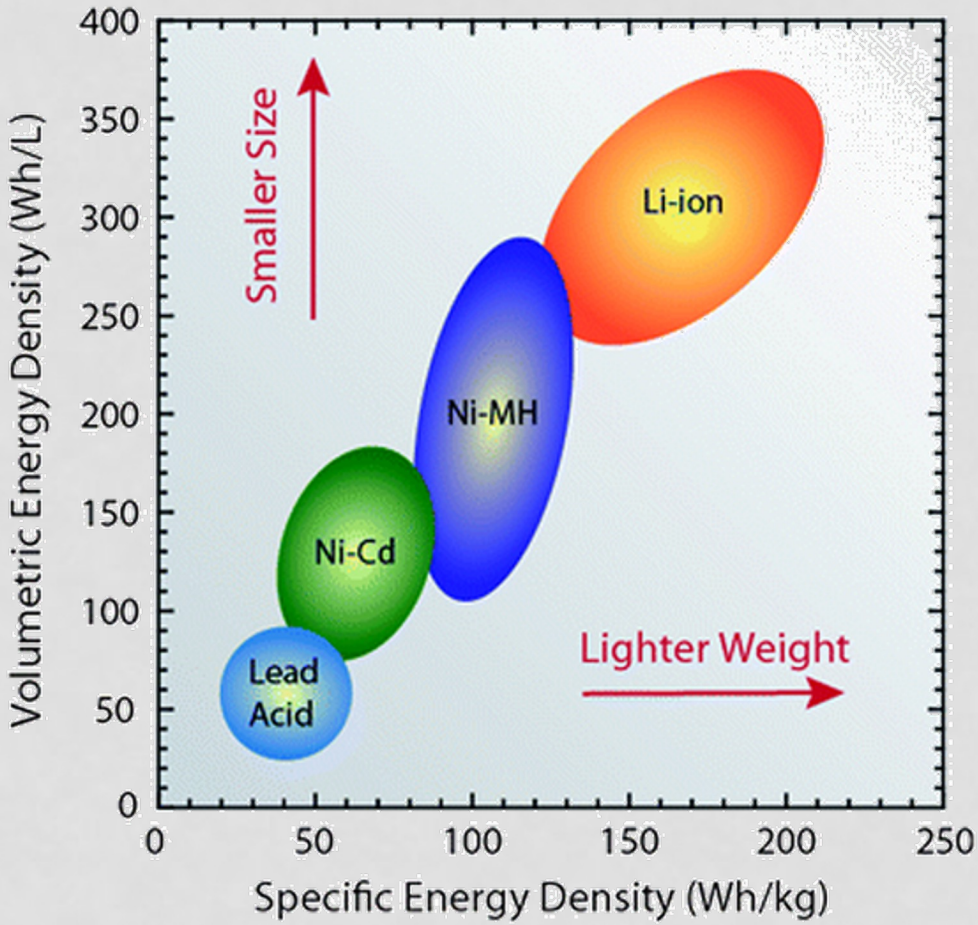
- Battery Main Types are:

1- Lead Acid

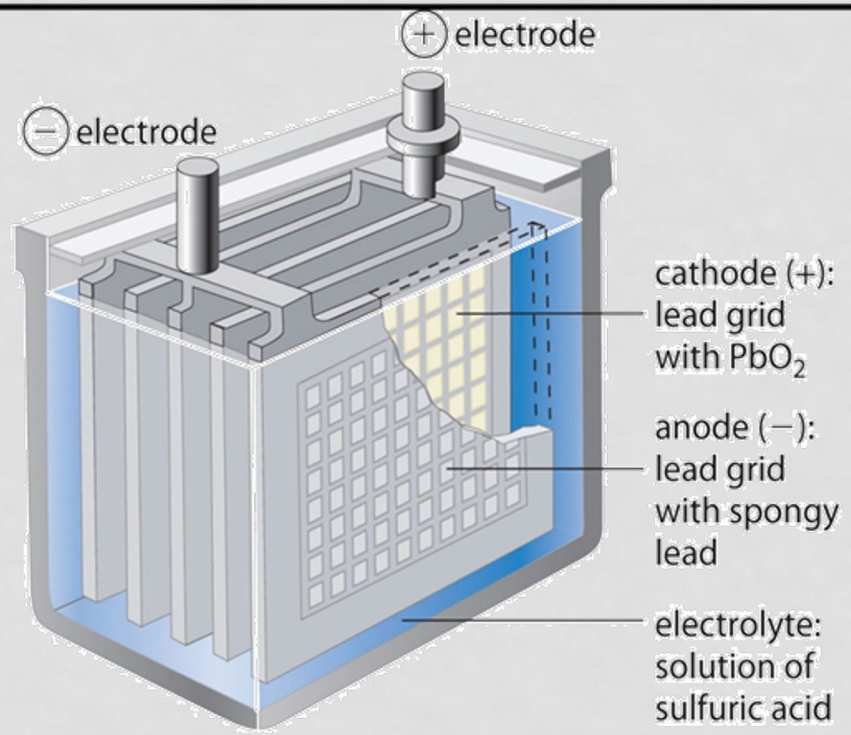
2- Nickel–cadmium (Ni–Cd )

3- Nickel–metal hydride (Ni–MH)

4- Lithium –ion



# Lead-acid

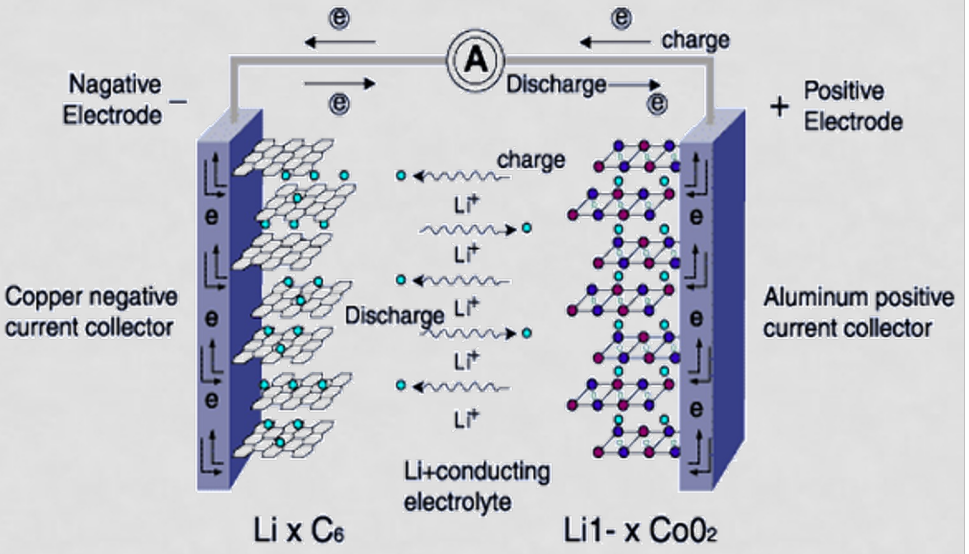



cell reaction:

$Pb(s) + PbO_2(s) + 2HSO_4^-(aq) + 2H^+(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$

**2 V**

# Lithium ion




$LiCo0_2 + C_6 \underset{\text{Discharge}}{\overset{\text{charge}}{\rightleftharpoons}} Li1\text{-}xCo0_2 + LixC_6$

**3.2-3.7 V**

# 3.(A)- LEAD ACID

## Advantages

1. *Low Cost*
2. *Available in a wide variety of sizes*
3. *Efficiency > 75%*
4. *Low or no maintenance*
5. *Recyclable*

## Disadvantages

1. *Short life cycle*
2. *Energy density is relatively low*
3. *Hydrogen evolution is potentially dangerous*

# 3.(B)- LITHIUM ION

## Advantages

1. *Can be fully charged in a short time*
2. *High Efficiency (80%-90%)*
3. *Higher energy density than lead-acid batteries*

## Disadvantages

1. *Expensive*
2. *Deep discharge may short circuit the cell*
3. *Cell rupture may lead to potential explosion, it is more dangerous than lead-acid !*

# 4. COMMON ISSUES (LEAD ACID)

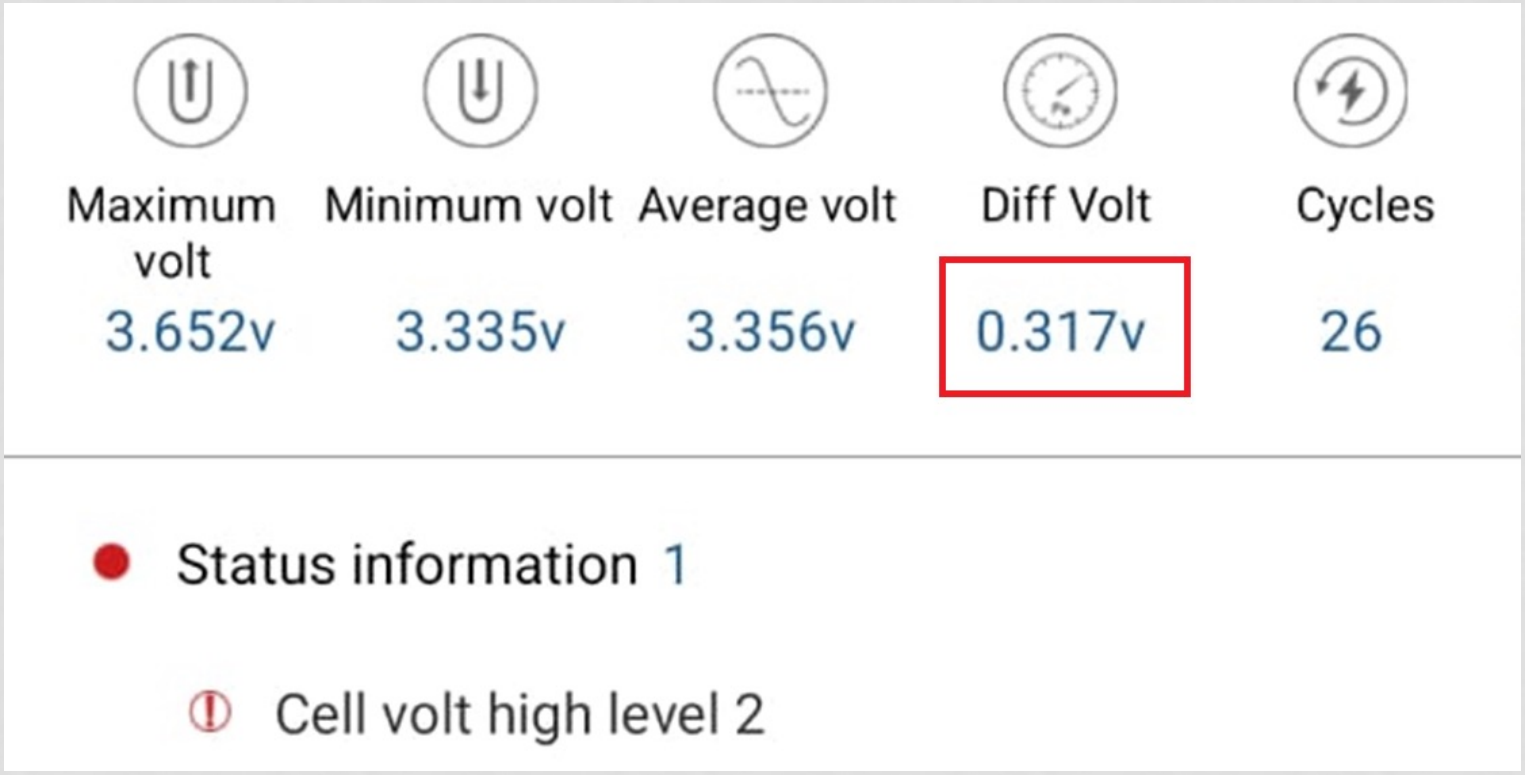
- New batteries connected to old batteries
- Batteries placed on floor !
- Batteries exposed to moisture and humidity
- High room temperature !
- Difference in DC cables' length

# 4. COMMON ISSUES (LEAD ACID)

- All batteries have the same lifespan
- Batteries placed on roofs at a distance from floor level
- Batteries placed in a closed cabinet with ventilation
- Same cables' length

# 4. COMMON ISSUES (LITHIUM)

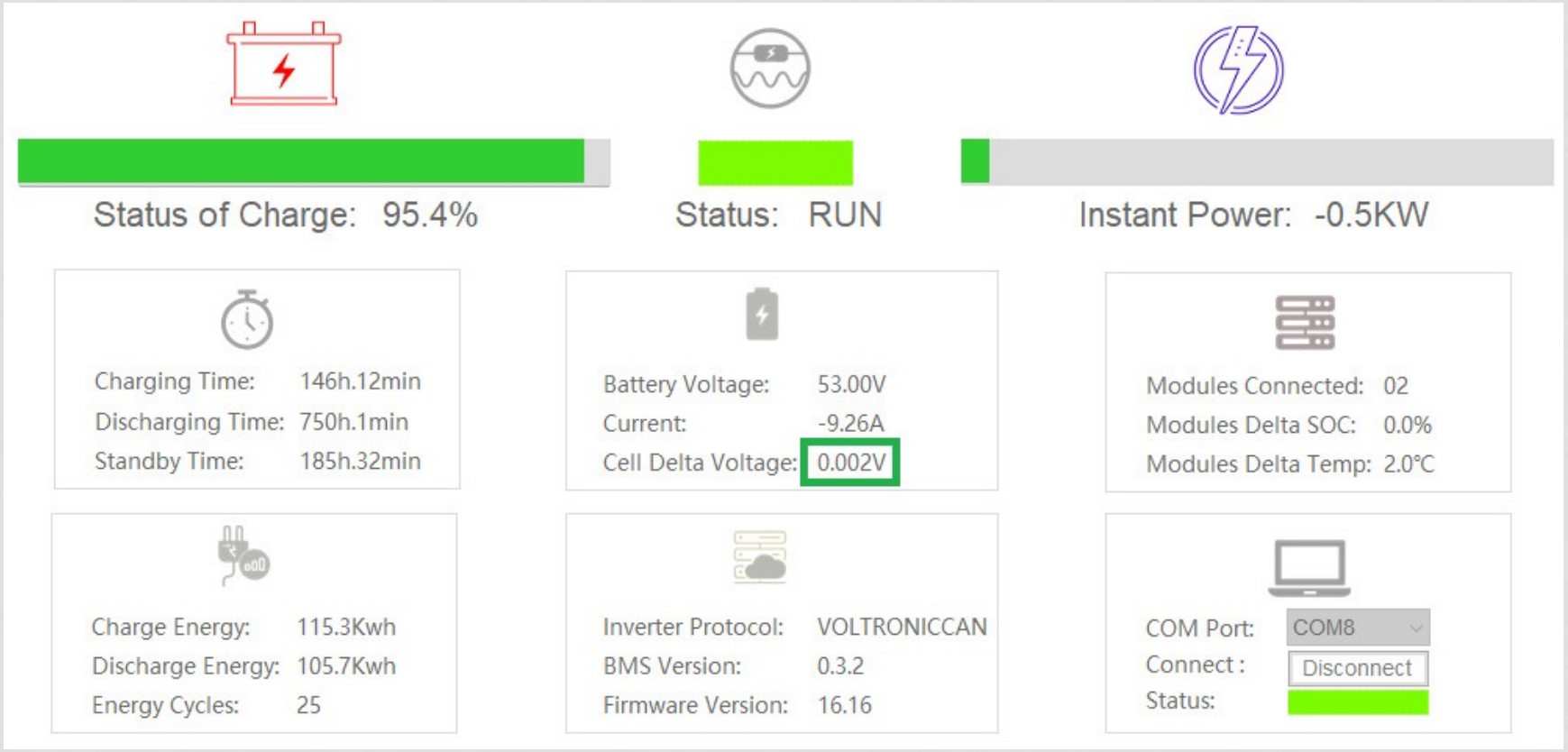
## Low Quality Battery




0.317V Cell Delta Voltage!

# 4. COMMON ISSUES (LITHIUM)

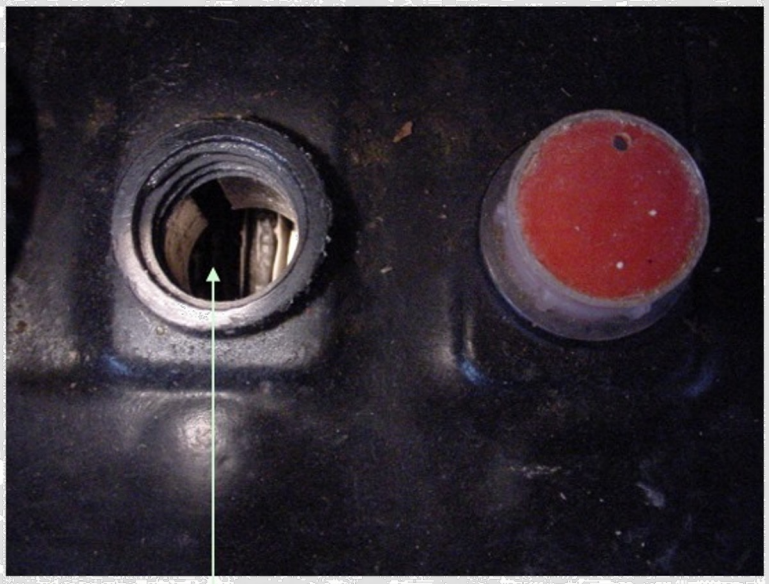
## High Quality Battery




2mV Cell Delta Voltage

# 5. BATTERY FAILURE: CAUSES

Poorly maintained “self-regulating” system. Note corrosion of terminals!



Electrolyte level critically low. Battery recovery after exposure of Pb plates to oxygen for a long period is unlikely.

# 5. BATTERY FAILURE: CAUSES

Can you handle the pressure??

- **Over Charging and Discharging !**
- **Non-regulated Usage !**

# 5. BATTERY FAILURE: CAUSES

- **Lithium Battery damaged due to a short circuit**

# 6. LITHIUM BATTERY SYSTEM CONFIGURATIONS

## Low Voltage Batteries

- High DC current
- Low efficiency
- Used for low-demand applications

## High Voltage Batteries

- Low DC current
- High efficiency
- Used for high-demand applications

✓ High voltage battery systems are more suitable for large-size facilities.

# 7. HIGH VOLTAGE BATTERY SYSTEMS: EXAMPLE 1

**Real Life Examples**

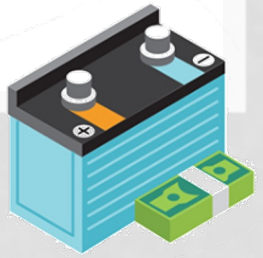
- High voltage battery bank in Jwayya Hospital –South Lebanon
- Maximum 50A (DC) at each cluster

# 7. HIGH VOLTAGE BATTERY SYSTEMS: EXAMPLE 2

**Real Life Examples**

- High voltage battery bank in a sweets factory (Tyre- South Lebanon)
- Capable to handle inrush current obtained with industrial loads

# 8. COST BENEFIT ANALYSIS



01 COST (initial, operational, maintenance)

02 Cycle life and degradation

03 Efficiency, Resilience and Reliability

04 Technology Advancements

05 Financing issues, government incentives & regulations

A misguided selection of batteries can result in unnecessary financial losses due to inadequate cost-effectiveness

# 9. RECOMMENDATIONS FOR PEOPLE

**To choose a battery take into account the following features:**

- ✓ Long lifespan with large number of cycles
- ✓ Large Depth of Discharge
- ✓ Ability to stay at low State of Charge for a long time without capacity loss
- ✓ High energy efficiency (≥ 85%); very low self-discharging rate
- ✓ High energy density, specially when there are space/weight limitations
- ✓ Good safety measures
- ✓ Maintenance issues

# 10. RECOMMENDATIONS FOR MUNICIPALITIES

**The municipalities are advised to:**

- ✓ Raise the public awareness about the aforementioned points
- ✓ Make site inspections for the facilities to check and evaluate the battery systems there and act accordingly (if needed)
- ✓ Organise large-scale procurements of batteries for the whole village (after being approved by qualified engineers), in order to ensure the quality requirements and low-cost as well

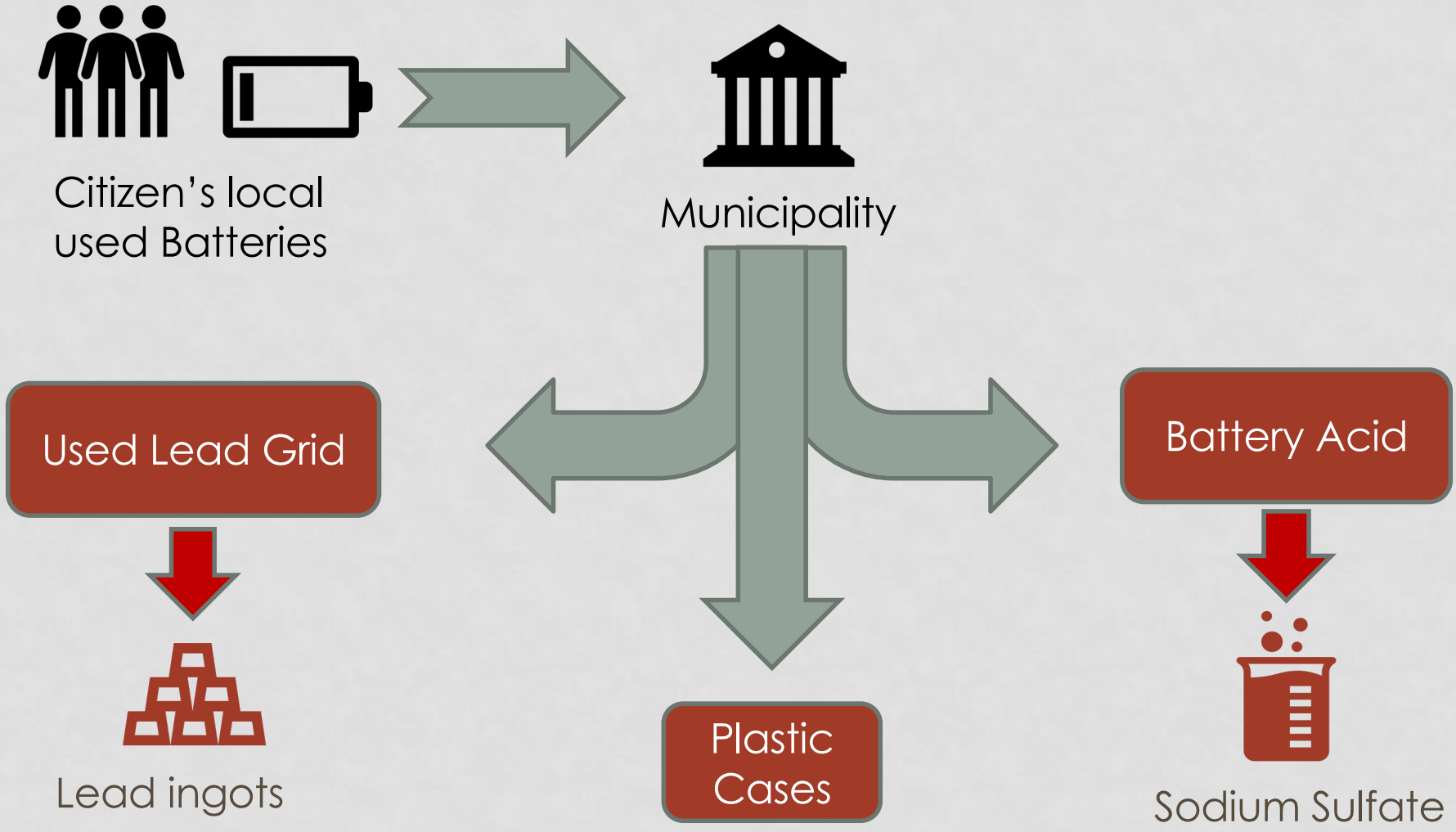
# 10. RECOMMENDATIONS FOR MUNICIPALITIES

**The municipalities are advised to:**

- ✓ Long term approach: Establish a battery system for the whole village (when there is a unified network with eligible infrastructure), to improve the total energy efficiency and reach a better monitoring/control (as following the birth of ≈1 GWh batteries ! )

- ✓ Monitor "Recycling of Batteries" projects

# 11. DISPOSAL AND RECYCLING OF LEAD ACID BATTERIES



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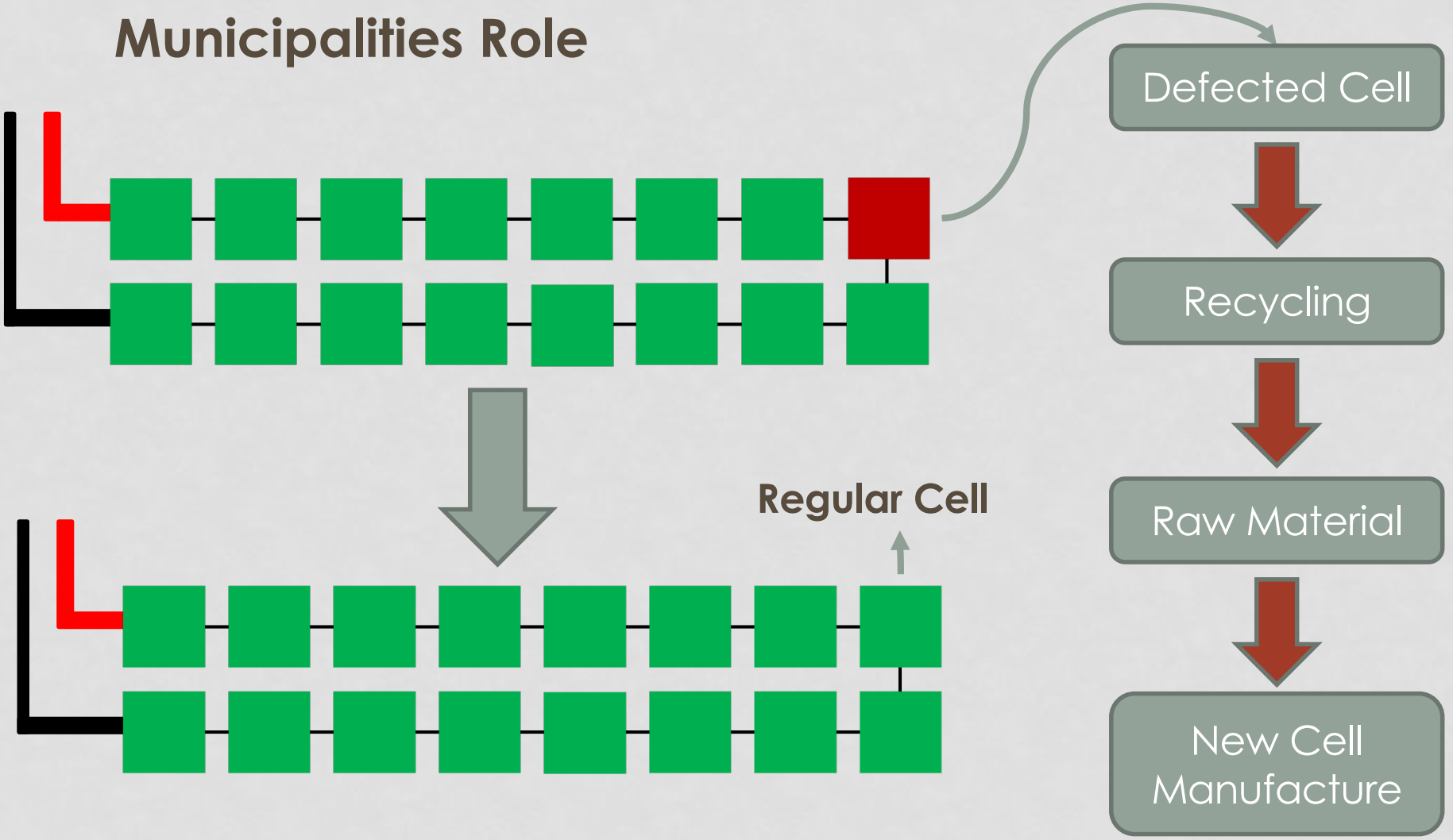

# 11. DISPOSAL AND RECYCLING

## DO NOT !

- Do not put damaged or defective batteries in regular waste bins.
- Do not store damaged or defective batteries near flammable materials.
- Do not crush the batteries to avoid short-circuiting or leakage.
- Do not store batteries in large quantities nearby.


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THANK YOU FOR ATTENTION

QUESTIONS?