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Life Cycle Assessment of LFP and NMC battery Production in Nevada, USA

<u>Group No : 12</u>

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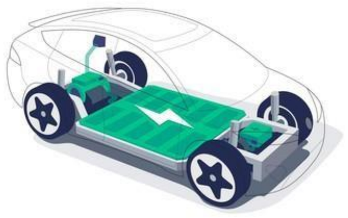


Introduction

The greatest threat to our planet is the belief that someone else will save it."
— Robert Swan

- Green Transition : Fossil fuels to Sustainable energy
- Need for efficient energy storage for EVs and other electronic devices
- Invention of Li-Ion batteries

- Current Method : *Lithium Iron Phosphate batteries (LFP)*
- Alternative Method : *Nickel Manganese Cobalt Lithium Ion batteries (NMC)*

- Geographical Locations
- LFP Batteries : *Gigafactory, Storey county, Nevada, USA*
- NMC Batteries : *Dragonfly Energy, Reno, Nevada, USA*

Scope and Boundary : Cradle to Gate

Background of the problem

LFP batteries advantages:

- → Better durability, thermal stability and longer life cycle
- →Lower Production cost

LFP batteries challenges:

→ Lower Energy Density, limited cold weather performance
→Bulkier design
→ Higher carbon footprint on the environment

NMC as an Alternative:

→ High energy density, effective performance over wide range of temperatures
→Better profitability
→ Compact design and easy transportation

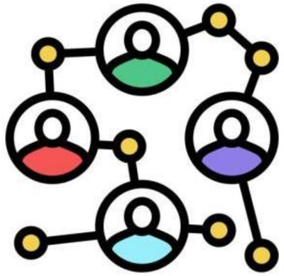
Approach to Measure sustainability

- Sustainability Metrics : Environment, Economic and Social

Category	**Environment Sustainability**	**Social Sustainability**	**Economic Sustainability**
Indicator Analysed	1. Abiotic Depletion Potential 2. Global warming Potential 3. Acidification Potential	1. Health and safety 2. Demography 3. Inequality 4. Cultural tensions 5. Employment 6. Education 7. Economic Development	1. Efficiency 2. Gross Profit

- Sustainability score calculation

Stakeholder Consideration



- Local communities surrounding mining projects
- Manufacturing Industry
- Government and National regulatory agencies
- NGOs
- Employees/Workers
- Automobile companies (retailers)

- Consumers of electric vehicle and other electronic products
- Waste management companies
- Investors
- Researchers and academic institutions

Issues addressed : Environmental. Economical and Social and benefits after considering the alternative

Environmental Indices Calculations

Impact	Formula Used	LFP	NMC	Direction
Abiotic Depletion Potential (ADP)	$ADP_i = \frac{\frac{DR_i}{(R_i)^2}}{\frac{DR_{ref}}{R_{ref}^2}}$ $abiotic\ depletion = \Sigma_i ADP_i \times m_i$	15.691 kg Sb eq	9.427 kg Sb eq	– +
Global Warming Potential (GWP)	$GWP_i = \frac{\int_0^{TH} a_i c_i dt}{\int_0^{TH} a_{CO_2} c_{CO_2} dt}$ • $I_{GW} = \sum_i (GWP_i \times m_i)$;	348.710 kg CO_2 eq	229.45 kg CO_2 eq	– +
Acidification Potentials (ARP)	$\eta_i = \frac{\alpha_i \text{ moles of } H^+ \times 1}{1 \text{ mole of precursor } i \times MW_i} = \frac{\alpha_i}{MW_i}$; $ARP = \frac{\eta_i}{\eta_{SO_2}}$	3.254 SO_2 eq	1.653 SO_2 eq	– +

Performance score for LFP and NMC

MS: Material Selection, **EU:** Energy usage**, SR :** Solid residue**, LR:** Liquid Residue**, GR:** Gaseous residue

LFP

	MS	EU	SR	LR	GR
Pre manufacturing	3	2	2	2	3
Product Manufacturing	2	1	2	1	2
Product Use	3	2	4	4	3
Packaging	2	1	2	1	2
Product Recycling	1	1	1	1	1
	11	7	11	9	11

49 (SCORE); %**Score=49/ (25*4) =49%**

NMC

	MS	EU	SR	LR	GR
Pre manufacturing	1	2	1	1	2
Product Manufacturing	1	2	2	1	2
Product Use	3	3	4	4	2
Packaging	2	2	2	2	2
Product Recycling	2	2	2	2	2
	9	11	11	10	10

51 (SCORE); %**Score=50/ (25*4) = 51%**

Economic Analysis of LFP and NMC Processes

- The economic study of manufacture of LFP batteries and NMC batteries in Nevada, highlights significant variations in costs and resource availability.

Raw Materials Cost:

LFP

Raw Material	Mass (kg)	Unit Price (USD/kg)	Total Cost (USD)
Lithium Carbonate	234.18	26.23	$6142.54
Iron	354.02	12.21	$4332.34
Conductive Carbon	57.10	1.98	$113.06
Phosphoric Acid	621.13	2.61	$1621.15
Total	**1,266.43**		**$12,209.29**

NMC

Raw Material	Mass (kg)	Unit Price (USD/kg)	Total Cost (USD)
Nickel (II) Sulfate	538.0	3.63	1,952.94
Manganese (II) Sulfate	524.96	1.3	682.45
Cobalt (II) Sulfate	538.87	8.77	4,725.88
Sodium Hydroxide	834.38	0.51	417.19
Lithium Carbonate	385.33	26.23	10107.21
Total	**2821.54 Kg**		**$ 17,885.46**

Energy Cost

For LFP

Energy needed for 1000 kg = 1000 kg×65KWh/kg=65000 KWh

- Energy Cost = 65000 kWh×0.06 $/kWh=$3900

For NMC

- Energy needed for 1000 kg: 1000kg×100kWh/kg =10000kWh
- Energy Cost = 10000kWh×0.06$/kWh =$6000

NV Electricity Rates | Electricity Local

Economic Analysis of LFP and NMC Processes

Type of cost	LFP (Amount in $/1000kg)	NMC (Amount in $/1000kg)
Cost of Raw Materials	12209.29	17885.46
Cost of Energy	3900	6000
Manufacturing Cost(Raw+Energy+Misc.)	16,123.35	23889.28
Selling Price	34,769.06	79,477.60
Gross Profit	18,645.71	55,588.32
Efficiency	2.16	3.33

Social Indicators

- We have analysed multiple social sustainability indicators for LFP and NMC method

1. Health and Safety

- *Chemical Exposure:*
    - **LFP:** Phosphates are highly reactive and causes formation of phosphoric acid, which is a corrosive byproduct (-)
    - **NMC:** The intermediates of NMC processing are more chemically stable during production (+).

    - **LFP:** Thermally stable at higher temperature (+)
    - **NMC:** Thermally unstable at higher temperature (-)
- *Dust Exposure*:
    - **LFP:** Fine particles LFP cathode powder disperse easily and cause respiratory risks. **(-)**
    - **NMC:** Greater particle size/slurry form during process reduces airborne exposure risks **(+)**

2. Demography

- *Displacement:*
    - **LFP:** Rising costs of houses near Gigafactory caused displacement of lesser privileged people (-)
    - **NMC:** Influx of people resulted in initial inflation in housing but lesser affordability brought the housing priced down (+)

3. Inequality

- *Economic Disparity:*
    - **LFP and NMC:** Depriving the middle-skilled ones; better economic opportunities only for the highly skilled and low-wage workers (-)

4. Cultural Tensions

- *Indigenous Communities*:
    - **LFP:** Issues related to destruction of native land (Native Americans) (-)
    - **NMC:** Local culture at risk due to difficulty of newcomers to assimilate and Reno-Sparks Indian Colony faces urbanization and economic (-)

5.Employment

- ***Job Creation:***
  - **LFP:** Gigafactory local employment reduced from 7.5% to 3.4% from 2010 to 2013 (**+**).
  - **NMC:** NMC companies created 2,300+ jobs and increased the average wage to $32.67 (+).

6. Education

- ***Skill Development:***
  - **LFP:** Training program of 1,000+ skilled workers by Truckee Community College under Gigafactory (+)
  - **NMC:** Collaboration of Dragonfly Energy with University of Nevada and entrepreneurs (+).

7. Economic Development

- ***Community and Infrastructure Investment:***
  - **LFP:** Gigafactory contributes to local infrastructure such as education, healthcare and transportation (+).
  - **NMC:** Dragonfly Energy contributes to national projects and assists in local businesses (+).

Conclusion

- **1) Environmental Impact:** Compared to the LFP method, which produces fine particulate matter that causes respiratory problems and more environmental damage, the NMC battery production process emits fewer pollutants.
- **2) Economic Metrics:** NMC batteries have stronger long-term economic viability than LFP batteries due to their substantially larger gross revenues, despite higher initial cost and production cost.
- **3) Social Impact:** Both LFP and NMC producing companies contributed significantly to job creation in the Nevada region. However, indigenous tribes have been displaced by mining for both processes.
- **4) Stakeholder Interests:** Economic and environmental concerns are given top priority by stakeholders, and NMC performs better than LFP in terms of adhering to more stringent government environmental laws.
- **5) Research and Development:** In order to promote sustainable battery production and encourage innovation, NMC manufacturers make significant investments in R&D, work with academic institutions, and assist startups.
- **6) Technological Advantage:** NMC batteries are a more viable option for electric vehicles because of its higher energy density, compact & smaller size, and improved performance in colder climates.
- **7) Final Verdict:** When stakeholder interests and environmental, economic, and social factors are taken into account, ***NMC batteries stand out as a better, more sustainable option than LFP batteries***.

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