

India

**Underweight** (no change)

**Highlighted Companies**

**Gujarat Fluorochemicals Ltd**  
**REDUCE, TP Rs1946, Rs2395 close**  
 Gujarat Fluorochemicals has witnessed substantial re-rating in past six months from 19x one-year forward to 42x P/E. We don't find any justification for such a high valuation and hence, downgrade the stock to Reduce with a TP of Rs1,946.

**Navin Fluorine International Ltd**  
**HOLD, TP Rs3476, Rs4000 close**  
 Business fundamentals are in place but stretched valuation doesn't leave any upside potential from current levels.

**SRF Limited**  
**HOLD, TP Rs8481, Rs2159 close**  
 A major portion of earnings is driven by commodity verticals like nylon tyre cord and BOPP/PET films. We have concerns over sustainability of earnings and hence, our HOLD rating on the stock.

**Summary Valuation Metrics**

P/E (x)	Mar22-F	Mar23-F	Mar24-F
Gujarat Fluorochemicals Ltd	44.08	42.73	33.79
Navin Fluorine International Ltd	65.88	52.78	42.01
SRF Limited	9.8	8.1	7
P/BV (x)	Mar22-F	Mar23-F	Mar24-F
Gujarat Fluorochemicals Ltd	6.08	5.32	4.6
Navin Fluorine International Ltd	10.44	8.9	7.52
SRF Limited	1.59	1.35	1.14
Dividend Yield	Mar22-F	Mar23-F	Mar24-F
Gujarat Fluorochemicals Ltd	0%	0%	0%
Navin Fluorine International Ltd	0.19%	0.24%	0.31%
SRF Limited	0.9%	1.08%	1.08%

**Analyst(s)**



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# Chemicals - Overall

## Li-Ion battery - Deciphering facts over fiction

- Three chemistries - NMC, NCA and LFP - rule the scene but new innovations are continuous such as a semi-solid battery, CMC binder, etc.
- India's PLI scheme can attract several big players and an eco-system can develop in the country for Lithium-Ion or Li-Ion battery manufacturing.
- In our view, investors can take a portfolio stance and BUY multiple stocks that can benefit from this development. It's too early to identify a winner.

### Currently India is battery-pack assembler, PLI can be a game changer

Li Ion battery is a technology-intensive Industry. Currently, most Indian companies involved in Li-Ion industry are battery-pack assemblers at best (at the same time, almost all have plans to invest in battery manufacturing). Globally, three chemistries are ruling the Li-Ion battery space - NMC (Lithium-Nickel-Manganese-Cobalt-Oxide), NCA (Lithium-Nickel - Cobalt-Aluminium Oxide) and LFP (Lithium-Iron Phosphate). While India lacks lithium, as a country, we have good chemistry skills and therefore can do well in binder, anode, and electrolyte manufacturing. India's Productivity-Linked Incentive or PLI scheme is awesome for any new player in Indian market who doesn't want to take an equity risk as it offers 1) up to US\$26m incentive per GW, essentially at 70:30 debt-equity ratio new companies can install their plant at zero equity investment, and 2) a graded time scale for increase in value addition (Indian government doesn't want the plant to fully manufacture batteries right from Day 1 – it has given a five-year time frame to achieve 60% value addition).

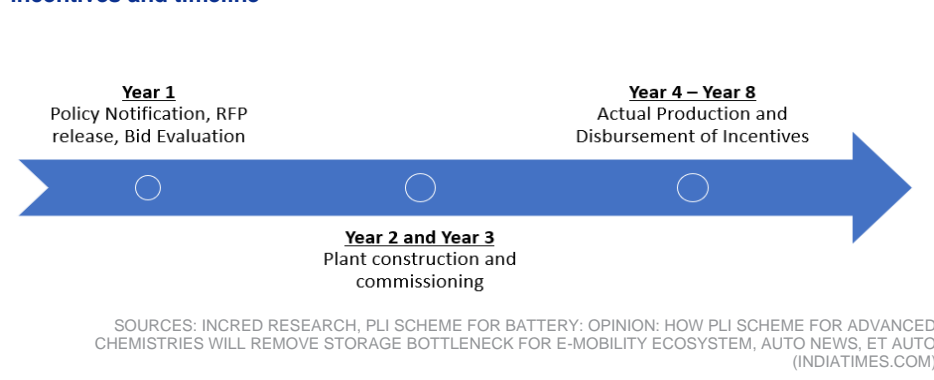
### Eco-system can develop in binder, anode, and electrolyte segments

Among cathode binders, PVDF is used but two developments are noteworthy: 1) A cheaper and more efficient material CMC (Carboxymethyl Cellulose) is making its presence felt, and 2) there is development of a semi-fluid Li-Ion battery that doesn't need a binder. Anode will always be required, and with a hub of huge refineries, Indian companies can manufacture synthetic spherical graphite that is needed to manufacture the anode. A 5GW Li-Ion plant requires around 4,700t of anode whose market value at current rates can be around US\$40m. Electrolyte is another area where Indian companies can make it big, given their expertise in fluorine chemistry. As of now, only Gujarat Fluorochemicals has announced its plan to make LiPF6 electrolyte.

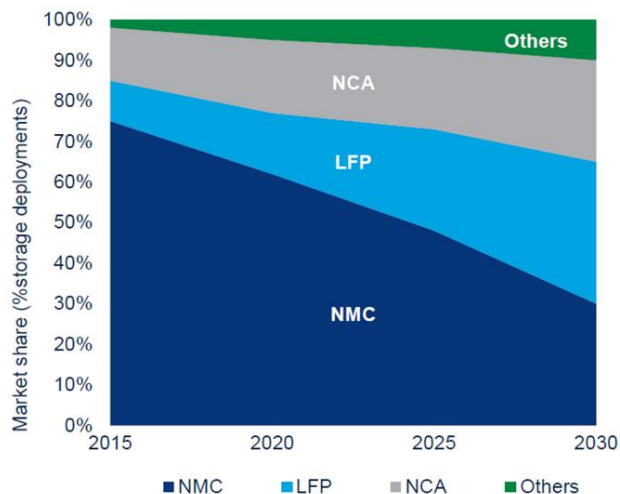
### Likely beneficiaries from development of Li-Ion ecosystem

It's too early to identify a winner. Maybe a basket approach is needed for investment i.e., invest in a group of companies which can potentially benefit from the development of Li-Ion battery eco-system in India. Multiple Indian companies have developed fluorine chemistry skills like (Gujarat Fluorochemicals, Navin Fluorine, SRF, etc.). However, as of now, only Gujarat Fluorochemicals makes PVDF and has plans to make LiPF6 electrolyte. Currently, Himadri Chemicals (UNRATED), and Tirupati Graphite (NOT LISTED) can manufacture graphite anode. Other companies need to develop these skills.

**Figure 1: India's PLI scheme for Li-Ion battery is one of the most attractive in terms of incentives and timeline**



**Figure 2: NMC, NCA and LFP are main battery chemistries now and are likely to remain so in the coming future as well, in our view**



Source: Wood Mackenzie Energy Storage Service

SOURCES: LFP VS NMC IN STATIONARY STORAGE CHEMISTRY | WOOD MACKENZIE | WOOD MACKENZIE, INCRED RESEARCH, NCA=LITHIUM NICKEL COBALT ALUMINIUM OXIDES, LFP= LITHIUM-ION PHOSPHATE BATTERY, LMC= LITHIUM MANGANESE COBALT

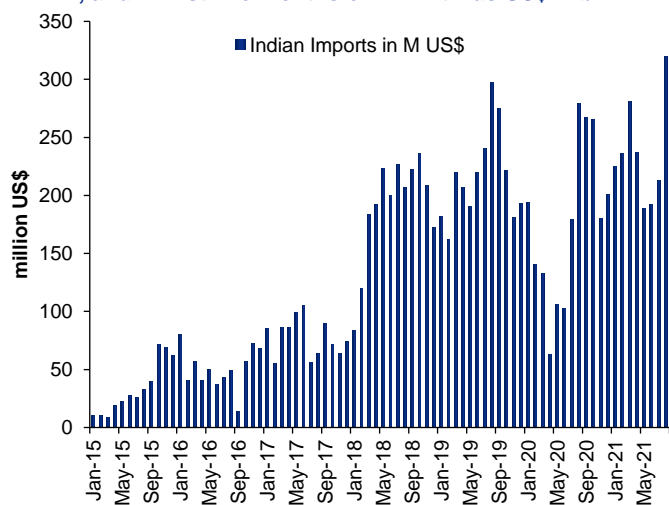
**Figure 3: Following companies are involved in one way or the other in battery manufacturing (this doesn't include potential PLI winners)**

1. TDS Lithium-ion battery Gujarat
2. Exide Industries
3. Tata Chemicals
4. Amperex Technologies
5. Lucas TVS+ 24M Technologies
6. Li energy
7. Manikarana Power Limited
8. Epsilon Carbon
9. Amara Raja

Most of the above companies only assemble imported batteries into battery packs and sell. Their value addition is minimal. Tata Chemicals has started one battery recycling plant.

SOURCES: COMPANY REPORTS, INCRED RESEARCH

**Figure 4: India's import value of storage batteries was US\$2.2bn in FY21, and in first five months of FY22 it was US\$1.2bn**



SOURCES: COMPANY REPORTS, INCRED RESEARCH

**Figure 5: Hence, Indian government has come up with a PLI scheme for Li Ion batteries**

Incentive	Up to US\$26.2m per GW
Cost of Plant*	US\$66.8m per GW
Equity part of Investment	US\$20 m per GW
Bid date opening	22nd Jan 2022
Bidding parameter	Lowest Incentive

SOURCES: COMPANY REPORTS, INCRED RESEARCH

**Figure 6: India's eco-system around Li-Ion batteries come in the following areas:**

Full name	Cathode	Anode	Binders
NMC Nickel-manganese-cobalt	LiNiMnCoO <sub>2</sub>	Graphite	PVDF/ CMC
LFP Lithium-Iron phosphate	LiFePO <sub>4</sub>	Graphite	PVDF/ CMC
NCA Lithium nickel cobalt aluminum oxide	LiNiCoAlO <sub>2</sub>	Graphite	PVDF/ CMC
LTO Lithium titanate oxide	Cathode can be lithium manganese oxide or NMC	Li <sub>2</sub> TiO <sub>3</sub>	PVDF/ CMC

SOURCES: INCRED RESEARCH, COMPANY REPORTS

**Figure 7: Indian companies can benefit in following areas:**

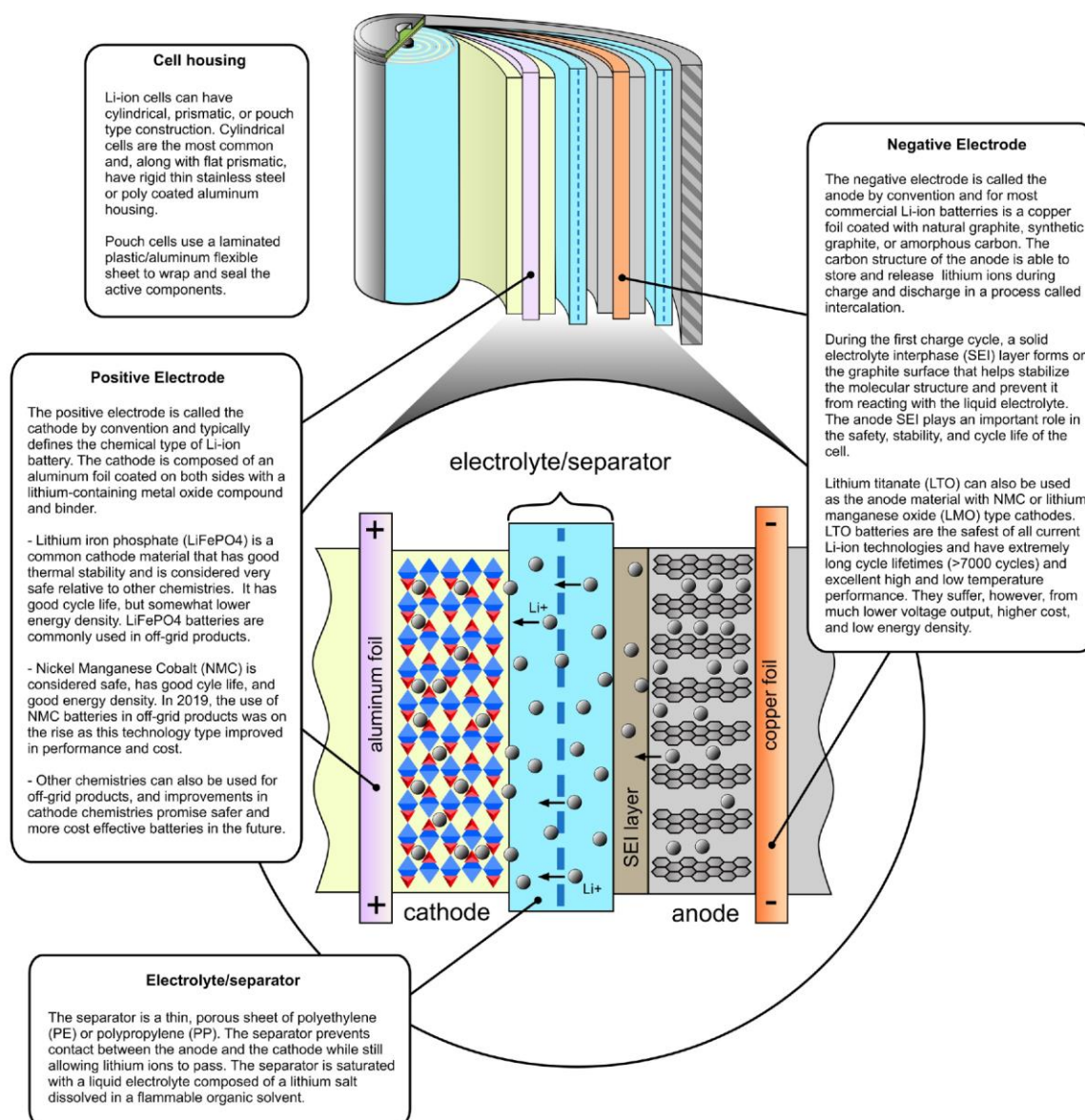
Areas for Indian companies to get advantage of PLI-based manufacturing	
Graphite Anode	Spherical graphite is needed for this purpose and as of now, only Himadri Chemicals, and Tirupati Graphite can make it.
Electrolyte LiPF <sub>6</sub>	Indian fluorine chemistry skill is well developed. As of now, only GFL plans to make LiPF <sub>6</sub> .
Binders	PVDF is only manufactured by GFL. However, PVDF is regarded as an inferior binder and new CMC binders are in vogue.

SOURCES: INCRED RESEARCH, COMPANY REPORTS

## Li-Ion - Making sense out of it & likely gainers

### Manufacture of Lithium-ion batteries

Figure 8: The construction of Lithium-ion batteries is given below:



SOURCES: TECHNICAL NOTES @LIGHTING GLOBAL, INCRED RESEARCH

### Different parts of Lithium-ion battery ➤

**Cathode** – It's active materials are the main elements dictating the differences in composition while building positive electrodes for battery cells. The cathode materials comprise cobalt, nickel and manganese in the crystal structure forming a multi-metal oxide material to which lithium is added. This family of batteries includes a variety of products that cater to different user needs for high energy density and/or high load capacity.

**Anode** - Currently, the anode comprises of a graphite mixture while the cathode combines Lithium and other choice metals, and all materials in a battery have a theoretical energy density. With Lithium-ion, the anode is well optimized, and design changes will yield little to no significant improvement in performance. On

the other hand, the cathode material is wide open to enhancements, and this explains why today's battery research is so heavily focused on this area.

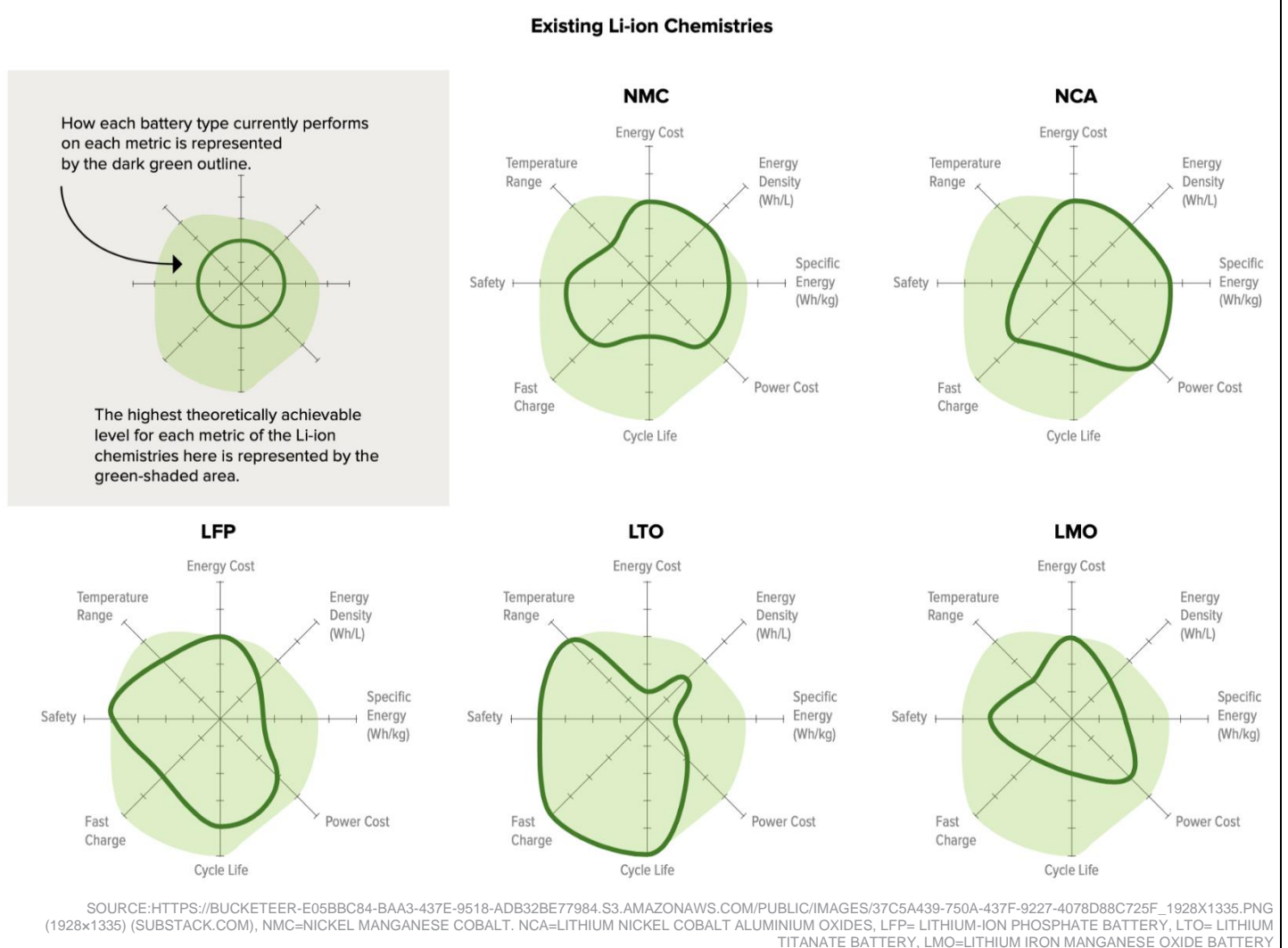
**Cathode binder** - Binder materials include Styrene Butadiene Copolymer (SBR), and Polyvinylidene Fluoride (PVDF) used in the cathode and anode electrode slurry-making process for Lithium-ion batteries. Binders such as SBR and PVDF hold the active material particles together and in contact with the current collectors i.e., the aluminum foil (Al foil) or the copper foil (Cu foil).

**Electrolyte** – It plays a key role in transporting positive lithium ions between the cathode and the anode. The most-used electrolyte comprises lithium salt, such as LiPF6 in an organic solution.

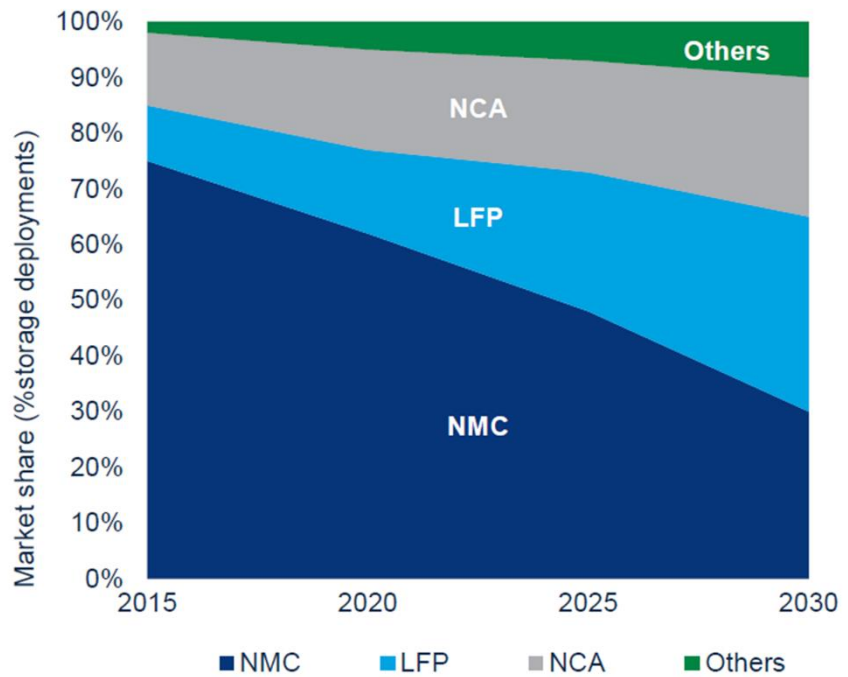
**Battery electrolyte additives** - In addition to lithium salt, a range of additives needs to be included in the finished electrolyte to give the required properties to the electrolyte solution. These Li-ion battery electrolyte additives improve the stability, preventing dendritic formation and degradation of the solution. The specific electrolyte formulation will vary depending on the specific anode and cathode materials being used, but it's important to keep in mind that the specific additives will impact overall battery performance, especially in high energy density automotive battery applications.

### Lithium-Ion batteries have five different chemistries, out of which NMC, NCA and LFP are most relevant

Figure 9: Chemistries used in making Lithium-Ion batteries



**Figure 10: NMC battery market share is likely to go down as LFP and NCA gain incremental market share; LFP market share growth will be driven by energy storage system applications**



Source: Wood Mackenzie Energy Storage Service

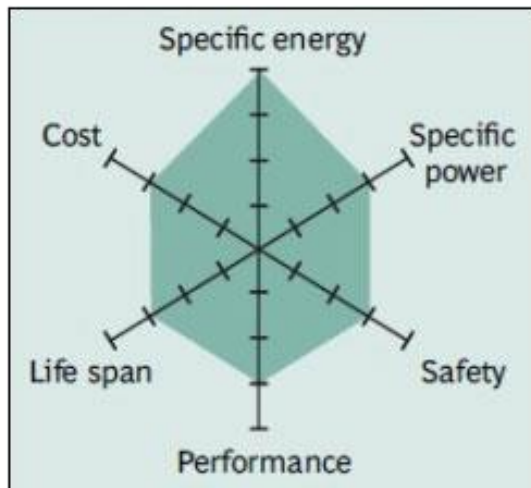
SOURCES: INCRED RESEARCH, LFP VS NMC IN STATIONARY STORAGE CHEMISTRY | WOOD MACKENZIE | WOOD MACKENZIE

**Nickel-manganese-cobalt (NMC) is the battery of choice for e-bikes, electric vehicles or EVs, industrial applications and medical usage ➤**

**Construction:** One of the most successful Li-ion systems is a cathode combination of nickel-manganese-cobalt (NMC). The secret of NMC lies in combining nickel and manganese. An analogy of this is table salt in which the main ingredients, sodium and chloride, are toxic on their own but mixing them serves as a seasoning salt and food preserver. Nickel is known for its high specific energy but poor stability; manganese has the benefit of forming a spinel structure to achieve low internal resistance but offers a low specific energy. Combining the metals enhances each other’s strengths.

**Usage:** NMC is the battery of choice for power tools, e-bikes, and other electric powertrains. The cathode combination is typically one-third nickel, one-third manganese and one-third cobalt, also known as 1-1-1. This offers a unique blend that also lowers the raw material cost due to reduced cobalt content. Another successful combination is NCM with five parts nickel, three parts cobalt and two parts manganese (5-3-2). Other combinations using various amounts of cathode materials are possible.

**Figure 11: NMC has well-rounded performance parameters**



SOURCES: INCRED RESEARCH, [HTTPS://BATTERYUNIVERSITY.COM/](https://batteryuniversity.com/)

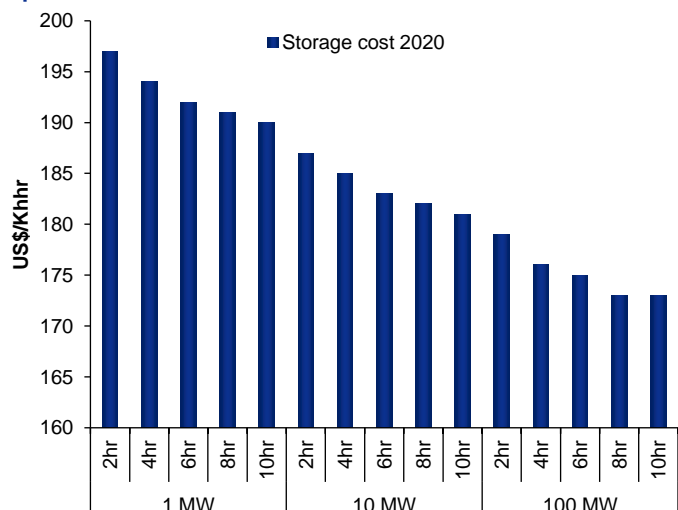
**Figure 12: NMC battery details**

**Lithium Nickel Manganese Cobalt Oxide: LiNiMnCoO<sub>2</sub>. cathode, graphite anode**  
**Short form: NMC (NCM, CMN, CNM, MNC, MCN similar with different metal combinations) since 2008**

<b>Voltages</b>	3.60V, 3.70V nominal; typical operating range 3.0–4.2V/cell, or higher
<b>Specific energy (capacity)</b>	150–220Wh/kg 0.7–1C, charges to 4.20V, some go to 4.30V; 3h charge typical. Charge current above 1C shortens battery life.
<b>Charge (C-rate)</b>	1C; 2C possible on some cells; 2.50V cut-off
<b>Discharge (C-rate)</b>	1,000–2,000 (related to depth of discharge, temperature)
<b>Cycle life</b>	210°C (410°F) typical. High charge promotes thermal runaway
<b>Thermal runaway</b>	~\$420/KwHr
<b>Cost</b>	E-bikes, medical devices, EVs, industrial
<b>Applications</b>	Provides high capacity and high power. Serves as Hybrid Cell. Favourite chemistry for many uses; market share is increasing. Leading system; dominant cathode chemistry.
<b>Comments</b>	

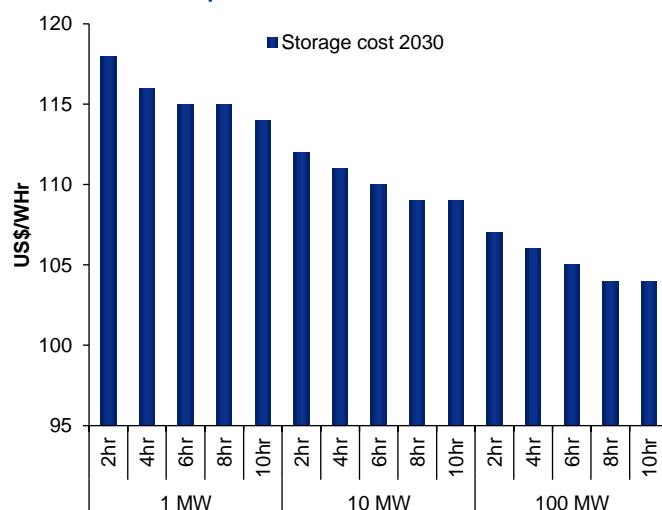
SOURCES: INCRED RESEARCH, [HTTPS://BATTERYUNIVERSITY.COM/](https://batteryuniversity.com/)

**Figure 13: Battery costs have fallen US\$190/KwHr for normal operations**



SOURCES: INCRED RESEARCH, [HTTPS://WWW.PNNL.GOV/](https://www.pnnl.gov/)

**Figure 14: Within a decade, costs can fall to as low as US\$114/KwHr for normal operations**



SOURCES: INCRED RESEARCH, [HTTPS://WWW.PNNL.GOV/](https://www.pnnl.gov/)

**NMC battery uses following chemicals for its manufacture ►**

**Lithium-nickel-manganese-cobalt oxides:** These are mixed metal oxides of lithium, nickel, manganese and cobalt. They have the general formula LiNi<sub>x</sub>Mn<sub>y</sub>Co<sub>z</sub>O<sub>2</sub>. Structurally, materials in this group are closely related to Lithium Cobalt(III) oxide (LiCoO<sub>2</sub>) and have a layered structure but possess an ideal charge distribution of Mn(IV), Co(III), and Ni(II) at the 1:1:1 stoichiometry. For more nickel-rich compositions, nickel is in a more oxidized state for charge balance. NMCs are among the most important storage materials for lithium ions in Lithium-Ion batteries. They are used on the positive side, which acts as the cathode during discharge.

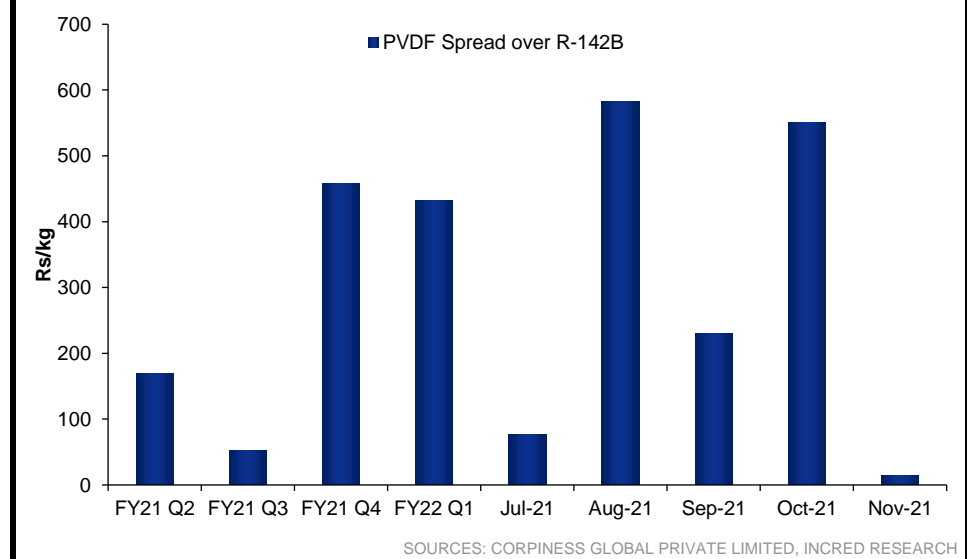
**Binder:** NMC electrodes can be used with sodium carboxyl methyl cellulose (CMC), polyvinylidene fluoride (PVDF), and alginate from brown algae as binders. CMC appears to be the best binder for NMC electrodes ([Source: The effect of different binders on electrochemical properties of LiNi1/3Mn1/3Co1/3O2 cathode material in lithium ion batteries - ScienceDirect](#)). Please note that CMC is much cheaper compared to PVDF in global markets. There are multiple research papers which point out that usage of conducting polymers, instead of PVDF, can give much better battery properties ([Review—Conducting Polymer-Based Binders for Lithium-Ion Batteries and Beyond \(iop.org\)](#))

**Anode:** The anode material is LiC<sub>6</sub> or Lithium Carbonate.

### Among Indian chemical companies, GFL can supply PVDF ➤

Among Indian chemical companies, Gujarat Fluorochemicals Ltd or GFL can supply PVDF to manufacturers of NMC batteries. It doesn't have the backward integration to R-142B as of now, but the company intends to manufacture the same in the coming future. As of now, its gross profit over R-142B touches zero.

**Figure 15: PVDF spreads over imported R-142B touched zero level in Nov 2021**



### Lithium-Iron Phosphate (LiFePO<sub>4</sub>) — LFP is one of the oldest Li-Ion batteries ➤

In 1996, University of Texas (and other contributors) discovered phosphate as a cathode material for rechargeable lithium batteries. Li-phosphate offers good electrochemical performance with low resistance. This is made possible with nano-scale phosphate cathode material. The key benefits are high current rating and long cycle life, besides good thermal stability, and enhanced safety and tolerance if abused. Li-phosphate is more tolerant to full charge conditions and is less stressed than other Lithium-Ion systems if kept at high voltage for a prolonged time

### Lithium-Iron Phosphate (LiFePO<sub>4</sub>) — LFP has multiple drawbacks ➤

1. Its lower nominal voltage of 3.2V/cell reduces the specific energy below that of cobalt-blended lithium-ion.
2. Li-phosphate has a higher self-discharge than other lithium-ion batteries, which can cause balancing issues with aging.
3. Cleanliness in manufacturing is of importance for longevity. There is no tolerance for moisture, lest the battery will only deliver 50 cycles.

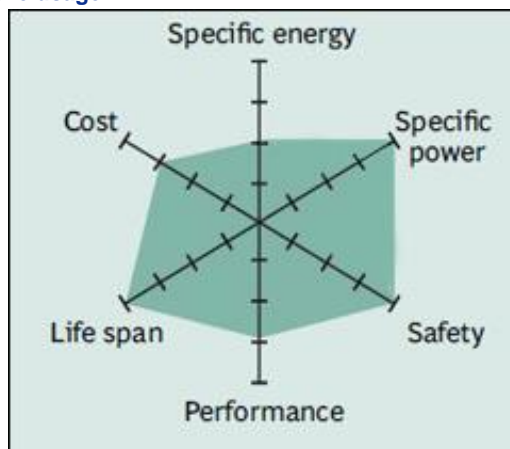
## Lithium-Iron Phosphate (LiFePO4) — SWOT analysis of the battery ➤

**Figure 16: LFP, the oldest battery, has lower voltage and is mostly used for stationary usage**

Lithium Iron Phosphate: LiFePO4 cathode, graphite anode	
Short form: LFP or Li-phosphate Since 1996	
<b>Voltages</b>	3.20, 3.30V nominal; typical operating range 2.5–3.65V/cell
<b>Specific energy (capacity)</b>	90–120Wh/kg
<b>Charge (C-rate)</b>	1C typical, charges to 3.65V; 3hr charge time typical
<b>Discharge (C-rate)</b>	1C, 25C on some cells; 40A pulse (2s); 2.50V cut-off (lower than 2V causes damage)
<b>Cycle life</b>	2000 and higher (related to depth of discharge, temperature)
<b>Thermal runaway</b>	270°C (518°F) Very safe battery even if fully charged
<b>Cost</b>	~\$580 per kWh
<b>Applications</b>	Portable and stationary needing high load currents and endurance Very flat voltage discharge curve but low capacity. One of safest Li-ions.
<b>Comments</b>	Used for special markets. Elevated self-discharge.

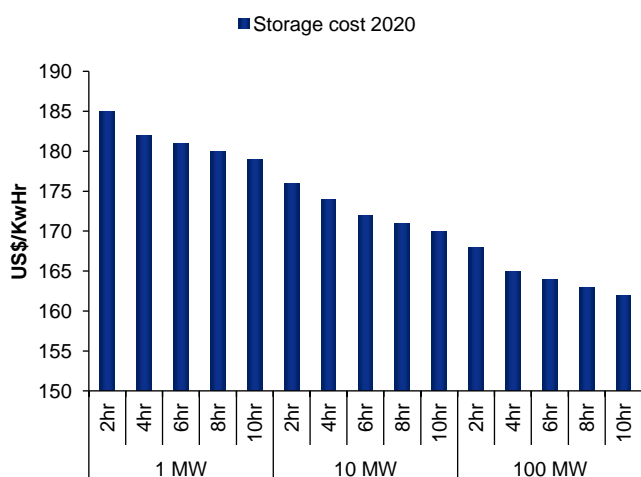
SOURCES: INCRED RESEARCH, [HTTPS://BATTERYUNIVERSITY.COM](https://batteryuniversity.com)

**Figure 17: Lower specific energy means battery cannot be used for mobile usage**



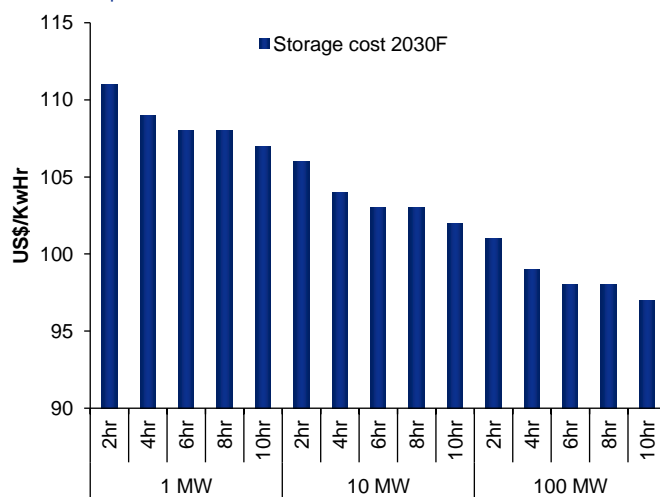
SOURCES: INCRED RESEARCH, [HTTPS://BATTERYUNIVERSITY.COM](https://batteryuniversity.com)

**Figure 18: As of now, LFP battery cost is lower than that of NMC battery**



SOURCES: INCRED RESEARCH, COMPANY REPORTS

**Figure 19: It is estimated that by 2030F, LFP battery cost will fall to US\$105/kWh**



SOURCES: INCRED RESEARCH, COMPANY REPORTS

### LFP uses the following chemicals for its manufacturing ➤

**Lithium Iron Phosphate (LiFePO4) for cathode:** LFP batteries use lithium iron phosphate as the cathode alongside a graphite carbon electrode with a metallic backing as the anode. Unlike many cathode materials, LFP is a polyanion compound composed of more than one negatively charged element. Its atoms are arranged in a crystalline structure, forming a 3D network of lithium ions compared to the 2D slabs from nickel manganese cobalt. The LFP battery operates similar to other Lithium-ion (Li-ion) batteries, moving between positive and negative electrodes to charge and discharge. However, phosphate is a non-toxic material compared to cobalt oxide or manganese oxide. What's more, LFP batteries are capable of delivering constant voltage at a higher charge cycle, in the range of 2,000–3,000

#### Binders:

- PVDF:** Traditionally, PVDF-based binders were used in LFP batteries. However, PVDF must be dissolved in a strongly polarized N-methyl pyrrolidone (NMP) solvent, which is relatively toxic, costly, and environmentally unfriendly. For wider applications, PVDF cannot effectively enhance the performance of LFP cathodes because it possesses weak van der Waals forces that are unable to provide durably strong adhesion for active



materials during cycling. In addition, PVDF is not good for enhancing the conductivity and ion diffusion of LFP cathodes due to its restricted molecular structure. PVDF can be used in multiple other forms like PVDF+HFP, PTFE, TrFE, TX, PFSiLi, etc. However, all of them suffer from the basic handicap that is there with PVDF.

2. **CMC:** Like with NMC batteries, CMC binders work best with LFO batteries as well.

**Anode:** The anode material is LiC6 or Lithium carbonate.

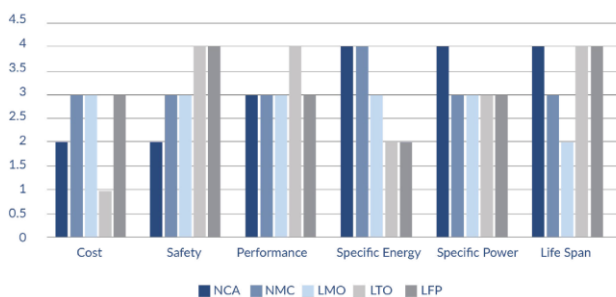
**Electrolyte:** LiPF6 is the most used electrolyte by battery manufacturers.

### Lithium-Nickel-Cobalt-Aluminum Oxide (NCA) is the battery of choice for automobiles ►

**Construction:** Lithium-nickel-cobalt-aluminium oxide battery, or NCA, has been around since 1999 for special applications. It shares similarities with NMC battery by offering high specific energy, reasonably good specific power and a long life span. Less flattering are safety and cost. NCA is a further development of lithium nickel oxide; adding aluminum gives the chemistry greater stability

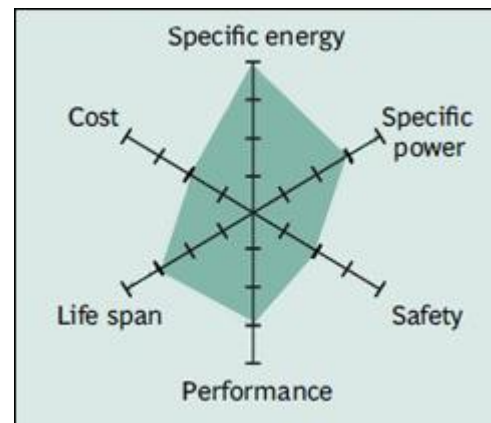
**Usage:** NCA is the battery of choice for the EV industry.

Figure 20: Among all Li-Ion batteries, NCA is most suited for EVs



SOURCES: COMPANY REPORTS, INCRED RESEARCH

Figure 21: High specific energy and power compared with lower cost makes it ideal for EVs



SOURCES: INCRED RESEARCH, [HTTPS://BATTERYUNIVERSITY.COM](https://batteryuniversity.com)

Figure 22: One of the cheapest batteries for usage in automobiles

**Summary Table**

<b>Lithium Nickel Cobalt Aluminum Oxide:</b>	LiNiCoAlO <sub>2</sub> cathode (~9% Co), graphite anode
Short form: NCA or Li-aluminum. Since 1999	
<b>Voltages</b>	3.60V nominal; typical operating range 3.0–4.2V/cell
<b>Specific energy (capacity)</b>	200-260Wh/kg; 300Wh/kg predictable
<b>Charge (C-rate)</b>	0.7C, charges to 4.20V (most cells), 3h charge typical, fast charge possible with some cells
<b>Discharge (C-rate)</b>	1C typical; 3.00V cut-off; high discharge rate shortens battery life
<b>Cycle life</b>	500 (related to depth of discharge, temperature)
<b>Thermal runaway</b>	150°C (302°F) typical, High charge promotes thermal runaway
<b>Cost</b>	~\$350 per kWh
<b>Applications</b>	Medical devices, industrial, electric powertrain (Tesla)
<b>Comments</b>	Shares similarities with Li-cobalt. Serves as Energy Cell. Mainly used by Panasonic and Tesla; growth potential.

SOURCES: INCRED RESEARCH, [HTTPS://BATTERYUNIVERSITY.COM](https://batteryuniversity.com)

### NCA uses the following chemicals for its manufacturing ►

#### Lithium-nickel-cobalt-aluminum oxide (LiNiCoAlO<sub>2</sub>) for cathode in NCA batteries:

These are a group of mixed metal oxides. Some of them are important due to their application in lithium-ion batteries. NCAs are used as active material on the positive pole (which is the cathode when the battery is discharged). NCAs are composed of the cations of the chemical elements such as lithium, nickel, cobalt and aluminium. The most important representatives as of this date have the general formula LiNi<sub>x</sub>Co<sub>y</sub>Al<sub>z</sub>O<sub>2</sub> with x + y + z = 1. In case of the NCA-comprising batteries currently available in the market, which are also

used in electric cars and electric appliances,  $x \approx 0,8$ , the voltage of these batteries is between 3.6V and 4.0V, at a nominal voltage of 3.6V or 3.7V. A version of the oxides currently in use in 2019 is  $\text{LiNi}_{0,84}\text{Co}_{0,12}\text{Al}_{0,04}\text{O}_2$ .

**Binders:**

1. **PVDF:** Traditionally, PVDF-based binders were used in LFP batteries. However, PVDF must be dissolved in a strongly polarized N-methyl pyrrolidone (NMP) solvent, which is relatively toxic, costly, and environmentally unfriendly. For wider applications, PVDF cannot effectively enhance the performance of LFP cathodes because it possesses weak van der Waals forces that are unable to provide durably strong adhesion for active materials during cycling. In addition, PVDF is not good for enhancing the conductivity and ion diffusion of LFP cathodes due to its restricted molecular structure. PVDF can be used in multiple other forms like PVDF+HFP, PTFE, TrFE, TX, PFSiLi, etc. However, all of them suffer from the basic handicap that is there with PVDF.
2. **CMC:** Like with NMC battery, CMC binder works best with LFO battery as well.

**Anode:** The anode material is graphite.

**Electrolyte:** LiPF6 is the most used electrolyte by battery manufacturers.

**Lithium titanate oxide (LTO) is a type of NMC battery ➤**

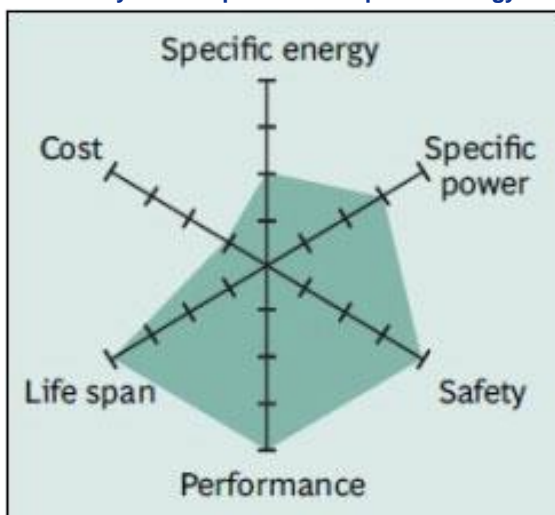
Batteries with lithium titanate anodes have been known since the 1980s. Li-titanate replaces the graphite in the anode of a typical lithium-ion battery and the material forms into a spinel structure. The cathode can be lithium manganese oxide or NMC. Li-titanate has a nominal cell voltage of 2.40V, can be fast charged and delivers a high discharge current of 10C, or 10 times the rated capacity. The cycle count is said to be higher than that of a regular Li-ion. Li-titanate is safe, has excellent low-temperature discharge characteristics and obtains a capacity of 80 percent at  $-30^{\circ}\text{C}$  ( $-22^{\circ}\text{F}$ ).

**As of now, mostly Japanese companies are using it ➤**

Lithium titanate batteries are used in certain Japanese-only versions of Mitsubishi’s electric vehicle, and Honda uses them in its EV-neo electric bike and Fit EV. They are also used in the Tosa concept electric bus. Due to their high level of safety and recharge capabilities, LTO batteries are used in car audio applications as well as mobile medical devices. Typical uses are electric powertrains, UPS and solar-powered street lighting.

**LTO battery doesn’t have great performance matrices ➤**

Figure 23: Battery scores quite low on specific energy and cost



SOURCES: INCRED RESEARCH, [HTTPS://BATTERYUNIVERSITY.COM](https://batteryuniversity.com)

Figure 24: LTO battery is extremely costly, almost double the price of NMC battery

<b>Lithium Titanate: Cathode can be lithium manganese oxide or NMC; <math>\text{Li}_2\text{TiO}_3</math> (titanate) anode</b>	
Short form: LTO or Li-titanate Commercially available since about 2008.	
<b>Voltages</b>	2.40V nominal; typical operating range 1.8–2.85V/cell
<b>Specific energy (capacity)</b>	50–80Wh/kg
<b>Charge (C-rate)</b>	1C typical; 5C maximum, charges to 2.85V
<b>Discharge (C-rate)</b>	10C possible, 30C 5s pulse; 1.80V cut-off on LCO/LTO
<b>Cycle life</b>	3,000–7,000
<b>Thermal runaway</b>	One of safest Li-ion batteries
<b>Cost</b>	~\$1,005 per kWh
<b>Applications</b>	UPS, electric powertrain (Mitsubishi i-MiEV, Honda Fit EV), solar-powered street lighting
<b>Comments</b>	Long life, fast charge, wide temperature range but low specific energy and expensive. Among safest Li-ion batteries. Ability to ultra-fast charge; high-cost limits to special application.

SOURCES: INCRED RESEARCH, [HTTPS://BATTERYUNIVERSITY.COM](https://batteryuniversity.com)

## Who can benefit in Indian context from the coming battery boom?

1. TDS Lithium-ion battery Gujarat
2. Exide Industries
3. Tata Chemicals
4. Amperex Technologies
5. Lucas TVS+ 24M Technologies
6. Li Energy
7. Manikarana Power
8. Epsilon Carbon
9. Amara Raja

### TDS Lithium-ion battery Gujarat Limited ►

TDSG is India's first Lithium-ion battery manufacturing plant in Gujarat, which is being set up jointly by Toshiba Corporation, Denso Corporation and Suzuki Motor Corporation to manufacture and supply Lithium-ion batteries. The Lithium-ion battery joint venture sees the equity stake split between Suzuki (50%), Toshiba (40%) and Denso (10%). The JV manufactures Lithium Titanium Oxide-based batteries.

LTO is a little strange choice as it won't be cost-effective, but because Japanese companies witnessed great success in the area in the past, they may have ventured with LTO battery in India.

### Exide Industries and Leclanche SA JV- Nexcharge ►

Exide Industries formed a 75:25 JV with Leclanche SA. This JV is called Nexcharge. The JV entity will initially import the cells from Leclanche's plant in Germany. It can manufacture a variety of Li-Ion batteries. The overall capacity of Nexcharge is ~1.5GWhr.

We quote Nexcharge CEO: "One of our core strength is that we can manufacture & offer battery packs with the popular chemistries like LFP, NMC, LTO etc. and cells with various form factors like Prismatic, Pouch & Cylindrical." ( [Source: "India Needs Schemes that can support the market expansion", Stefan Louis, Nexcharge - Saur Energy International](#))

Like many other competitors, Nexcharge doesn't manufacture ACC (Advance Chemistry Cells) in India. The JV entity imports the same and its production line makes the battery packs.

### Tata Chemicals plans a Li-Ion battery plant in Gujarat ►

As of now, Tata Chemicals is doing recycling of batteries. In future, it may go for ACC cell manufacturing. We quote from their website:

*"Lithium-ion cells are one of the most critical components for energy transition; and with our inherent strengths in chemistry, we at Tata Chemicals are creating a platform for electro-chemistry solutions.*

**Partnerships:** *We are partnering with Indian R&D centres (like ISRO, CSIR-CECRI and CMET) for indigenous development of actives, cells and recycling.*

**Manufacturing:** *We have a plant site at Dholera, Gujarat, which can house any of our manufacturing operations.*

**Engineering centre:** *Our scientists at the Innovation Centre in Pune are also working on multiple chemistries as well as cell design and active manufacturing technologies.*

**Recycling:** *With strong capabilities in chemistry, Tata Chemicals has already launched recycling operations to recover key materials."*

### Amperex Technology plans an Indian venture ►

The Economic Times reported in 2020 that Amperex Technology has acquired 180m acres of land at a cost of Rs 5.5bn in Haryana ([Amperex Technology Limited: Japanese firm Amperex Technology Limited acquires 180-acre at Rs 550 crore in Haryana - The Economic Times \(indiatimes.com\)](#)) to build a battery making plant in India. Since then, we haven't come across any further announcements.

### Lucas TVS and 24M Technologies are building a battery plant near Chennai ►

The first plant will be set up in Thervoy Kandigai, Gummudipundi near Chennai and Lucas TVS expects to build other plants across India to support the growing energy storage, electric mobility and lead acid battery replacement markets. The Chennai plant is expected to begin commercial production in the second-half of 2023F. Based on the aggressive targets set by the government in the renewable energy and electric mobility space, Lucas TVS plans to grow the capacity of the plant to a globally competitive scale of 10GWh in two stages. 24M Technologies works on innovative technology for Li-Ion battery which doesn't use any binders.

We quote from their website: *"Invented in the MIT lab of Dr. Yet-Ming Chiang, semi-solid electrodes use no binder, mixing electrolyte with active materials to form a clay-like slurry. The unique slurry allow us to create thick electrodes with less volume, mass and cost while enabling a simpler manufacturing process. It's simpler and safer with more reliable performance".* ([24M Technologies \(24-m.com\)](#))

### Li Energy plans to make LFP batteries near Chennai ►

Li Energy has made strategic technology partnerships with various entities to build an ideal solution for the Indian market. Prismatic lithium iron phosphate cell and laser welding battery packs are perfect for Indian thermal conditions, long life cycle, low cost and various road conditions, as per the company.

1. Stage 1 – The company will commission a 1.2GW battery assembly line.
2. Stage -2- Li-Ion cell manufacturing pilot line of 150MW planned; cathode anode and other materials to be imported.
3. Plans to do away with imports and make LFP, NMC and LTO batteries with CERIC- CSIR technology.
4. Scale up cell manufacturing facility to 1GW.

### Manikaran Power Limited- Battery raw material manufacturing ►

The company's plant will produce battery grade lithium hydroxide. Spodumene concentrate will be sourced across the world and locally sourced reagents would be used to produce battery grade lithium hydroxide in India.

#### Status of the project as per its website

*"Class 3 Study has been concluded. Capital and operating costs being evaluated with constant peer reviews. Full feasibility to be completed end-2021.*

*Plant capacity of 20,000tpa LCE (22,700tpa Lithium Hydroxide Product) is possible using a single processing train production facility allowing for a capital efficient design.*

*Currently undertaking a measured approach whereby the next phase is a Class 2 study (subject to financial criteria being met), which will be of 18 months duration and include significant further equipment vendor input to allowing for significant engineering to be completed prior to a potential construction phase.*

*Market assessment study has been undertaken by Benchmark Minerals to identify and assess the growth and potential of the overall lithium market."*

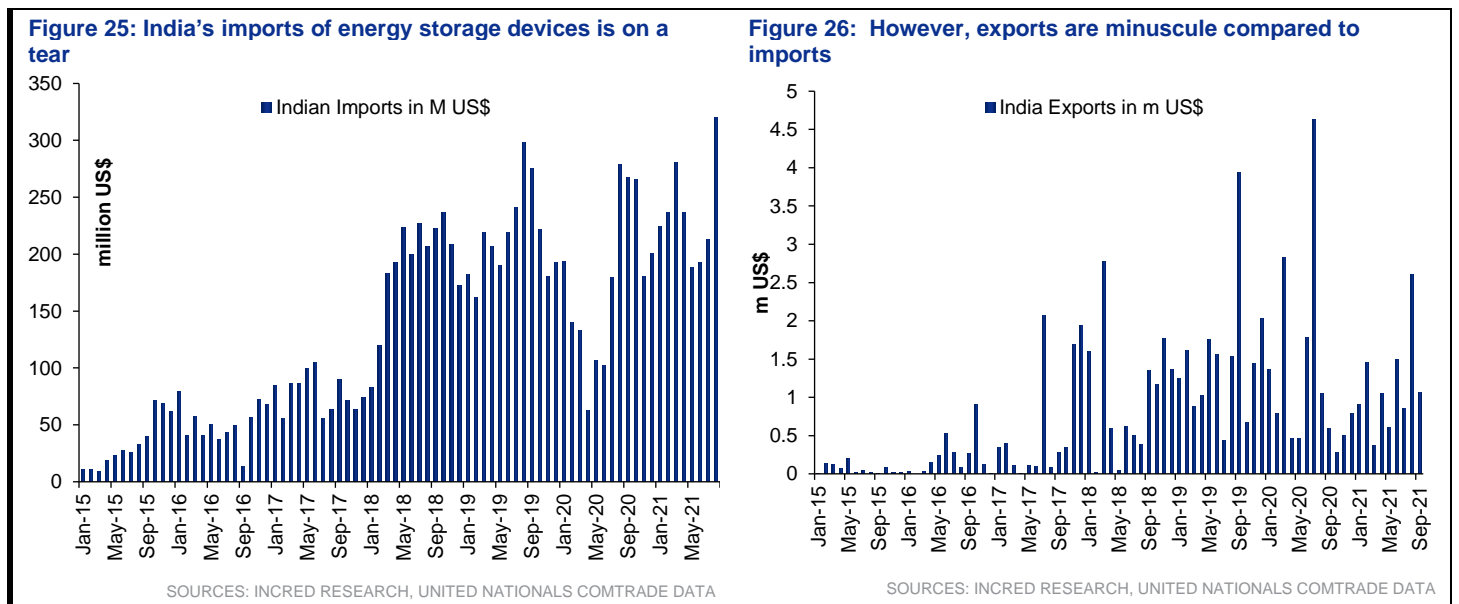
**Epsilon Carbon ➤**

The company made an announcement on its website in 2020 that it is foraying into making graphite anodes. We don't have any information after that.

**Amara Raja Batteries - investing in a Li-Ion technology hub, but production appears to be far off ➤**

As per the company, it wants to Invest US\$1bn over next five-to-seven years in making ACC cells rather than simply assembling them. Source: [Amara Raja Batteries plans \\$1 billion capex in 5-7 years, to focus more on new-age energy storage systems - The Economic Times \(indiatimes.com\)](#)

**PLI (production-linked incentive) scheme - can it change the course? Yes, it can**



The two charts above explain the reasons behind the government's initiative - Make in India. India's imports of energy storage devices, primarily Li-Ion batteries, totalled US\$2.4bn in FY21, and in the first five months of FY22 it was US\$1.2bn (a growth of 57% over the same period in FY21).

**Indian government came up with PLI scheme for making Li-Ion batteries in Oct 2021 ➤**

The government is carrying out a bidding process and seeks bids in response to the Request For Proposal or RFP from individuals, LLPs, funds, private entities, public entities or other international entities.

The selected bidders would be entitled to receive fiscal benefits in the form of a cash subsidy, in accordance with the programme. A bidder selected through this RFP, to be eligible for this subsidy, would have to commit to set up an Advance Chemistry Cell manufacturing facility of minimum 5GWh capacity and with value-addition of a minimum 25% within two years from the Appointed Date and minimum 60% value addition within five years from the Appointed Date, overall at the mother-unit level in case of an integrated unit, or at the project level through indigenous manufacturers, in a Hub and Spoke structure, in accordance with the programme agreement.

## Government can give subsidy up to Rs2bn per GWhr, which can cover total equity of the investment ➤

As per bid document RFP, the government can give subsidy up to Rs2bn per GWhr, which is a substantial part of any capex. On an average, the capital requirement for setting up a full ACC plant is around US\$66.7m/GWhr and hence, government subsidy can cover the total equity part of the investment.

## The bidding opens in Jan 2022 ➤

Opening of the technical bid is slated on 3 Jan 2022 and financial bid on 21 Jan 2022. Letter of Award to the successful bidder will be given on 4 Feb 2022 and validity of the bid is until 29 Jun 2022. Please click here for all the documents of the bid process ([MHI-NITI Aayog\\_DHI\\_ACC RFP.pdf \(heavyindustries.gov.in\)](#)).

## The PLI scheme is extremely attractive for any bidder, plant can come on paltry equity contribution ➤

Practically, the Indian government is ready to fund the total equity part of plant capex, and land is also available at ultra-cheap rates from different state governments. This scheme can change the course of ACC manufacturing in India, in our view.

## Who can benefit among Indian suppliers?

The basic requirement for a battery is 1) anode, 2) cathode, 3) electrolyte, and 4) binder. An eco-system can develop around the manufacturing of these components for ACC manufacturers.

## Cathode and anode material will depend upon the choice of chemistry chosen by winners of bid ➤

Cathode and anode materials will be dependent on the chemistry selected by winners of the bid.

**Figure 27: The material requirement for setting up the plant depends on the chosen chemistry**

	Full name	Cathode	Anode	Binders
NMC	Nickel-manganese-cobalt	LiNiMnCoO <sub>2</sub>	Graphite	PVDF/ CMC
LFP	Lithium Iron Phosphate	LiFePO <sub>4</sub>	Graphite	PVDF/ CMC
NCA	Lithium nickel cobalt aluminum oxide	LiNiCoAlO <sub>2</sub>	Graphite	PVDF/ CMC
LTO	Lithium titanate oxide	Cathode can be lithium manganese oxide or NMC	Li <sub>2</sub> TiO <sub>3</sub>	PVDF/ CMC

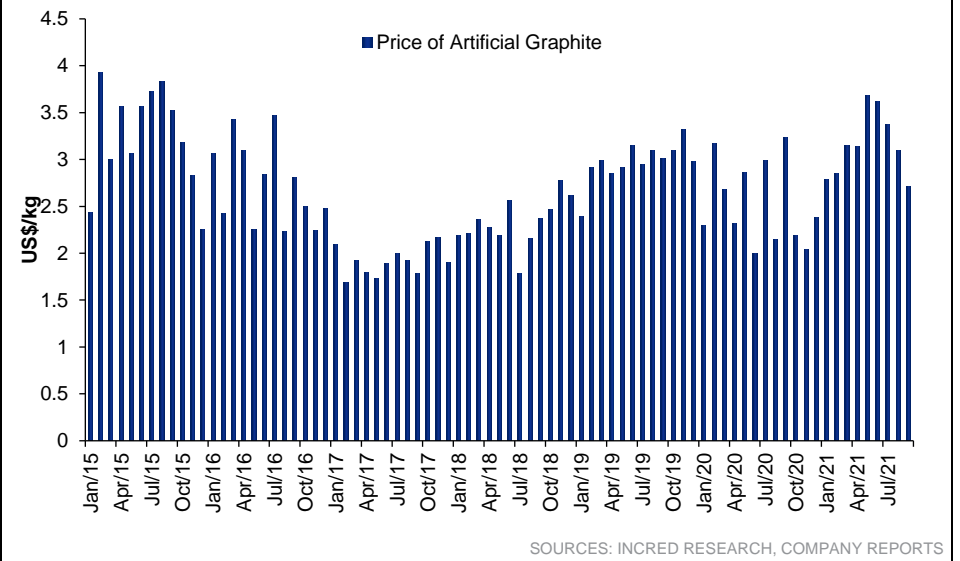
SOURCES: INCRED RESEARCH, COMPANY REPORTS

## As of now, Indian companies can only supply graphite anode, electrolyte or binder ➤

Cathode manufacturing is mostly done by companies themselves. Indian companies can supply graphite, electrolyte or binder used in a cathode.

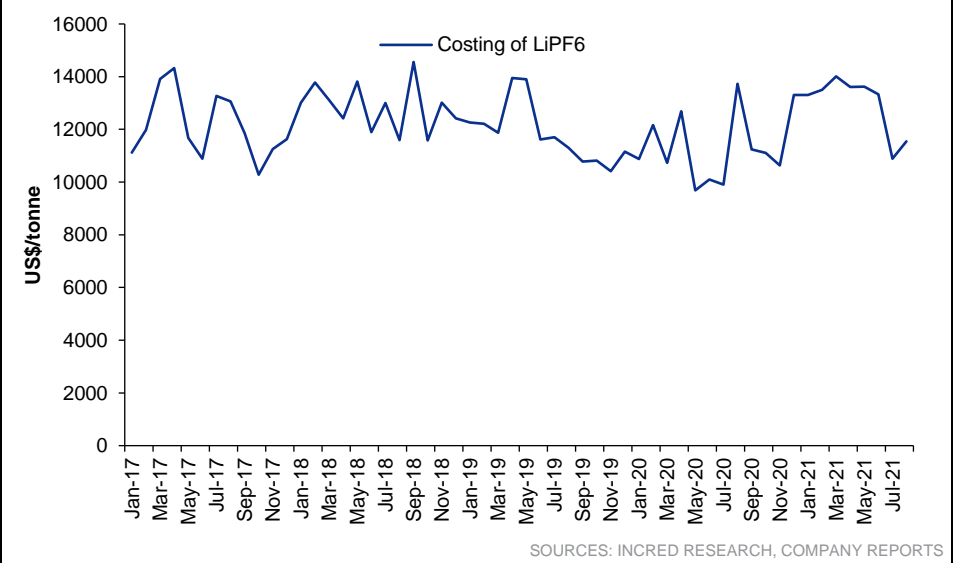
1. The most used electrolyte for Li-Ion batteries is LiPF<sub>6</sub>. As of now, no one manufactures it in India, but GFL (Gujarat Fluorochemicals Limited) intends to manufacture it in near future.
2. There are two battery grade graphite manufacturers in India – Himadri Chemicals, and Tirupati Chemicals. Their material can be used in anode manufacturing.
3. 1kWhr Li-Ion battery needs around 0.9kg spherical graphite to make anode.
4. Thus, even if a new plant comes in India with 5GW capacity, the graphite requirement is likely to be around ~4,700t.

**Figure 28: Artificial graphite costs around US\$3,000-4,000/t and spherical graphite around US\$7,000-8,000/t**



5. Electrolyte LiPF6 prices have been highly volatile although its manufacturing cost is quite stable

**Figure 29: While LiPF6 battery's cost of manufacturing has been stable at around US\$17,000/t, its prices are volatile between US\$20,000-90,000/t**



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<b>Description:</b>	Excellent	Very Good	Good	N/A	N/A

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## Corporate Governance Report of Thai Listed Companies (CGR). CG Rating by the Thai Institute of Directors Association (Thai IOD) in 2021, Anti-Corruption 2021

**ADVANC** – Excellent, Certified, **AMATA** – Excellent, Certified, **ANAN** – Excellent, n/a, **AOT** – Excellent, n/a, **AP** – Excellent, Certified, **ASP** – Excellent, n/a, **AWC** – Excellent, Declared, **AU** – Good, n/a, **BAM** – Very Good, Certified, **BAY** – Excellent, Certified, **BBL** – Excellent, Certified, **BCH** – Very Good, Certified, **BCP** – Excellent, Certified, **BCPG** – Excellent, Certified, **BDMS** – Excellent, n/a, **BEAUTY** – Good, n/a, **BEM** – Excellent, n/a, **BH** – Good, n/a, **BJC** – Very Good, n/a, **BLA** – Very Good, Certified, **BTS** – Excellent, Certified, **CBG** – Very Good, n/a, **CGET** – n/a, n/a, **CENDEL** – Excellent, Certified, **CHAYO** – Very Good, n/a, **CHG** – Very Good, n/a, **CK** – Excellent, n/a, **COM7** – Excellent, Certified, **CPALL** – Excellent, Certified, **CPF** – Excellent, Certified, **CPN** – Excellent, Certified, **CPNREIT** – n/a, n/a, **CRC** – Excellent, Declared, **DELTA** – Excellent, Certified, **DDD** – Excellent, n/a, **DIF** – n/a, n/a, **DOHOME** – Very Good, Declared, **DREIT** – n/a, n/a, **DTAC** – Excellent, Certified, **ECL** – Excellent, Certified, **EGCO** – Excellent, Certified, **EPG** – Excellent, Certified, **ERW** – Very Good, Certified, **GFPT** – Excellent, Certified, **GGC** – Excellent, Certified, **GLOBAL** – Excellent, n/a, **HANA** – Excellent, Certified, **HMPRO** – Excellent, Certified, **HUMAN** – Good, n/a, **ICHI** – Excellent, Certified, **III** – Excellent, Declared, **INTUCH** – Excellent, Certified, **IRPC** – Excellent, Certified, **ITD** – Very Good, n/a, **IVL** – Excellent, Certified, **JASIF** – n/a, n/a, **JKN** – n/a, Certified, **JMT** – Very Good, n/a, **KBANK** – Excellent, Certified, **KCE** – Excellent, Certified, **KEX** – Very Good, Declared, **KKP** – Excellent, Certified, **KSL** – Excellent, Certified, **KTB** – Excellent, Certified, **KTC** – Excellent, Certified, **LH** – Excellent, n/a, **LPN** – Excellent, Certified, **M** – Very Good, Certified, **MAKRO** – Excellent, Certified, **MC** – Excellent, Certified, **MEGA** – Very Good, n/a, **MINT** – Excellent, Certified, **MTC** – Excellent, Certified, **NETBAY** – Very Good, n/a, **NRF** – Very Good, Declared, **OR** – Excellent, n/a, **ORI** – Excellent, Certified, **OSP** – Excellent, n/a, **PLANB** – Excellent, Certified, **PRINC** – Very Good, Certified, **PR9** – Excellent, Declared, **PSH** – Excellent, Certified, **PTT** – Excellent, Certified, **PTTEP** – Excellent, n/a, **PTTGC** – Excellent, Certified, **QH** – Excellent, Certified, **RAM** – n/a, n/a, **RBF** – Very Good, n/a, **RS** – Excellent, Declared, **RSP** – Good, n/a, **S** – Excellent, n/a, **SAK** – Very Good, Declared, **SAPPE** – Very Good, Certified, **SAWAD** – Very Good, n/a, **SCB** – Excellent, Certified, **SCC** – Excellent, Certified, **SCGP** – Excellent, Declared, **SECURE** – n/a, n/a, **SHR** – Excellent, n/a, **SIRI** – Excellent, Certified, **SPA** – Very Good, n/a, **SPALI** – Excellent, Certified, **SPRC** – Excellent, Certified, **SSP** – Good, Certified, **STEC** – Excellent, n/a, **SVI** – Excellent, Certified, **SYNEX** – Very Good, Certified, **TCAP** – Excellent, Certified, **THANI** – Excellent, Certified, **TIDLOR** – n/a, Certified, **TISCO** – Excellent, Certified, **TKN** – Very Good, n/a, **TOP** – Excellent, Certified, **TRUE** – Excellent, Certified, **TTB** – Excellent, Certified, **TU** – Excellent, Certified, **TVO** – Excellent, Certified, **VGI** – Excellent, Certified, **WHA** – Excellent, Certified, **WHART** – n/a, n/a, **WICE** – Excellent, Certified, **WORK** – Good, n/a.

- CG Score 2021 from Thai Institute of Directors Association (IOD)

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#### Stock Ratings

Definition:

Add	The stock's total return is expected to exceed 10% over the next 12 months.
Hold	The stock's total return is expected to be between 0% and positive 10% over the next 12 months.
Reduce	The stock's total return is expected to fall below 0% or more over the next 12 months.

*The total expected return of a stock is defined as the sum of the: (i) percentage difference between the target price and the current price and (ii) the forward net dividend yields of the stock. Stock price targets have an investment horizon of 12 months.*

#### Sector Ratings

Definition:

Overweight	An Overweight rating means stocks in the sector have, on a market cap-weighted basis, a positive absolute recommendation.
Neutral	A Neutral rating means stocks in the sector have, on a market cap-weighted basis, a neutral absolute recommendation.
Underweight	An Underweight rating means stocks in the sector have, on a market cap-weighted basis, a negative absolute recommendation.

#### Country Ratings

Definition:

Overweight	An Overweight rating means investors should be positioned with an above-market weight in this country relative to benchmark.
Neutral	A Neutral rating means investors should be positioned with a neutral weight in this country relative to benchmark.
Underweight	An Underweight rating means investors should be positioned with a below-market weight in this country relative to benchmark.