

# CO2 utilisation for Lithium Ion Batteries

CO2 has a critical role to play in lithium battery production and recycling and with large-scale long-duration energy storage becoming more prevalent to balance electricity supply, Stephen B. Harrison, sbh4 consulting looks at the investment case.

Electricity demand is on the rise, driven by electrification of industrial processes, data centre build outs and increasing demand from domestic users in developing countries.

To meet the demand, new generation capacity is being added worldwide. However, in many grids, growth of non-programmable renewable generation is outpacing flexible and firm electricity sources. Long-duration energy storage (LDES) is therefore essential to balance the supply and demand of electricity.

## LIBs are the core technology for LDES

For daily balancing with a discharge period of up to 4 hours, lithium ion batteries (LIBs) are unquestionably state of the art. LIBs are the technology of choice for battery electric vehicles (BEVs) and handheld devices such as mobile phones and tablet computers.

Huge utility-scale LDES facilities are being implemented in many countries. They are typically able to supply 100 to 500 MW of power and store up to 2,000 MWh of energy.

For grid balancing, as is the major application in Europe, the discharge period of an LIB LDES scheme is generally optimised at 4 hours. For solar power time shifting in locations such as California, they must work overnight and typically discharge over an 8 to 12 hour period.

## CO2 for LIB production and recycling

LIBs are complex electrochemical devices. Throughout their production and re-processing, CO2 has a central role to play.

During charging and discharging electrons flow from the LIB anode and cathode, and vice versa, through an electrolyte which is supported in a carbonate solvent. That solvent is produced utilising carbon dioxide (CO2).



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At the end of life, valuable industrial metals such as lithium, cobalt, nickel and manganese are recovered during LIB recycling using hydrometallurgical processes which also utilise CO2.

## Carbonate electrolyte solvent production

The electrolyte is supported in a hydrocarbon solvent such as dimethyl carbonate (DMC) or ethylene carbonate (EC).

EC is produced by reacting ethylene oxide with CO2. For every Tonne of EC, 500 kg of CO2 are required. The CO2 purity must be very high to avoid contamination of the EC. For example, the CO2 must contain less than 20ppm of moisture.

DMC has traditionally been produced from the poisonous gas phosgene. The modern process for DMC production avoids phosgene and is therefore much safer. It reacts CO2 with MC and thereby also enables syn-

ergy within an integrated ethylene derivatives chemicals complex.

## CO2 utilisation for battery electrolyte solvents

In March of 2024, Dow1 announced their intent to invest in a new ethylene derivatives plant on the U.S. Gulf Coast. This will produce carbonate solvents which are used to support the electrolyte in LIBs and will support growth in BEV and LDES markets.

As part of Dow's Decarbonize & Grow strategy, the ethylene derivatives facility will capture more than 90% of the CO2 from Dow's existing ethylene oxide manufacturing process. This CO2 will be utilised to produce the carbonate solvents.

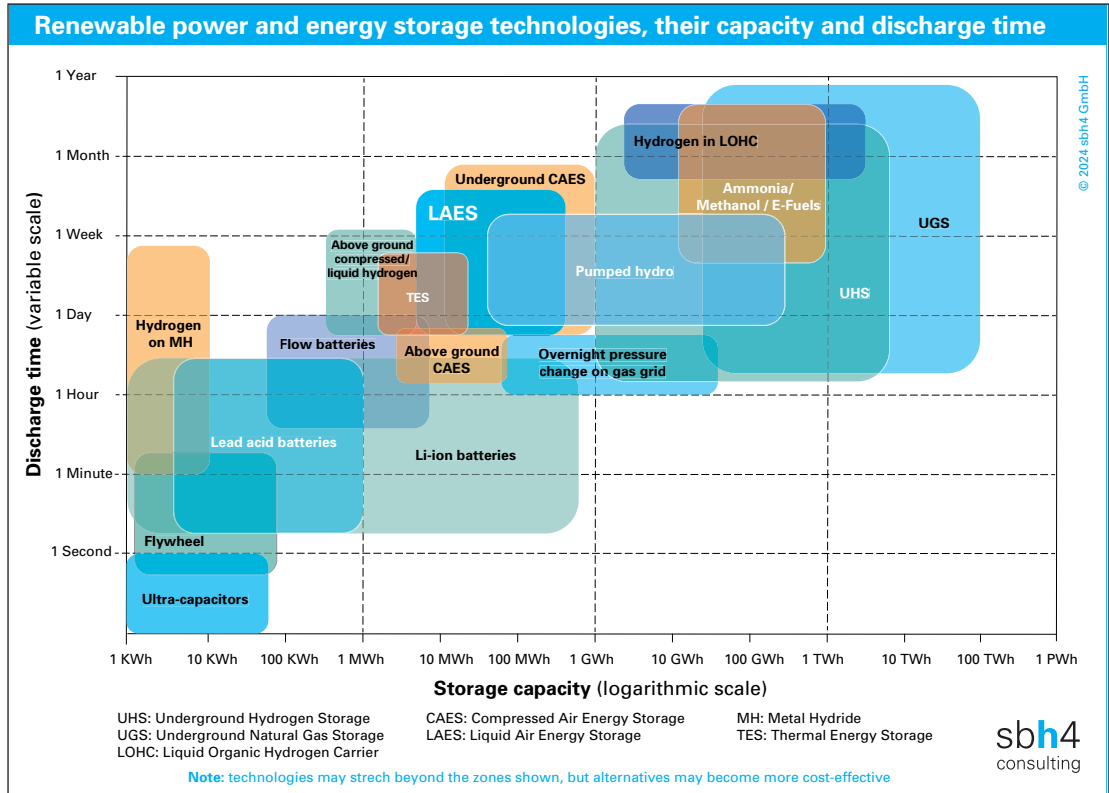
CO2 must be captured during ethylene oxide production to enable process operation, making this one of the lowest cost sources of CO2. Utilisation of the CO2 prevents its direct emission to the atmosphere.

## LIB technologies

There are many types of LIBs, each with different active materials in the LIB anode.

The highest energy density is achieved with Nickel, Manganese, Cobalt (NMC) LIBs. These are favoured in premium automotive applications and are displacing Lithium Cobalt Oxide (LCO) LIBs in premium mobile phones to extend their battery life.

Lithium Iron Phosphate (LFP) LIBs are known for their low cost and are regarded as being safer than NMC LIBs. They are heavier than NMC batteries, but for static power storage applications this weight penalty is of no consequence.



## Regulatory drivers and strategic materials

NMC and LCO LIBs contain large amounts of cobalt, manganese and nickel. In the EU cobalt and manganese are both recognised as both strategic and critical materials. Nickel is regarded as strategic. Recovery of these metals during LIB recycling is therefore of paramount importance.

Reflecting these points, the EU Battery Regulation (2023/1542) is now in force. It is a very stringent framework for battery life-cycle management.

In 2026, at least 65% of the total mass of an LIB must be recycled. That requirement rises to 70% in 2030. Zooming into cobalt and nickel, the reprocessing recovery at the end of 2027 must be at least 90%. By the end of 2031, that increases to 95%.

To extract nickel and cobalt, it is necessary to separate them from lithium in the LIB.

## CO2 utilisation for Lithium circularity

EU Battery Regulation currently requires 50% of the lithium to be recovered. This is aligned to smelting or pyrometallurgical recovery of LIB materials. However, this jumps to 80% for 2032 and beyond. This increase

will force the industry to implement chemical-based hydrometallurgical recycling which is more efficient at recovering lithium from LIBs.

The initial stages of LIB recycling are brutally mechanical. The batteries are crushed to release the electrolyte and its solvent. Copper and aluminium foils are shredded and separated using air blowers. The resulting powder, called black mass, is a mixture of anode and cathode materials. It is rich in metal oxides, lithium and graphite.

Hydrometallurgical recycling mixes the black mass with water. Then, CO<sub>2</sub> gas is sparged into the liquor. The dissolved CO<sub>2</sub> converts lithium ions to soluble lithium hydrogen carbonate, which can then be precipitated and captured using filtration.

## Dynamic market

As with any emerging technology, in the field of LDES and batteries, there is rapid innovation which leads to product substitution and obsolescence.

NMC batteries are being challenged by LFP. The economics and process for LFP battery recycling are very different to NMC LIBs. If NMC batteries are no longer used, the CO<sub>2</sub> demand for hydrometallurgy will decline.

For stationary LDES, vanadium redox flow batteries and iron-air batteries are challenging the dominance of LIBs. In EV mobility, solid state lithium ion and sodium ion batteries are potentially safer and more economical options.

If these newer technologies dominate, the need for CO<sub>2</sub> to produce EC and DMC electrolyte solvents for LIBs may peak 15 to 20 years from now, plateau and then progressively decline.

## Place your bets now

In the short- to mid-term, investing in CO<sub>2</sub> supply for LIB electrolyte solvent production and hydrometallurgy, would seem to be an extremely good bet to leverage a rapidly growing LDES market for stationary and mobile applications.

On the other hand, as innovation races ahead and substitute LDES and battery technologies establish themselves as challengers to LIBs, it will be essential to manage investments towards the peak of demand to avoid over-capacity in a declining market.

### More information

<https://sbh4.de>