Industrial Life Cycle Assessment for Radical Emissions Reductions

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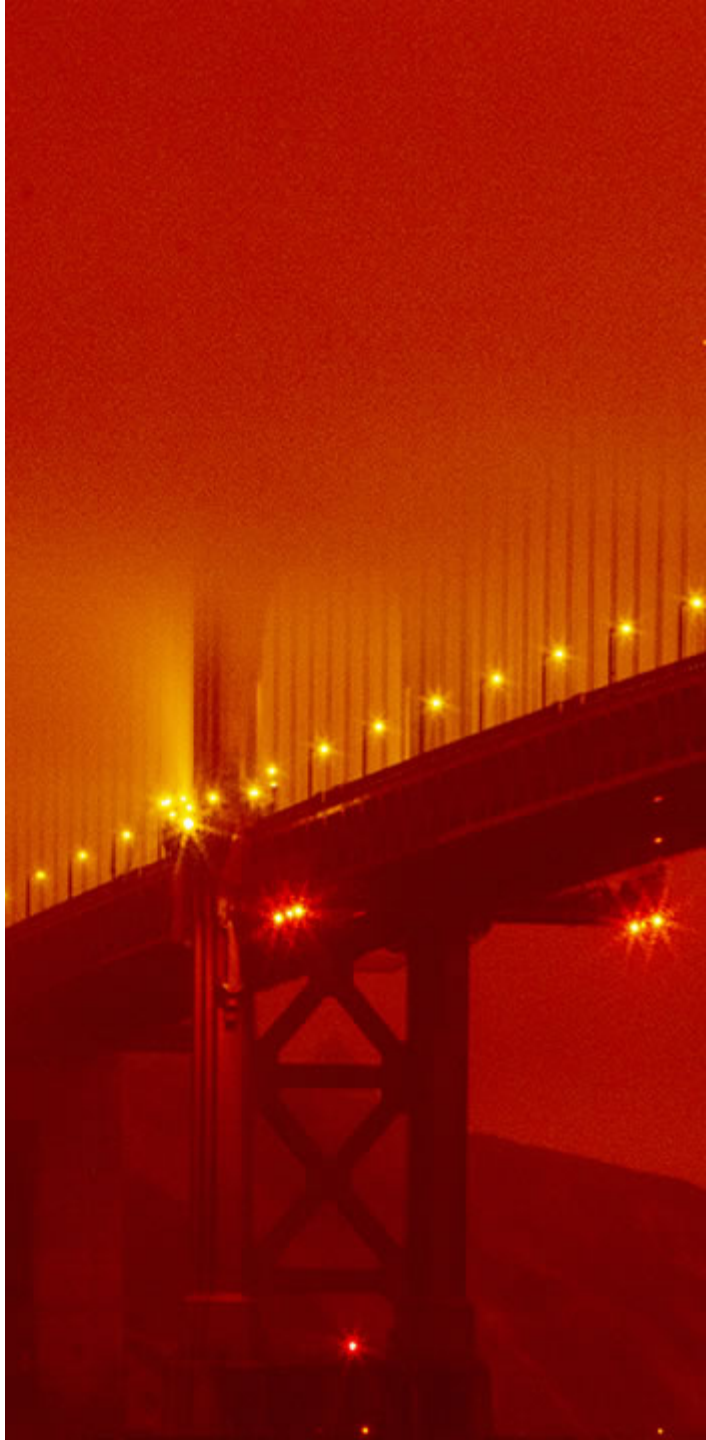
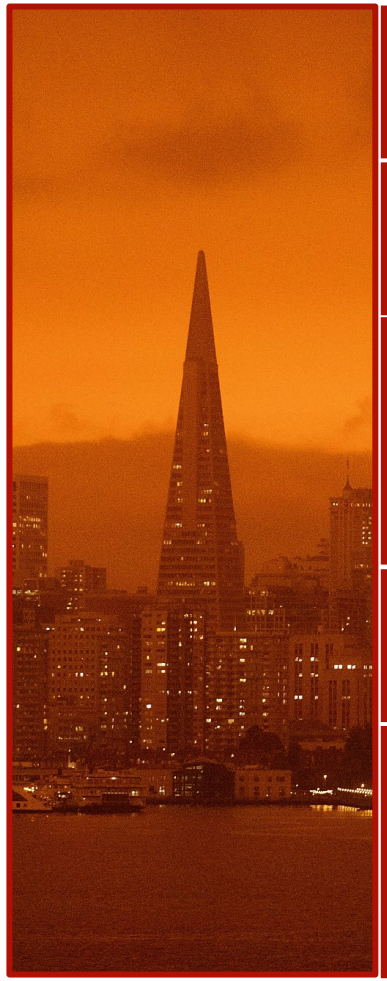
Veloz: Creating Sustainable Practices from Mine to Wheel and Beyond
29 October 2020




My city on 9 September 2020.
This is real.

Take Me To Your Leader



1. "The embodied emissions of the materials you use to make the batteries are **significant and need to be understood**.
2. If you were to power all your EV manufacturing using coal, **it would make no difference** at the end of the day.
3. One thing we did when we built the Nevada Gigafactory was to **make it all electric**, there is literally no natural gas line, so there is little to no local emissions at that factory. When you weave natural gas through your facility, it makes it **much harder to chase it out**.
4. The emissions **all the way back up to the mine** are significant too.
5. When we look at TWh scales of production, we need to make sure we are not creating unintended consequences as we go through this industrial shift. **That is why we are in this situation in the first place**, and we need to rapidly remediate that."

- JB Straubel
Former Tesla CTO & Current Redwood Materials CEO

Quote from the Stanford Storage X webinar on 16 October 2020

Stanford | ENERGY
StorageX Initiative

1 The embodied emissions of the materials you use to make the batteries are **significant and need to be understood**.

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Buyers at battery companies have **massive power today to guide their future** CO_2 emissions (which 97% do not yet exist) because there is **massive variability** in the CO_2 emissions of manufacturing chemicals from different resources/processes

Clean Product (low tCO_2/t)	Dirty Product (high tCO_2/t)	Ratio of CO_2 Intensity for Dirty/Clean
$LiOH \cdot H_2O$		9
$NaOH$		2
$NiSO_4 \cdot 6H_2O$		5
$MnSO_4 \cdot H_2O$		3
$CoSO_4 \cdot 7H_2O$		4
Graphite		6

Data From:

MINVIRO

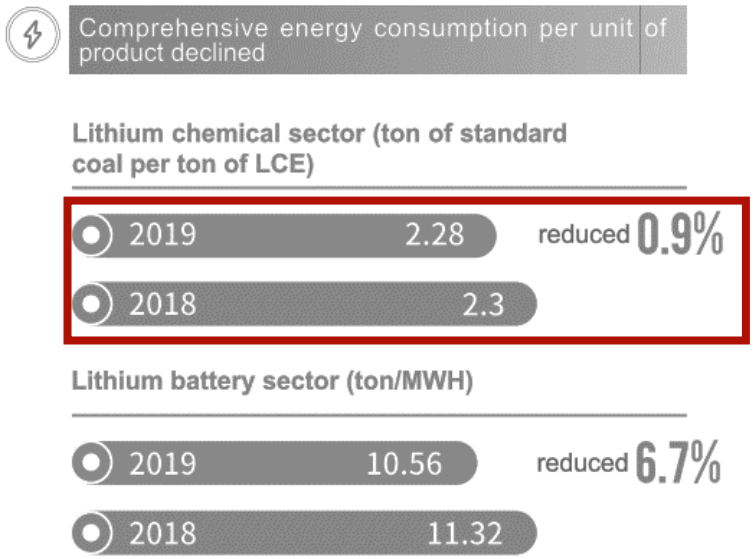
Considering only the materials above, what would be the **delta in CO_2 intensity** of manufacturing if a procurement team bought all the **lowest CO_2 intensity** chemicals vs. all the **highest CO_2 intensity** chemicals to make an NMC 811 cell?

$$\Delta CO_2 = 55\ kgCO_2/kWh$$

This represents ~50% of the total embodied emissions of making the cell, and at **3TWh/year production**, is equal to Ireland + Switzerland + Portugal's **annual CO_2 emissions combined**

So, a team of **10 people in California have the power today** to eliminate the emissions of **three entire small European countries** in 2030 using only their 2020s' procurement policy

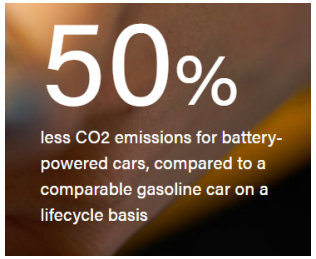
2 If you were to power all your EV manufacturing using coal, **it would make no difference** at the end of the day.



Source: Major Chinese Lithium Company's Sustainability Report

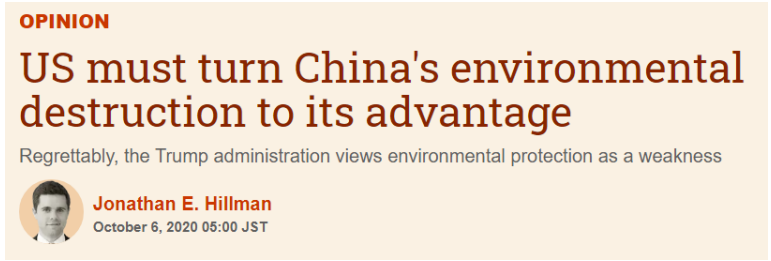
Statistically meaningless difference **presented deceptively** for greenwashing

One of the world's major $LiOH \cdot H_2O$ suppliers, whose lithium values go into Tesla's cathode, burns > 2 tonnes of coal per tonne of LCE to process spodumene concentrates from Australia



RECHARGE

Only 50%? What's the point of this energy transition?



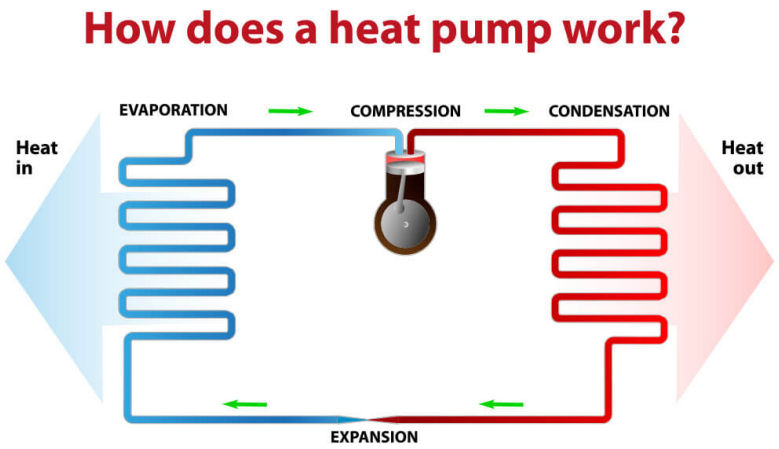
China's domination of the lithium chemical manufacturing section of the value chain would be weakened if the price of their products included the price of dumping CO_2 in the atmosphere… **So why do Western lithium buyers representing the EV revolution buy Chinese lithium chemicals?**

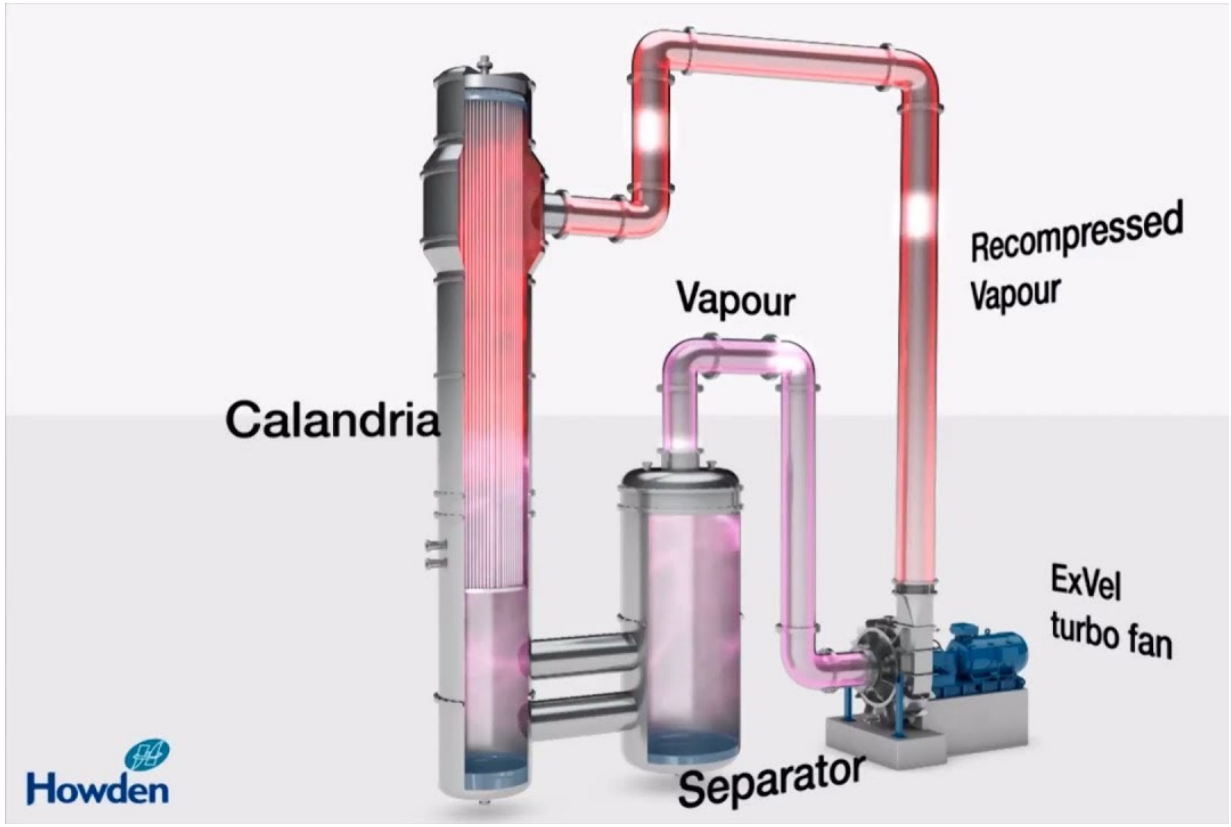
3

One thing we did when we built the Nevada Gigafactory was to **make it all electric**, there is literally no natural gas line, so there is little to no local emissions at that factory. When you weave natural gas through your facility, it makes it **much harder to chase it out**.

Be deliberate about "chasing out" fossil fuels from your processing flowsheets

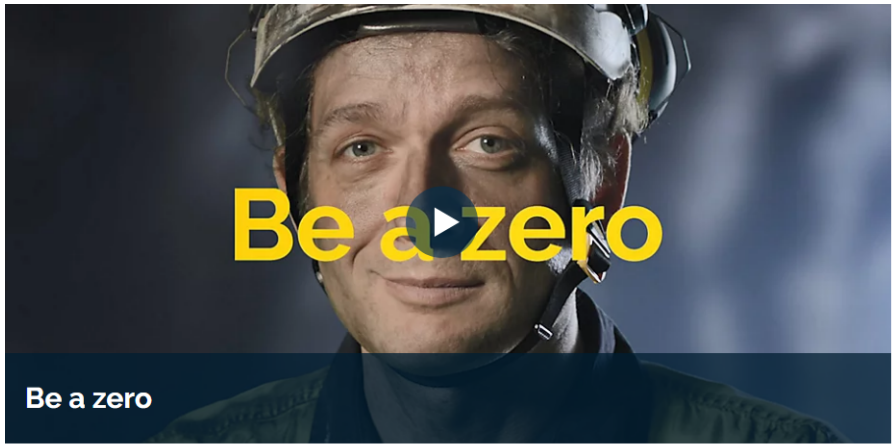
Electricity is much easier to decarbonize than heat – Solar and wind energy project development is **much more straightforward** than mineral project development





Mechanical Vapor Recompression (MVR) evaporators shift energy input from heat (harder to decarbonize) to power (easier to decarbonize)

4 The emissions **all the way back up to the mine** are significant too.



Minetruck Battery is
100% exhaust free

The future is electric

We are leading the change towards sustainability in mining through battery electric, zero-emission equipment. The result is a safer and healthier underground working environment. This contributes to a sustainable future and a smaller environmental footprint. It is a power change that changes everything.

There are a number of options for **electric mining** (and if battery metals are mined electrically, it's like the metals are mining themselves!)

That energy can be decarbonized using wind, solar, and other low carbon sources

5

When we look at TWh scales of production, we need to make sure we are not creating unintended consequences as we go through this industrial shift. **That is why we are in this situation in the first place, and we need to rapidly remediate that.**

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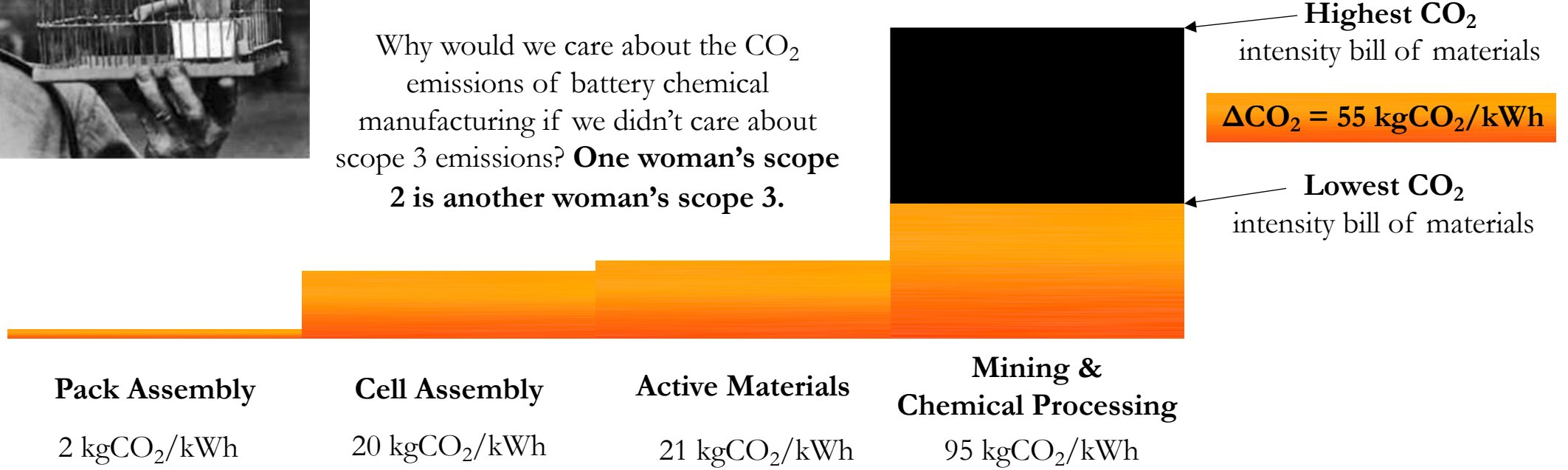
Battery and EV industry, **let this be your canary in the coal mine:**

1. LCAs of LIBs are **dramatically underestimating** CO_2 emissions of your supply chains
2. The efficacy of LIBs for reducing CO_2 emissions and avoiding climate change is **not guaranteed** unless we change the way we mine and process chemicals
3. **Decarbonizing cell/battery assembly plants is almost irrelevant** compared to decarbonizing battery chemical mining and processing – the canary chirps "SCOPE 3"!

Why would we care about the CO_2 emissions of battery chemical manufacturing if we didn't care about scope 3 emissions? **One woman's scope 2 is another woman's scope 3.**



Data From:

Argonne NATIONAL LABORATORY

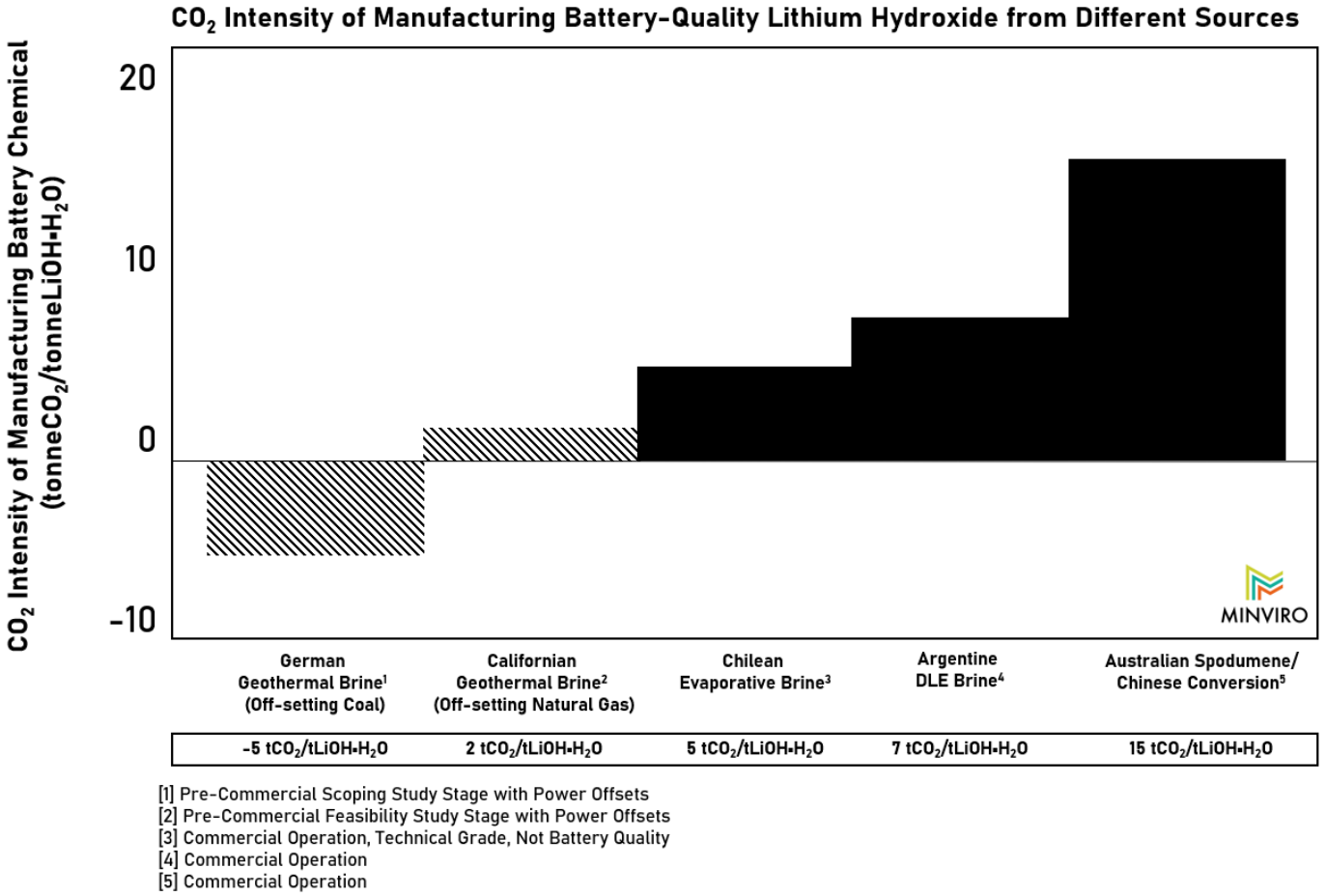
MINVIRO

Case Study 1: Geothermal Lithium Projects

We can kill two birds with one stone by producing low carbon energy and lithium chemicals simultaneously

Assuming they are technically feasible (e.g. economic):

1. Buyers need to give these projects off-take agreements
2. Investors need to finance these projects
3. Engineers need to build these projects



[1] Pre-Commercial Scoping Study Stage with Power Offsets
[2] Pre-Commercial Feasibility Study Stage with Power Offsets
[3] Commercial Operation, Technical Grade, Not Battery Quality
[4] Commercial Operation
[5] Commercial Operation

Everyone in the Lithium Industry Has a Role to Play

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There are three classes of mining and chemical industry *homo sapiens* who can **make a big difference to avoid CO_2 emissions** of battery chemical extraction and processing:

1. **Engineers**
- Reduce the fossil fuels you weave into your process by **electrification** (e.g. MVR, electric calcination, heat pump)
- Tap into concentrated solar, photovoltaics, geothermal, and wind for **low CO_2 heat and power**
- Don't design your process the same way your old employer did it: **revisit 1st Principles** to find better solutions

2. **Institutional Investors**
- Don't invest in or lend to any new project that would produce $LiOH \cdot H_2O$ emitting **>5tCO_2/tonneLCE**
- Work with independent, professional life cycle assessment (LCA) practitioners to **guide investment decisions**

3. **Battery Chemical Buyers**
- Require **ISO-compliant life cycle assessments** for the manufacture of all materials you buy to make your batteries and **set yourself targets** for supply chain CO_2 emission reduction (e.g. don't buy >10tCO_2/tonneLCE after January 2023)
- Modify your procurement decision making process by applying a **synthetic $100/tonne carbon tax** to yourself
- **Chase coal out of your battery supply chain** by not buying any battery chemical with coal in **its** supply chain from 2023

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