5-Min Monthly Read - November 2023

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Market Update

Battery prices fall to record low of $139/kWh in 2023

Reversing the price increase in seen in 2022, the average price of lithium-ion battery packs dropped 14% to $139/kWh, according to BloombergNEF (BNEF).

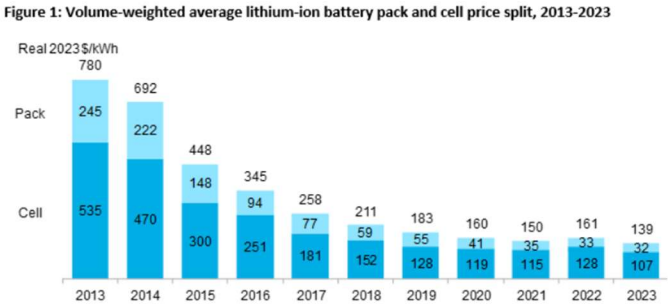


Figure 1: Volume-weighted average lithium-ion battery pack and cell price split, 2013-2023

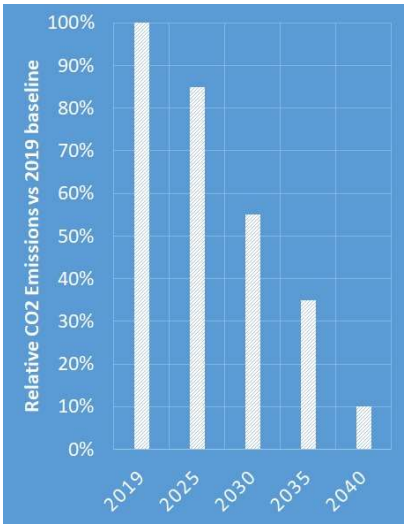
Source: BloombergNEF. Historical prices have been updated to reflect real 2023 dollars. Weighted average survey value includes 303 data points from passenger cars, buses, commercial vehicles, and stationary storage.

- For battery electric vehicles (BEVs), pack prices were even lower at $128/kWh. Cell average prices were $89/kWh, indicating that cells account for 78% of the total pack price on average.
- Note that the $139/kWh is a global average price but there are differences locally. Pack prices were lowest in China, at $126/kWh. Packs in the US and Europe were $140 and $151/kWh, respectively.
- Battery production for energy storage and electric vehicles is expected to reach 950 GWh this year.

Regulations / Reports

European Parliament approves revised HD CO_2 targets

The European Parliament voted in favor of adopting the proposed CO_2 standards for heavy-duty vehicles. Key elements of the targets include:



- Reduction in CO2 emissions of 45% by 2030, 65% by 2035, and 90% by 2040.
- ZEV mandate for urban buses starting 2030, but with an exemption until 2035 for urban buses fueled by biomethane under certain conditions.
- Vocational vehicles included along with small trucks with a gross vehicle weight < 5 tons.
- Methodology to be developed to allow for the use of carbon neutral fuels (these could be synthetic fuels but also biofuels – more details needed)
- The Parliament voted against the carbon correction factor (CCF) which will reduce the CO_2 emission targets based on the use of renewable fuels

Note that the EU Council has also agreed to support the CO2 reductions in the previous month.

Next step involves discussions of the Parliament with individual governments for the final legislation.

CARB Workshop advances proposal for Tier 5 Non-Road Standards

A workshop held on Oct 30th – 31st, 2023 by the California's Air Resourced Board (CARB) discussed proposed changes to the emission standards for non-road machinery (construction, agricultural, gen-sets, etc.)

Timing

Tier 5 limits to be introduced in two stages, an interim starting in 2029-2031 and a final starting in 2033-2034. Some of the latest changes proposed:

Criteria Pollutants

- Hydrocarbon limit reduced by ~ 60% for all engines > 56 kW.
- NOx limit to be reduced by 90% for 56 – 560 kW engines. For gensets > 560 kW the proposed reduction is a modest 30%. NOx limit is introduced for 19 – 56 kW engines.
    - Included are provisions for a 20 mg/kWh compliance margin and an in-use conformity factor.
- PM limit reduced by 75% for 56 – 560 kW engines and for gensets > 560 kW.
- HC, NOx, and PM are also limited on the new low load cycle. NOx limits are 50% higher (vs. NRTC) whereas the same PM limits apply for LLC as for the NRTC.
- A California state-specific averaging, banking and trading (ABT) credit bank will be created starting 2026 for early Tier 5 compliant engines. Credit multipliers are included for early compliance with NOx, up to 1.75x for 3 years early compliance. There are no multipliers for CO_2 or PM.
- Replacement / re-built engines will have to meet the tightest emission standards, there are new reporting requirements.
- An off-road Diesel Aftertreatment Accelerated Aging Cycle (DAAAC) can be used for engine certification.

GHG

- CO2 emissions to be reduced by 6% for 56 – 560 kW engines. For the rest, caps will be based on 80th percentile of data for current engines.
- N_2O and CH_4 caps of 0.15 and 0.13 g/kW-hr, respectively. CO_2 credits may be used to offset N_2O and CH_4 emissions (but not vice versa).

Tier 4 Final and Proposed CARB Tier 5 Limits apply to NRTC and Steady -State/RMC. All values in g/kWh.

Engine Rating, kW	Engine Rating, hp	Application	CO		NMHC		NOx			NOx + NMHC		PM		
			Tier 4f	Tier 5f	Tier 4f	Tier 5f	Tier 4f	Tier 5i	Tier 5f	Tier 4f	Tier 5f	Tier 4f	Tier 5i	Tier 5f
0 – 8	0 – 11	All	8.0	8.0	-	-	-	6.0	5.0	7.5	-	0.4	0.3	0.2
8 – 19	11 – 25	All	6.6	6.6	-	-	-	5.5	4.0	7.5	-	0.4	0.2	0.1
19 – 56	25 – 75	All	5.0	5.0	-	0.19	-	3.7	2.5	4.7	-	0.03	0.015	0.008
56 – 130	75 – 750	All	5.0	5.0	0.19	0.08 LLC = 0.19	0.4	0.22	0.04 LLC = 0.06	-	-	0.02	0.005 Same for LLC	
130 – 560		All	3.5	3.5	0.19	0.08 LLC = 0.19	0.4	0.22	0.04 LLC = 0.06	-	-	0.02	0.005 Same for LLC	
> 560	> 750	Gen Sets	3.5	3.5	0.19	0.08	0.67	0.50	0.35	-	-	0.03	0.015	0.008
		Mobile Machines	3.5	3.5	0.19	0.19	3.5	3.50	3.00	-	-	0.04	0.04	

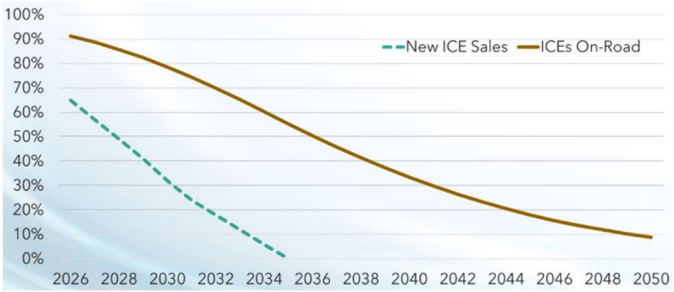
Since non-road emissions are the next frontier, consider adding these to your conference list for next year:

Emissions Analytics Off-Highway Powertrain and Fuels USA 2024, May 8-9, Irvine, California
https://conferences.emissionsanalytics.com/offhighway-us/index.html

Emissions Analytics Non-Road Powertrain and Fuels Europe 2024, September 18-19, Munich, Germany
https://conferences.emissionsanalytics.com/nonroad-eu/

CARB workshop on Advanced Clean Cars (ACC II) amendments for light-duty vehicles

Even if CARB achieves its goal of 100% ZEV sales by 2035, it expects internal combustion engine (ICE) powered vehicles on the roads for another three decades.



In a workshop held on November 15, 2023, CARB discussed potential changes to the greenhouse gas (GHG), criteria pollutant, and zero emission vehicle (ZEV) assurance measures under the ACC II rule.

- For GHG, CARB is proposing to align with EPA fleet-averaged proposal of 82 g-CO_2/mi in 2032, but is considering anti-backsliding measures to avoid increasing internal combustion engine CO2 emissions with increasing ZEV penetration. Also discussed were PHEV utility factors (EPA has reduced them) and the increasing use of ethanol.
- For criteria pollutants, CARB is proposing to align with EPA Tier 4 standards through changing the Bin structure (e.g. adding the Bin 10), adopting the 0.5 mg/mi PM standard and lowering the class 2b/3 NMOG+NOx fleet average to 60 mg/mi by 2032 MY.

ICCT report on updated GPF cost

The International Council on Clean Transportation (ICCT) has published a new report updating the cost of gasoline particulate filters, which are expected to be mandatory on light- and medium duty vehicles following the Tier 4 final rule next year (CARB is expected to align, see above). According to the revised cost study, the incremental cost of a catalyzed GPF relative to the three-way catalyst (TWC) it replaces, is expected in the $94 - $140 range for a 1.5 to 3L engine. The analysis assumes a 20% increased PGM loading when switching to the GPF and a GPF-to-engine displacement volume ratio of 0.8. These are near-term costs, which are expected to fall further by ~ 20% in longer term with economies of scale.

Clarifications on the Inflation Reduction Act (IRA)

The U.S. Department of the Treasury and Internal Revenue Service (IRS) released proposed guidance on the eligibility criteria for clean vehicle section 30D tax credit as included in the Inflation Reduction Act (IRA). It provides a maximum credit of $7,500 per plug-in vehicle: $3,750 if certain critical minerals requirements are met and $3,750 if certain requirements are met. The vehicle must be of GVWR < 14,000 lbs, with an externally rechargeable battery with capacity > 7 kWh (basically any plug-in hybrid or BEV), assembled within N. America.

However, the credits do not apply to vehicles which use batteries coming from a "foreign entity of concern" (FEOC) starting 2025, and to vehicles manufactured or assembles at an FEOC starting 2024. The U.S. Department of Energy (US DOE) has provided guidance on FEOCs - especially relevant on this list is China, which controls much of the supply chain for batteries.

Conference Summaries

Life-Cycle Analysis for Transportation Symposium, Nov 16 – 17, 2023

The second Life-Cycle Analysis for Transportation Symposium (LCATS) was held on November 16–17, 2023, in San Antonio, Texas. This Southwest Research Institute-hosted forum is proving to be a great place to discuss lifecycle methodologies for assessing various pathways for decarbonizing transport and the policy implications. Download a summary of the conference.

Speaking of lifecycle analysis, consider listening to Brandon Bartneck's "Future of Mobility" podcast, and this specific one where he interviews Kelly Senecal on the "Life Cycle Analysis Sins, E-fuels, Decarbonization & Our Eclectric Future".

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