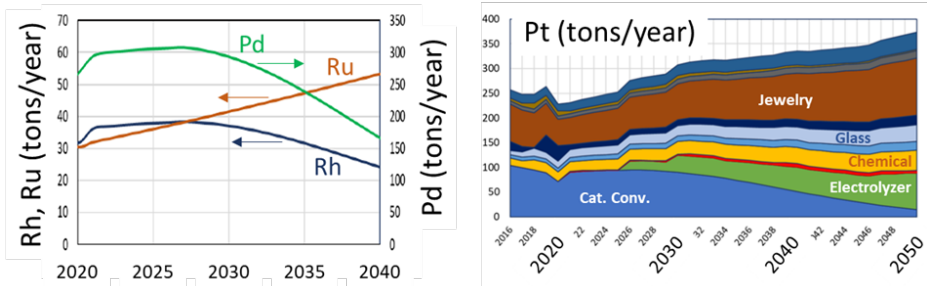


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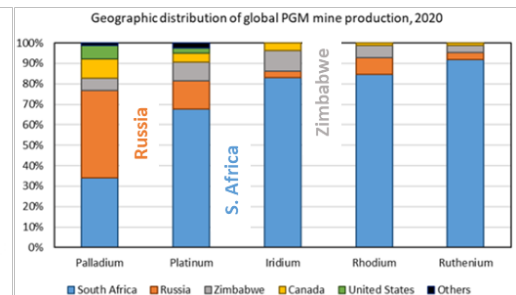
Spotlight on materials

The US Dept. of Energy has published a [supply chain deep dive assessment](#) which has a lot of valuable information on a wide range of technologies critical to decarbonization (energy storage, CO₂ capture, batteries, nuclear energy, solar/PV, etc.) The reports highlight the changing demand for the critical materials used in these technologies and the implications of a global market dependent on few countries with very high shares of natural reserves or production. For automotive, PGM demand is expected to peak later in this decade due to electrification, but demand for Pd continues to be strong due to its need for H₂ production.

How much will be required globally?

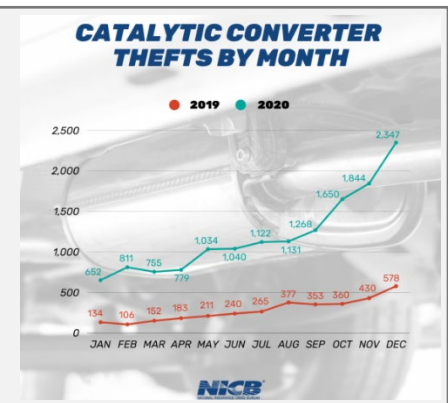


Where will it be mined?



In the meantime, very high PGM prices have increased catalytic converter thefts. Over 2000 catalytic converters are being stolen each month in the US alone, according to the [National Insurance Crime Bureau](#). According to [Edmunds](#), it takes less than two minutes to remove a catalytic converter.

Recently, a bill was [introduced](#) that proposes funding for marking catalytic converters to address the issue. “Covered activities under this section include a die or pin stamping of the full vehicle identification number onto the outside of the catalytic converter in a conspicuous manner on motor vehicles.”



The situation is similar for batteries, in that a handful of countries dominate the supply chain today. A nice graphic from [VisualCapitalist](#) shows that almost half of the battery cost for a Li-ion battery is associated with raw materials, which have increased in price recently.

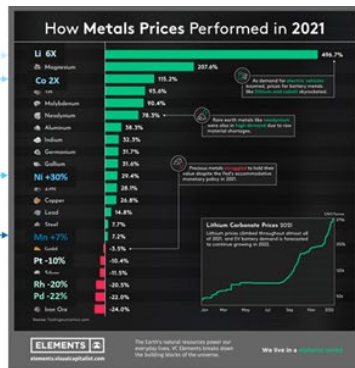
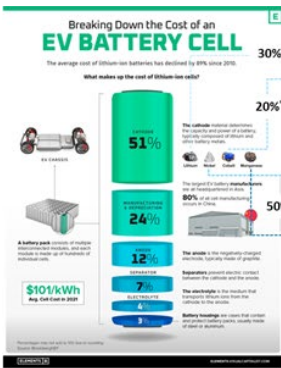


Table 2. 2020 Lithium-ion Battery Refined Material Capacity by Country, Percent of Total by Material

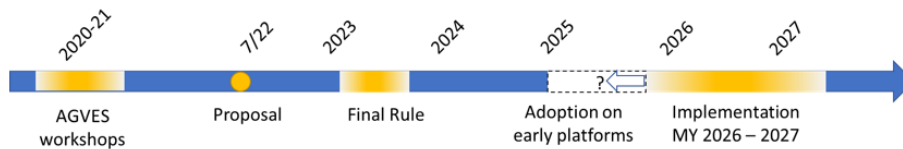
C1 Nickel Sulfate		Cobalt Sulfate		Lithium Hydroxide and Carbonate		Manganese (HPMSM)	
Russia	21%	China	72%	China	61%	China	95%
China	16%	Finland	9%	Chile	26%	Belgium	<5%
Japan	15%	Canada	4%	Argentina	10%	Japan	<5%
Canada	13%	Norway	4%	US	3%		
Australia	10%	Australia	3%				
Norway	8%	Japan	3%				
Finland	6%	Madagascar	2%				
Madagascar	5%	Morocco	1%				
UK	3%	Belgium	1%				
South Africa	2%						
France	1%						

Source: NREL Analysis, BloombergNEF Metals Database, Mining and Refining (2021) and Global Manganese Outlook 2020-2030 (2020)

Regulatory Update

Euro 6e / Euro 7

Euro 7 Timing (speculation)



The date for releasing the Euro 7/VII proposal has been postponed again, this time to July 20th, 2022. This will likely push out the implementation date as well to sometime after model year 2025.

In the meantime, there are discussions on a Euro 6e step, which proposes to lower the conformity factors for NOx from 1.43 to 1.1 and for particle number (PN) from 1.5 to 1.34. Also discussed is an improved treatment of the CO₂ emissions of plug-in hybrids, following reports which showed that utility factors – that is the percentage of driving in pure electric mode – is much lower than certification values. On-board fuel and energy consumption data will be used to revise the CO₂ calculations. This change will likely further increase the share of full electrics to meet the CO₂ standards.

Deadlines extended for 56 – 130 kW non-road mobile machinery (NRMM) Euro V

European Stage V NRMM regulations were slated to apply starting Jan 1, 2021. Due to Covid related supply chain disruptions, the EU Parliament had extended the transition deadlines for engines < 56 kW and ≥ 130 kW by one year (starting Jan 2022). Earlier this year the European Commission has also extended the deadlines for machinery fitted with 56kW - 130kW engines. The amendment provides a 6-month extension for manufacture of the machinery fitted with those engines and a 9-month extension for placing on the market.

Particulate standards for Transport Refrigeration Units (TRUs)

CARB has approved new standards for diesel powered TRUs, which will require (a) newly manufactured non-truck TRU engines (on trailers, domestic shipping containers, railcars, and generator set units) to meet Tier 4 off-road PM standard for 25-50 hp engines, (b) to convert all truck TRUs operating in California to zero-emission by end of 2029 and (c) use a refrigerant with a global warming potential less than or equal to 2,200, or no refrigerant at all.



Market Update

Ford - separate EV and ICE business units

Ford has announced that it will create distinct EV (Ford Model e) and ICE (Ford Blue) businesses to compete in the EV space more effectively while continuing to improve ICEs. The company aims for carbon neutrality by 2050 and plans to sell 30% of its vehicles as EVs (~2 million vehicles) by 2026 and 50% by 2030.

Stellantis strategic plan to 2030

Stellantis [announced](#) its strategic plan for achieving 50% reduction in carbon emissions by 2030 (vs. 2021) and net zero by 2038. The plan will require 50% sales in the US and 100% in Europe to be battery electric by 2030, and cumulative BEV sales of 5 million vehicles by the end of this decade. Battery capacity will increase from 140 GWh to 400 GWh. Hydrogen fuel cell technology will also be pursued for large vans starting 2024 – 2025, and for heavy-duty trucks. The target also includes achieving one third of the global sales online through a digital marketplace, by 2030. The company announced the first electric Jeep SUV and a new Ram 1500 BEV pickup, slated to arrive in 2023 and 2024, respectively.



Electric truck market

In [Europe](#), a total of 346 new electric trucks > 16 tons were registered in 2021. Volvo Trucks is leading with a 42% share of those sales and has letters of intent to buy 1,100 electric trucks globally.

In the [US](#), a total of 1,215 medium heavy duty electric trucks have been sold through the end of 2021, with over 60% in California. However, over 60% of the electric trucks in the US are non-operational due to support or operational performance issues.

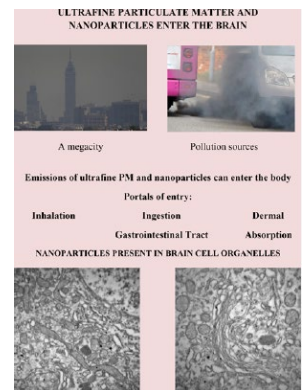
Other than lack of charging infrastructure, upfront costs are currently a barrier for HD electrification. The [ICCT](#) has published an assessment of zero-emitting truck costs which shows that the range of costs reported for a 500-mile sleeper Class 8 electric truck in 2020 was \$300K – 600K compared to \$150K for an equivalent diesel. Battery packs are the biggest (~ 60%) contributors to the overall cost of an electric truck, with pack prices in the \$150 – 350 /kWh range (vs ~ \$130 /kWh for light-duty).

Technology Update

US dropping the lead on ultrafine particulates, study highlights

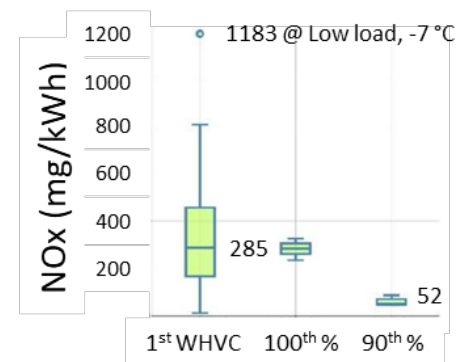
A [recent publication](#) examines the growing evidence that particulate emissions from combustion sources are linked with health effects associated with brains in young individuals, especially for the vulnerable population living close to high traffic roadways. On the lack of standards limiting ultrafine particles in the US, the authors say the following:

“.. this approach raises the question: *are we dropping the ball?* As research continues to answer the remaining questions about UFP sources, exposures, impacts, and controls, the precautionary principle should call us to accelerate and expand policy interventions to abate or eliminate UFP emissions and to mitigate UFP exposures.”



HD Demonstration for Euro VII

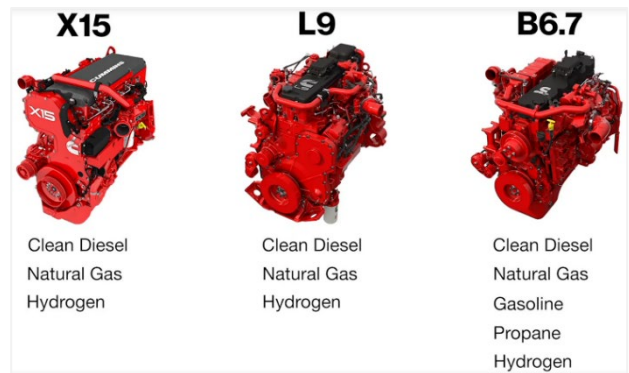
A [recent study](#) investigated the potential for reducing tailpipe emissions from a heavy-duty Euro VI-C compliant European truck equipped with a 13L engine and an advanced after-treatment system including a close-coupled DOC and SCR with twin dosing. Testing was done at various loads, temperatures and driving conditions. Overall significant reductions in NOx emissions were obtained, well below the current Euro VI limit of 460 mg/kWh, although the emissions were variable depending on the wide range of test conditions. Particle number emissions increased by ~ 20% when including 10 – 23nm particles, but overall PN was below the current limits.



Renewable fuels are advancing

- **Cummins fuel-agnostic ICE platform**

Cummins [unveiled](#) a fuel-agnostic ICE platform which will have similar components below the head gasket, while making changes above the head gasket to suit the various fuel types – diesel, natural gas and H₂. Other than diesels, Cummins has 15L natural gas and hydrogen engines for long-haul, and will be announcing gasoline, propane and H₂ ICEs for medium-duty and vocational applications. These will apply to the B6.7, L9 and X15 series engine platforms and can utilize low carbon fuels such as renewable natural gas for deeper wells-to-wheel CO₂ reduction. The move clearly helps with commonality of parts across various engines and lower cost.



- **Demonstration of Class 8 diesel with ethanol fuel**

[ClearFlame Engine Technologies](#) has completed an on-road demonstration of a Class 8 truck running with a Cummins X15 (15L) engine converted to run on renewable E98 ethanol. Other than the wells-to-wheel GHG reduction, the technology allows the use of relatively lower cost three-way catalysts as opposed to the complex SCR-based deNOx after-treatment. The technology is not limited to ethanol only and any liquid fuel (e.g. methanol) can be used.

- **Hydrotreated Vegetable Oils (HVOs) for diesel engines**

HVO is a renewable paraffinic fuel (also called synthetic or renewable diesel) produced from waste residues from the food industry. It has a higher cetane rating and very low sulfur content but does require after-treatment system similar to a diesel. The main advantage is the significant (70 – 95%) reduction in wells-to-wheel GHG emissions without requiring a change to the fueling infrastructure or compromising on the diesel engine performance. Engine testing is being done to show the compatibility with HVO:

- [Audi](#) has approved the use of HVO for diesel engines on the A4, A5, A6, A7, A8, Q7, and Q8 models.
- [Kohler Engines](#) has approved HVO for all its diesel engines.
- [Ford](#) has approved the use of HVO for its Transit vans two years ago.
- What about the impact of HVO on tailpipe criteria emissions? A [recent study](#) at UC Riverside showed that in use heavy duty vehicles emit lower HC, NOx and PM when operating with HVO fuel.

Don't miss these upcoming events ...

31st CRC Real World Emissions Workshop, March 13th – 17th, San Diego, California

<https://crcao.org/2022-31st-crc-real-world-emissions-workshop/>

11th Annual PEMS Conference, March 17th – 18th, Riverside, California

<https://www.cert.ucr.edu/pems>

SAE On-Board Diagnostics Digital Summit – Europe, March 15th – 17th, online

<https://www.sae.org/attend/obd-europe>

SAE World Congress, April 5th – 7th, Detroit and online

<https://www.sae.org/attend/wcx>
