Market Intel
Pathways for clean vehicles and fuels, advanced technologies, mobility and autonomous rides, and multi-modal transportation

March 2023:

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Commonly asked questions and topics for debate in clean transportation

In late February, I heard from a colleague who always has fascinating comments to make. He's an environmental engineer currently working for a federal agency, and has worked for private companies over the years. He's worked on electric vehicle batteries and race car powertrains.

I told him about a network I've been working with in travel and transportation that's bringing together professionals in that field with carbon dioxide reduction as the end
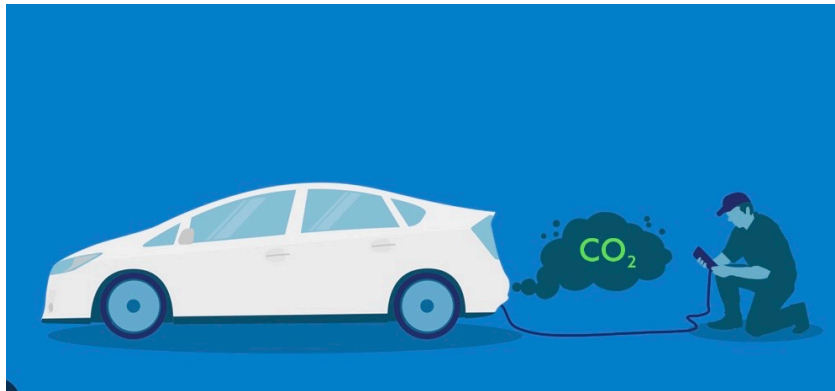
goal. He made a joke about it, and when asked about it, he clarified that basing everything on cardon emissions is off the mark. He goes by the pollution measure.

I'd heard and read that comment many times over the past decade and a half. It was a good reminder to be clear on

commonly asked questions in clean transportation. Here are a few……

Carbon, GHG, and Air Pollution
To start with, it's important to see that there are actually three definitions to compare when measuring emissions and negative impact on the environment: carbon dioxide (CO2), greenhouse-gas emissions, and air pollution.

Carbon dioxide (CO2): is not, by itself, considered to be an air pollutant. Carbon dioxide is a colorless and non-flammable gas at normal temperature and pressure. Although much less abundant than nitrogen and oxygen in the Earth's atmosphere, carbon dioxide is an important constituent of our planet's air. CO2 enters the atmosphere through burning fossil fuels (coal, natural gas, and oil), solid waste, trees and other biological materials, and also as a result of certain chemical reactions (e.g., manufacture of cement).

Concerns have been mounting that CO2 concentation in the atmoshere has significantly increased due to human activity. Activivties such as the burning of fossil fuels increase that concentation and create a "greenhouse effect." This will drive increases in global temperatures and lead to global warming and climate change. Some of the devastating effects will be rising sea levels, flooding, and turbulent, destructive weather conditions.

Greenhouse gases (GHG): Gases that trap heat in the atmosphere are called greenhouse gases (GHG). As described in the C02 definition, the trapping of this heat will create a "greenhouse effect" and its desctructve, devastating impacts.

Carbon dioxide accounts for about 79% of total GHGs in the U.S., accordng to the US Environmental Protection Agency. Methane, primarily from agriculture, contributes 11%, nitrous oxide 7%, mostly from industry and agriculture. Flourinated gases can make up 3% of the total and come from a variety of household, commercial, and industrial applications and processes.

Air pollution: Air pollution is contamination of the indoor or outdoor environment by any chemical, physical or biological agent that modifies the natural characteristics of the atmosphere, according to the World Health Organization (WHO). Common sources of air pollution are motor vehicles, industrial facilities, forest fires, and household combustion devices. Household combustion devices include space heaters, ranges, ovens, stoves, furnaces, fireplaces, water heaters, and clothes dryers. Ambient (outdoor) air pollution in both cities and rural areas can cause strokes, heart diseases, lung cancer, and acute and chronic respiratory diseases, says the WHO.

The EPA has identified six pollutants as "criteria" air pollutants because it regulates them by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels. These six pollutants are carbon monoxide, lead, nitrogen oxides, ground-level ozone, particle pollution (often referred to as particulate matter), and sulfur oxides (sulfur dioxides).

Which one leads in defining clean vehicles?
Greenhouse gas appears to be the most commonly cited emissions measure, but air pollution is sometimes the second measure. For example, when you look into California's zero-emission vehicles (ZEVs), it's not clearly defined but it does come down to these two standards from California policy. The Union of Concerned Scientists defines ZEVs as electric vehicles and hydrogen fuel cell vehiles which generate "fewer

global warming emissions than gas-powered cars, and which don't produce tailpipe pollution.

Fleets, of course, would be an excellent source for defining the standards. In Gladstein, Neadross & Associates *State of Sustainable Fleets* for 2022, youll find that GHG is the most commoonly cited guideline. The report does cover all three. Corporate fleets are cited — PepsiCo, Target, Amazon, Verizon, and Walmart — for hitting net-zero carbon emissions by 2040 — as the goal. In another section of the report, natural gas and propate are citied as altnernative fules that can achieve signifitant Nox and particulate matter (PM) emission reductions from medium-duty and heavy-duty vehicles when compared to diesel trucks. Those are air pollution measures.

To generarlize these questions, it depends on the source you're reading. If you're looking at content from South Coast Air Quality Management District, you're likely to see air pollutins citied as the measures. If its from the EPA, then GHG will probably be it. If you're looking at European Union or United Nations, carbon dioxide (CO_2) is likely to be the standard. Yet, you'll be able to find all three standards used in some reports and guidelines. You will find all three mentioned in California's programs — low carbon fuel standards (LCFS), air pollution guidelines from AQMD, and reducing greenhouse gas emissions to 1990 levels is mentioned in California climate policies.

Air pollutiion is the measure typically used in studies and policies looking at the harmful impact fossil fuel-powered vehicles can have on people, especially respiratory conditions. California's environmental justice law addresses exposure to air pollution in disadvantaged communities.
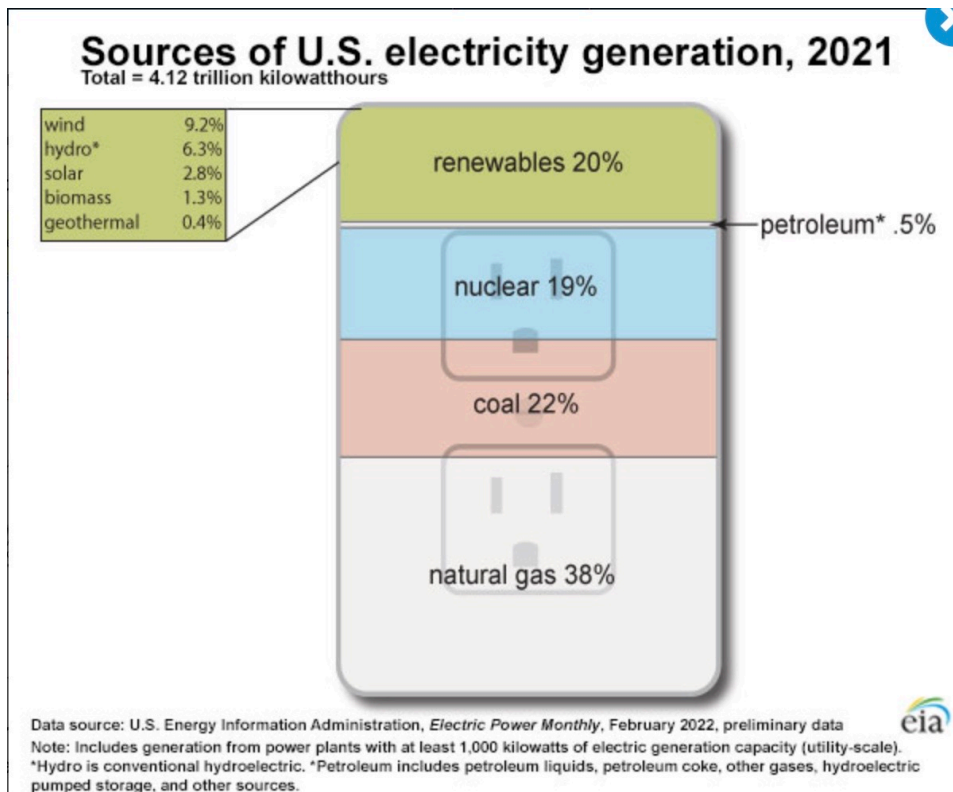
Here's another one: climate pollution
A March 1, 2023 press release headline from the U.S. EPA reads: "Biden-Harris Administration Announces Over $250 Million to Fund Innovative Projects That Tackle Climate Pollution."

The funding source is the $5 billion Climate Pollution Reduction Grants (CPRG) program created by President Biden's Inflation Reduction Act. It's based on reducing pollution and ensuring investments to maximize benefits especially for low-income and disadvantaged communities. That covers air pollution and its health dangers. The accouncement include other sustainablity terms — "climate plans," "greenhouse gas emissions inventories," "decarbonization," and "clean energy economy" are included.

EVs and what fuels the power plants

If you're discussing the role that electric vehicles are playing in reducing GHG emissions, inevitably the topic of where the electric power is coming from will be brought up. That battery electric vehicle may have zero emissions, but what's the power source? What if if that power plant is fired up on coal or natural gas?

Sources of U.S. electricity generation, 2021
Total = 4.12 trillion kilowatthours

wind	9.2%
hydro*	6.3%
solar	2.8%
biomass	1.3%
geothermal	0.4%

renewables 20%

petroleum* .5%

nuclear 19%

coal 22%

natural gas 38%

Data source: U.S. Energy Information Administration, *Electric Power Monthly*, February 2022, preliminary data
Note: Includes generation from power plants with at least 1,000 kilowatts of electric generation capacity (utility-scale).
*Hydro is conventional hydroelectric. *Petroleum includes petroleum liquids, petroleum coke, other gases, hydroelectric pumped storage, and other sources.

It's good to get a good look at where our energey is coming from in the U.S. If you include nuclear power, clean energy makes up 39% of our electricty as of February 2022. Nuclear power, which makes up 19% of that total, is going through a major period of change. The current power plants are nuclear fission-based. They are managed through complex safety and security features, but there's still a major concern about uncontrolled nuclear reaction in a nuclear reactor that could result in widespread contamination of air and water.

There's a lot of enthusiasm for the next generation nuclear fusion plant breakthrough that was revealed in December at the Lawrence Livermore National Laboratory in California. Kim Budil, the director of Lawrence Livermore National Laboratory, said on Tuesday that cheap, abundant electricity from nuclear fusion is still "probably decades" away. So, it's nuclear fission for now.

What about trains — how clean and safe is rail transport, really?

The February 3 Norfolk Southern derailment in East Palestine, Ohio, and the fatal passenger train crash in Greece this month, have brought up some big questions about the state of rail transport in the U.S. — for people and for freight. For the 38 cars that came off the tracks, 11 of them were tank cars that dumped more than 100,000 gallons of hazardous chemicals, including vinyl chloride in Ohio. The EPA said its tests showed the air and municipal drinking water in East Palestine had become safe. The vinyl

chloride is likely to be examined more in the future, as it's been linked to cancer. was the railroad company.

Two BNSF trains derailed in separate incidents in Arizona and Washington state on March 16, with the latter spilling diesel fuel on tribal land along Puget Sound.
No injuries were reported. It wasn't clear what caused either derailment. Most of 2,500 gallons of spilled diesel fuel leaked on the land side of the berm in Washington rather than toward the water, according to the state Ecology Department.

So let's look at the numbers……

Transport Statistics in the US
Transportation Sector Greenhouse Gas Emissions by Source in 2020
Rail — 2%
Ships and Boats — 2%
Aircraft — 8%
Medium and Heavy Duty trucks — 26%
Light-duty Vehicles — 57%
Other — 5%*
*("Other" sources include buses, motorcycles, pipelines, and lubricants)
Source: US Environmental Protection Agency. Transportation made up 27% of US GHG in 2020.

US Transportation Fatalities in 2020
Light-duty vehicles: 25,536
Pedestrians: 6,516
Motorcyclists: 5,579
Pedacyclists: 938*
Large Trucks: 831
Rail: 744
Source: National Highway Traffic Safety Administration (NHTSA), National Safety Council
Pedacyclsts are bicyclists and other cyclists.

Rail Transportation Safety
Rail safety — both freight and passenger — has been improving for decades, with fatalities rare and injuries recently being only slightly above fatalities. Derailments and other accidents are still high, but that number has also been declining and many of them are minor incidents. Accidents were about 1,600 per year in the U.S. in 2020 and 2021, according to the Bureau of Transportation Statistics.

Rail vs. Trucking:
Rail shipping is much more cost-effective than truck shipping for several reasons. Rail is a much more fuel-efficient mode of transportation. Railcars can also carry much more volume than trucks; one rail car is equivalent to about four full truck loads. The cost of maintaining rail cars is also significantly lower, according to RSI Logistics.

While the Covid pandemic, political issues and a truck driver shortage have created supply shortfalls in trucking in 2022, rail has remained relatively stable. Rail is more

resistant to these sorts of shifts partly because rail required less labor per ton shipped than truck. The rail industry has significantly less employee turnover than that of the trucking industry.

When comparing the speed of rail vs trucking shipping, the advantage goes to trucking. Extensive highways allow trucks to (usually) follow a shorter path between two points and deliver their cargo faster. Trucks are also generally easier to load and unload. However, the speed advantage of trucking over rail starts to fade over longer distances.

Flexibility is the main advantage of trucking. While railcars must travel along fixed rail routes, trucks have access to a much wider range of roads and highways.