Four paths to Sustainable Mobility

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1. Introduction

These are paths, not end-points. At any point along our journey a new technology may alter these paths or provide an additional path. In the U.S. with our freedom-of-choice, the different paths will allow us, as a whole, to move forward more quickly without forcing compliance by government edicts. I believe this is a strength in our free-enterprise economy, and allows our future journey to follow the most efficient path for each task.

The paths described below are in progress to various degrees for all forms of mobility.

These paths are:

1. Battery-Electric
2. Green-fuel
3. Grid-tied-Electric
4. Hybrid

In the sections below I will briefly cover each of the above, and reference earlier posts.

2. Battery Electric Vehicles (BEVs)

I have written extensively on these with "EVs…" posts, and other more specialized posts. The reason for this focus is that the growth of these road vehicles have been very rapid, and they are approaching mainstream.

2.1. Road-Going BEVs

The first modern battery-electric cars were the Nissan Leaf (in 2010) and the Tesla Roadster (in 2008). In the intervening 10-15 years the EVs have reached 6% of sales (2022, US), and continue to rapidly gain market share. Where I live (California) BEVs have a 9% market share.

Furthermore the technology supporting BEVs continues to rapidly advance on many fronts, resulting in reduced prices and increased capabilities.

My last "EV…" post. Is described and linked below.

EVs Late-Summer 2023: *This paper covers the following subjects:*

Technology

- *What's next for Batteries?*
- *GM Bets Big on Iron*

Business

- *Tesla:*
  - *Tesla's Native Lands Partnerships*
  - *Why Elon is Glad*

    - *2024 Model 3*
- *LG Energy / Honda Venture*
- *Subaru's New EV Strategy*
- *New Nissan Vehicles*
- *Nikola, Still Struggling and Focused on Hydrogen*

https://energycentral.com/c/ec/evs-late-summer-2023

In the future, I will focus more on BEV Technology. As I've said above, the BEV Business is approaching mainstream for road vehicles. Also, as of late I have posted "EV…" papers about every month and each has approached my maximum length (5,000 words). I will slowly reduce the size and frequency of these over time as road-going BEV technology becomes more mature.

2.2. Marine BEVs

It appears that the leading candidate for marine battery-electric vehicles involve battery-swapping. I wrote about this in section 4 of the post summarized and linked below.

Oceanic Solutions – Ships and Shipping: *Much of the world's goods travel by container ships, the primary subject of this paper. A current challenge is modifying these vessels such that they operate sustainably. This paper will review two potential solutions: a short-term solution, and a limited solution.*

https://energycentral.com/c/ec/oceanic-solutions-%E2%80%93-ships-and-shipping

Note that earlier sections of the above post primary deal with green fuel, the subject of the next section below.

3. Green Fuel

Sustainable (a.k.a. green) fuel has a powerful trick: it can slowly make existing internal combustion vehicles more sustainable through three routes.

Lower net GHG Emissions: This will happen slowly over time as green fuels become less carbon intensive via:

- Decreased carbon emissions in the manufacturing process
- Decreased net GHG content in the fuel by being bio-based rather than petro-based

Higher Prices for Petro-Based Fuels: This will happen via cap-and-trade adders for net GHG emissions, carbon-tax adders or both.

Lower GHG Emissions for Petro-Based Fuels: In the future I believe there will be a range of fuel-types. First of all note that currently almost all gasoline has some plant-based content via ethanol:

The most common use of ethanol as a fuel is as fuel ethanol in mixtures of finished motor gasoline. Most of the gasoline sold in the United States contains some ethanol. The exact amount may vary by region and season of the year. In general, the ethanol content of motor gasoline does not exceed 10% by volume.[1]

[1] EIA, "Ethanol as a transportation fuel," July 2023, https://www.eia.gov/energyexplained/biofuels/ethanol-use.php

In California the ethanol content is 10%.

3.1. Green Aviation Fuel and Green Road Fuel Synergy

Biomass will form an increasing percentage of gasoline in the future through the evolution of the primary processes used to make green fuel as described below.

Thermochemical conversion of biomass includes pyrolysis and gasification. Both processes are thermal decomposition processes wherein biomass feedstock materials are heated in closed, pressurized vessels at high temperatures. The processes mainly differ in the temperatures and in the amount of oxygen present during conversion.[2]

- *Pyrolysis entails heating organic materials to between 800° F and 900° F (400° C and 500° C) in the nearly complete absence of free oxygen. Biomass pyrolysis produces fuels such as charcoal, bio-oil, renewable diesel, methane, and hydrogen.*
- *Hydrotreating is used to process bio-oil (produced by fast pyrolysis) with hydrogen under elevated temperatures and pressures in the presence of a catalyst to produce renewable diesel, renewable gasoline, and renewable jet fuel.*

Note that, in the last bullet, renewable jet fuel (a.k.a. sustainable aviation-fuels) is the only reasonable method of reducing the GHG emitted by our current fleet of large jet transports. The technologies and industrial processes described above for this production will also drive sustainable gasoline forward. Regarding this path for jet transports, see the earlier post summarized and described below.

Future Sustainable Aviation-Fuels & Large Air-Transports: *This post is on the large aircraft and "clean fuels." Some of these fuels are reasonable analogs for existing jet fuels, and thus will not require significant airframe modification, but some (read: hydrogen) will require significant redesigns.*

https://energycentral.com/c/ec/future-sustainable-aviation-fuels-large-air-transports

3.2. Green Fuel for Ocean-Vessels

It is likely that large ocean-vessels will transition to green fuels at some point. However this will likely be green-methanol. See section 3 in "Oceanic Solutions – Ships and Shipping," summarized and linked in subsection 2.2 above.

4. Grid-tied Electric

Most large tracked mass-transit systems are tied through transformers and switchgear to the grid. Thus few or no batteries are required. This is the most efficient method to move passengers, and as our grids approach 100% renewable power (2045 for California), these vehicles will offer the lowest GHG emissions.

[2] .EIA, "Biomass explained," June 2023, https://www.eia.gov/energyexplained/biomass/

5. Hybrids

When one hears “hybrid-electric vehicle” currently, most think of the Prius and all of its descendants. However, as more advanced hybrid technologies emerge, these will evolve as more exotic variants emerge. The subsections below describe some of these.

5.1. Hybrid Tracked Vehicles

Tracked vehicles are very efficient. On level tract segments, at a constant speed they use minimal energy. Downhill or other braking they use regeneration to produce electricity and potentially recharge onboard storage batteries. Currently the preferred technology for near-future short tracked-vehicle routes will use hydrogen fuel cells plus batteries. This will be used for Valley Link, the short commuter-rail system that will run through my Livermore Valley and San Joaquin Valley to the East. This will ultimately connect the Bay Area’s primary commuter rail system, BART to the California High-Speed Rail (HSR). Valley Link is also building a green-hydrogen production facility in Tracy (in San Joaquin Valley, just over the Altamont Pass from Livermore). Note that both BART and HSR use / will use grid-tied electric trains.

5.2. Fuel-Cell Plug-in Road Hybrids

Current fuel-cell electric road vehicles (FCEVs) also use batteries (see next subsection). Fuel-cell electric generators are most efficient at a constant load. Batteries buffer these generators and allow them to be operated at close to a constant load.

However, for this category we will propose a hybrid with a much larger battery, and also allow it to be plugged in to recharge. A large majority of personally-owned BEVs are driven less than 100 miles per day, on average. Adding a small fuel-cell generation system to a BEV with an 80 to 100 mile battery-powered range would potentially allow:

- Trips of well over 100 miles
- Daily ranges of 200 to 300 miles without recharging
- Travel to areas without charging access

It should be pointed out that powering any vehicle with a hydrogen fuel cell will require much wider availability of hydrogen refueling than currently exists. I believe this will happen over time, but it may be around 2030 (in California) before it does.

The fuel-cell Honda CRV next year described below will be the first step to the vehicles described in this section.

5.3. Fuel-Cell Electric Vehicles

There are currently fuel-cell electric vehicles on the road, mainly the Honda Clarity and the Toyota Mirai, and mainly in California. As pointed out in the previous section, these are really hybrids. Also Honda stopped making the Clarity in 2021, but are planning plug-in fuel-cell electric vehicle (a new version of the CRV small SUV) for next year. Go through the link below for details.

https://www.caranddriver.com/news/a42796089/2024-honda-cr-v-powered-by-hydrogen-details/

Other upcoming fuel-cell electric models that seem to be likely include the 2025 Hyundai Nexo and Hyundai Staria Fuel Cell. See the article linked below for more information on these.

https://topelectricsuv.com/featured/upcoming-hydrogen-fcev-cars/