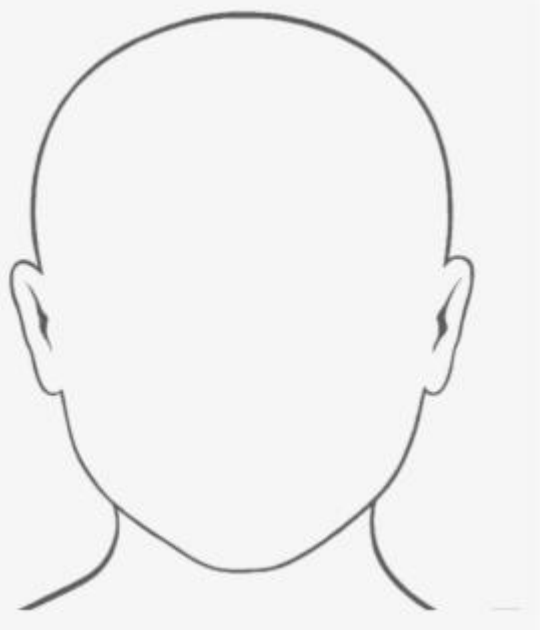




The Future of Internal Combustion Engines (ICE)

Efren Sabastian

Wales Institute for Science & Art
BEng Motorsport Engineering

Introduction

ICEs power over 1.4 billion vehicles globally (IEA, 2023), but face existential threats from electrification and emission regulations (e.g., EU 2035 ICE ban).

Why ICE still matters:

- ICE vehicles dominate global fleets; transition to EVs will take decades, especially in developing nations.
- Hard to electrify sectors such as aviation, shipping and heavy machinery rely on ICEs due to energy density needs.
- Synthetic fuels and hydrogen combustion could decarbonize ICEs without scrapping existing assets.

Key Innovations

Synthetic E-fuels (Porsche, Audi)

- Carbon neutral fuels made from renewable energy + captured CO₂.
- Works in existing engines, no modifications needed.

Hydrogen Combustion (Toyota, Yamaha)

- Burns hydrogen instead of gasoline, only emits water vapour.
- Toyota racing 300hp hydrogen engine in GR Corolla.

Ultra-Efficient HCCI Engines (Mazda)

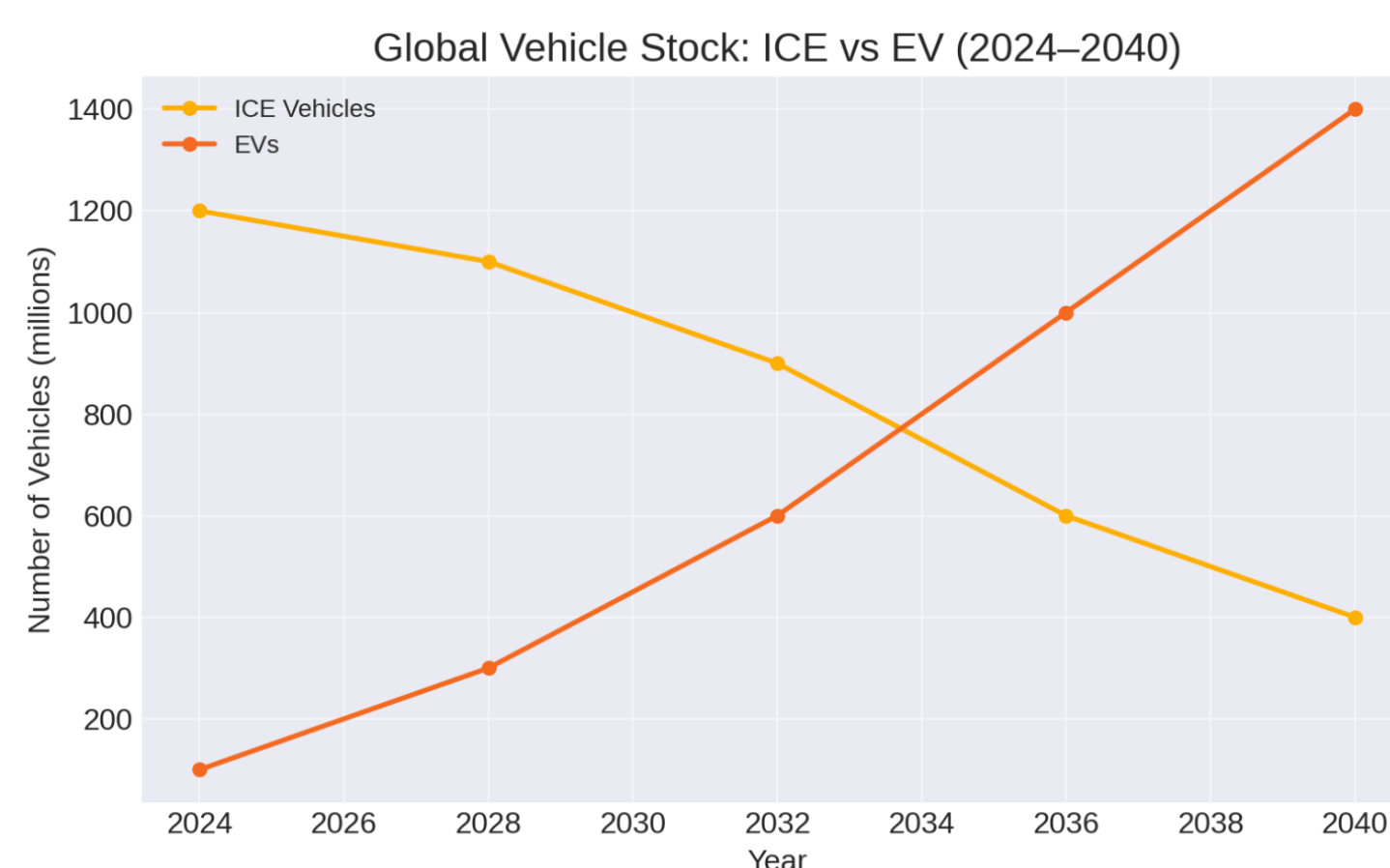
- Combines gasoline and diesel tech for 30% better efficiency.
- Mazda's Skyactiv-X already achieves 16:1 compression ratio

Plasma Ignition Systems (NASA)

- Uses plasma to ignite lean fuel mixtures.
- Reduces fuel use by 10-15% in tests.

The ICE Evolution 2024- 2040

Although the rise of electric vehicles is increasing at a steady rate, innovations in ICE tech are evolving in parallel. From synthetic fuels to plasma ignition, the ICE continues to adapt.



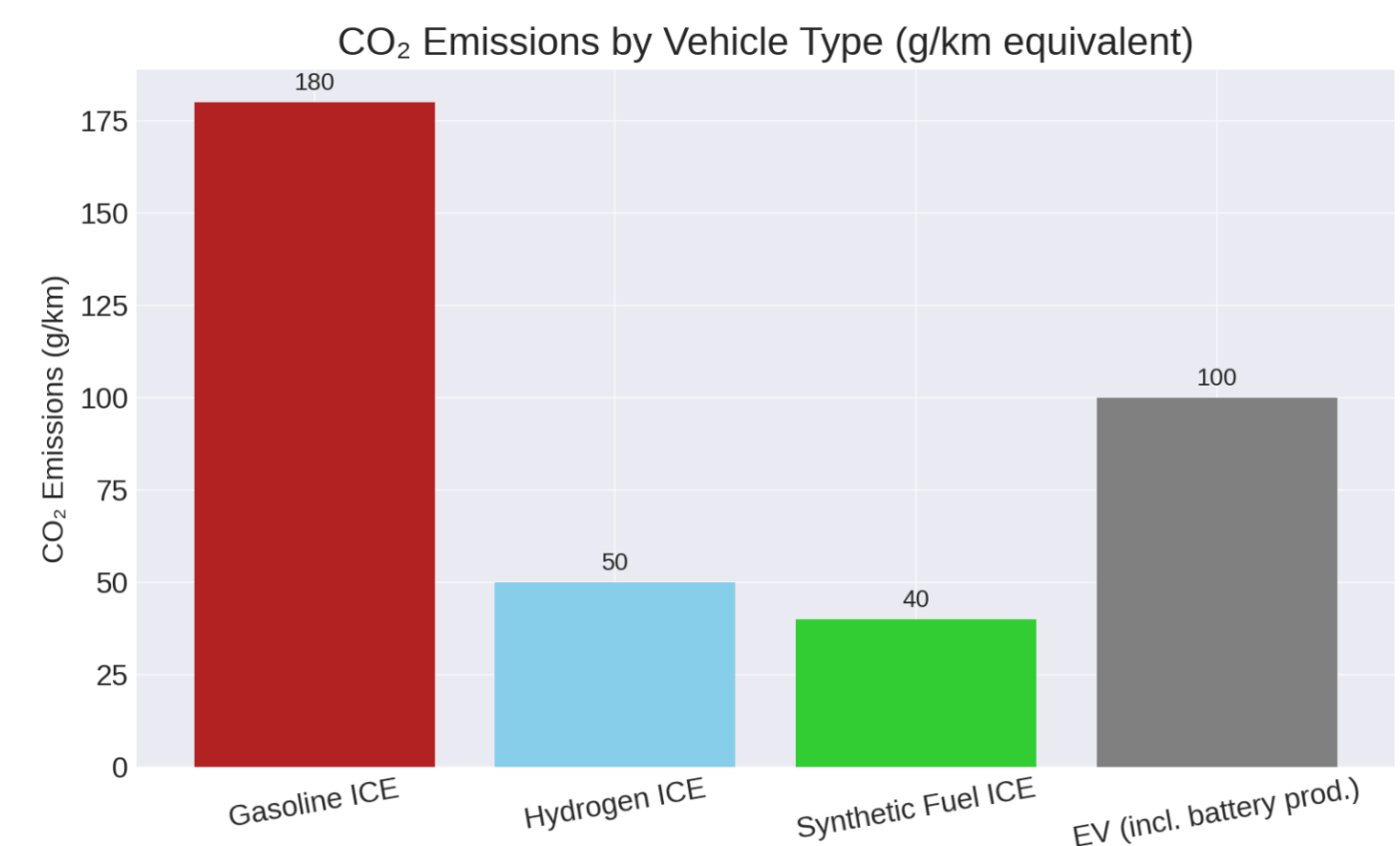
Projected Vehicle stock shows ICE dominance declining by 2040, with EVs surpassing because of policy shifts and technology improvements. However, ICEs will still dominate in developing nations and non-road sectors.

Porsche's eFuel Pilot Plant

In 2022, Porsche began producing synthetic efuel at its Haru Oni plant in Chile, using water, wind energy and captured CO₂. The resulting methanol-based fuel can power traditional ICE engines vehicles with up to 90% fewer CO₂ emissions, requiring no engine modifications.



Decarbonizing the ICE



This bar graphs compares the CO₂ emissions (in grams per kilometre) of different vehicle powertrains, including traditional and low-carbon internal combustion engines (ICEs) and electric vehicles (EVs)

Key insights:

Gasoline ICEs emit the most at 180g/km, highlighting the need for cleaner alternatives

Hydrogren ICEs cut emissions to 50g/km, as they mainly emit water vapour.

Sythhetic Fuel ICEs go even further, emitting just 40g/km, thanks to carbon neutral fuel production

Evs, while zero emissions they still contribute around 100g/km when including battery manufacturing and electricity generation.

Low carbon ICE technology like hydrogen and synthetic fuels can outperform EVs in lifecycle emissions, especially in sectors where electrification is impractical

References

- International Energy Agency (IEA), 2023. Global EV Outlook 2023. [online]Available at: <https://www.iea.org/reports/global-ev-outlook-2023> [Accessed 24 Apr. 2025].
- Porsche AG, 2022. Porsche begins production of synthetic fuel in Chile. [online] Newsroom Porsche. Available at: <https://newsroom.porsche.com/en/2022/company/porsche-efuel-production-chile-26464.html> [Accessed 24 Apr. 2025].
- Toyota Europe, 2022. Toyota develops hydrogen-powered GR Yaris. [online] Available at: <https://newsroom.toyota.eu/toyota-develops-hydrogen-powered-gr-yaris/> [Accessed 24 Apr. 2025].
- Mazda, 2019. Skyactiv-X: Innovative combustion engine technology. [online] Available at: <https://www.mazda.com/en/innovation/technology/skyactiv/skyactiv-x/> [Accessed 24 Apr. 2025].
- NASA, 1983. Plasma Ignition System Research. [online] NASA Technical Reports. Available at: <https://ntrs.nasa.gov/> [Accessed 24 Apr. 2025]