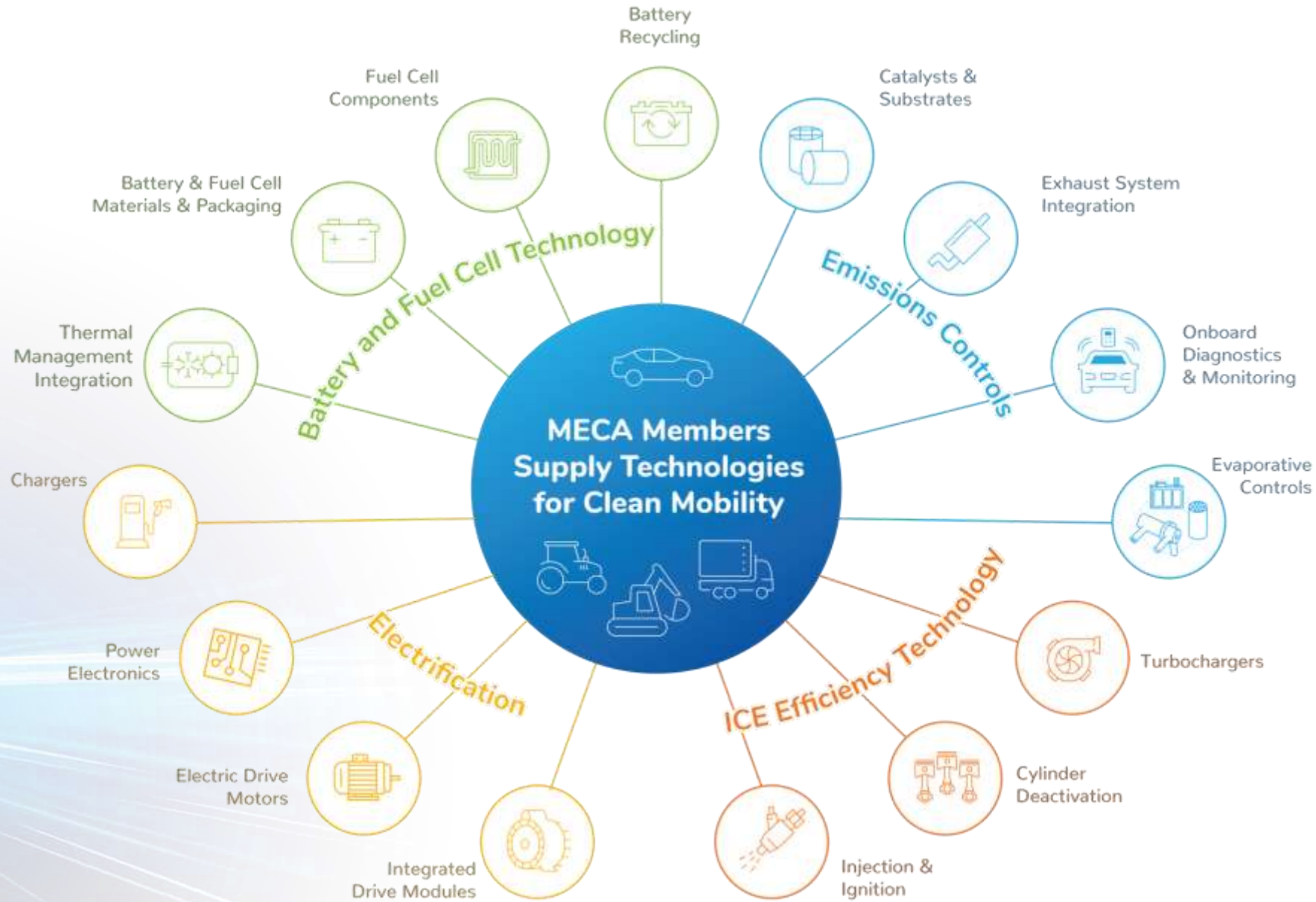


Multiple Technology Pathways Provide the Most Resilient Approach Toward Meeting Air Quality and Emission Goals

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ECT 2026: Alternate Fuels and Aftertreatment Systems
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Our members supply technology for every pathway



Air quality and climate goals should be fixed. The path to meet them should not.

Markets shift

The “end of the combustion engine” has been forecast for over a decade

Policies swing

Rules built around one technology are exposed when politics or markets change

Energy differs by region

Grid and fuel carbon intensity decide which option is cleanest locally



Technology-neutral standards proved most durable

2024

EPA finalizes light/medium-duty and heavy-duty Phase 3 GHG rules; light-duty compliance modeled on 68% BEV sales by 2032

2025

Congress revokes California's waivers for its zero-emission car and truck sales mandates; EPA reopens recent rules

2026

EPA rescinds the GHG endangerment finding and repeals all federal vehicle and engine GHG standards

Still standing: criteria pollutant standards, including MY2027 heavy-duty NOx and the 0.5 mg/mile light-duty PM limit – met by engines and aftertreatment, whatever the EV share

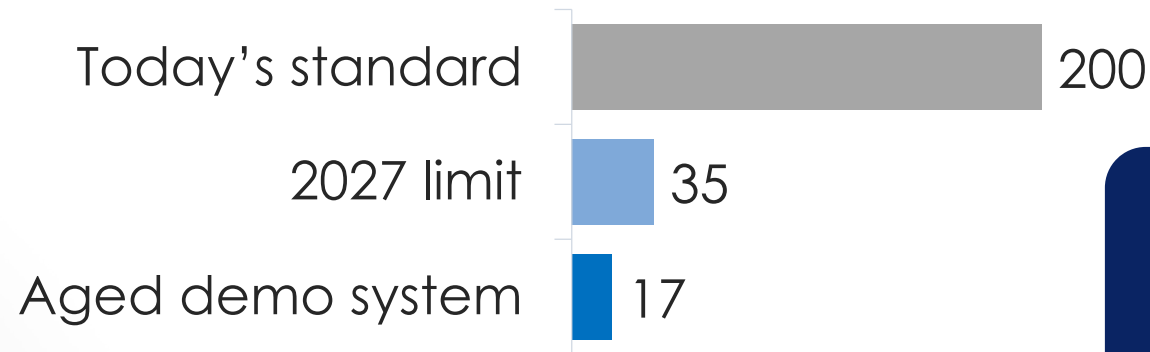
Sources: U.S. EPA final rules (2024, Feb 2026); Congressional Review Act resolutions (2025)

Low-NOx systems deliver near-zero emissions



Light-off SCR + DOC/DPF
+ dual SCR, dual dosing;
cylinder deactivation

Composite FTP NOx after 650,000 miles (mg/hp-hr)



>10× below today's standard
on the FTP

Up to 100× lower than today's
trucks at low load (LLC: 15 vs.
50 limit)

VERSUS EURO 7

WHTC NOx, system aged 700,000
km (mg/kWh)

55

cold

12

hot

Euro 7 limit: **200**

Hybrids and catalysts reach ultra-low emissions

212

MY2026 models certified at ≤ 15 mg/mile NMOG+NO_x – the 2032 U.S. fleet average

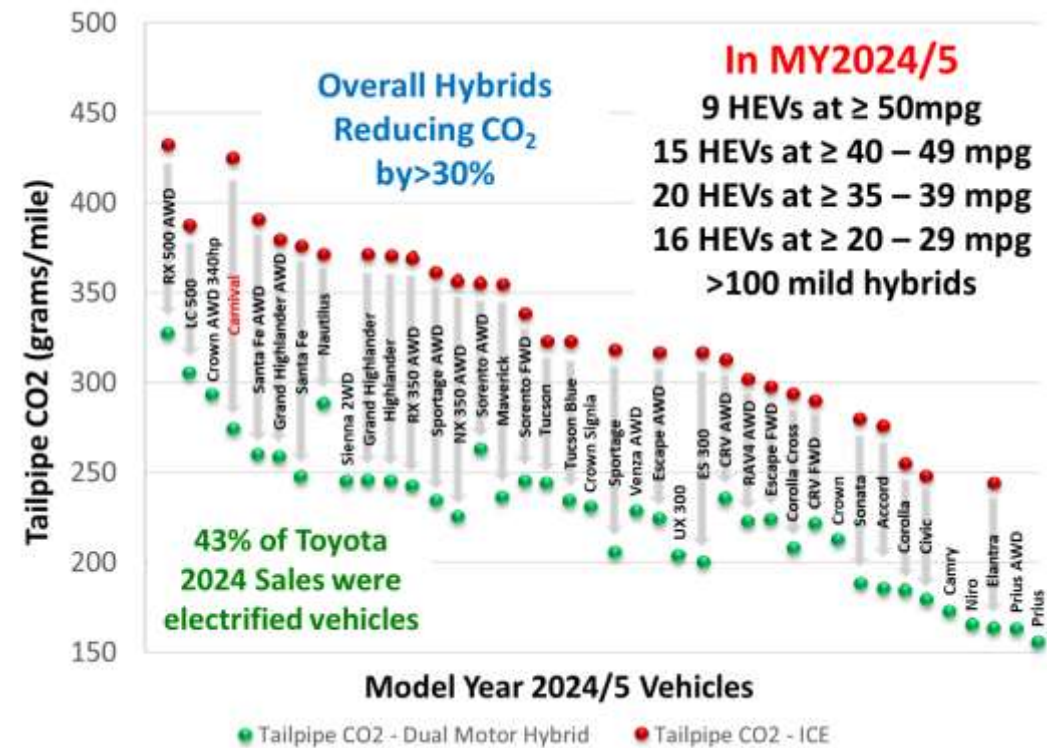
83

models certified at ≤ 10 mg/mile NMOG+NO_x

80+

U.S. models with gasoline particulate filters (8 OEMs) for the 0.5 mg/mile PM limit

Cold start is the target: 70–80% of remaining NMOG+NO_x occurs in the first 20–30 seconds. Hybrids can employ additional catalyst heating strategies; electric heaters use just 0.01–0.05 kWh per start.



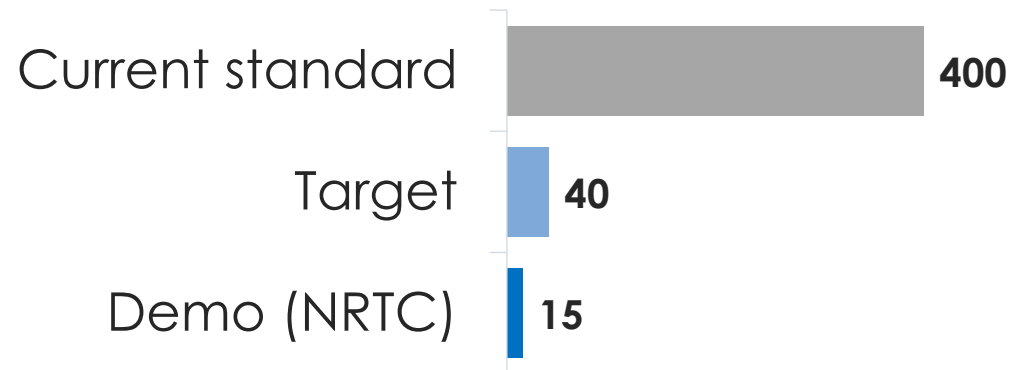
Hybrid versions cut tailpipe CO₂ by ~30% vs. their conventional siblings (MY2024/25)

Source: U.S. EPA and CARB certification data

Proven controls transfer to equipment and gensets

Nonroad Tier 5 demonstration

6.8 L Tier 4 Final engine, NO_x in mg/kWh



Plus **6% lower CO₂** on the NRTC with cylinder deactivation

SCR on a large generator

Cummins QSK78 (3,500 hp) diesel genset

94.6%

NO_x reduction

98%

PM reduction

96%

CO reduction

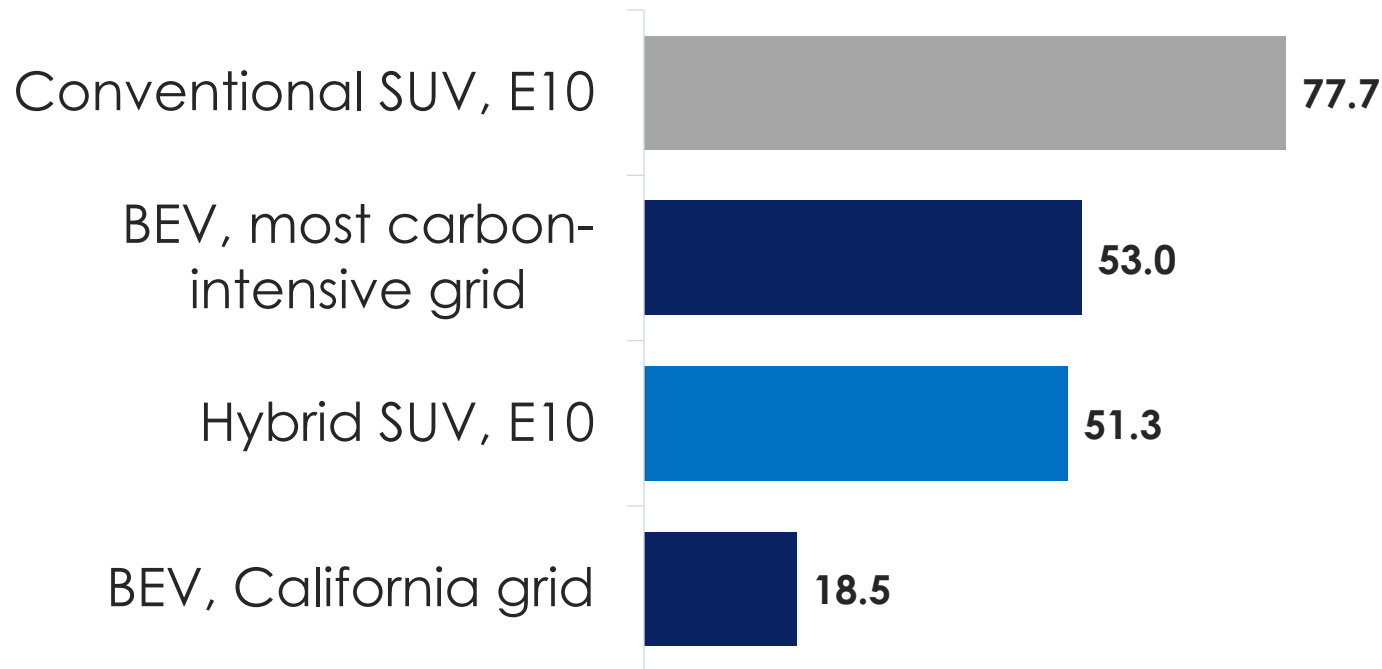
92%

VOC reduction

Relevant as data centers add banks of diesel and natural gas back-up generators

The energy source decides the climate result

Lifecycle CO₂ (tons), family SUV, 2030, 150,000 miles:
vehicle production + fuel/electricity + tailpipe



What the tailpipe misses

In parts of the U.S., a hybrid on E10 is competitive with a BEV charged from the local grid

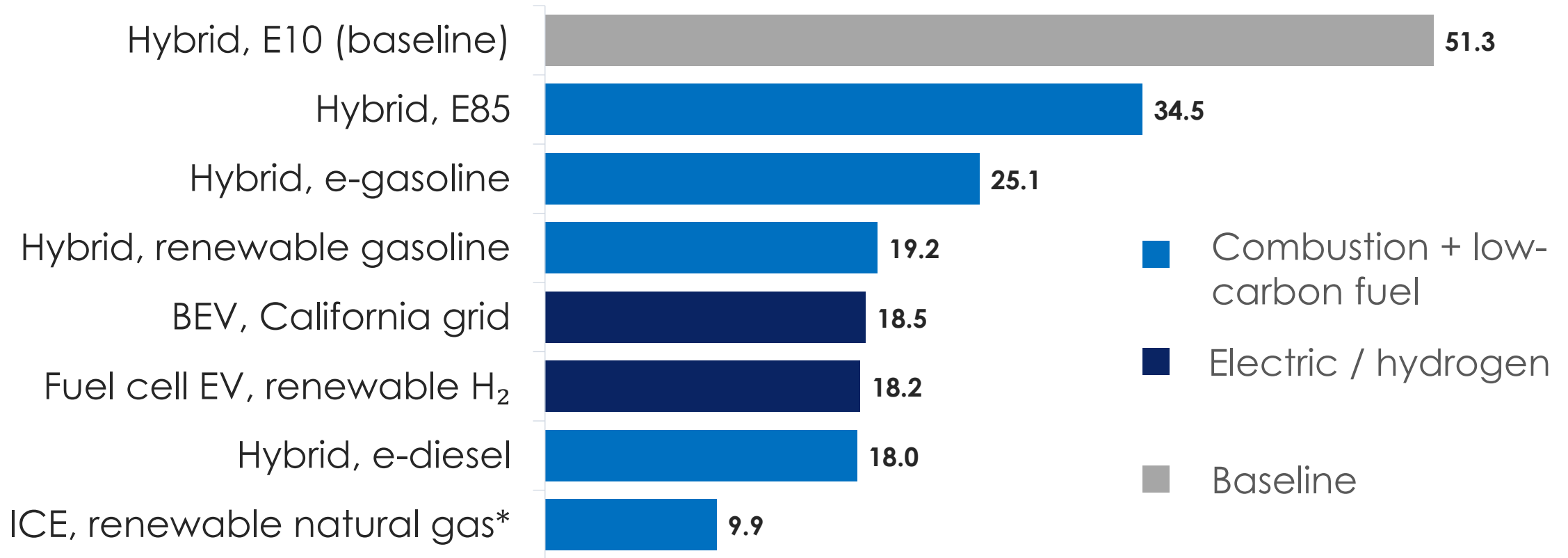
Building a 300-mile BEV emits ~14 tons CO₂ vs. ~8 tons for a conventional SUV – more as batteries grow

Vehicle rules count only the tailpipe; fuels are regulated separately

Source: MECA lifecycle analysis using Argonne GREET 2020, 2030 U.S. regional electricity mixes

Low-carbon fuels complement electric and H₂ options

Lifecycle CO₂ (tons), family SUV, 2030, 150,000 miles



MECA LCA, GREET 2020. *RNG pathway for one U.S. region; e-fuels made with renewable power

Efficiency and hybrids cut truck CO₂ affordably

Technology	Added cost	CO ₂ reduction
Advanced engine technology	< \$1,000	5%
48V mild hybrid	< \$5,000	5–10%
Full hybrid (>200 V)	\$15–30k	10% line-haul 25% vocational
Plug-in hybrid	\$25–50k	20% line-haul 50% vocational

Full hybrids reuse mature medium-duty EV motors, inverters and batteries

Electric driving in cities without waiting for charging networks

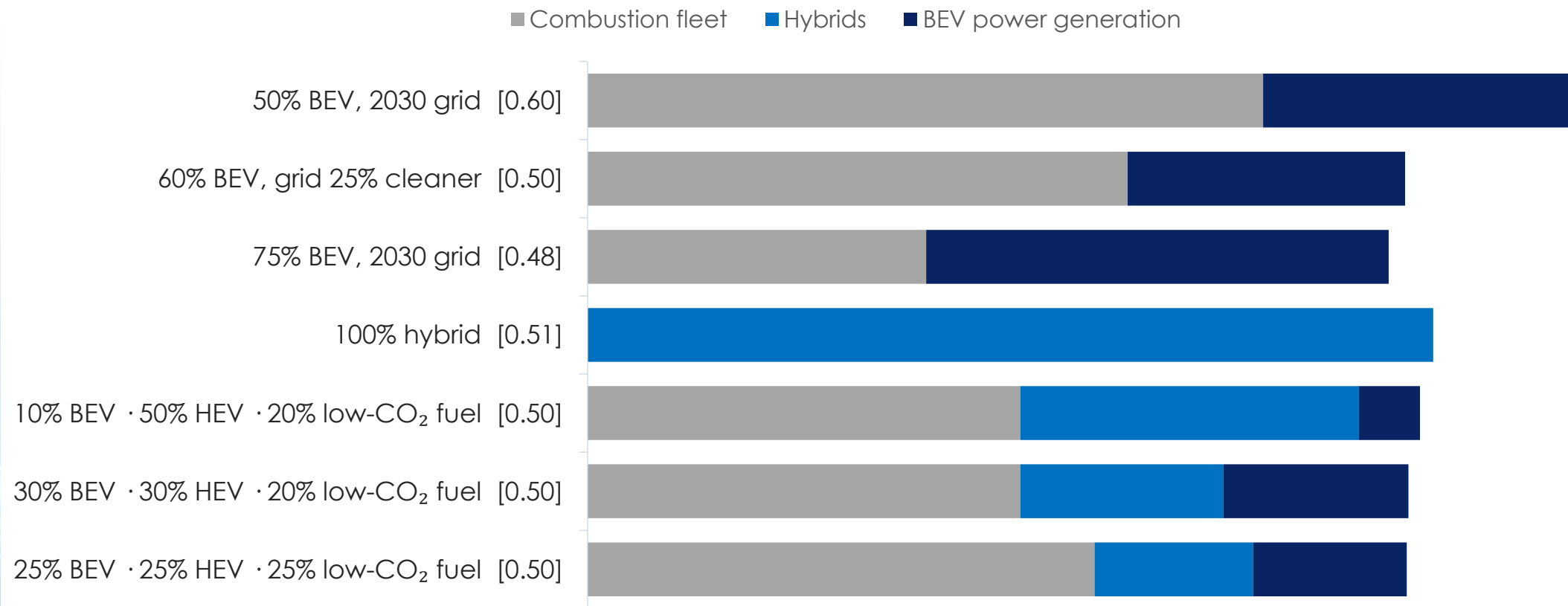
Stack with renewable diesel or RNG for deeper cuts

All at 2027 U.S. NOx levels



A technology mix hits the target with less risk

U.S. passenger car GHG in 2030, share of 2005 level (total in brackets).
Top four: one dominant technology; bottom three: a mix



Source: MECA fleet GHG analysis; 2018 fleet $\approx$ 0.90 of 2005 level

Pair the move to ethanol with evaporative controls

Standard	Evaporative limit	Refueling (ORVR)
India BS6	2.0 g/day (1-day)	None
India BS6 Phase 3	~0.88 g/day (2-day)	None
Euro 7	~0.63 g/day (2-day)	None
China 6b	0.70 g/day (2-day)	0.05 g/L
Brazil PL7	0.50 g/day (2-day)	0.05 g/L
U.S. Tier 3	0.30 g/day (2- & 3-day)	~0.05 g/L

70 kPa

vapor pressure allowed for E20, vs. 60–65 kPa certification fuel

15×

modeled in-use evaporative emissions vs. the certification limit, Delhi 2022 summer conditions

>65%

of new car sales are petrol

Euro 7 g/day approximated from 1.5 g/test; modeled Delhi evaporative emissions, April–July 2022

Four principles for resilient standards

1 Set performance limits, not technology mandates

Let every powertrain and fuel compete to meet the same limit

2 Test the real world

Low-load and cold-start cycles, in-use compliance, multi-day evaporative tests

3 Treat fuel and vehicle as one system

Credit low-carbon fuels and upstream energy through lifecycle methods

4 Keep rules stable

Suppliers invest years ahead; sudden reversals strand that investment

Many pathways, one destination

- 1** Advanced aftertreatment delivers **near-zero tailpipe criteria emissions** on every combustion pathway – trucks, cars, equipment and generators
- 2** On a lifecycle basis, **low-carbon fuels and hybrids** rival battery-electric and fuel cell vehicles in many settings
- 3** A **mix of technologies** reaches the same fleet target as single-technology scenarios, with no single point of failure
- 4** **Technology-neutral, stable, real-world standards**, paired with fuel policy, are the most resilient path – and BS7 is the moment to apply them

THANK YOU.

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