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Fuel efficiency standards to decarbonize Australia's light-duty vehicles

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Introduction

Only a few major vehicle markets lack an established regulation or compliance requirements for light-duty vehicle (LDV) CO_2 emissions or fuel efficiency, and Australia is one.[1] Such regulations are among the key policies that drive reductions in greenhouse gas (GHG) emissions from internal combustion engine vehicles (ICEVs) and promote electric vehicle (EV) uptake, both of which help combat climate change.[2]

Australia has set an economywide net-zero carbon emissions target for 2050.[3] Transport is currently the third largest source of emissions in the country, after electricity generation and stationary energy sources, and it is responsible for nearly a quarter of total GHG emissions.[4] LDVs are passenger cars (PCs) and light commercial vehicles (LCVs), and these account for nearly two-thirds of Australia's total transport emissions and 12% of the country's total GHG emissions.[5]

Since 2017, all LDVs introduced in the Australian market have been imported, and the majority of these vehicles are new.[6] The major sources of vehicle imports to Australia

1 "Passenger Vehicle Fuel Economy," International Council on Clean Transportation, accessed on December 5,2022, https://theicct.org/pv-fuel-economy/.

2 Dale Hall, et al., *Decarbonizing Road Transport by 2050: Effective Policies to Accelerate the Transition to Zero-emission Vehicles*, (ICCT: Washington, DC, 2021), https://theicct.org/publication/zevtc-effective-policies-dec2021/

3 Australian Government Department of Industry, Science, Energy and Resources, *Australia's Long-term Emissions Reduction plan*, 2021, https://unfccc.int/sites/default/files/resource/Australias_LTS_WEB.pdf

4 Stationary energy sources involve burning fuels other than for electricity generation and transport, such as to power mining, manufacturing, buildings, agriculture, forestry and fishing, and the military; and Australian Government Department of Industry, Science, Energy and Resources, *Australia's Emissions Projections 2021*, October 2021, https://www.dcceew.gov.au/sites/default/files/documents/australias_emissions_projections_2021_0.pdf

5 ibid.; and Australian Government Department of Infrastructure, Transport, Regional Development, Communications and the Arts, *Fuel Efficiency Standards*, accessed on December 5, 2022, https://www.infrastructure.gov.au/infrastructure-transport-vehicles/vehicles/fuel-efficiency-standards

6 "Representing the Australian Automotive Industry," Federal Chamber of Automotive Industries, accessed on December 5, 2022, https://www.fcai.com.au/about

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are Japan, Thailand, South Korea, the European Union, and China.[7] As shown in Figure 1, LDVs in Australia are generally higher emitting than in other major markets that have fuel efficiency or CO_2 standards in place. For example, Australia's fleet-average CO_2 emissions for new vehicles in 2020 in grams per kilometer on the New European Driving Cycle (NEDC) were higher than EU emissions by 46% for PCs and by 37% for LCVs, and compared to the United States, 31% higher for PCs and 24% higher for LCVs.[8]

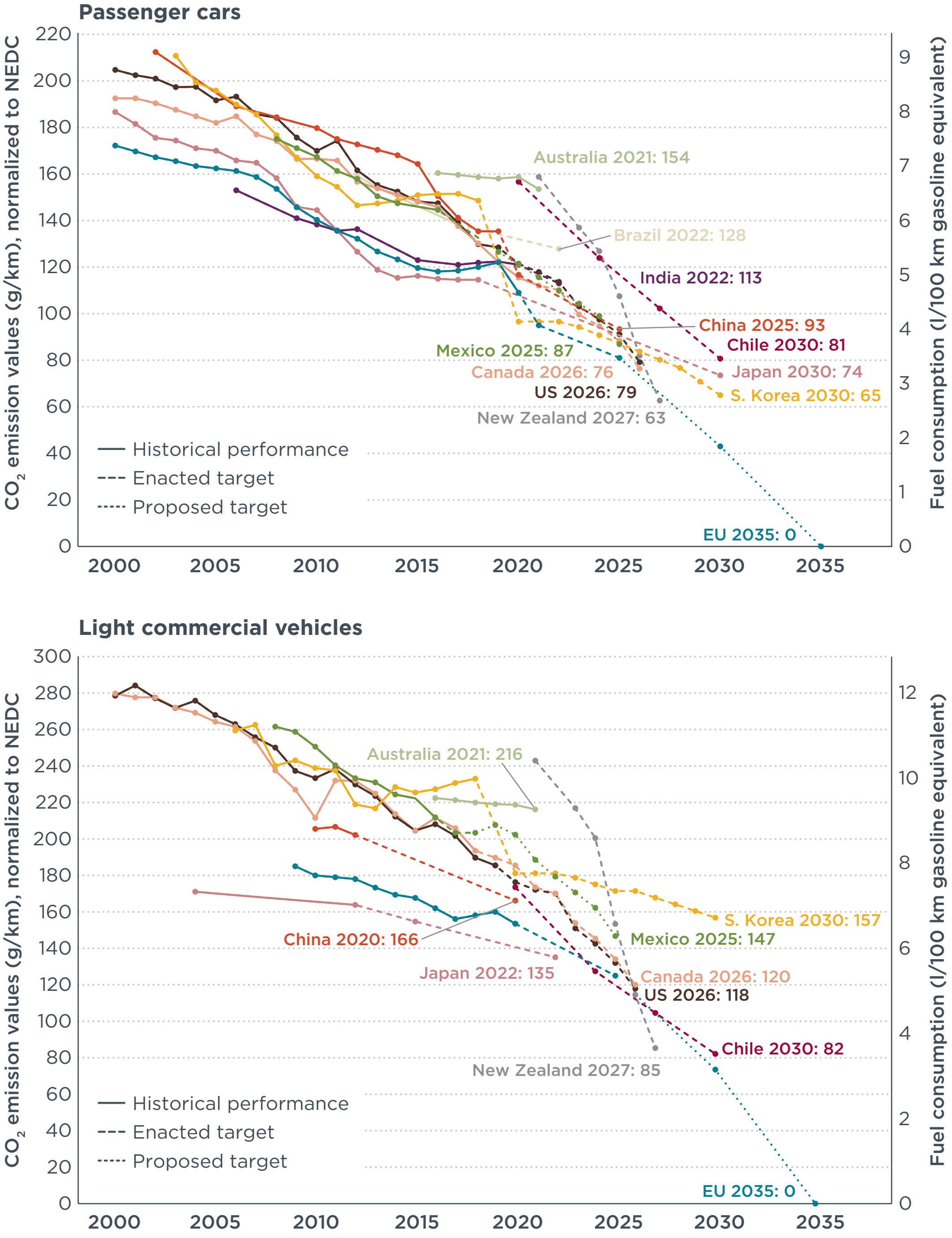

Figure 1. Historical trends and CO_2 emission standards, normalized to NEDC, for passenger cars and light commercial vehicles for Australia and other regions.

7 "Cars in Australia," OEC, accessed on December 5, 2022, https://oec.world/en/profile/bilateral-product/cars/reporter/aus#:~:text=Australia%20imports%20Cars%20primarily%20from,and%20Finland%20(%2499.4M)

8 National Transport Commission, *Carbon Dioxide Emissions Intensity for New Australian Light Vehicles 2020*, (Melbourne, Victoria, 2021), https://cdn-nrspp-s3-aus.s3.ap-southeast-2.amazonaws.com/wp-content/uploads/sites/4/2021/11/30061913/Carbon-dioxide-emissions-intensity-for-new-Australian-light-vehicles-2020.pdf; and Sonsoles Diaz, ed. *European Vehicle Market Statistics Pocketbook 2021-22*. (ICCT: Berlin, Germany, 2021), https://eupocketbook.org/.

Australia's EV market has grown over the past 2 years. There are state government incentives in place and signs of market development such as increased model availability and lower prices.[9] However, EV uptake in Australia is still significantly behind leading countries. In 2021, the EV share of new LDV sales in Australia was only 2%; that is much lower than the EU average of 17% and the global average for major vehicle markets of 9%.

In the second half of 2022, the Australian government started a public consultation seeking input related to introducing mandatory national vehicle fuel efficiency standards.[10] This is intended to incentivize the supply and purchase of EVs and to contribute to the achievement of Australia's climate targets. To help understand the impact of different policies on the future CO_2 emissions from the on-road LDV fleet, we constructed and modeled four scenarios: a business-as-usual scenario without any standards; a scenario corresponding to existing voluntary CO_2 emission targets; a scenario corresponding to existing state-level EV targets; and a scenario that reflects world-class ambitions. After presenting the results, this paper ends with policy recommendations.

Policy background

Australia elected a new prime minister in mid-2022 and the new administration promptly took action to accelerate GHG emissions reduction, including by setting a new target of 43% economywide CO_2 emissions reduction below the 2005 level by 2030.[11] This target is more stringent than the earlier 26%–28% one.[12] The federal government is also emphasizing transport decarbonization by developing a national EV strategy and considering fuel efficiency standards for the LDV fleet.[13] Australia is investing significant amounts not only to support EV uptake by offering EV incentives, but also to generate renewable energy, upgrade its electricity grid, and develop EV charging infrastructure.[14] Additionally, some state governments have individual economywide net-zero targets for 2050 that match the national ambition, and some have a target date that is sooner than 2050.[15] For example, the Australian Capital Territory has a 2045 net-zero target and Tasmania has a net-zero target for 2030, due to its ability to generate 100% of its electricity from renewable energy sources including hydropower and wind.

There is already a fuel consumption labeling requirement for new LDVs sold in Australia.[16] It is known as Australian Design Rule (ADR) 81/02 and it requires that fuel consumption and CO_2 emissions be determined according to the NEDC test cycle. However, data have established that the NEDC cycle does not represent real-world driving conditions closely, and when using it, the divergence between type-approval and real-world emissions grows over time. The average gap between NEDC type-approval and real-world CO_2

9 Electric Vehicle Council, *State of Electric Vehicles*, March 2022, https://electricvehiclecouncil.com.au/wp-content/uploads/2022/03/EVC-State-of-EVs-2022.pdf

10 See Minister for Climate Change and Energy Chris Bowen's speech at an electric vehicle summit in Canberra, https://www.cnbc.com/2022/08/19/australia-plans-fuel-efficiency-standards-to-boost-electric-car-supply.html; and Australian Government Department of Industry, Science and Resources, *National Electric Vehicle Strategy: Consultation Paper*, September 2022, https://app.converlens.com/industry/national-electric-vehicle-strategy. In its recent consultation on national EV strategy, Australia defined fuel efficiency standards as measured in grams of CO_2 released per kilometer. Hence, we refer to the fuel efficiency standard as a CO_2 emission standard in the rest of this paper.

11 "Australia," Climate Action Tracker, accessed on December 5, 2022, https://climateactiontracker.org/countries/australia/

12 Australian Government, *The Plan to Deliver Net Zero the Australian Way*, 2021, https://apo.org.au/sites/default/files/resource-files/2021-10/apo-nid314748.pdf

13 Australian Government Department of Industry, Science and Resources, *National Electric Vehicle Strategy: Consultation Paper*.

14 "Powering Australia," Australian Government Department of Climate Change, Energy, the Environment and Water,, accessed on December 5, 2022, https://www.energy.gov.au/government-priorities/australias-energy-strategies-and-frameworks/powering-australia; Jordan Mulach, "What Does a New Labor Government Mean for EVs?, *WhichCar?*, May 23, 2022, https://www.whichcar.com.au/news/what-does-a-new-labor-government-mean-for-evs

15 Electric Vehicle Council, *State of Electric Vehicles*.

16 Vehicle Standard (Australian Design Rule 81/02 – Fuel Consumption Labeling for Light Vehicles) 2008, Australian Government. Federal Register of Legislation, https://www.legislation.gov.au/Details/F2022C00213/Html/Volume_1

emissions was reported to have increased from 6% in 2001 to 39% in 2018 for PCs in the European Union.[17] The European Union subsequently adopted a state-of-the-art test, the Worldwide Harmonized Light Vehicles Test Procedure (WLTP). Compared to the NEDC, WLTP type-approval CO_2 emissions are 21% higher, on average, and leave a much smaller gap with real-world emissions, estimated to be 14% in 2018. In 2021, the European Commission also started using real-world data from onboard fuel and energy consumption monitoring (OBFCM) devices to monitor performance and develop mechanisms to counteract any future widening of the gap between official fuel consumption values and real-world driving.

In 2020, Australia's Federal Chamber of Automotive Industries (FCAI) published voluntary CO_2 emissions targets for new LDVs.[18] FCAI is the representative organization for companies that distribute LDVs in Australia.[19] As Table 1 shows, the voluntary CO_2 emissions targets are specified for new LDVs from 2020 through 2030 for two types: MA (PCs and light SUVs) and MC+NA (heavier SUVs and LCVs).[20] Although such segmentation might encourage vehicle importers to classify vehicles as MC+NA to qualify for the less-stringent targets, we do not focus on standard design in this analysis and used the combined target in the far right column of Table 1 to reflect the FCAI targets. We weighted the FCAI CO_2 emissions targets using the 2020 sales share for the two vehicle types, 66% for MA and 34% for MC+NA, to estimate the combined fleet-average targets for new LDVs.[21] The CO_2 emissions of each vehicle were determined according to ADR 81/02.

Table 1. FCAI fleet-average CO_2 emissions targets (g/km) on the New European Driving Cycle

Year	Passenger cars + light SUVs (MA)	Heavy SUVs + light commercial vehicles (MC+NA)	Combined target for MA and MC+NA*
2020	154	197	169
2021	150	193	165
2022	146	189	161
2023	140	183	155
2024	134	177	149
2025	128	172	143
2026	122	166	137
2027	116	160	131
2028	110	154	125
2029	104	149	119
2030	98	143	113

* Combined targets were estimated based on the weighted average of their 2020 sales shares including all power trains, 66% MA and 34% MC+NA.

17 Jan Dornoff et al., *On the Way to "Real-World" CO_2 Values: The European Passenger Car Market in its First Year After Introducing the WLTP*, (ICCT: Berlin, Germany, 2021) https://theicct.org/publication/on-the-way-to-real-world-co2-values-the-european-passenger-car-market-in-its-first-year-after-introducing-the-wltp/; Jelica Pavlovic et al., "How Much Difference in Type-approval CO2 Emissions from Passenger Cars in Europe Can be Expected from Changing to the New Test Procedure (NEDC vs. WLTP)?," *Transportation Research Part A* 111, (May 2018): 136–147, https://doi.org/10.1016/j.tra.2018.02.002

18 Federal Chamber of Automotive Industries, *CO_2 Standard: Rules for Calculating Brand Targets and Assessing Brand Compliance*, (Kingston, ACT, March 12, 2020), https://www.fcai.com.au/library/publication/fcai_rules_for_calculating_co2_compliance.pdf

19 "About the FCAI," Federal Chamber of Automotive Industries, https://www.fcai.com.au/about.

20 FCAI defines vehicle classes based on their body type, footprint, and other features such as number of seats and gross weights for LCVs. The light and heavier SUVs are determined based on footprint, defined as a product of vehicle length and width in meters. The FCAI definition for SUVs includes five segments based on footprint: light (≤ 7.6 m2), small (7.601–8.1 m2), medium (8.101-8.8 m2), large (8.801-9.8 m2), and upper large (≥ 9.801 m2).

21 National Transport Commission, *Carbon Dioxide Emissions Intensity for New Australian Light Vehicles 2020.*

Compliance with the FCAI voluntary targets is determined via a weight-based approach and a variety of flexibilities are allowed for each vehicle type, including off-cycle credits, super credits, and air-conditioning credits; there is also the ability to carry compliance credits and debits forward and to transfer credits across vehicle types and among auto companies.[22] Off-cycle credits include credits for any low-emitting or fuel-efficient technology not covered on the test cycle. The FCAI includes all EU and U.S. off-cycle credits and, following the European Union and the United States, allows a maximum of 7 g/km per unit of off-cycle credits for each auto company. Super credits are given for sales of low-emitting and zero-emission vehicles and vary by vehicle emission level relative to their individual compliance target level. Low-emitting vehicles are counted as two vehicles if CO_2 emissions are within one-third of the compliance target level and as one and a half vehicles when they emit more than one-third but less than two-thirds of the compliance target level. All vehicles with 0 g/km emissions are counted as three vehicles.

Since FCAI's is a voluntary process, there is no mechanism to assess compliance and there are no penalties for noncompliance. No government agency collects, tracks, or discloses the performance of auto companies or their use of any of the compliance flexibilities. The FCAI has called for the government to make these voluntary targets and the compliance methods the mandatory standard for Australia's LDV fleet.[23]

Meanwhile, in terms of setting goals for EV uptake, state governments in Australia have generally been more active than the federal government.[24] Table 2 shows the major EV sales targets in Australian states, listed in descending order of their share of the national market for all LDVs in 2021. Five out of eight Australian states, together accounting for 87% of LDV sales in 2021, aim to have 100% EV sales by 2035–2036. A few of them also have interim targets of around 50% EV sales by 2030. The other three states do not have EV sales targets but have targets for their government fleets.

22 Federal Chamber of Automotive Industries, *CO_2 Standard: Rules for Calculating Brand Targets and Assessing Brand Compliance*, (Kingston, ACT, March 12, 2020), https://www.fcai.com.au/library/publication/fcai_rules_for_calculating_co2_compliance.pdf

23 Jordan Mulach, "New Vehicle Emissions Drop as Peak Bodies Call for Government Mandates," *WhichCar?*, March 29, 2022, https://www.whichcar.com.au/news/new-vehicle-emissions-2021

24 Electric Vehicle Council, *State of Electric Vehicles*; Kathryn Fisk, "Australia's EV Policies: What's Happening in Each State and Territory in 2021 – Updated," *WhichCar?*, August 9, 2021, https://www.whichcar.com.au/news/australian-states-territories-ev-policies-september-2021

Table 2. Summary of state-level EV sales targets.

State	National market share[a]	EV sales target		Source	
		2030	2035	2030	2035
New South Wales	31%	~50%[b]	100%	NSW EV strategy[c]	COP26 signatory[d]
Victoria	26%	50%	100%	Victoria's zero-emissions vehicle roadmap[e]	
Queensland	22%	50%	~100%[f]	Queensland's new zero-emission vehicle strategy[g]	
South Australia	7%	—	100%		COP26 signatory
Australian Capital Territory	1%	—	100%		COP26 signatory
Northern Territory, Tasmania, Western Australia[h]	13%	No target			
National average		~45%[i]	~86%[i]		

[a] Estimated based on 2021 sales data by state. *Source*: Mike Costello, "VFACTS: Australia's 2021 New Car Sales Detailed in Full," *CarExpert*, January 6, 2022, https://www.carexpert.com.au/car-news/vfacts-australias-2021-new-car-sales-detailed-in-full

[b] 52% by 2030–2031

[c] New South Wales Government. *NSW Electric Vehicle Strategy*, June 2021, https://www.energy.nsw.gov.au/sites/default/files/2022-09/nsw-electric-vehicle-strategy-210225.pdf

[d] Government of the United Kingdom, *COP26 Declaration on Accelerating the Transition to 100% Zero Emission Cars and Vans*, updated November 17, 2022, https://www.gov.uk/government/publications/cop26-declaration-zero-emission-cars-and-vans/cop26-declaration-on-accelerating-the-transition-to-100-zero-emission-cars-and-vans

[e] Victoria State Government, *Victoria's Zero Emissions Vehicle Roadmap*, May 2021, https://www.energy.vic.gov.au/__data/assets/pdf_file/0031/583726/Zero-emission-vehicle-roadmap.pdf

[f] Queensland's 100% target is for 2036

[g] "Queensland's New Zero Emission Vehicle Strategy," Queensland Government, updated September 20, 2022, https://www.qld.gov.au/transport/projects/electricvehicles/zero-emission-strategy

[h] EV sales targets for government fleet only are in Western Australia: 25% EV sales by 2025 to 2026; Tasmania: 100% EV sales by 2030; and Northern Territory: increase number of EVs by 200 by 2030.

[i] State-level EV sales targets were weighted by their individual national market share. For 2030, we assumed that the states with a 100% EV target by 2035 will reach 50% EV sales by 2030, even if there is no interim target announced for 2030.

Meeting these state-level targets weighted by their national market share would lead to nationwide EV sales shares of 45% by 2030 and 86% by 2035. For this analysis, we assumed the states with a 100% EV sales target by 2035 reach approximately 50% EV sales by 2030, even if they have not announced an interim target for 2030. Despite these relatively ambitious policies for LDV decarbonization, states in Australia are not able to set fuel efficiency standards.[25] Federal legislation is needed to set such standards and establish the corresponding compliance and enforcement mechanisms.

Methods

To evaluate the impact of different technological and regulatory pathways on the CO_2 emissions from LDVs in Australia, we developed four scenarios and combined the policy assumptions therein with projections of vehicle sales and the carbon intensity of Australia's electricity grid.

We used ICCT's Roadmap model to estimate the real-world representative tank-to-wheel (TTW) and well-to-wheel (WTW) CO_2 emissions for each scenario.[26] TTW emissions are the tailpipe emissions of the vehicles and WTW emissions are emissions from fuel production, processing, distribution, and use, in addition to the TTW emissions.[27] This WTW analysis is thus different from a life-cycle analysis, which would also include upstream emissions related to vehicle production and end-of-life emissions such as

25 Ibid.

26 ICCT Roadmap model version 1.9, (2022), https://theicct.github.io/roadmap-doc/versions/v1.9/

27 "Emissions from Electric Vehicles," U.S. Department of Energy. Alternative Fuels Data Center, accessed on December 5, 2022, https://afdc.energy.gov/vehicles/electric_emissions.html#:~:text=Well%2Dto%2Dwheel%20emissions%20include,and%20burning%20it%20in%20vehicles.

from material recycling, recovery, and disposal.[28] We only analyze the vehicle emissions related to driving and the electricity grid emissions that result from powering EVs.

Overview of policy scenarios

We developed four policy scenarios:

1. **Baseline scenario** is a business-as-usual scenario with no mandatory CO_2 emission standard and no EV policies at the national level. It is based on Australia's recent trend of tailpipe CO_2 emissions reduction from ICEVs and assumes minimal growth in EV sales that is solely the result of improving economics.
2. **FCAI-aligned scenario** assumes that Australia adopts the voluntary FCAI targets as the mandatory CO_2 emission standard from 2024 to 2030. It assumes a combination of gradual ICEV emissions reduction and increasing EV sales to meet the emissions targets. We assume no further ICEV emissions reduction and minimal growth in EV sales post 2030 in the absence of FCAI targets.
3. **State targets-aligned scenario** assumes a national CO_2 emission standard that aligns in stringency with the aggregate of state EV sales targets starting in 2024 and a gradual reduction in ICEV emissions. It is a bottom-up scenario that accounts for how the existing state EV sales targets will contribute to national EV sales growth. We further assume the new ICEVs become more efficient and lower emitting in response to the CO_2 emission standard.
4. **World-class standards-aligned scenario** assumes standards that align Australia with the following: world-leading global EV sales targets starting in 2024; the New Zealand CO_2 standards for 2025; California's ZEV mandate by 2030, which is 68% EV market share; and the European Union's proposed CO_2 emission standards by 2035, which implies 100% battery electric vehicles (BEV) market share. Similar to the FCAI-aligned and State targets-aligned scenarios, we assume standards will reduce the new ICEV emissions at a higher rate than the Baseline scenario.

Table 3 is an overview of the inputs and assumptions for each scenario over the years, and the CO_2 emissions reductions are relative to the baseline year 2019. We selected 2019 as the baseline because that is the most recent year for which LDV tailpipe certified CO_2 emissions data is available from the National Transport Commission (NTC) report.[29] The fleet average CO_2 emissions of 2020 and 2021 are available in the more recent NTC reports, but the published statistics include the impact of FCAI off-cycle credits and super credits for EVs and low-emitting vehicles without disclosing the amount of credits gained from each category. In Table 3, the EV sales share refers to the EV market share of new vehicle sales in a given year, and that includes BEVs and plug-in hybrid electric vehicles (PHEVs). Until BEVs become the dominant technology, both ICEVs and PHEVs are assumed to become more efficient and relatively lower emitting through technology improvements, to help meet increasingly stringent standards.

28 Georg Bieker, *A Global Comparison of the Life-cycle Greenhouse Gas Emissions of Combustion Engine and Electric Passenger Cars*, (ICCT: Berlin, Germany, 2021), https://theicct.org/publication/a-global-comparison-of-the-life-cycle-greenhouse-gas-emissions-of-combustion-engine-and-electric-passenger-cars/

29 National Transport Commission, *Carbon Dioxide Emissions Intensity for New Australian Light Vehicles 2019*.

Table 3. Overview of scenario inputs and assumptions

Scenario	EV sales share					Annual reduction in CO_2 emissions	
	2025	2030	2035	2040	2050	ICEV	PHEV
Baseline	5%	8%	11%	15%	30%	0.5% (2020–2050)	2% (2020–2025) 1% (2026–2035) 0% (post 2035)
FCAI-aligned	15%	22%	25%	29%	44%	0.5% (2020–2023) 3% (2024–2030) 0% (post 2030)	
State targets-aligned	22%	45%	86%	87%	87%	0.5% (2020–2023) 3% (2024–2035) 0% (post 2035)	
World-class standards aligned	35%	68%	100%	100%	100%		

For each of the three scenarios that include standards, we assume the following best practices to ensure effectiveness:

» A mandatory standard for LDVs with adequate compliance and enforcement mechanisms takes effect starting in 2024.

» The standards have more stringent CO_2 emissions targets each year that push for continuous improvement of the new fleet.

» Australia adopts a real-world representative test procedure such as the WLTP to minimize and stabilize the gap between type-approval and real-world emissions and uses on-board fuel and energy consumption monitoring data to monitor the gap and adjust the emissions targets in the standards if the gap increases over time.

The levels of EV uptake and the tailpipe emissions reduction rates in Table 3 are discussed in detail in the following two sub-sections. However, we expect that manufacturers will have flexibilities that allow them to comply with standards through a variety of different technology pathways.

Electric vehicle sales share

For each scenario other than the State targets-aligned scenario, the sales shares for BEVs and PHEVs were estimated based on the 84%–16% split observed from national EV sales data in 2021.[30] For the State targets-aligned scenario, we took 100% BEV sales for the states that signed the COP26 declaration to work toward 100% ZEVs and for the other states, we used data shared by Australia's EV Council for the BEV-PHEV split in sales in 2021.

The Baseline scenario assumes minimal EV sales shares for Australia and is in line with a baseline scenario for major vehicle markets' minimum EV sales shares, taken from recent ICCT work.[31] These minimal EV sales shares align with IEA's Stated Policies Scenario and are the result of a natural improvement in ICEV fuel economy and reduction in battery cost over time.

For the FCAI-aligned scenario, we estimated annual EV sales shares as a function of the FCAI fleet-average CO_2 emissions targets and emissions reduction from ICEVs and PHEVs from 2024 to 2030.[32] We assumed new ICEV and PHEV emissions reduce annually as shown in Table 3 with technology improvement, for example higher ICEV energy efficiency. In the absence of further standards beyond 2030, we assumed EV sales shares grow at a slower rate after 2030. We did not include the various FCAI

30 National Transport Commission, *Carbon Dioxide Emissions Intensity for New Australian Light Vehicles 2021*, (Melbourne, Victoria, September 2022), https://www.ntc.gov.au/sites/default/files/assets/files/Carbon%20Dioxide%20Emissions%20Intensity%20for%20New%20Australian%20Light%20Vehicles%202021.pdf

31 Arijit Sen and Josh Miller, *Emissions Reduction Benefits of a Faster, Global Transition to Zero-emission Vehicles*, (ICCT: Washington, DC, 2022), https://theicct.org/publication/zevs-global-transition-benefits-mar22/

32 The FCAI voluntary emissions targets are for 2020 to 2030, and this scenario assumes the mandatory standards will align with the FCAI targets beginning in 2024.

credits in our modeling. Including those credits further lowers the stringency level of the FCAI target. For example, with FCAI super credits, the EV sales share would drop to 6% in 2025 and 9% in 2030, and these are significantly lower than our assumed levels in Table 3. We thus considered the maximum stringency for FCAI targets without adjusting for weights and credits.

For the State targets-aligned scenario, national EV sales shares were estimated by summing the contributions from each state based on their individual EV sales targets and their respective shares of total national vehicle sales. To estimate interim targets, we assumed the EV sales shares double every 5 years before they reach the target year and targeted sales. For instance, if a state has a 100% EV sales target by 2035, we assumed that the state would reach 25% EV sales by 2025 and 50% by 2030.

For the World-class standards-aligned scenario, the 2025 EV sales share is aligned with the New Zealand fleet-average CO_2 emissions target for 2025.[33] Assuming a combination of EV uptake and ICEV emissions reduction will be used to meet the standards, we adjusted the EV sales share to align Australia's 2025 fleet-average CO_2 emissions with New Zealand's fleet-average 2025 CO_2 emissions target. If ICEV emissions decline faster than the 3% assumed, the EV sales share could be less than 35% and still catch up with New Zealand's standards in 2025. The 2030 EV sales share is aligned with California's Advanced Clean Cars (ACC)-II requirement of 68% EV sales by 2030.[34] The 2035 EV sales share is aligned with the European Union's proposed Fit for 55 standard of 0 gCO_2/km by 2035, which we modeled as 100% BEV sales.[35]

Recent studies have demonstrated that the share of real-world electric driving for PHEVs is much lower than anticipated by the type-approval procedure in Europe and PHEVs have similar levels of real-world CO_2 emissions as ICEVs.[36] The European Commission recently adopted the Euro-6e amendment to the European type-approval procedure to obtain more real-world representative CO_2 emissions values for PHEVs.[37] Thus, in the World-class standards scenario, we considered PHEVs as an interim technology before a complete transition to BEVs by 2035.

ICEV emissions reductions

For the Baseline scenario, we assumed that ICEV technology reduces CO_2 emissions at a rate of 0.5% per year from 2020 to 2050, in the absence of any CO_2 emission standards or EV policies. This is based on the trend of ICEV CO_2 emissions reduction in Australia from 2015 to 2019.[38]

For each of the other three scenarios, we assumed that new ICEVs become more efficient and lower-emitting as the standards become more stringent each year until BEVs become the dominant technology. We assumed that mandatory CO_2 emission

33 We estimated New Zealand's fleet-average emission target for 2025 by sales-weighting the 2025 emission targets for PC and LCV reported in the Land Transport (Clean Vehicles) Amendment Act (2022), https://www.legislation.govt.nz/act/public/2022/0002/latest/whole.html#LMS536334

34 California Air Resources Board. "California Moves to Accelerate to 100% New Zero-emission Vehicle Sales by 2035," news release no. 22–30, August 25, 2022, https://ww2.arb.ca.gov/news/california-moves-accelerate-100-new-zero-emission-vehicle-sales-2035

35 Council of the EU, "Fit for 55 Package: Council Reaches General Approaches Relating to Emissions Reductions and Their Social Impacts," news release, June 29, 2022, https://www.consilium.europa.eu/en/press/press-releases/2022/06/29/fit-for-55-council-reaches-general-approaches-relating-to-emissions-reductions-and-removals-and-their-social-impacts/

36 Patrick Plötz et al., *Real-World Usage of Plug-in Hybrid Electric Vehicles in Europe: A 2022 Update on Fuel Consumption, Electric Driving, and CO_2 Emissions*, (ICCT: Washington, D.C., 2022), https://theicct.org/publication/real-world-phev-use-jun22/

37 European Commission, "Commission Regulation (EU) …/… of XXX Amending Commission Regulation (EU) 2017/1151 as Regards the Emission Type Approval Procedures for Light Passenger and Commercial Vehicles," Comitology Register, July 22, 2022, https://ec.europa.eu/transparency/comitology-register/screen/documents/082562/2/consult?lang=en.

38 Based on the data from NTC report (2021), the 2015 CO_2 emissions for ICE vehicles was reduced by 0.4% in 2020 and by 0.5% in 2019. https://www.ntc.gov.au/sites/default/files/assets/files/Carbon%20dioxide%20emissions%20intensity%20for%20new%20Australian%20light%20vehicles%202020.pdf

standards are implemented beginning in 2024. Before 2024, there is still a baseline of 0.5% annual CO_2 emissions reduction for ICEVs. After the standards are in place, ICEV emissions start to reduce at the rate of 3% per year through 2030 for the FCAI-aligned scenario and through 2035 for the State targets-aligned and World-class standards-aligned scenarios. The 3% reduction rate is consistent with the rates in the EU PC market for ICEVs in the 2021–2025 time frame, from prior ICCT work.[39] As Australia already has substantially higher ICEV emissions than other markets, including the European Union, there is enough potential to lower ICEV emissions by adopting technologies already widely available in the major markets to cost-effectively comply with the standards. For example, the annual reduction rate of 3% starting in 2024 will reduce the PC fleet emissions in Australia to 110 g/km in 2035. This emissions level is close to the average CO_2 emissions level of PCs that we estimated in the European Union for 2030.[40] Thus, 3% is a conservative estimation of the progress of ICEV technology improvement and these technologies will be available and affordable, as they will have been adopted by major markets much earlier.

FCAI CO_2 emissions targets currently exist through 2030 and for the FCAI-aligned scenario, ICEV emissions after 2030 are assumed to remain the same as the 2030 level. This effectively assumes that the baseline 0.5% reduction rate from 2030 to 2050 happens by 2030. For the other two scenarios, all or a majority of the new vehicle sales will be BEVs after 2035 and hence no further emissions reduction of ICEV technology was assumed.

We assumed that PHEV technology will have the same rate of emissions reduction across all scenarios. The annual rates of CO_2 emissions reduction are consistent with prior estimates for the EU PC market for PHEV technology.[41] Since the focus for electrification is on BEVs globally and BEV technology will get cheaper over time, manufacturers will be less likely to invest in improving PHEV technology and we assumed no further emissions reduction for PHEVs after 2035.

Key scenario elements

Table 4 summarizes the key elements of the scenarios for selected years. These estimates assess the different stringency levels for fleet-average emissions targets based on each policy option and the breakdown of estimated ICEV average emissions and EV market shares for a given policy scenario. Auto companies can achieve compliance through different mixes of technologies as long as the fleet-average target is met.

39 Peter Mock and Sonsoles Díaz, *Pathways to Decarbonization: The European Passenger Car Market in the Years 2021–2035*, (ICCT: Berlin, Germany, 2021), https://theicct.org/wp-content/uploads/2021/06/decarbonize-EU-PVs-may2021.pdf

40 Ibid.

41 Ibid.

Table 4. Summary of key elements in the four scenarios

Scenario	Scenario elements	2019	2023	2025	2030	2035	2040	2050
Baseline	Fleet-average CO_2 emissions target (g/km)[a]	180	171	167	158	149	139	110
	Fleet-average CO_2 emissions annual reduction[b]	—	—	1.2%	1.1%	1.2%	1.4%	2.3%
	BEV sales share	0.44%	2.8%	4%	7%	9%	13%	25%
	PHEV sales share	0.14%	0.5%	1%	1%	2%	3%	5%
	CO_2 emissions of ICEVs (g/km)[a]	181	177	175	171	167	162	155
FCAI-aligned	Fleet-average CO_2 emissions target (g/km)[a]	180	171	143	113	109	103	83
	Fleet-average CO_2 emissions annual reduction	—	—	9%	5%	0.7%	1.1%	2.1%
	BEV sales share	0.44%	2.8%	12%	18%	21%	24%	37%
	PHEV sales share	0.14%	0.5%	2%	4%	4%	5%	7%
	CO_2 emissions of ICEVs (g/km)[a]	181	177	166	143	143	143	143
State targets-aligned	Fleet-average CO_2 emissions target (g/km)[a]	180	171	131	82	19	16	16
	Fleet-average CO_2 emissions annual reduction	—	—	13%	9%	25%	3.4%	0.0%
	BEV sales share	0.44%	2.8%	19%	37%	83%	87%	87%
	PHEV sales share	0.14%	0.5%	3%	7%	3%	0%	0%
	CO_2 emissions of ICEVs (g/km)[a]	181	177	166	143	123	123	123
World-class standards-aligned	Fleet-average CO_2 emissions target (g/km)[a]	180	171	110	50	0	0	0
	Fleet-average CO_2 emissions annual reduction	—	—	20%	15%	—	—	—
	BEV sales share	0.44%	2.8%	30%	57%	100%	100%	100%
	PHEV sales share	0.14%	0.5%	5%	11%	0%	0%	0%
	CO_2 emissions of ICEVs (g/km)[a]	181	177	166	143	123	123	123

[a] All CO_2 emissions estimates are based on the New European Driving Cycle (NEDC).

[b] Annual reductions in fleet-average targets are estimated from 2023 onward, as standards begin in 2024. For example, the rate for 2025 is the annual reduction rate from 2023 to 2025 and the rate for 2030 is the rate from 2025 to 2030.

Under the Baseline scenario, the assumed 30% of EV sales and 14% emissions reduction from ICEVs compared to the 2019 level will only get Australia to fleet-average emissions of 110 g/km by 2050. If there are instead standards aligned with FCAI's voluntary fleet average CO_2 target of 113 g/km for 2030, the EV sales share could reach 22% by 2030 with only a 5% annual reduction in fleet-average CO_2 emissions from the 2025 level. The more stringent scenario with a State-targets aligned national standard would get Australia to fleet-average emissions of 82 g/km in 2030 and 19 g/km in 2035. Furthermore, the World-class standards scenario would need to reach 50 g/km fleet-average emissions in 2030—less than half of FCAI's proposed target—and 0 g/km in 2035.

We further estimated that using the FCAI-aligned CO_2 targets might allow ICEV emissions to backslide if national EV uptake ends up being aligned with the aggregated state-level targets, as illustrated in Figure 2. The bar chart shows the growth in national EV sales share and the top line chart shows the concurrent emissions curves under the FCAI-aligned scenario. While fleet-average emissions decrease in response to increasing EV uptake, ICEV emissions can increase because the FCAI fleet-average target is easily attainable with increasing EV uptake alone. Indeed, if the aggregated national EV sales share of 45% is achieved in 2030, the ICEV emissions would only need to be about 200 g/km to meet the FCAI 2030 target; this level is 10% higher than the baseline 2019 level and about 13% higher than the 2023 level before the standards take effect. Thus, the FCAI targets are not stringent enough to spur ICEV emissions reduction if state EV targets are met and might even lead to backsliding of ICEV emissions.

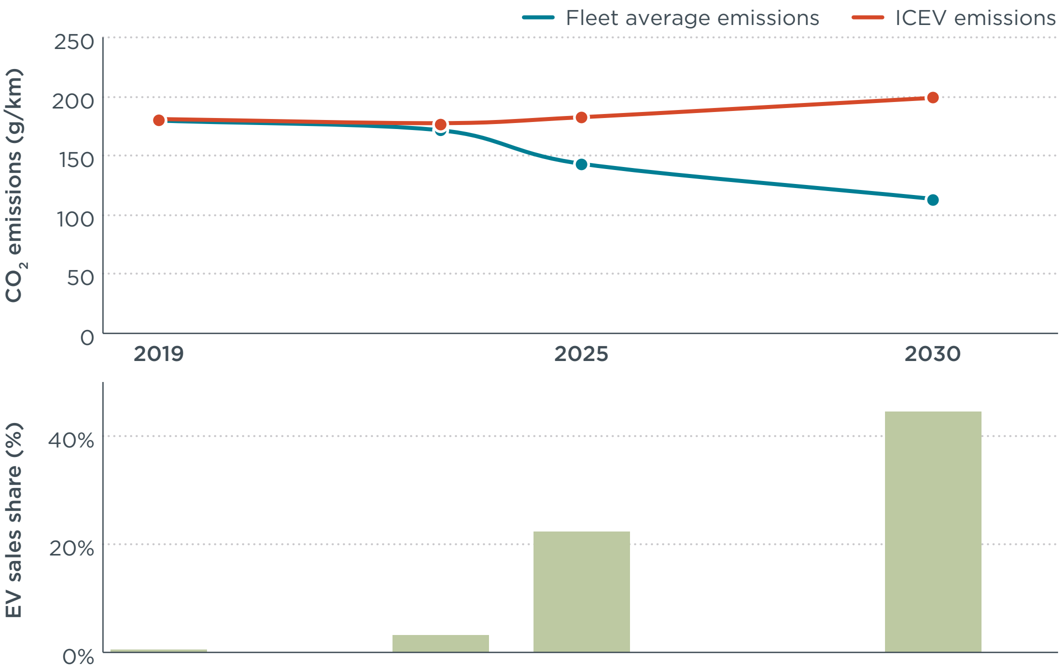

Figure 2. National EV sales shares aggregated from state-level EV sales targets for selected years and concurrent FCAI fleet-average and ICEV emissions.

Electricity grid carbon intensity

Reductions in electricity grid emissions over time reduce the WTW emissions of EVs. Australia's electricity grid carbon emissions for 2020–2030 were available from the projected CO_2-equivalent emissions factors, estimated by Australia's Department of Industry, Science, Energy and Resources, and this is shown in the solid blue line in Figure 3.[42] The Australian government's emissions projections include the policies and measures adopted as of October 2021 and these projections closely align with the International Energy Agency (IEA)'s 2021 projections for the Sustainable Development Scenario (SDS), based on the Global Energy and Climate model.[43] The SDS was one of the four 2021 World Energy Outlook (WEO) energy-projection scenarios, and it assumed effective actions to meet the Paris climate goals and lead to significantly reduced air pollution. The WEO projections include Australia within the Asia-Pacific region.

Given the close alignment between the Australian government's estimates and the SDS, we used the emissions reduction rate of the SDS to estimate our Australia-specific grid emissions for the other years in this analysis, 2019 and 2030 to 2050. This is shown in the dashed blue line in Figure 3; the post-2022 grid emissions for Australia are on average 10% lower than the SDS and follow a relatively faster emissions reduction path to reach close to zero in 2050. We used this Australia-specific grid emissions data for each of our four policy scenarios to estimate WTW emissions impacts.

42 Australian Government Department of Industry, Science, Energy and Resources, *Australia's Emissions Projections 2021*.

43 International Energy Agency. *Global Energy and Climate Model Documentation*, October 2022, https://www.iea.org/reports/global-energy-and-climate-model/understanding-gec-model-scenarios

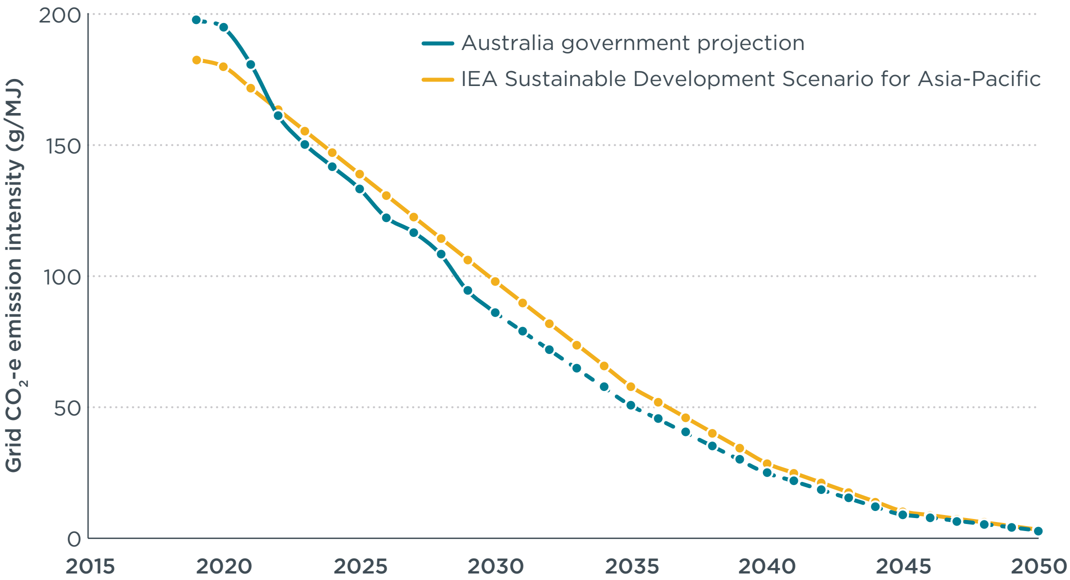

Figure 3. Electricity grid emissions intensity estimates for Australia in the 2019 to 2050 timeframe.

Projecting stock, sales, and emissions

The Roadmap model was fed a range of Australia-specific inputs, including historical stock data from the *Australian Infrastructure Statistics Yearbook* and sales data from FCAI.[44] For future stock and sales projections, Roadmap default values were used; these are based on IEA activity projections to 2050 and vehicle fleet turnover data.[45] The historical mileage data suggests that vehicle activity was substantially reduced in 2020 as compared to 2019, likely due to COVID-19.[46] We assumed for the modeling that the mileage returned to the 2019 level in 2021 and remained stable afterward. The policy assumptions, including the annual EV sales shares and annual ratios of ICEV efficiency improvement relative to 2019 CO_2 emissions, were then combined to calculate stock turnover and the resultant real-world energy consumption and CO_2 emissions from the LDV stock at the national level. The estimated TTW CO_2 emissions from the LDV stock in 2019 were validated with the reported 2019 level from the Australian government.[47]

Modeling results

This section presents the model-predicted LDV stock distribution by power train and the CO_2 emissions impacts, measured on both a TTW and WTW basis, from 2019 through 2050. Each scenario is discussed in terms of the effect of a CO_2 emission standard on EV penetration in the LDV stock and the extent of LDV fleet decarbonization.

EV penetration

Figure 4 shows the historical and projected yearly LDV stock share by power train for each of the four scenarios from 2019 through 2050. The total LDV stock in Australia is projected to increase by 14% from 2019 to 2050. Stock in the Baseline and FCAI-aligned scenarios is dominated by ICEVs throughout the time period considered and under these, Australia would end up in 2050 with an LDV stock of 82% and 68% ICEVs, respectively.

44 Historical stock data was from Australian Government Department of Infrastructure, Regional Development and Cities, *Australian Infrastructure Statistics Yearbook 2018*, (Canberra, Australia, 2018), https://www.bitre.gov.au/sites/default/files/infrastructure-statistics-yearbook-2018.pdf and the FCAI sales data was from Federal Chamber of Automotive Industries, *FCAI Annual Report 2012*, (Kingston, ACT), https://www.fcai.com.au/annual-reports/index/view/publication/48

45 ICCT Roadmap model version 1.9.

46 "Survey of Motor Vehicle Use, Australia," Australian Bureau of Statistics, accessed on December 5, 2022, https://www.abs.gov.au/statistics/industry/tourism-and-transport/survey-motor-vehicle-use-australia

47 Australian Government Department of Industry, Science, Energy and Resources, *Australia's Emissions Projections 2021*.

However, the other two scenarios are more progressive for EV penetration. In the State targets-aligned scenario, EVs begin to dominate the LDV stock in 2040 and would comprise 83% of the stock by 2050, with BEVs being 82% of total stock. In the World-class standards-aligned scenario, EVs make up more than half of the stock as early as 2037 and would nearly entirely replace ICEVs by 2050, when BEVs are projected to have a 96% share of the stock. Across all the scenarios, BEV shares dominate over PHEVs; this is expected with more advanced battery technology and significant reduction in battery cost over time. Further, given the higher real-world emissions of PHEVs than type-approval procedures currently reflect, as discussed earlier, PHEVs are not a long-term solution for auto companies to meet stringent standards.

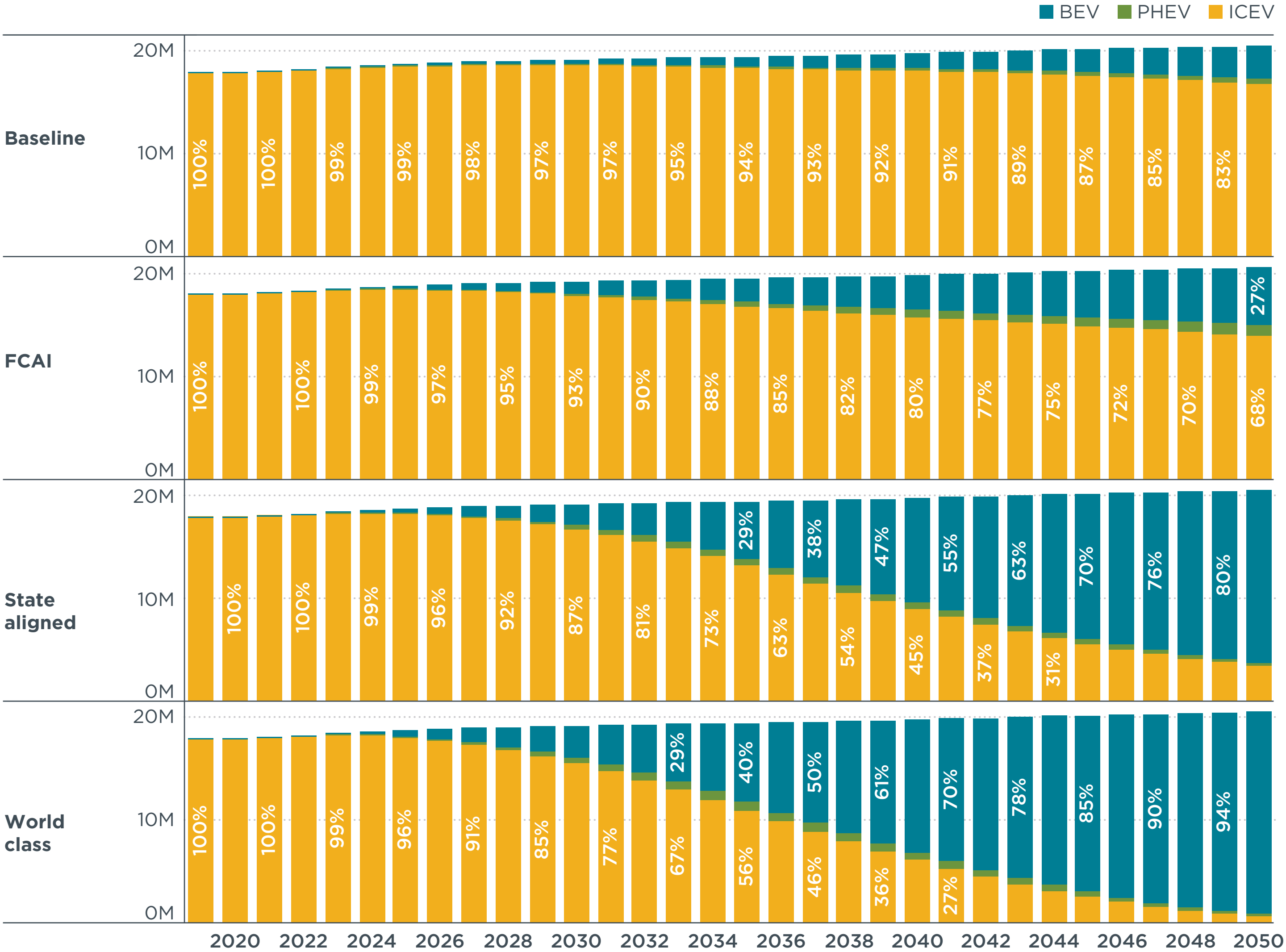

Figure 4. Australia's light-duty vehicle stock by power train from 2019 to 2050 for each policy scenario based on Roadmap model projections.

CO_2 emissions impacts

Figure 5 illustrates the annual TTW and WTW CO_2 emissions impacts of each policy scenario for Australia's LDV stock from 2019 through 2050. For all scenarios, there is a sharp drop in CO_2 emissions from 2019 to 2020 due to reduced vehicle activity during COVID-19 in 2020. The emissions level returns to pre-pandemic levels by around 2021 and then continues to increase at least through 2024 for all scenarios; this represents the post-pandemic recovery in vehicle activity, the increased size of the vehicle fleet, and is before any standards start to influence emissions.

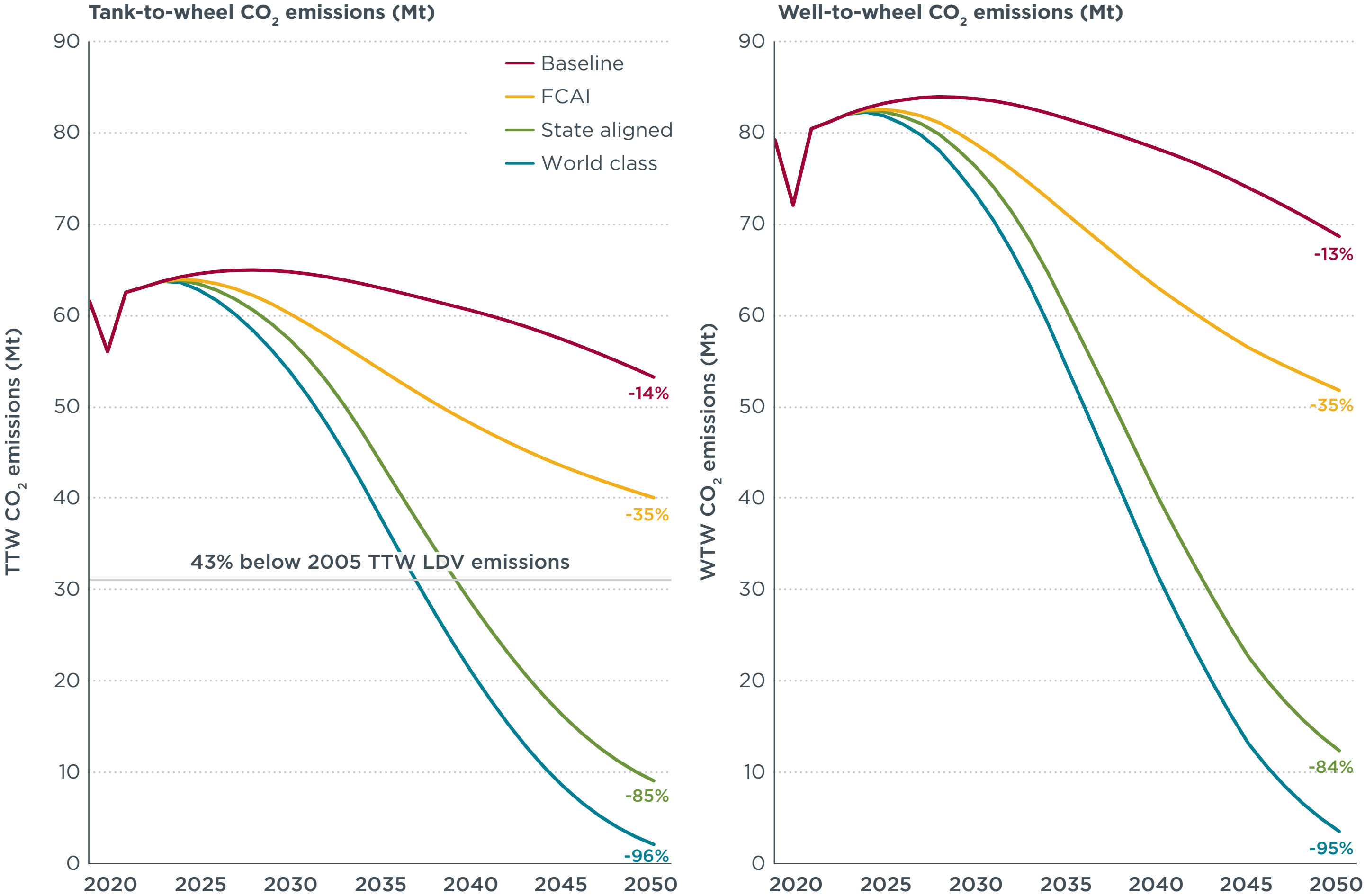

Figure 5. Estimated CO_2 emissions under our four policy scenarios for Australia's LDV stock from 2019 to 2050.

In the Baseline scenario, CO_2 emissions keep increasing through 2029 before EV penetration in the fleet starts to reduce emissions. Compared to the 2019 level, Baseline emissions are 14% lower on a TTW basis and 13% lower on a WTW basis in 2050.

For the State targets-aligned and World-class standards-aligned scenarios, emissions level off a few years earlier than in the Baseline and FCAI-aligned scenarios. However, it is only the World-class standards trajectory that can bring emissions close to zero in 2050 on both TTW and WTW bases. The State targets-aligned scenario reduces WTW emissions by 84% in 2050, but that is still far from than the World-class trajectory. Moreover, when considering cumulative emissions from 2019 to 2050, the State targets-aligned scenario would emit 165 Mt more, or 10% higher WTW CO_2 emissions, than the World-class scenario. The FCAI-aligned scenario would only reduce emissions by 35% in 2050 from the 2019 level, and in 2050, 40 Mt of tailpipe and 52 Mt of WTW emissions will still be generated by the LDV stock.

Recall that Australia has a new target of 43% economywide CO_2 emissions reduction below the 2005 level by 2030. Compared to the reported TTW emissions from the fleet in 2005, the State targets-aligned scenario can achieve a 42% emissions reduction in 2039 and the World-class standards-aligned scenario can achieve a 43% reduction in 2037, as shown in Figure 5.[48] In 2030, both scenarios have roughly the same emissions level as the reported 2005 level. Thus, Australia will likely need to use additional

48 CO_2 emissions from LDVs in Australia were 54 Mt in 2005, per the Australian Government Department of Industry, Science, Energy and Resources, *Australia's Emissions Projections 2021*.

measures to reach such emissions reduction earlier when following the World-class standards-aligned or State targets-aligned pathways.

Key findings and policy recommendations

This work has demonstrated the impact of CO_2 emission standards of different stringency in achieving a decarbonized LDV fleet in Australia compared to a Baseline, business-as-usual scenario. We also evaluated what level of policy ambition is needed to fully decarbonize Australia's LDV fleet in 2050.

Our major findings include:

» Only the most ambitious scenario considered, the one aligned with World-class standards, would come close to fully decarbonizing Australia's LDV fleet by 2050, as it eliminates 95% of WTW CO_2 emissions. To fully decarbonize its LDV fleet, we expect Australia would need additional measures, such as accelerated fleet turnover to phase out ICEVs as early as possible and a faster transition to a decarbonized grid.

» Our State targets-aligned scenario, which includes already announced state EV targets, is not as effective as the World-class standards scenario but would achieve an 84% reduction in CO_2 emissions by 2050. It would also result in 165 Mt more cumulative CO_2 emissions from 2019 to 2050 than the World-class standards scenario.

» The World-class standards-aligned and State targets-aligned scenarios would achieve about a 43% CO_2 emissions reduction from the LDV stock compared to 2005 by 2037 and 2039, respectively. Here, too, additional measures, likely including those that accelerate fleet renewal, would be needed to achieve a 43% emissions reduction compared to the 2005 level by 2030.

» Aligning standards with the current FCAI voluntary standards would only yield an EV market share of 22% of new LDV sales by 2030. Not only is this pathway inadequate for accelerating electrification of the LDV stock to help achieve Australia's climate target, FCAI-aligned targets would allow backsliding of ICEV emissions if EV sales growth aligns with State targets. This could result in Australians bearing increased fuel costs from purchasing less-efficient and higher-emitting ICEVs.

To achieve a fully decarbonized or almost fully decarbonized LDV fleet by 2050, this analysis demonstrates that Australia needs to implement CO_2 emission standards. The ICCT recommends the following:

» Adopt stringent standards starting no later than 2024 that align with the world-class ambition and achieve 100% ZEV sales by 2035. This means achieving a fleet-average CO_2 emissions target of 50 gCO_2/km on the NEDC cycle, or 72% reduction compared with the 2019 baseline, by 2030 and 0 gCO_2/km by 2035 for the new LDV fleet. A relatively conservative approach that Australia could consider for the short-term is to align the standards with the state EV targets ambition by 2030, which will achieve a fleet-average CO_2 emissions target of 82 gCO_2/km by 2030, or a 54% reduction compared with the 2019 baseline. Nevertheless, any standards that are less stringent than the world-class ambition will delay Australia's progress in fully decarbonizing its LDV fleet by 2050.

» Amend ADR 81/02 to mandate the use of the WLTP cycle for type-approval and base the standards on that WLTP data. Introduce onboard fuel and energy consumption monitoring (OBFCM), as is already required in the European Union, to monitor the gap between type-approval and real-world fuel consumption and to enable adjustment of manufacturer targets accordingly, in cases where the gap with real-world fuel consumption is larger than the average gap under WLTP or where the gap is growing over time.

- Collect and use unadjusted CO_2 emissions type-approval data for each year and use the latest available data (e.g., from 2021 or 2022) as the baseline data to support development of the CO_2 emission standards.
- Once the standards are in place, establish a comprehensive compliance and enforcement mechanism to monitor and determine compliance, such as in the European Union.
- Consider other best practices in design to maximize the effectiveness of the standards, such as establishing only one standard curve for passenger cars and light-commercial vehicles as opposed to separate curves for MA, MC, and NA; this would discourage vehicle importers from switching vehicle segmentation to be subject to more lenient standards.