

# CARB ON-ROAD MOTORCYCLE (ONMC) PUBLIC WORKSHOP



## Stakeholder Update on Tentative Regulatory Proposal

November 17, 2020

# WORKSHOP GOALS

- Update stakeholders on progress of ONMC rulemaking activity
- Introduce concepts for a regulatory proposal
- Request for supporting cost data
- Request for regulatory alternatives and supporting data

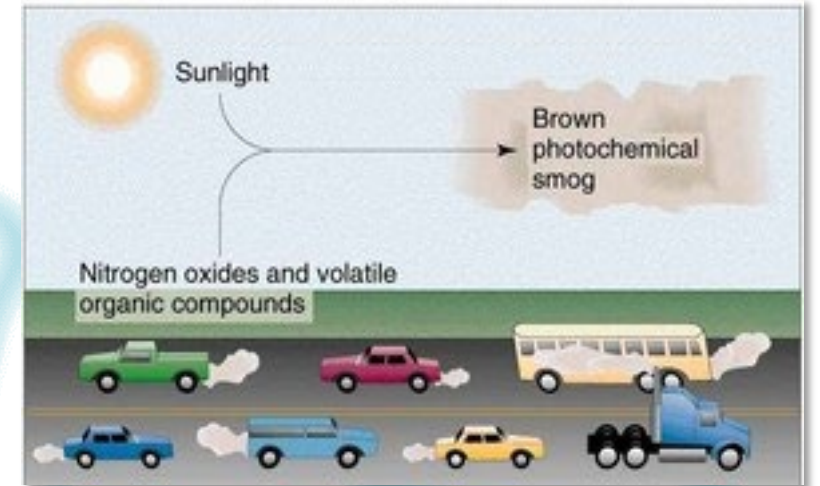
# OUTLINE

- ONMC Background
- Exhaust Standards and Recent Activity
- Evaporative Standards and Recent Activity
- Tentative Regulatory Proposal
- Cost Survey and Data Requests



# NEED FOR EMISSIONS REDUCTIONS

- Over 90% of Californians breathe unhealthy levels of air pollutants during some part of the year
- A major source of these pollutants is transportation related combustion
  - Nitrogen Oxides (NO<sub>x</sub>)
  - Reactive Organic Gases (ROG)
  - Carbon Monoxide (CO)
- Together NO<sub>x</sub> and ROG form ozone in sunlight
  - Ground level ozone is a major component of smog
- CARB's mission involves protecting the public health by providing safe clean air to all Californians



# NEED FOR EMISSIONS REDUCTIONS (CONTINUED)

- **Push For Zero Emissions Vehicles**
  - 2016 Zero Emission Vehicle (ZEV) Action Plan
    - Create programs to incentivize zero emission vehicles
  - Executive Order B-48-18
    - 5 million ZEVs in California by 2030
    - 250,000 vehicle chargers installed in California by 2025
  - Executive Order N-17-20
    - Require all passenger cars sold in state to be ZEV by 2035
- **CARB 2020 Mobile Source Strategy (MSS) proposes aggressive targets**
  - 100% of 2035 LDV sales to be ZEV and PHEV
  - <https://ww2.arb.ca.gov/resources/documents/2020-mobile-source-strategy>

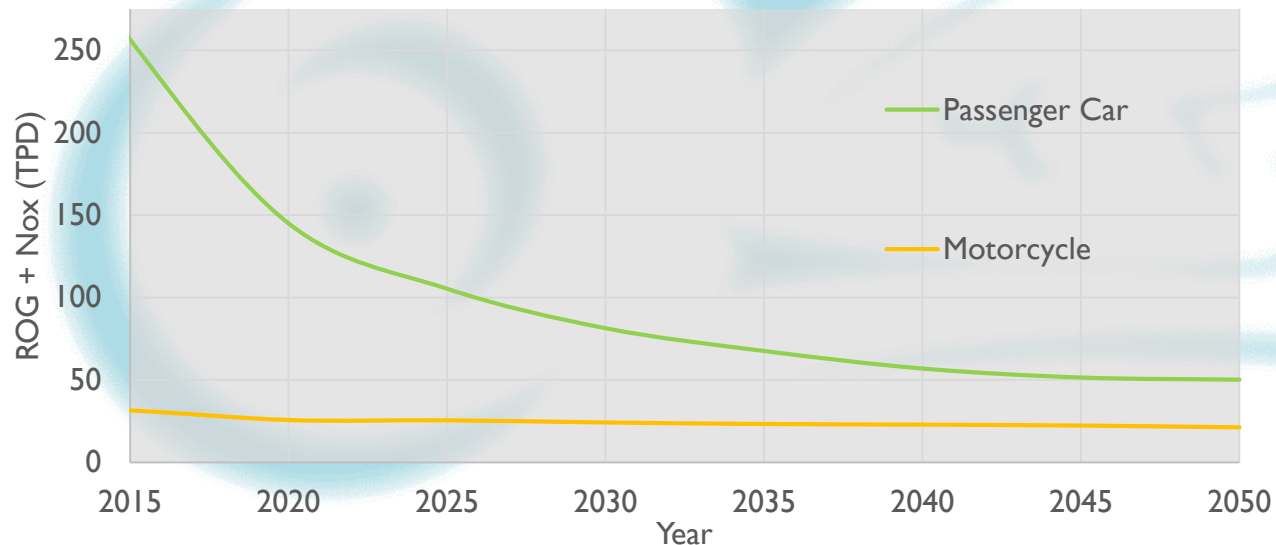


# ONMC EMISSIONS INVENTORY IN CA

- 2020 ONMC EMFAC emissions estimates\*

- ~ 27 TPD of NO<sub>x</sub> + ROG
- ONMC Population ~ 700,000
- Passenger Car Population ~ 15,000,000

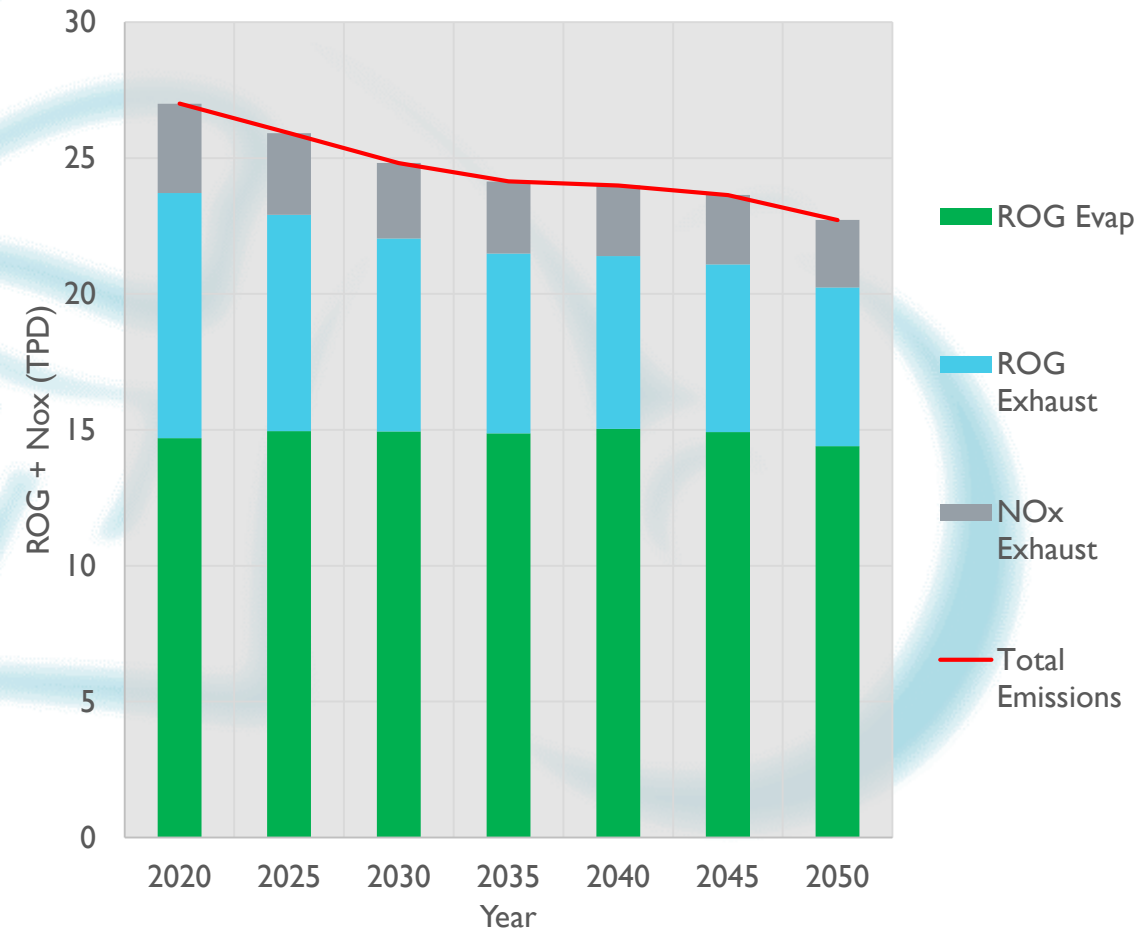
Passenger Car vs Motorcycle  
Current Trend ROG + NO<sub>x</sub>



\*EMFAC 2020 to be finalized in January 2021



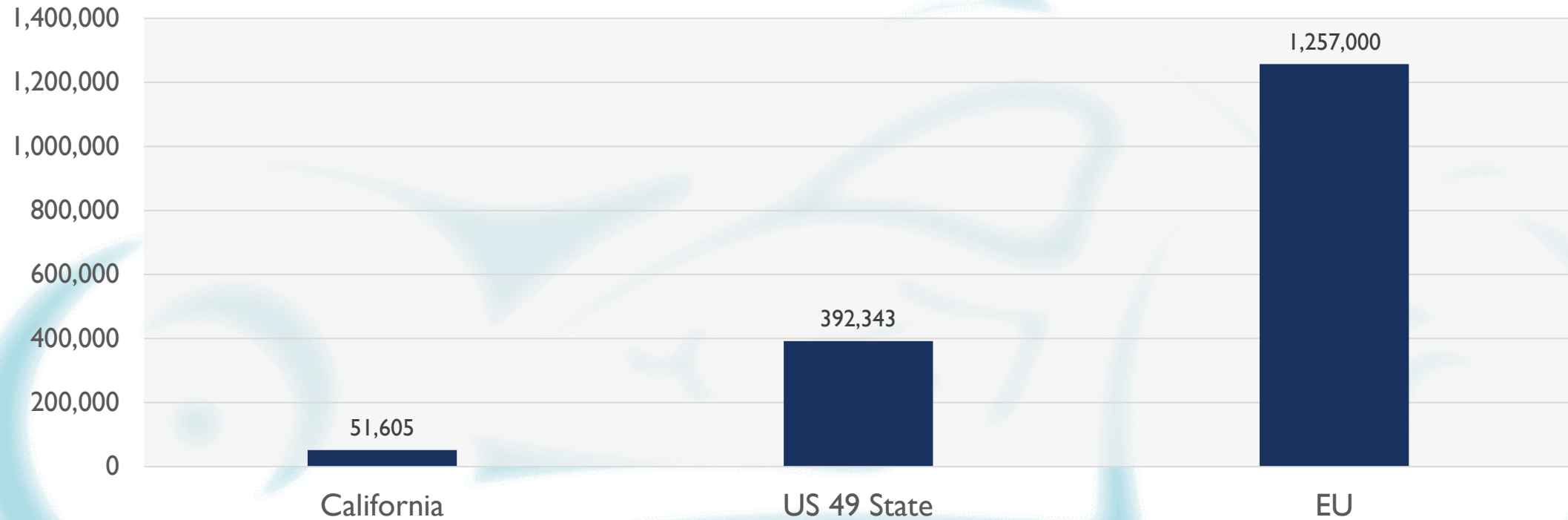
Total Baseline ROG + NO<sub>x</sub>





# ONMC MARKET SIZE

## 2018 ONMC Sales



- California population from Ca DMV registration
- US 49 state population from EPA certification data
- EU population from Statista

# STAKEHOLDER OUTREACH

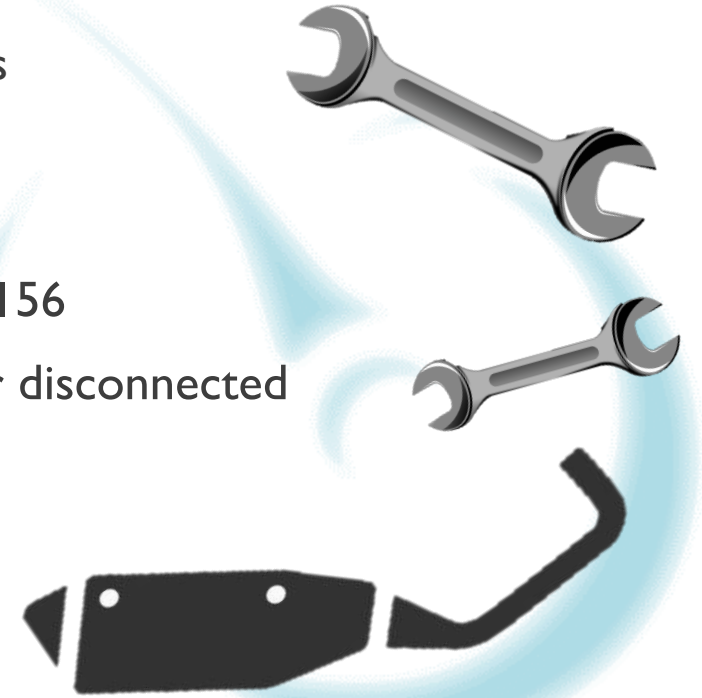
- Met individually with most manufacturers - 2017
  - Most expressed preference for CARB harmonization with recent Euro 5 standards
  - Significant cost savings possible with harmonization
- Project Kickoff Workshop – April 2018
- Established ongoing technical working groups for stakeholders to provide input in areas of:
  - Test procedures and EU certification protocols
  - On board diagnostics (OBD) and verification
  - Zero Emissions Motorcycle (ZEM) incentives
- Participating in UN working groups on motorcycle regulations
- Conducting joint emissions testing with U.S. EPA, ECCC and manufacturers





# TAMPERING SURVEY

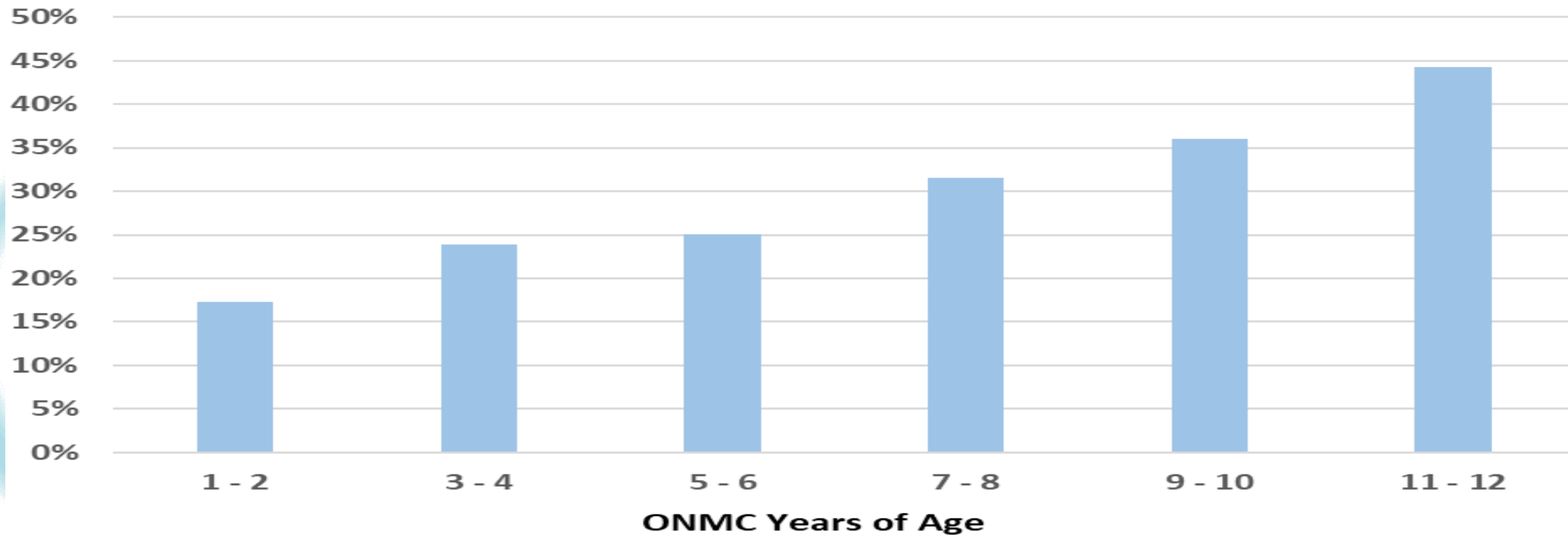
- CARB staff surveyed 2017 ONMC classified ads for evidence of tampering
  - Analysis included 2000 online random classified ads
  - Sampling excluded street legal modifications and other allowable exceptions
- Emissions related tampering fell into two main categories:
  - Installation of parts without a CARB EO or not exempt from CVC §27156
  - Emissions control systems/components that were removed, modified or disconnected
- Key Findings
  - 93% of sample population was Class III ONMCs
  - 31% of the Class III sample appeared to be tampered
  - Exhaust tampering was most common type of tampering



# TAMPERING SURVEY (CONTINUED)

- Tampering frequency increases with vehicle age

**Percent of Sample Tampered by Years of Age**



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# HISTORY OF ON-ROAD MOTORCYCLE EXHAUST REGULATIONS

- Exhaust standards last updated in 1998, effective 2008
  - UDDS Test Cycle (based on LDV driving)
  - No OBD
  - US EPA and ECCEC harmonized with CARB exhaust standards, effective 2010
- EU has adopted more stringent exhaust standards, other nations have followed suit
  - Euro 5 effective 2020
  - WMTC Test Cycle (based on real world motorcycle riding)
  - Basic OBD
  - UN mostly harmonized with EU on test procedures



# ONMC EXHAUST EMISSION STANDARDS

## HC + NO<sub>x</sub> Standards



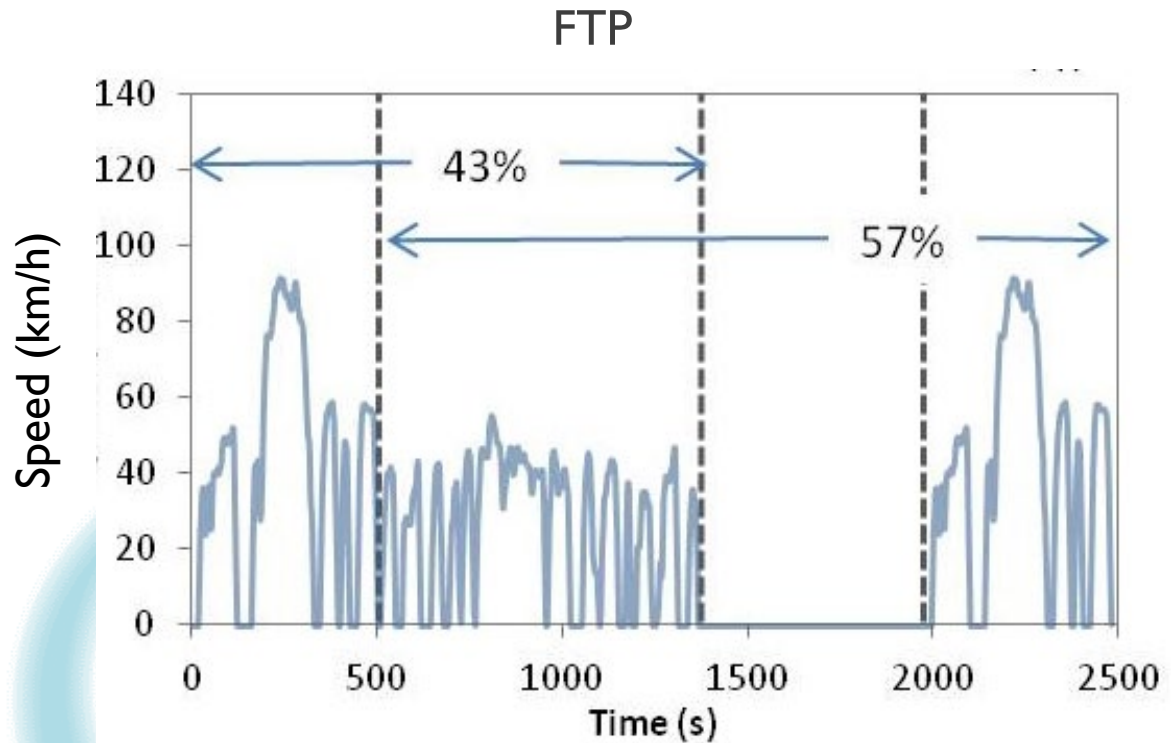
# ONMC EXHAUST EMISSION STANDARDS

## CO Standards



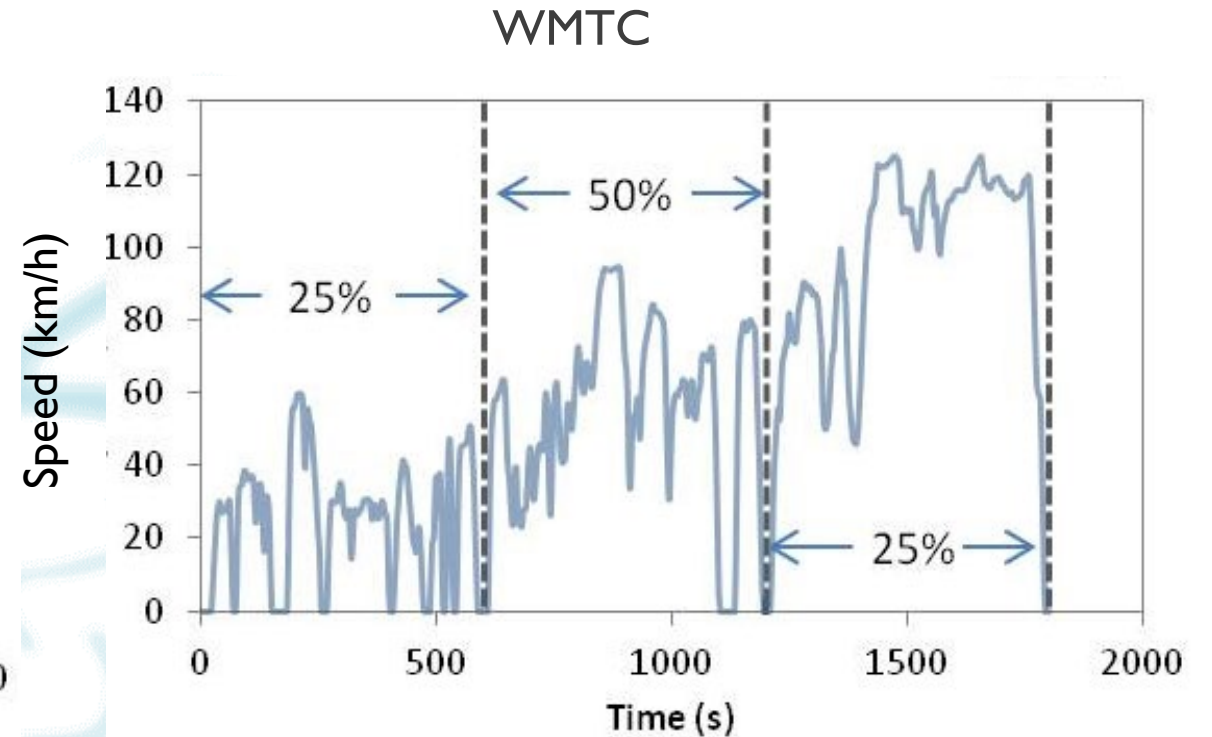


# DRIVE CYCLES: FTP (CARB / EPA) vs. WMTC (EURO 5)



- Max speed: 91 km/h
- Average Speed: 34 km/h\*
- Duration: 1877 s\*
- Distance: 18 km

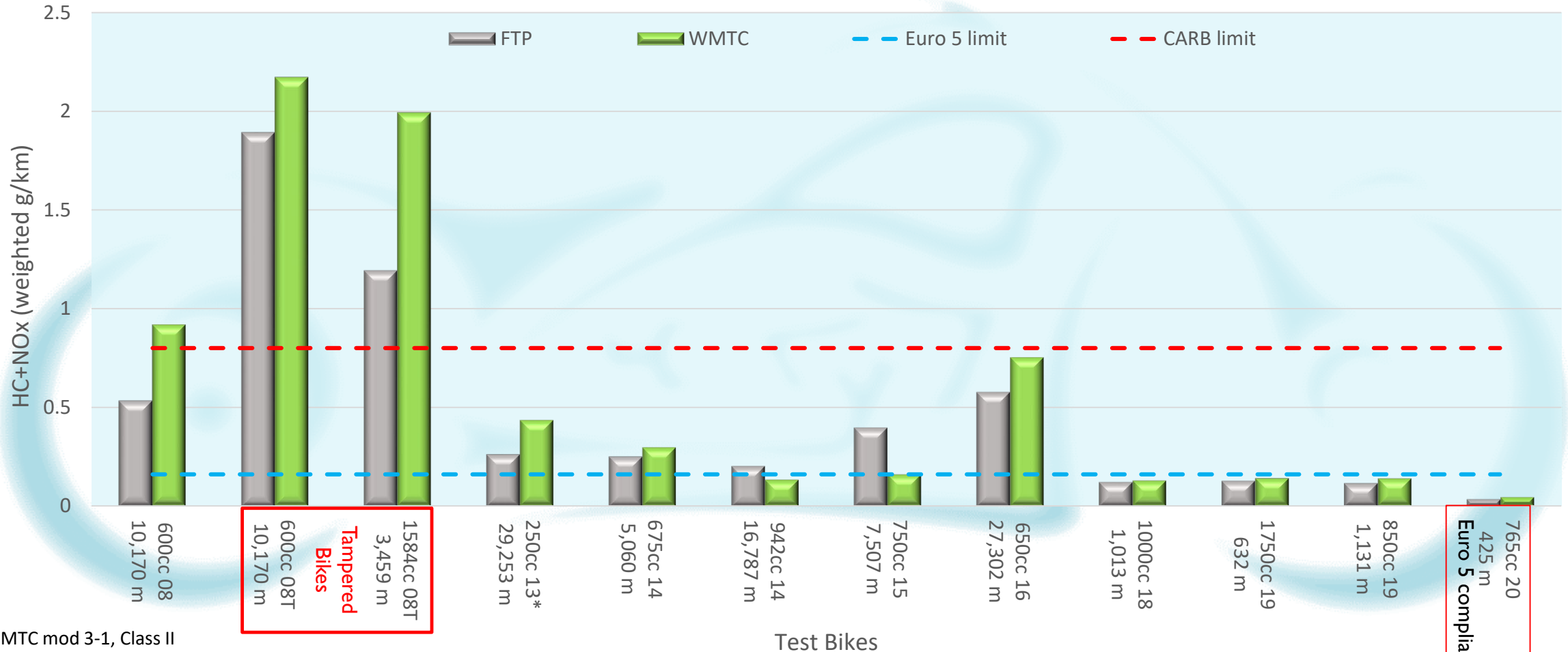
\* Does not include 600 s soak period



- Max speed: 125 km/h
- Average Speed: 58 km/h
- Duration: 1800 s
- Distance: 29 km

# CARB INVENTORY EXHAUST TEST DATA (PRELIMINARY RESULTS)

## HC+NOx Emissions By Bike and Test Cycle

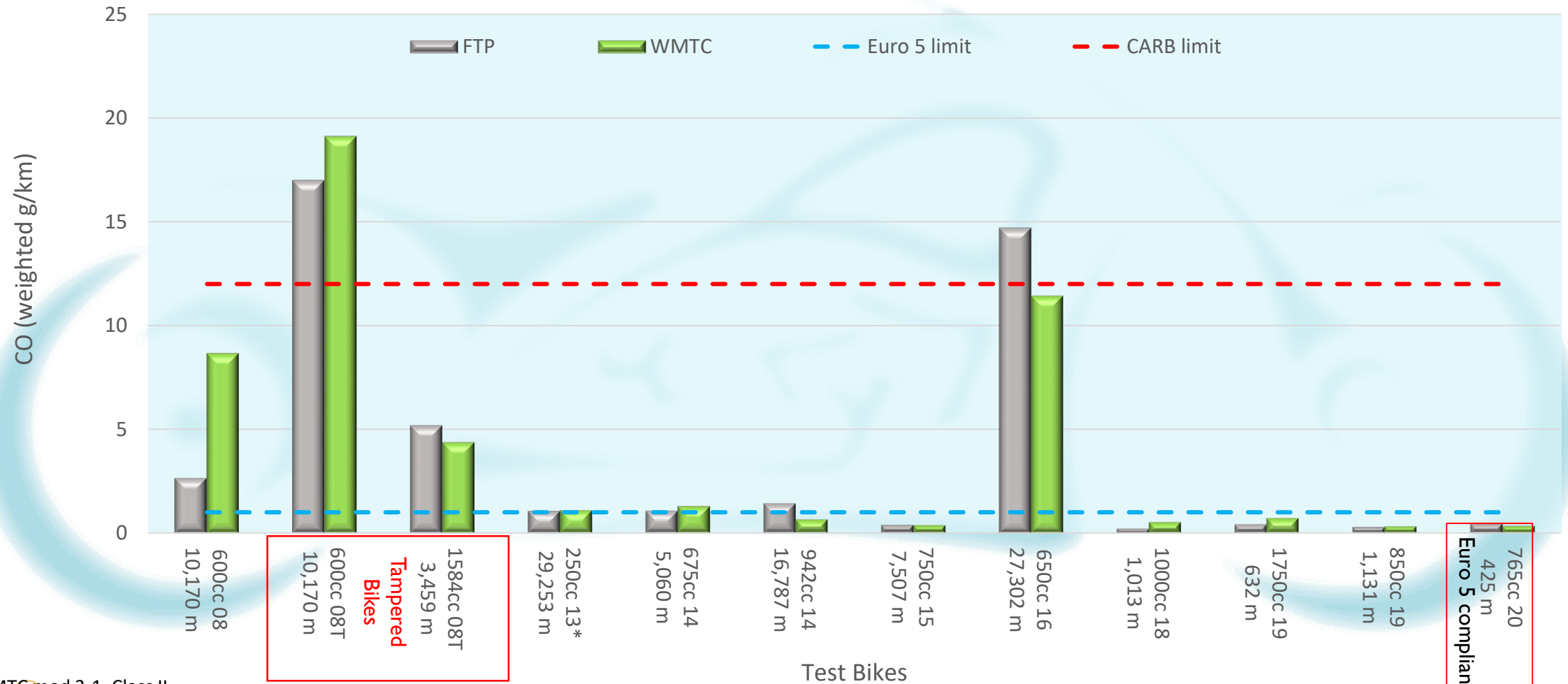


\* WMTC mod 3-1, Class II

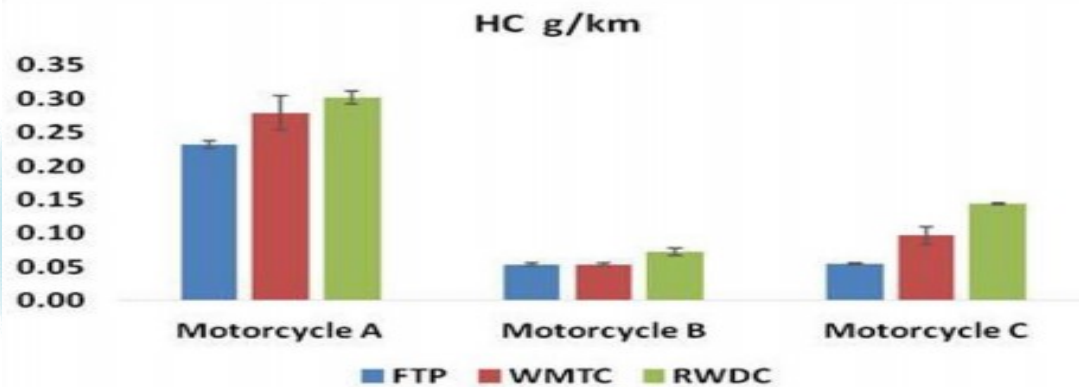
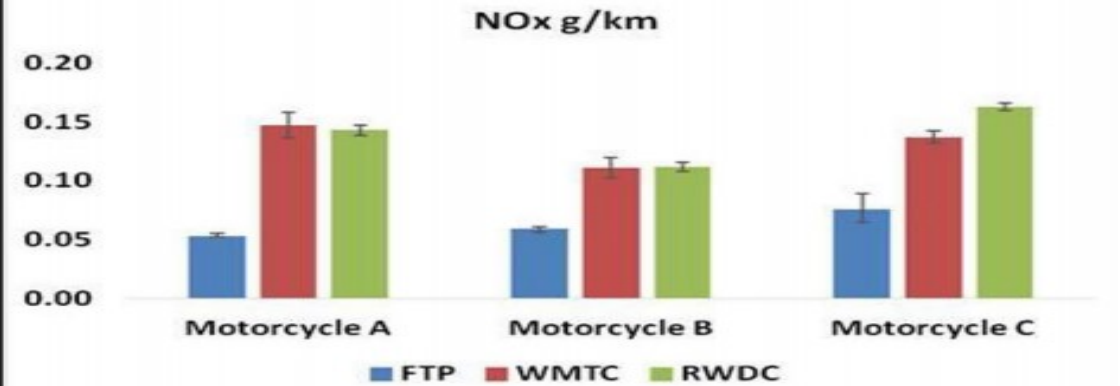
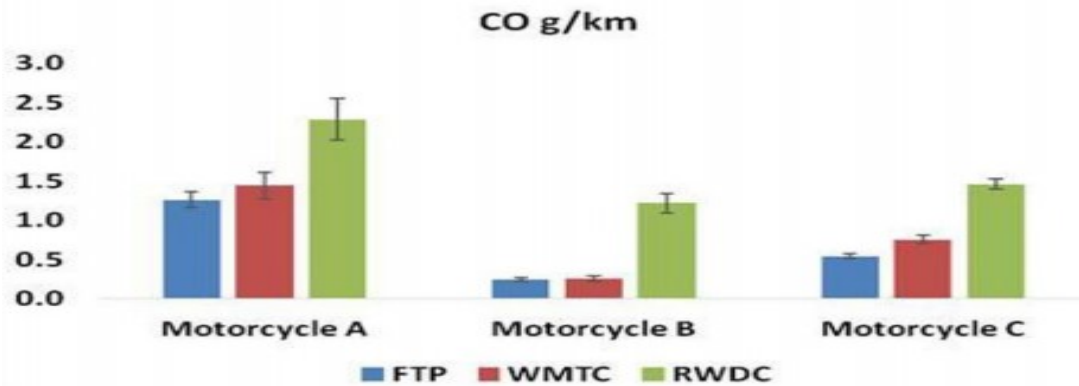


# CARB INVENTORY EXHAUST TEST DATA (PRELIMINARY RESULTS)

## CO Emissions By Bike and Test Cycle



# ADDITIONAL DATA FROM ECCC



Test Bike	MY	Size (cc)	Controls
A (Sport)	2017	296	SFI/TWC/ PAIR/HO2S
B (Cruiser)	2016	749	SFI/TWC/ 2HO2S
C (Touring)	2015	1198	SFI/TWC/ PAIR/2HO2S

Rosenblatt, D., Stokes, J., Caffrey, C., and Brown, K.F., "Effect of Driving Cycles on Emissions from On-Road Motorcycles," SAE Technical Paper 2020-01-0377, 2020, doi:10.4271/2020-01-0377.

# CARB INVENTORY EXHAUST TESTING OBSERVATIONS

- WMTC is generally more aggressive than FTP drive cycle, resulting in higher emissions for most bikes tested
  - Difference between FTP and WMTC varies by model (control technology, engine calibration, displacement, etc.)
- The Euro 5 compliant motorcycle emits lower than non-Euro 5 compliant motorcycles
  - EU5 standards approach limits of feasibility for current ONMC control technology, especially NMHC
- Some late MY CARB compliant motorcycles are closely related to Euro 5 compliant models, and are therefore already close to meeting Euro 5 Standards
- Tampered motorcycles generally emitted much higher than non-tampered motorcycles



# NEXT STEPS - EXHAUST

- Protocol comparison testing must be completed
  - 4 bikes being testing in El Monte
  - Additional testing of Euro 5 models planned at ECCC, US EPA, and OEMs
  - Determine impact of drive cycle (WMTC, FTP) and fuel formulation (EU5, CARB, and EPA cert fuels)
- Evaluate applicability of WMTC to small displacement ONMC





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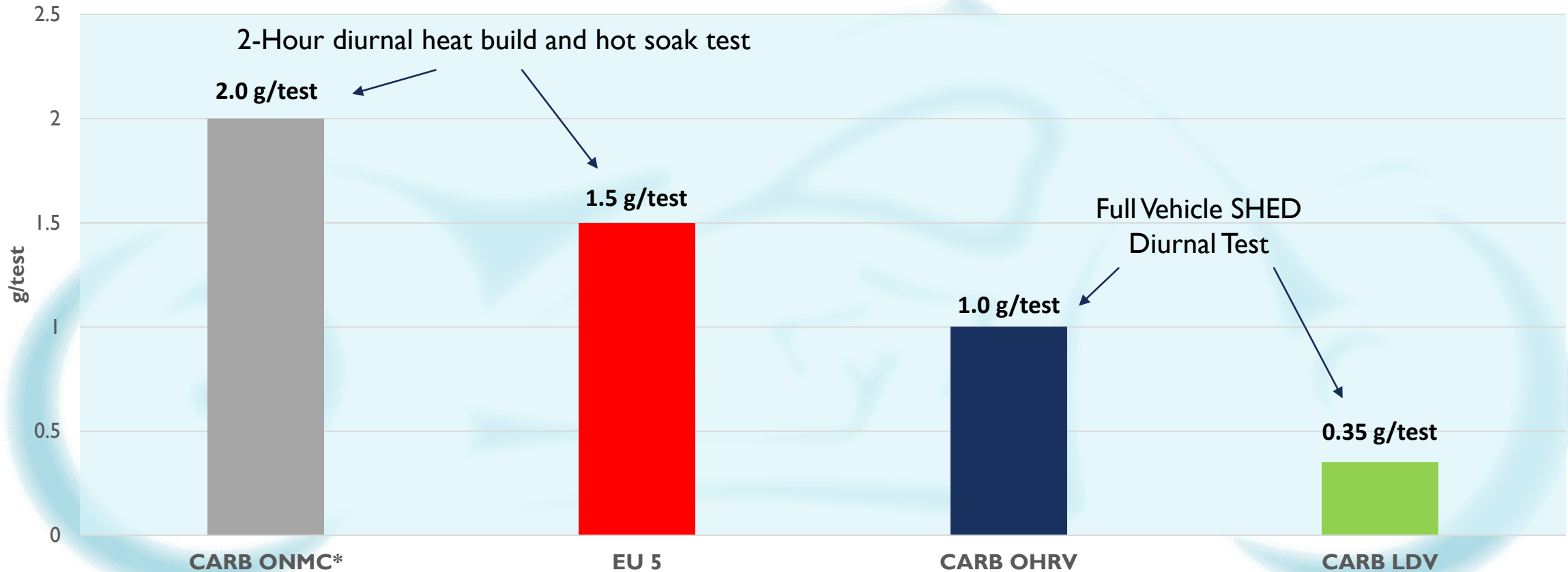


# HISTORY OF ON-ROAD MOTORCYCLE EVAPORATIVE REGULATIONS

- Current evaporative standards and test procedures were implemented in 1986
  - 2-hour diurnal heat build and hot soak test, not representative of full vehicle evap emissions
- EU also uses the CARB heat blanket procedure, with minor modifications
- U.S. EPA evaporative requirements include only tank and hose permeation standards
- Most other vehicle categories use full vehicle multi-day SHED diurnal test
  - Includes CARB LDV and off highway motorcycles

# ONMC EVAP EMISSION STANDARDS

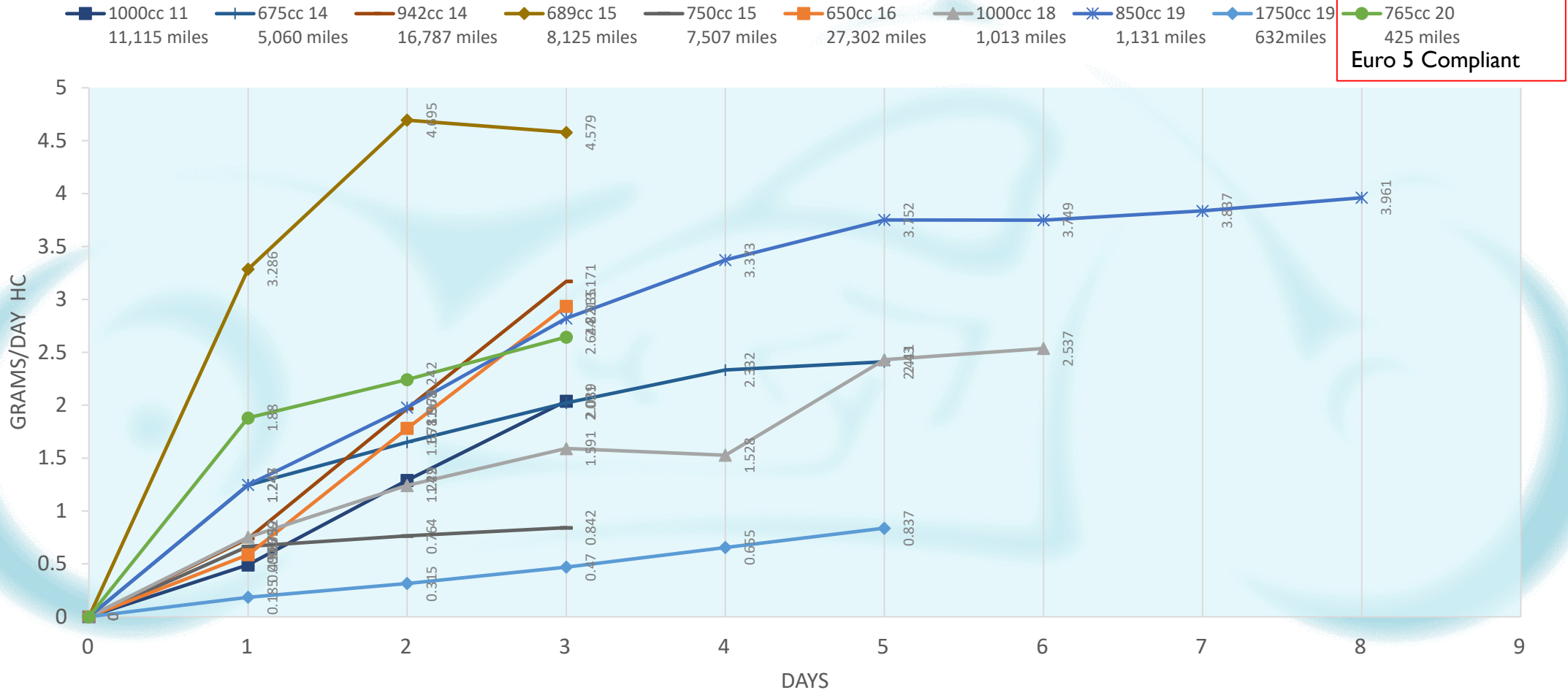
Evap Standards



\* Practically, manufacturers design to 1.8 g/test to gain exemption from CARB fuel tank fill pipe specifications.

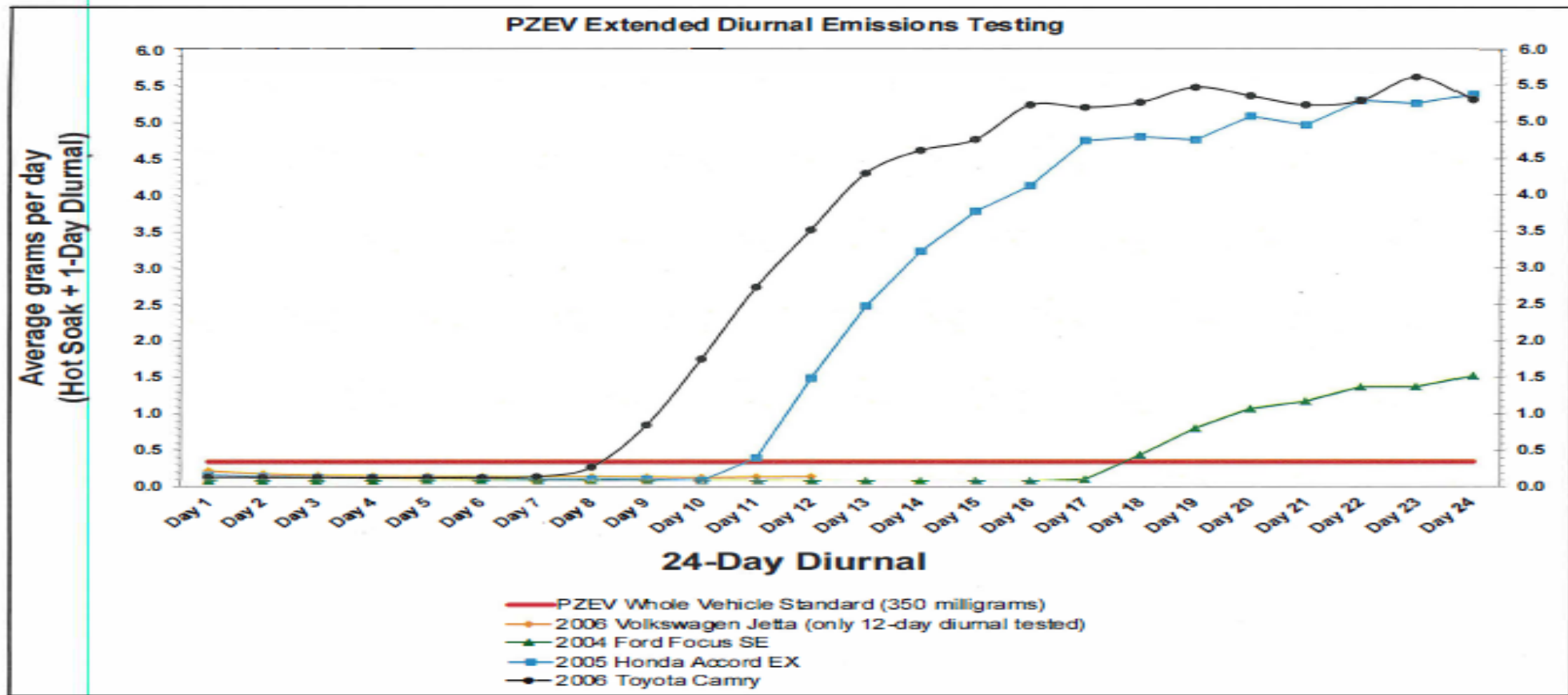
# CARB INVENTORY EVAP TEST DATA

## MC EVAP RATES OVER TIME (65-105-65 DIURNAL)



# CARB LDV EVAP TEST DATA

## Example Long Term PZEV Evaporative Profiles



# CARB INVENTORY EVAPORATIVE TESTING OBSERVATIONS

- Wide range of emissions from various models, although all models passed the current heat blanket certification tests
  - Poor correlation between current test procedures and real world emissions
- No noticeable improvement for Euro5 bike versus CARB-certified bikes
  - Additional testing of Euro5 models would be useful, will be conducted by U.S. EPA
- Motorcycles appear to have high initial evaporative emissions compared to LDV
  - Opportunity for emissions reductions
  - Staff is investigating this further with a focus on carbon canister design



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# REGULATORY PROPOSAL - OBJECTIVES

- Bring lower emissions motorcycles to the California market as quickly as possible
- Minimize costs by aligning standards with other jurisdictions where possible
- Require additional cost-effective reductions in subsequent years
  - Focus on evaporative emissions, which make up the majority of ONMC ROG
- Ensure compliance with emissions standards over the vehicle's useful life
- Transition towards zero emissions motorcycles (ZEMs) as technology improves and costs decrease

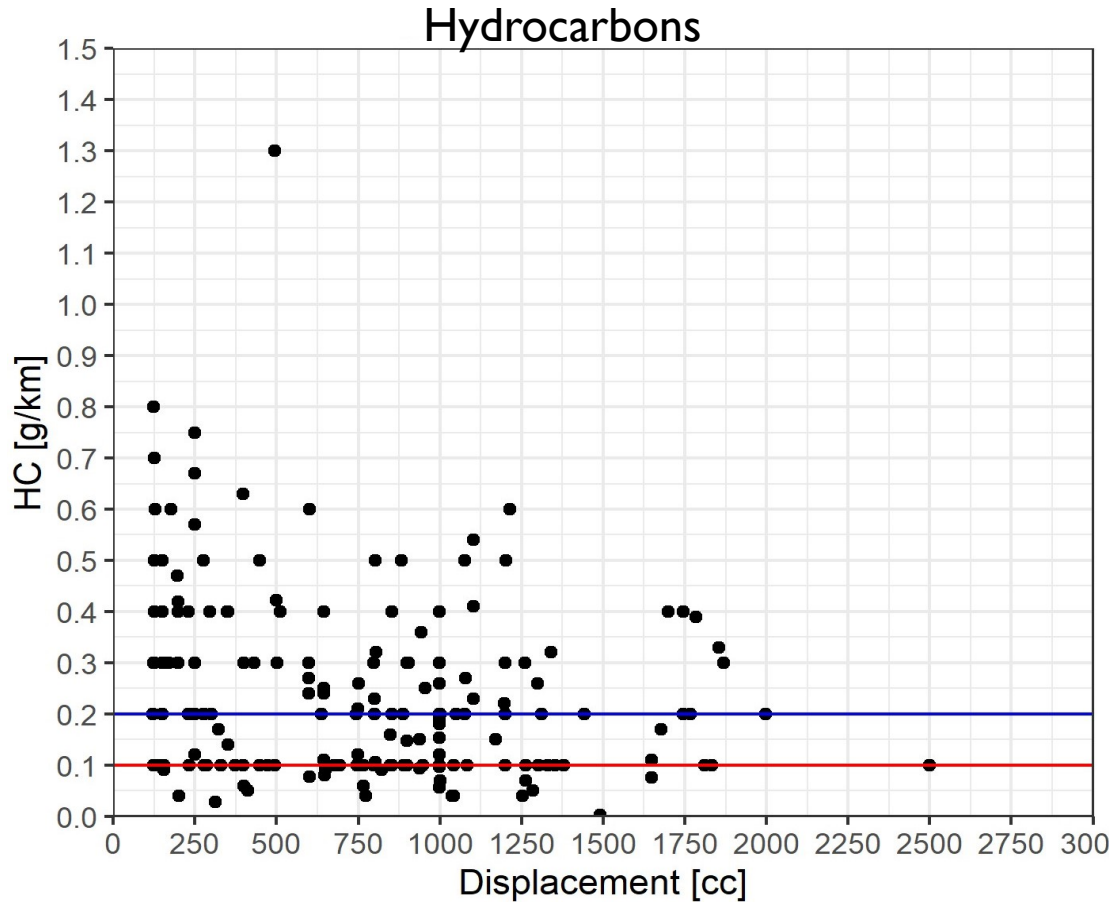
# REGULATORY PROPOSAL – EXHAUST

- MY 2023 - 50% of sales must meet Euro 5 exhaust requirements
- MY 2024+ - All motorcycles must meet Euro 5 exhaust requirements
- Manufacturers may use their EU test data if engine family has EU Type Approval
  - EU spec fuel may be used for testing if manufacturer is using EU Type Approval data
  - Vehicle must also comply using CARB LEVIII fuel
  - CARB confirmatory and compliance testing will be conducted using CARB LEVIII fuel
- Manufacturers may use CARB-specific test data (not from EU Type Approval)
  - CARB LEV III fuel is required unless using EU Type Approval test data
  - Testing need not be witnessed by an EU Technical Services representative

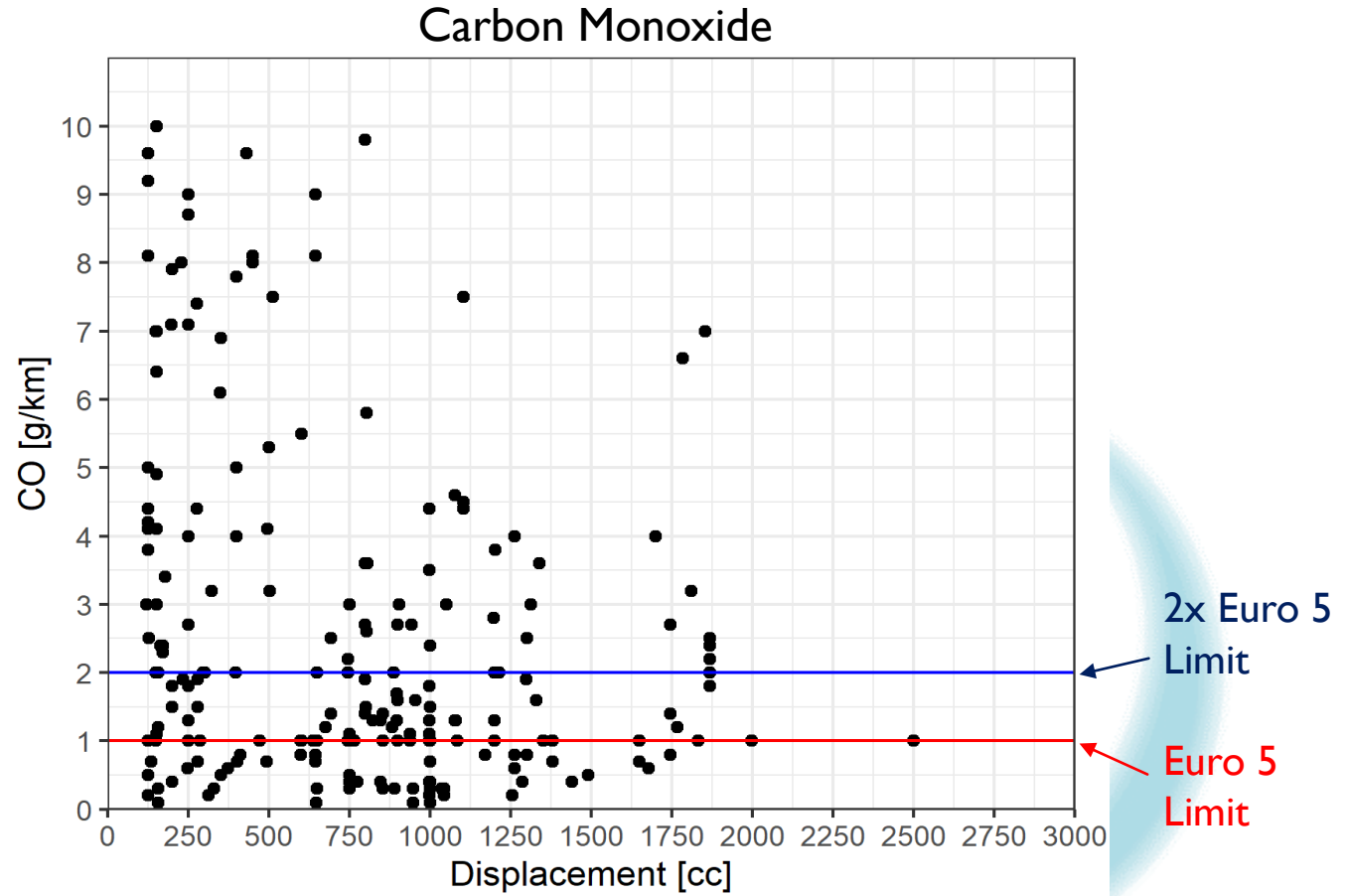
# REGULATORY PROPOSAL – EXHAUST FOR SMALL DISPLACEMENT BIKES

- MY 2024+: CARB will certify Class IA bikes (<50cc)
  - CARB currently defers regulations of Class IA bikes to U.S. EPA
  - Must meet Euro 5 exhaust and evaporative requirements
- Exhaust testing must be done using the phases of the WMTC prescribed in Euro 5 regulations, except as follows:
  - Bikes with displacement between 50cc and 150cc, and max speed of > 85km/h, shall use WMTC Subclass 2-1 (max speed 82.5 km/h) instead of Subclass 1-3 (max speed 50 km/h)
    - Ensures that the WMTC is equally stringent to FTP for all motorcycle classes
- Regulation will include procedure for determining max speed
  - Max Speed determination will only be required when using lower speed variants of WMTC

# HC AND CO CERT LEVELS FOR ALL 2020 CARB ONMC ENGINE



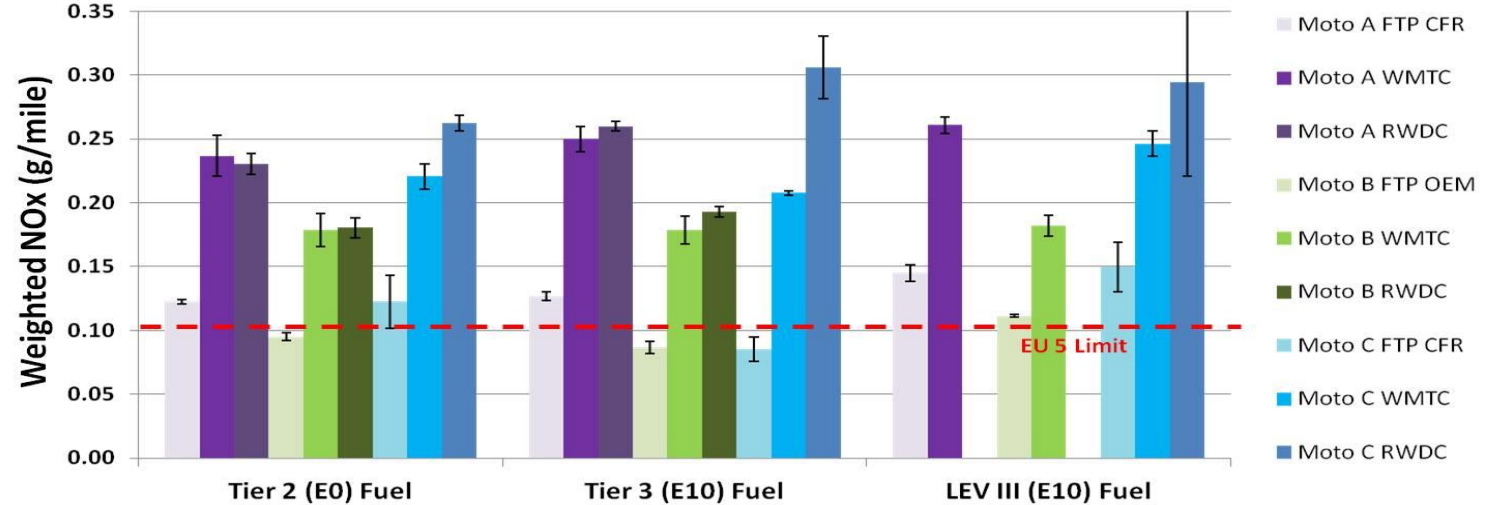
38.6% are at or below 0.10 g/km HC  
60.1% are at or below 0.20 g/km HC



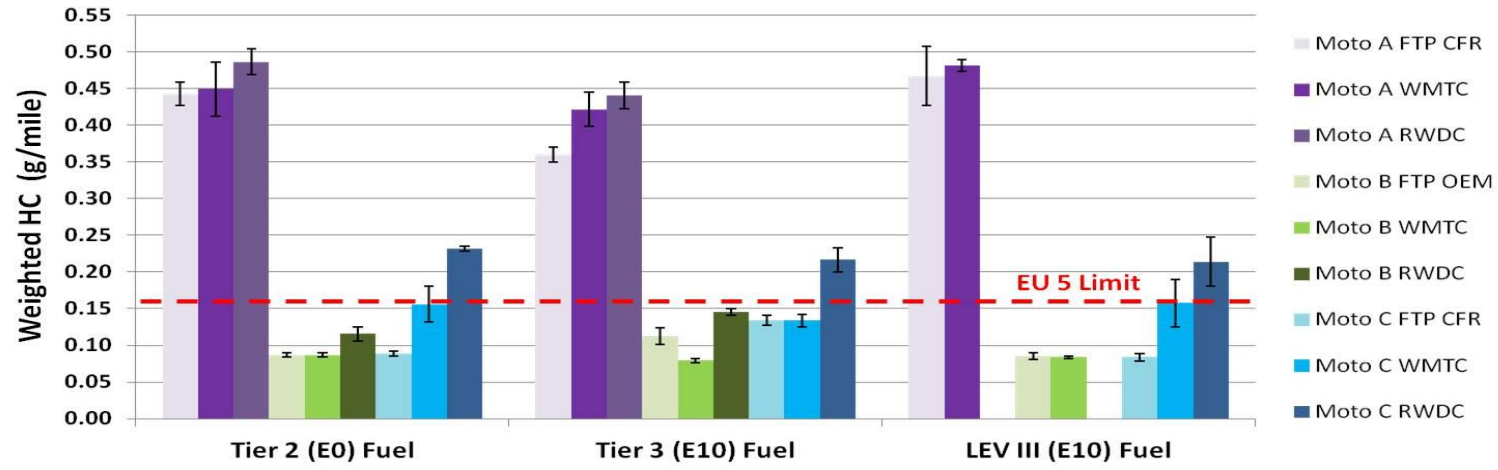
40.4% are at or below 1.0 g/km CO  
62.3% are at or below 2.0 g/km CO

# ECCC DATA SHOWING THE EFFECT OF TEST FUELS ON EMISSIONS

**NOx Emissions for Tier 2, Tier 3 and LEV III Fuels**



**HC Emissions for Tier 2, Tier 3 and LEV III Fuels**





# REGULATORY PROPOSAL – OBD

- MY 2023 - 50% of all Class III sales must meet Euro 5 OBD requirements
- MY 2024-25 - All Class III sales must meet Euro 5 OBD requirements
- MY 2026+ - Class III sales must meet Euro 5 OBD plus additional CARB-specific requirements:
  - Evap system, cold start, crank case ventilation, fuel system, engine cooling, and variable valve timing based on CARB LDV
  - OBD faults that indicate catalyst removal must limit vehicle speed, prompting owners to make timely repair
- OBD certification based on Euro 5 requirements
  - Manufacturers may use their EU OBD test results if OBD system has Euro 5 Type Approval
  - EU Type Approval for OBD will be accepted by CARB
  - CARB staff will review/approve the additional CARB-specific requirements

# CARB-SPECIFIC OBD REQUIREMENTS

Monitor	Comments
Evaporative System Monitoring	CARB will require detection of fuel system leaks (0.20” orifice) and comprehensive evaporative component monitoring.
Cold Start Emission Reduction Strategy Monitoring	If a vehicle incorporates a specific engine control strategy to reduce cold start emissions, the OBD system shall monitor the commanded elements/components for proper function.
Crankcase Ventilation Monitoring	Manufacturers shall monitor the CV system on vehicles so-equipped for system integrity.
Engine Cooling System Monitoring	The OBD system shall monitor the thermostat on vehicles so-equipped for proper operation. The OBD system shall monitor the engine coolant temperature (ECT) sensor for circuit continuity, out-of-range values, and rationality faults.
Variable Valve Timing (VVT) Monitoring	The OBD system shall monitor the VVT system on vehicles so-equipped for target error and slow response malfunctions.
Fuel System Monitoring	The OBD system shall monitor the fuel delivery system to determine its ability to comply with applicable standards

Refer to CARB LDV OBD requirements – [CCR, Title 13, section 1968.2](#) for additional details

# CATALYST REMOVAL

- Starting in 2026, OBD system must detect catalyst removal and reduce vehicle max speed to 40 mph
  - Discourages tampering, encourages prompt correction
  - Applies only to catalyst removal, not degradation of catalyst over time
- Once the OBD system identifies missing catalyst:
  - Speed reduction triggered after no more than 10 engine starts, 500 miles driven, or 10 hours of driving time
  - Once triggered, vehicle max speed will be limited until corrected and cleared
- Manufacturer may de-rate power or max speed stepwise prior to reaching CARB limits
  - To ensure rider safety, manufacturers should provide adequate warning of impending speed reduction

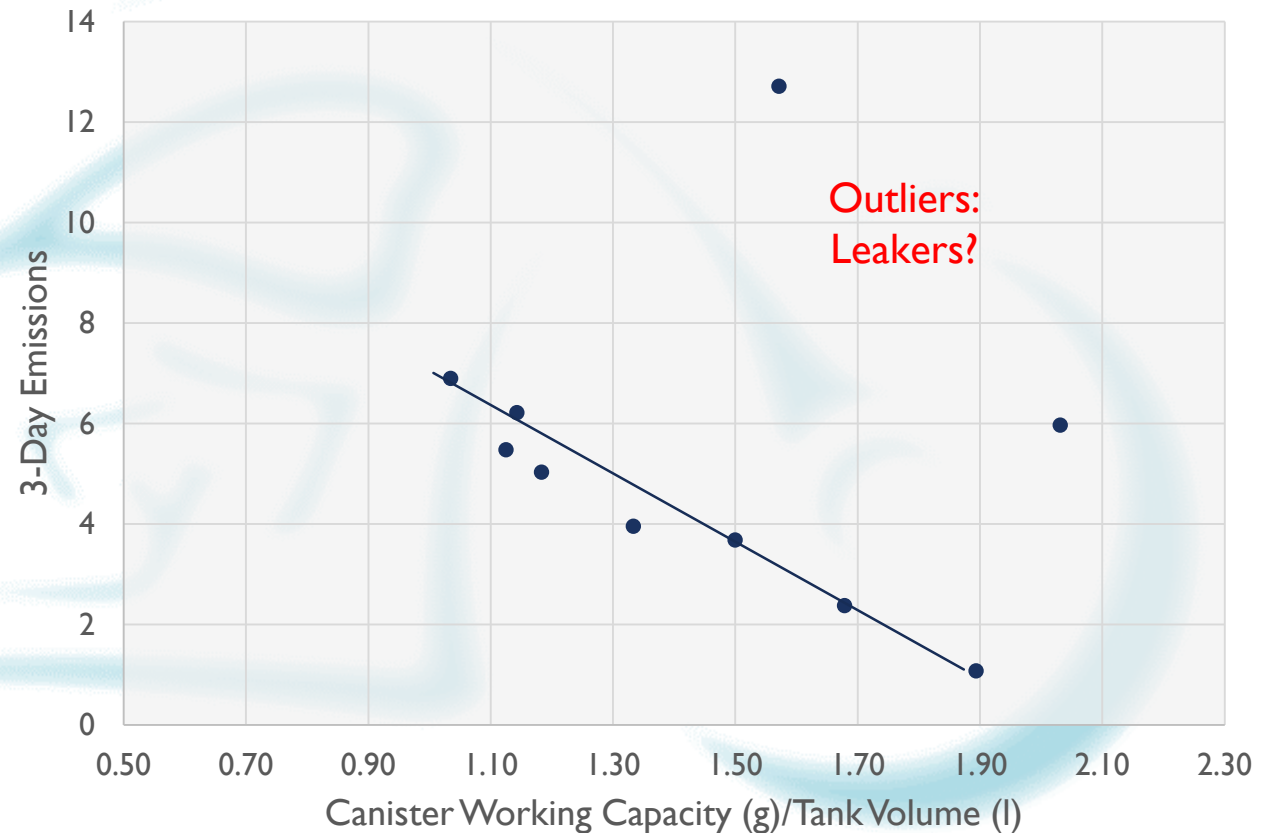
# REGULATORY PROPOSAL – EVAPORATIVE CONTROLS

- MY 2023-2024: All motorcycles must meet either Euro 5 or current CARB evaporative system requirements
- MY 2025-26: All motorcycles must meet either Euro 5 or current CARB evaporative system requirements, plus additional evaporative component performance specifications
  - U.S. EPA tank and hose permeation requirements
  - Minimum ratio requirement for carbon canister working capacity to fuel tank volume
  - Maximum carbon canister bleed emissions
- MY 2027+: All motorcycles must meet diurnal SHED standard
  - SHED test protocol based on CARB TP-933 and LDV requirements

# EVAPORATIVE COMPONENT REQUIREMENTS

- CARB inventory testing showed strong correlation between emissions and canister working capacity / fuel tank volume
- Working with MECA and US EPA to develop ONMC evap canister performance standards
- May require improved canister design, but no other changes to approved Euro 5 models

Canister Working Capacity/Tank Size vs. Total 3-Day Emissions



# DEVELOPMENT OF SHED TEST PROTOCOL

- Manufacturers and CARB staff have identified potential for improvement to TP-933
- CARB will work with U.S. EPA and stakeholders to develop appropriate ONMC SHED test protocol
  - Vehicle prep procedure, temperature profile, test duration, pass/fail criteria
- Goal is to develop a test protocol that can become 50-state requirement if EPA updates their ONMC regulations



# REGULATORY PROPOSAL - DURABILITY

- MY 2023-2024 – Durability demonstration must be conducted per either Euro 5 or current CARB requirements
  - Manufacturers using EU durability demonstration protocol must also use EU useful life distance
  - Manufacturers using catalyst bench aging option will be required to conduct in-use verification

Durability Method	Current CARB	Current EU	EU 2024+	CARB 2025+
Full Mileage		X	X	X
Partial Mileage	X	X	X	X
Bench Aging		X	X	X
Mathematical (fixed)		X		

# PROPOSED INCREASE TO USEFUL LIFE MILEAGE

- MY 2025+ - All **NEW** engine families are subject to increased useful life distance

CARB/EPA Class	Most Common Comparable EU Class	Current EPA/CARB Distance (kilometers)	Current Euro 5 Distance (kilometers)	Proposed CARB Distance for MY 2025+ (kilometers)	% Increase over current CARB/EPA Distance
IA (<50cc)	L1e-B, L2e	6,000	5,500	6,000	0%
IB (50-169 cc)	L3e-A1	12,000	11,000	15,000	25%
II (170-279 cc)	L3e-A2	18,000	20,000	25,000	38.8%
III (279+ cc)	L3e-A3	30,000	35,000	50,000	66.6%

- Median age of motorcycles dropping from DMV registration = 18.5 years
- Median age of motorcycles with 50,000km = 10.5 years\*

\* 2017 NHTSA Motorcycle Safety Survey

# IN-USE VERIFICATION PROGRAM

- In-use verification program (IUVP) will be based on current CARB Light-Duty Vehicle (LDV) requirements
- Testing will be required on Class III motorcycles certified using catalyst bench aging
  - Applicable only to engine families with yearly sales of 300 or more units in California
- Testing done on four motorcycles per engine family
  - All test motorcycles must have a minimum 15,000 km
  - At least one motorcycle in each test group have a minimum of 22,500 km (75% of useful life)
  - Program will be based on current CARB LDV requirements

# DURABILITY FOR EVAPORATIVE EMISSIONS SYSTEMS

- If manufacturers do not conduct full or partial mileage durability demonstration, evaporative component durability must be established



Fuel Tank

- Slosh testing
- Pressure / vacuum cycling
- Thermal cycling
- UV exposure
- Fuel cap cycling



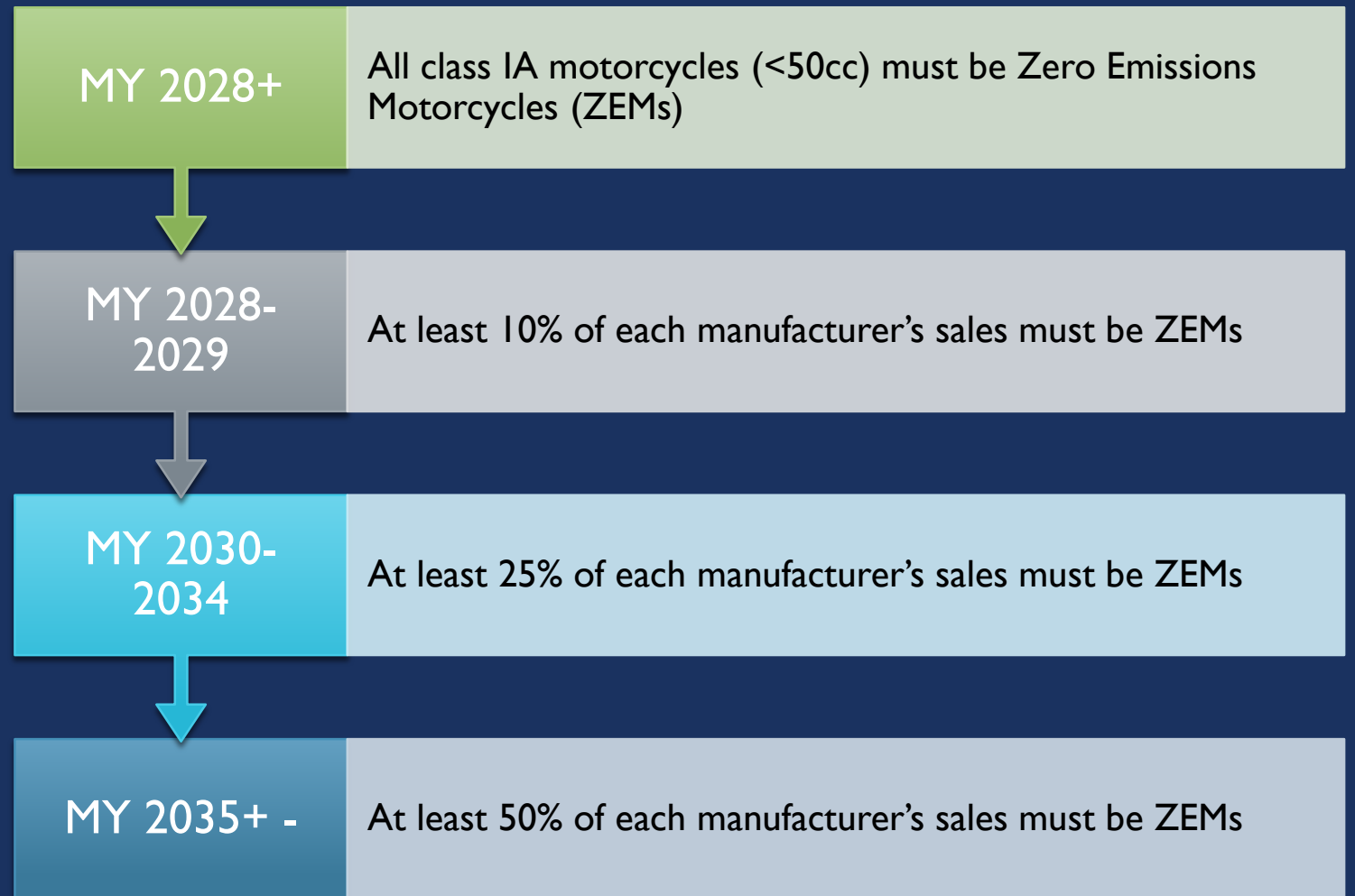
Carbon Canister

- Vibration exposure
- Thermal cycling
- Dust
- UV exposure

# PROPOSED CERTIFICATION PROCESS

- CARB Executive Order required for all new motorcycles sold in California
- Application process based on current CARB requirements
- Submit all required test data and supporting documentation to CARB for review
- EU Type Approval documents may be submitted when applicable
  - EU Type Approval does not guarantee CARB certification
- Data that cannot be submitted via EPA's EV-CIS system must be submitted electronically to CARB

# REGULATORY PROPOSAL – TRANSITION TO ZERO EMISSIONS



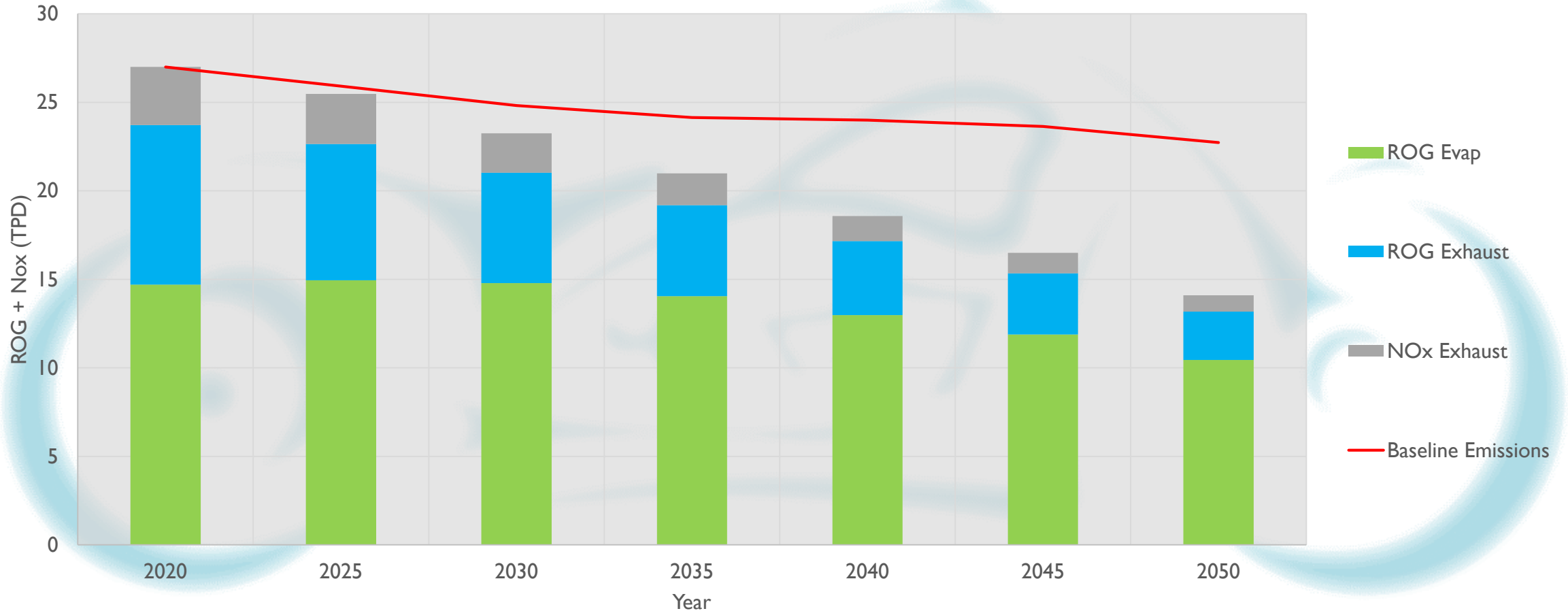


# ZEM CREDITS AND CERTIFICATION REQUIREMENTS

- Manufacturers may trade ZEM credits
  - CARB staff will work with stakeholders to set appropriate credit value for ZEMs with performance equivalent to small displacement motorcycles
- ZEMs must be certified by CARB
  - Basic performance demonstration, similar to current requirements for CVRP program
  - Basic durability requirements
  - Labeling, warranty, and administrative requirements
- ZEM program will be modeled after CARB LDV ZEV requirements
  - [CCR, Title 13, sec 1962.2](#)

# PRELIMINARY ESTIMATED BENEFITS OF REGULATORY PROPOSAL

Baseline ROG + NOx with Projected Reductions\*



\*Reductions are understated in that a ROG evaporative standard has not yet been determined from which to estimate complete emissions reductions.

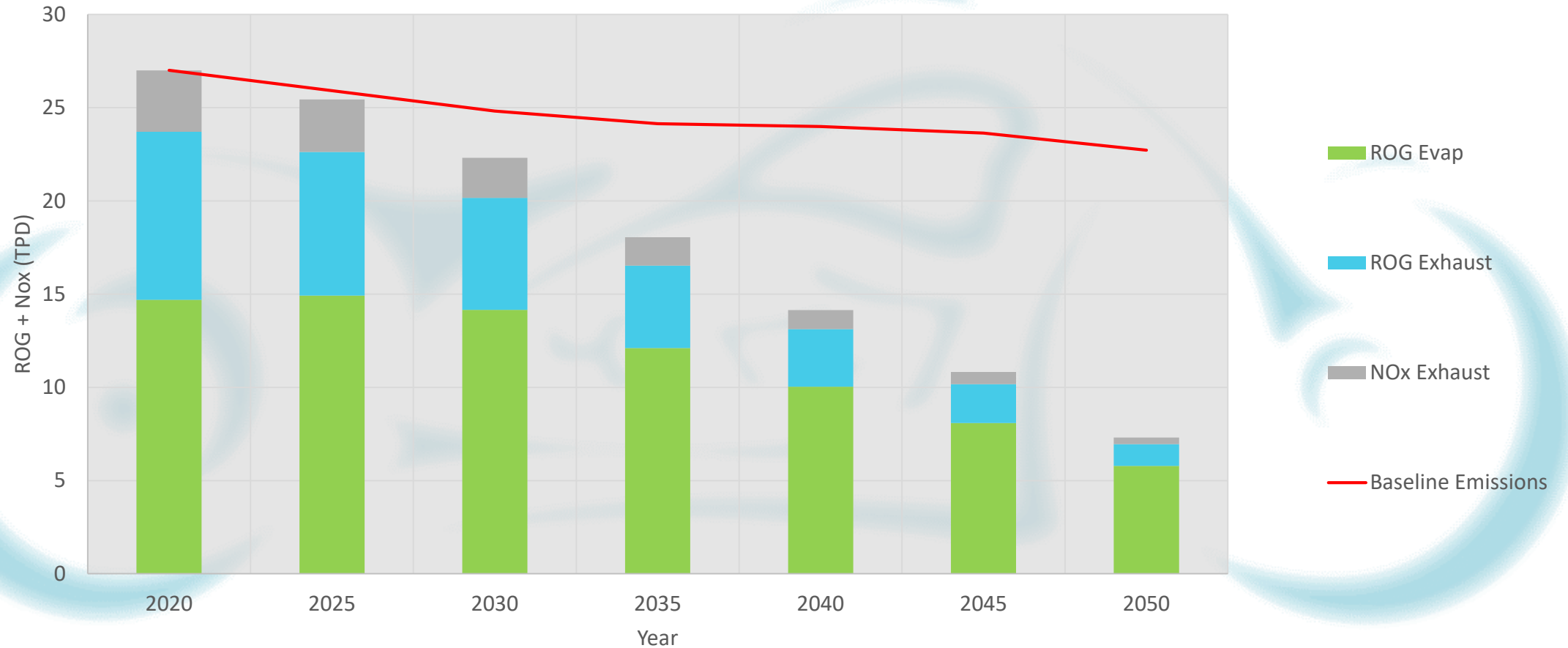
# CARB IS UPDATING THE MOBILE SOURCE STRATEGY (MSS)

- MSS outlines trajectories needed in all mobile sectors to meet air quality and climate goals, including significant reductions from ONMC
- Meets SB 44 requirements & incorporates Governor's EO direction
- Staff have considered a scenario that significantly reduce criteria and greenhouse gas emissions from motorcycles
- Proposed 2020 MSS assumes 100% ONMC new sales to be ZEVs in 2035
  - Consistent with other vehicle categories, but more aggressive than regulatory concepts being proposed today

<https://ww2.arb.ca.gov/resources/documents/2020-mobile-source-strategy>

# PRELIMINARY ESTIMATED BENEFITS OF MSS PROPOSAL

## Baseline ROG + NOx with Projected Reductions



# ESTIMATED TIMELINE



# BEYOND CARB'S 2021 RULEMAKING...

- U.S. EPA staff is following CARB and UN rule development, and will re-evaluate motorcycle regulations in Spring 2021
  - CARB staff will support and coordinate with U.S. EPA in any future federal ONMC regulations
- Develop real world driving standards or “not to exceed” limits
  - Based on on-road emissions using miniature PEMS
  - Requires development of mini-PEMS standards, and protocols for collecting on-road data
- Increased confirmatory and compliance testing at new Riverside lab
- Statewide Smog Check program for motorcycles
  - Reduce tampering and ensure real world emissions benefits
- Look for additional opportunities to advance the ZEV motorcycle market
  - Close the gap between staff’s regulatory proposal and the 2020 MSS scenario



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# SURVEY COST RESULTS

- In May 2020, CARB sent out a survey requesting manufacturers to participate in a survey to identify regulatory costs
  - At that time, the focus of the proposal was on harmonization with Euro 5
- Useful responses were received from manufacturers representing approximately 38% of the market for ONMCs sold in California
- The survey indicated that the cost due of improved parts for current CARB compliant bikes to meet Euro 5 standards would be approximately \$191
  - The most common items mentioned were improved catalyst and post catalyst O2 sensor

# NEW COST SURVEY REQUEST

- Since the May 2020 survey, there have been changes in the direction of the proposal to include:
  - Increased goals for ZEM sales
  - More stringent evaporative emissions standards
  - CARB regulation of Class Ia (< 50cc) motorcycles
  - Increased durability and California-specific OBD requirements
- To understand the cost of these additional requirements on stakeholders, CARB is requesting manufacturers answer this new survey
  - This survey will be emailed out to manufacturers in the coming days
  - This survey is an additional opportunity to answer Euro 5 harmonization questions from the May 2020 survey

# REQUEST FOR ALTERNATIVES

- CARB welcomes public input on alternatives to the proposed regulatory concepts discussed in this workshop
- Proposed alternatives should:
  - Yield the same or greater benefits than those associated with the proposed concepts
  - Achieve the goals at equivalent or lower cost
  - Include associated cost/benefit information, methodology and data sources to enable comparison of economic impacts
- Please submit alternatives by **December 3, 2020**
  - Submit via email to [Jason.mcphee@arb.ca.gov](mailto:Jason.mcphee@arb.ca.gov)



# CONTACTS AND QUESTIONS

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