CALIFORNIA
AIR RESOURCES BOARD

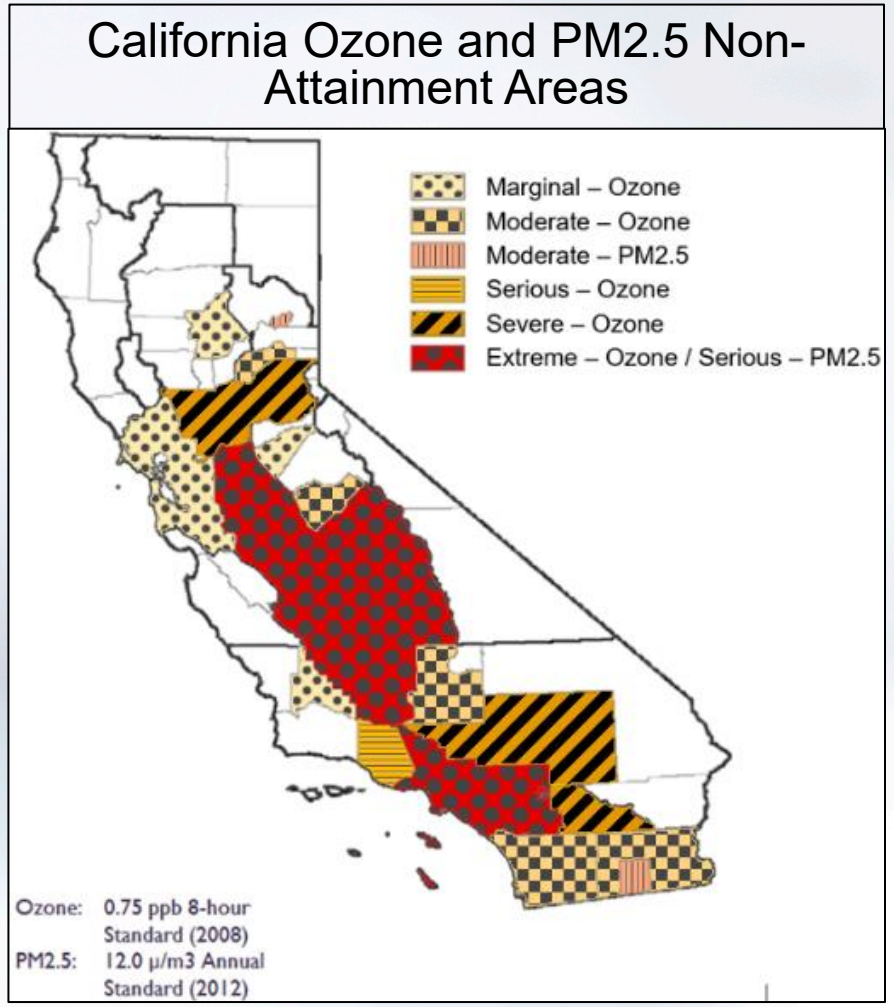
Clean Technology Adoption in Off-Road Sector

2022 AQMP Mobile Source Working Group

April 7, 2021

Major NOx and $PM_{2.5}$ Emission Reductions Needed

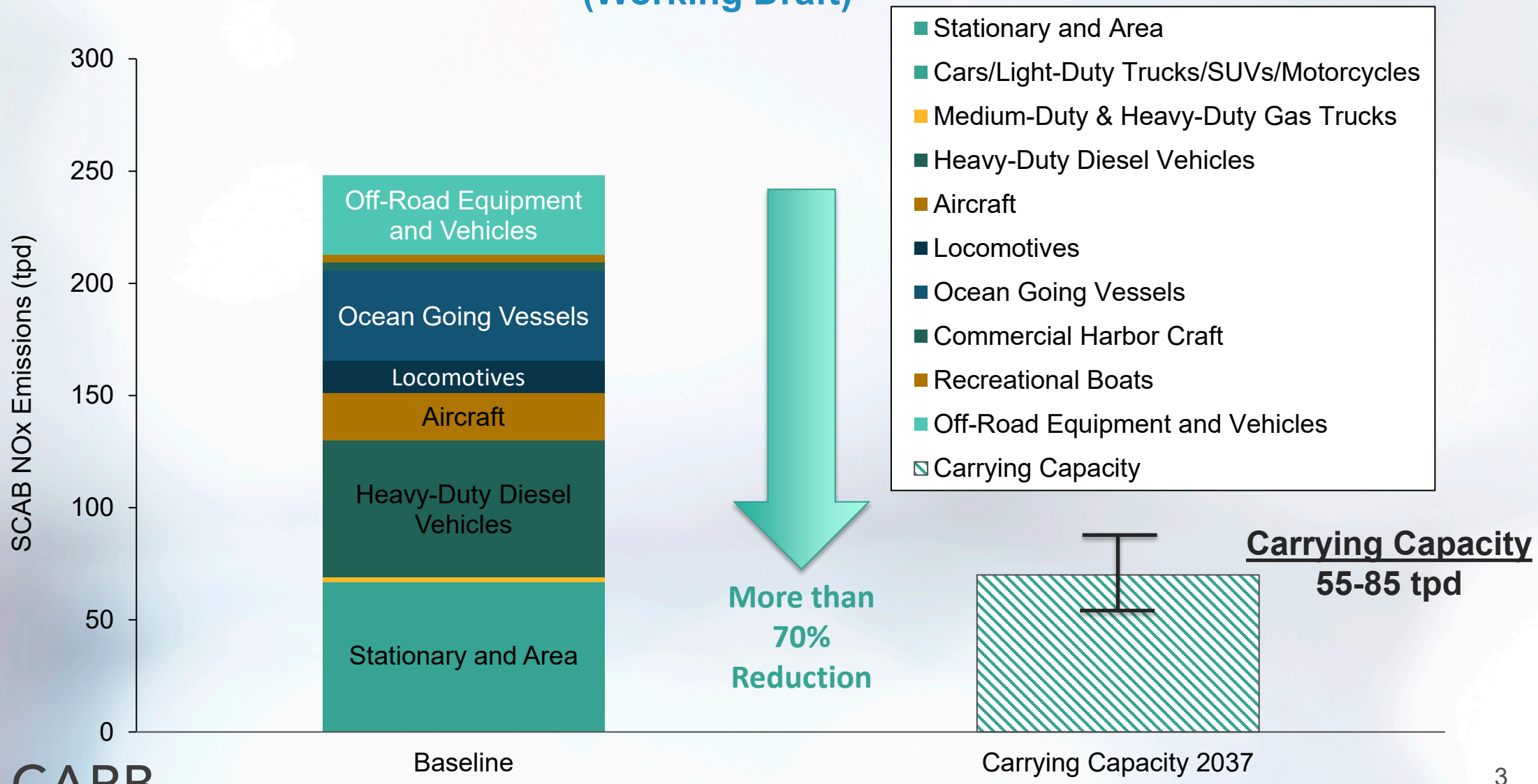
- California has the worst air quality in the nation
- Key challenges
  - San Joaquin Valley – PM2.5
  - South Coast - Ozone
- Off-road equipment are one of the largest contributors
- Actions beyond current programs needed to meet air quality goals in various regions



CARB

South Coast 2037 Attainment

(Working Draft)



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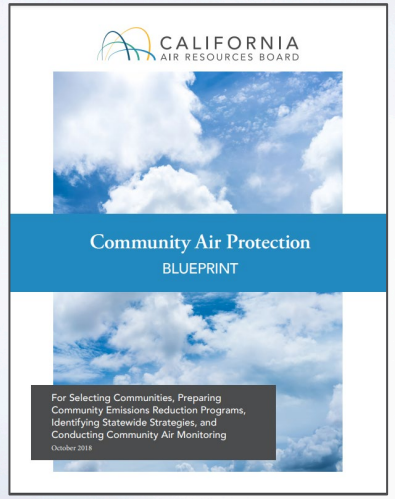
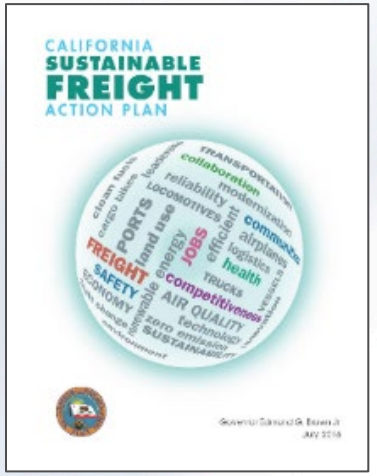
Disadvantaged Community Focus

- Assembly Bill 617 directs CARB to identify community level strategies
- Communities seek rapid transition to zero-emissions

Zero-Emission Key to California's Future

- Multiple criteria, air toxics, and climate pollutant emissions reduction plans
- Core strategies
  - Zero-emissions everywhere feasible
  - Cleaner fuels and cleaner combustion everywhere else





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Executive Order N-79-20

Full transition to
ZE off-road equipment
by 2035*
*where feasible

100% ZEV sales by 2035

Full transition to
ZEV short-haul/drayage trucks
by 2035

Full transition to **ZEV buses** &
heavy-duty long-haul trucks
by 2045*

Transition of all off-road equipment operations to zero-emission where feasible by 2035

Strategies, in coordination with other State agencies, U.S. Environmental Protection Agency and local air districts, to achieve 100 percent zero-emission from off-road vehicles and equipment operations in the State by 2035.

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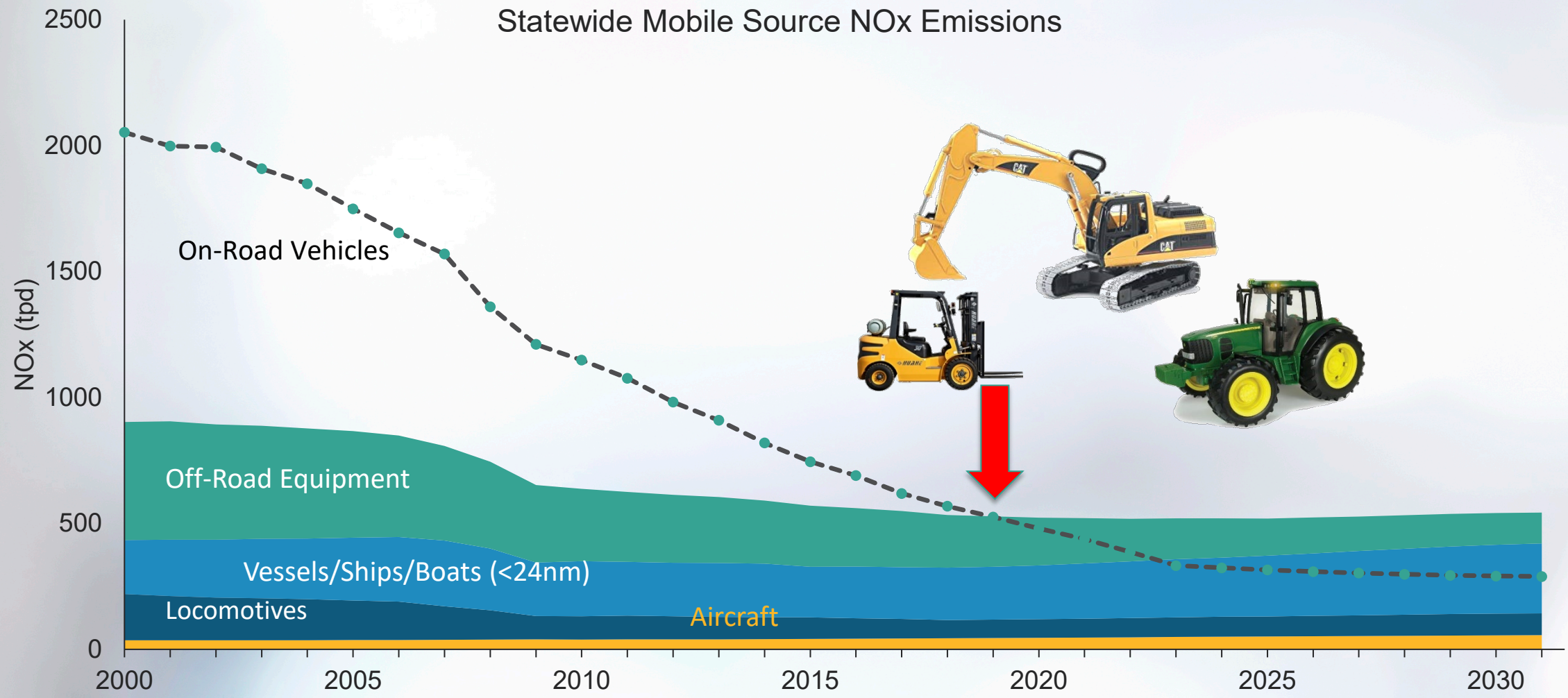
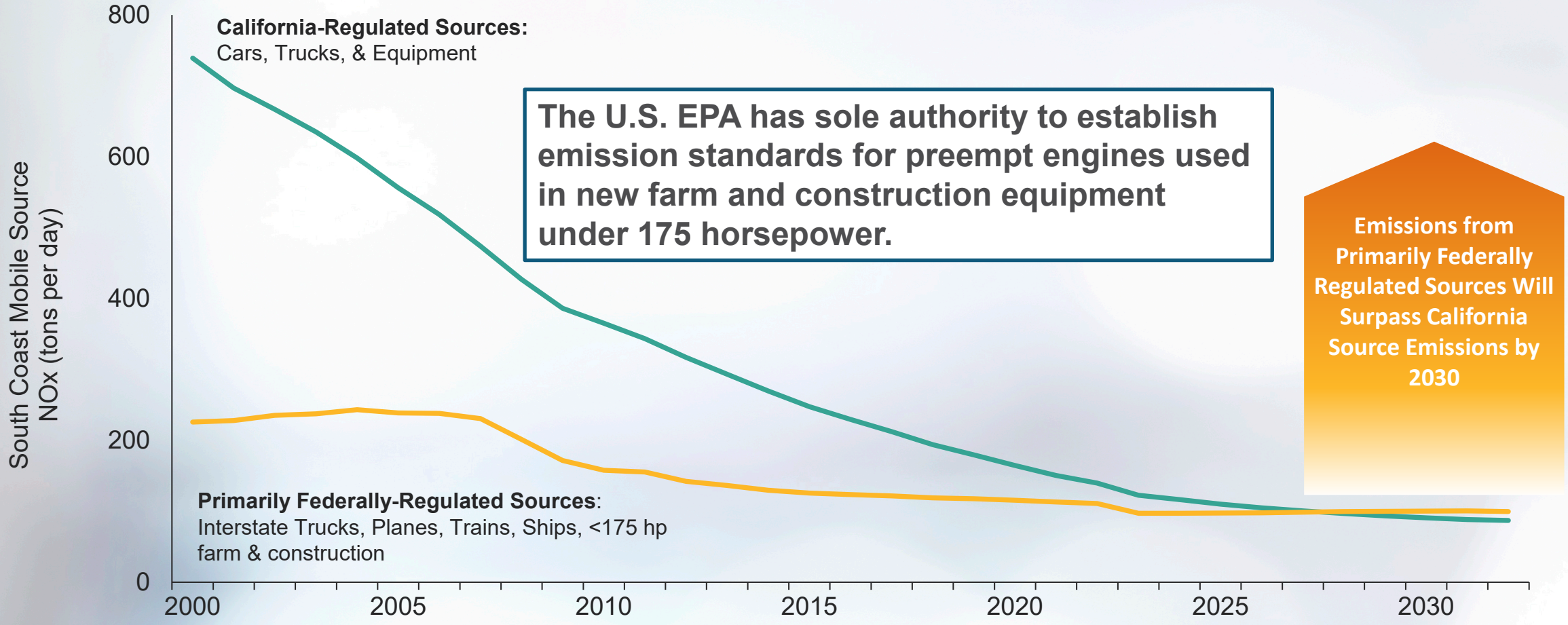
Growing Importance of Off-Road



CARB

Ref: CEPAM 2019 Summer

Controlling Federal Sources is Critical to Achieving our Clean Air and Climate Targets



Source: CARB, CEPAM 2016 SIP - Standard Emission Tool (v1.05), https://www.arb.ca.gov/app/emsinv/fcemssumcat/fcemssumcat2016.php

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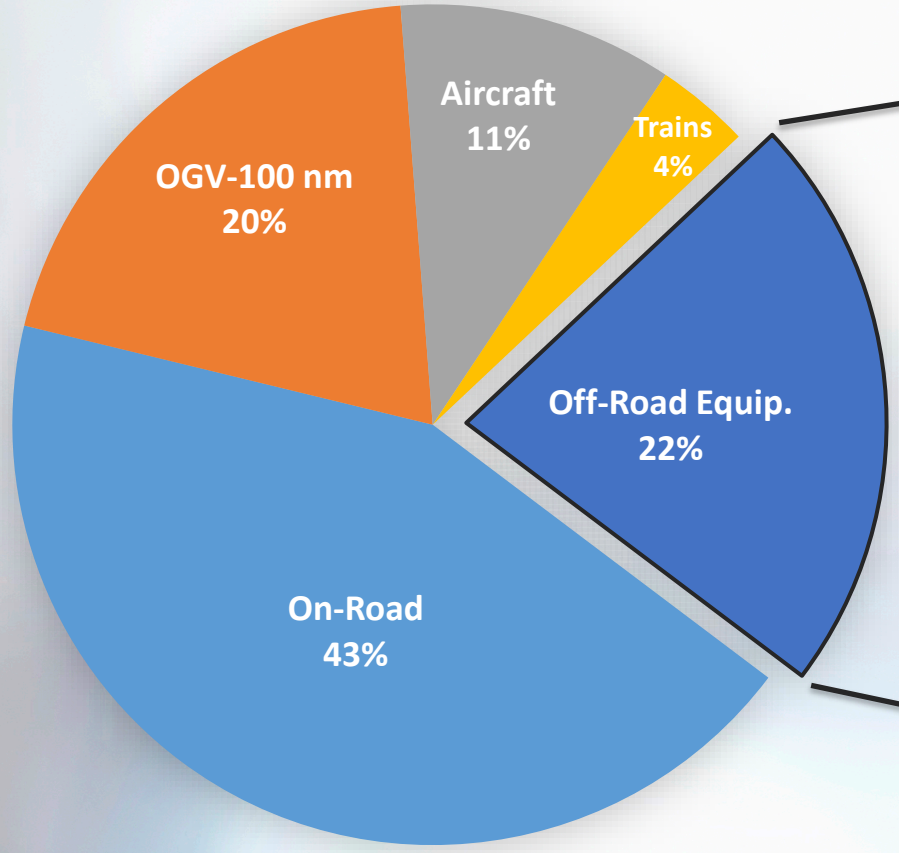
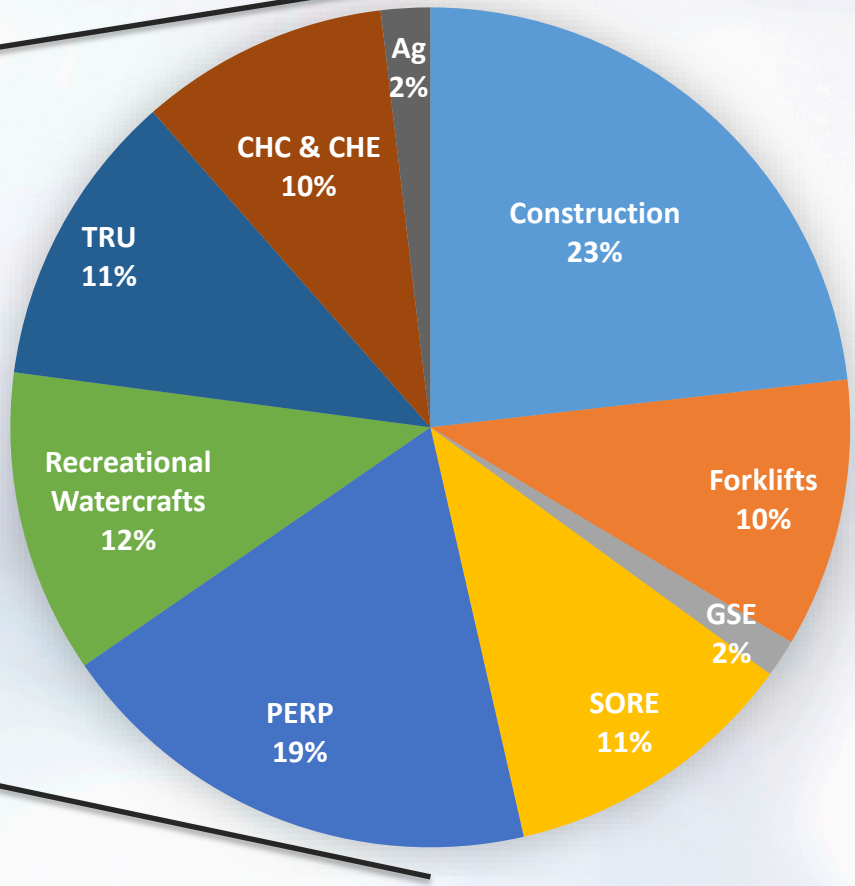
Off-Road NOx Emission Contribution

Mobile Source NOx emissions in SC in 2037



Off-Road Equipment NOx emissions in SC in 2037



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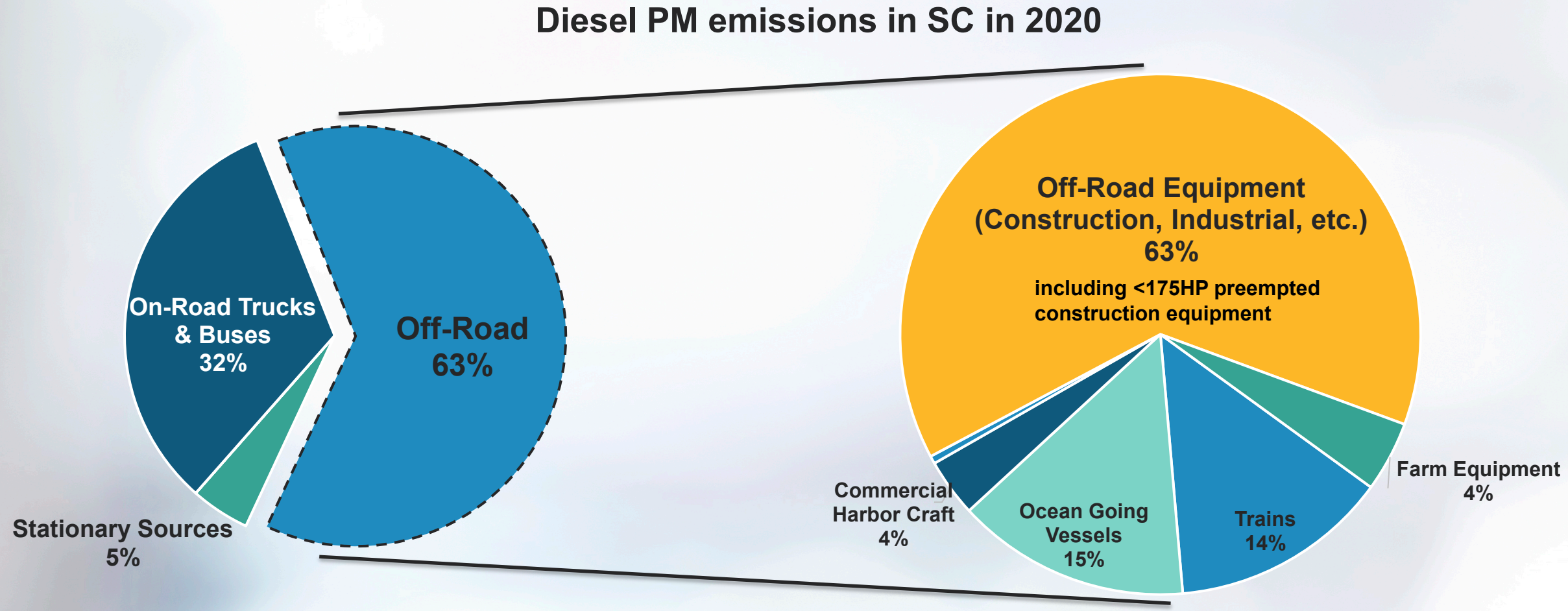
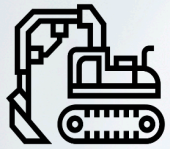
Off-Road Diesel PM Emission Contribution



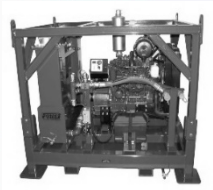
Zero-Emission Technology



Low HP Construction & Agricultural equipment

- Most current commercialized electric equipment are under 150 HP
- Mobile battery solutions may play key role in solving infrastructure limits
- Under 100 hp tractors and forklifts have potential for electrification
- Federal preemption to set emission standards for preempt engines used in new farm and construction equipment under 175 horsepower.

Portable equipment

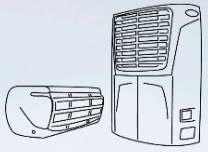


- Portable diesel-fueled engines with a rated brake horsepower of 50 and greater (≥ 50 bhp)
- Fuel cells have shown long term potential, additional research and demos needed

Cargo Handing Equipment

- Electric Top-pick and yard tractors at ports and intermodal railyards
- Battery electric forklifts
- Hydrogen fuel cell forklifts show potential as well

TRUs



- In-use emission regulation
- Full electrification of truck TRUs by 2034 (regulatory proposal)
- Full electrification of trailer TRUs (2020 MSS proposal)

Hybridization

OGVs

- Demo hybrid auxiliary engine
- If we include hybrid auto carrier and Roro vessels, the OGV sector has a potential to reduce diesel use by 35%

- Clean Off-Road Equipment Voucher Incentive Project
- Hybrid RTG cranes offer 40% fuel savings

Locomotives

- Demonstration projects for fuel cell-powered line-haul and switcher locomotives in 2025
- Battery electric demo starts in 2021 (switcher) and 2022 (line haul)
- SBCTA Fuel-cell MU passenger locomotive demo in 2022
- Caltrans aims to reduce 35% of the total fuel usage per passenger train mile by 2030

CHCs

- Hybrid Tug, Ferry, and Excursion units comprise 49% of the total diesel consumption of the sector
  - In-use short run ferries become zero-emission by 2028 (9% of ferries)
- Potential for all tugs to go to diesel-electric (~20% efficiency gain) by 2030, all excursion vessels go to plug-in hybrid by 2030

Construction & Agricultural Equipment

- Many construction and agricultural demo cases have shown common hybrid modules used with a similar range of horsepower
- On average, 25% of efficiency improvement due to hybridization
- 400 ~ 600 hp construction and agricultural equipment types may find interim solution in hybridization

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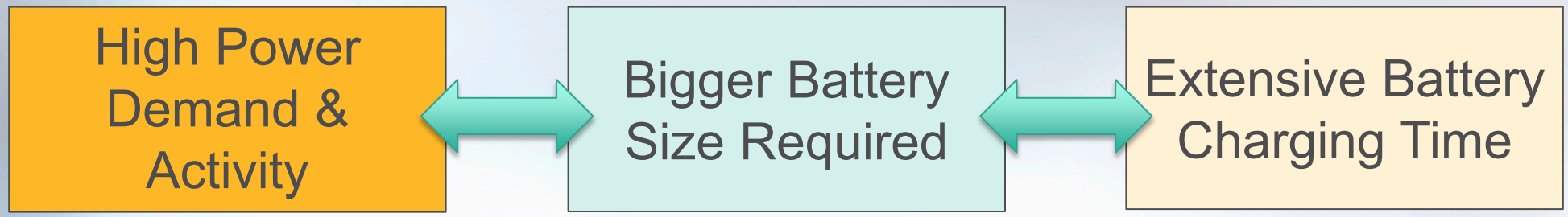
Key Technical Barriers for Off-Road Electrification

- Pace of commercialization
  - Technology readily available
  - Some equipment types commercially available, others in demonstration phase
- Limited access to charging infrastructure
- Operational limitations



Existing Market Potential for Zero-Emission Construction Equipment

- Various construction equipment types have demonstrated a high potential of clean technology adoption according to previous and on-going demo projects.
- Similar horsepower ranges to electrified on-road heavy-duty applications; some transferability of technologies
  - Semi-truck HP range: 400~600HP
  - 175 HP and lower CE types → higher electrification potential
- Additional demonstration projects for higher horsepower ranges are key

Hybrid Construction Equipment Demonstrations

Caterpillar's large hybrid excavator

- Caterpillar hybrid excavator (336F H, 2014)
- 30% fuel savings compared with the similarly sized baseline machine without hybrid technology.

Volvo CE's electric hybrid wheel loader

- Volvo Construction Equipment hybrid electric wheel loader (LX1, 2016)
- 50~55% fuel efficiency improvement
- 33~35% GHG emission reduction compared to Volvo CE's diesel-powered base model.

Examples of Zero Emissions Construction Equipment (1)

- PON/CAT Z-line 323F excavator
- Full battery electric
- 164 hp
- 300 kWh energy storage
- Units in service in Norway and Netherlands
- Purchasable today

https://www.pon-cat.com/no/pon-equipment/nyheter/z-line

Examples of Zero Emissions Construction Equipment (2)

- JCB 220X
- Hydrogen Fuel Cell 20 ton excavator prototype
- In proving grounds testing for >18 months

https://www.jcb.com/en-gb/news/2020/07/jcb-leads-the-way-with-first-hydrogen-fuelled-excavator

Examples of Zero Emissions Construction Equipment (3)

- Volvo EX02
- Fully electric compact excavator prototype
- 38 KWh energy storage
- Enough to operate the machine for eight hours in an intense application

https://www.volvoce.com/global/en/this-is-volvo-ce/what-we-believe-in/innovation/prototype-electric-excavator/

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Examples of Zero Emissions Construction Equipment (4)

- CASE Project Zeus Backhoe
- Battery powered electric backhoe
- 90 KWh energy storage
- Capable of typical 8hr workday
- Purchasable today

Link 1: https://www.constructionequipment.com/case-580-ev-fully-electric-backhoe-loader?oly_enc_id=8464A9098134D5C

Link 2: https://www.casece.com/northamerica/en-us/resources/articles/media-case-unveils-project-zeus-580ev-first-fully-electric-backhoe-loader

Examples of Zero Emissions Construction Equipment (5)

- Volvo L25
- Electric Compact Wheel Loader
- 39 KWh energy storage
- Enough to operate the machine for eight hours
- Expected charging time of 2 hours (Off board charging time 400 VAC 32A)

https://www.volvoce.com/united-states/en-us/products/electric-machines/l25-electric/#overview

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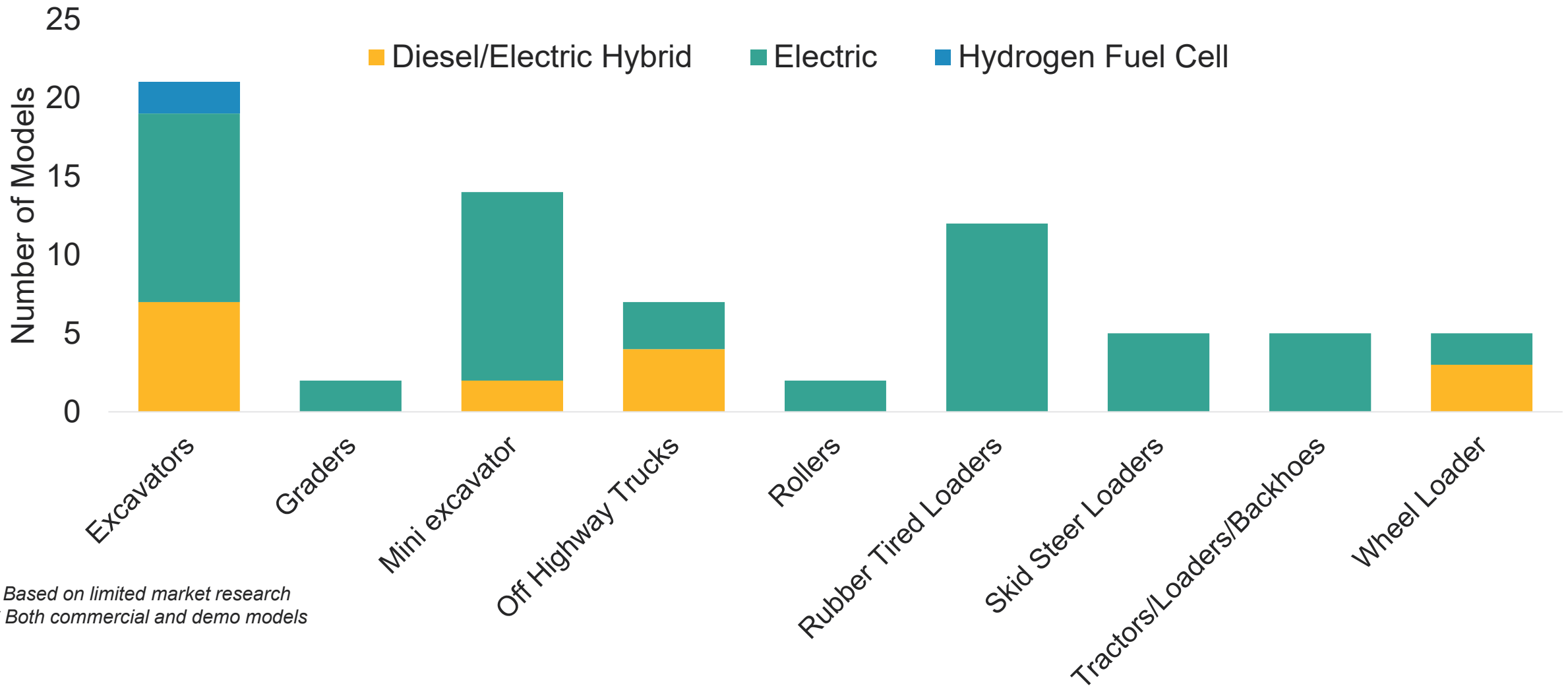
Current Technology Availability: Construction



* *Based on limited market research*
** *Both commercial and demo models*

Assessing Electrification and Hybridization Potential

Hybridization

- Current commercially available technologies and demonstration projects provide application horsepower ranges

Electrification

- Horsepower ranges of currently available commercial models and demos
- Review of current battery capacity and charging times
- Research on daily and maximum power use from different construction and off-road applications
- Determining where current battery technology could meet power requirements

AN EXAMPLE OF ELECTRIFICATION FEASIBILITY ASSESSMENT

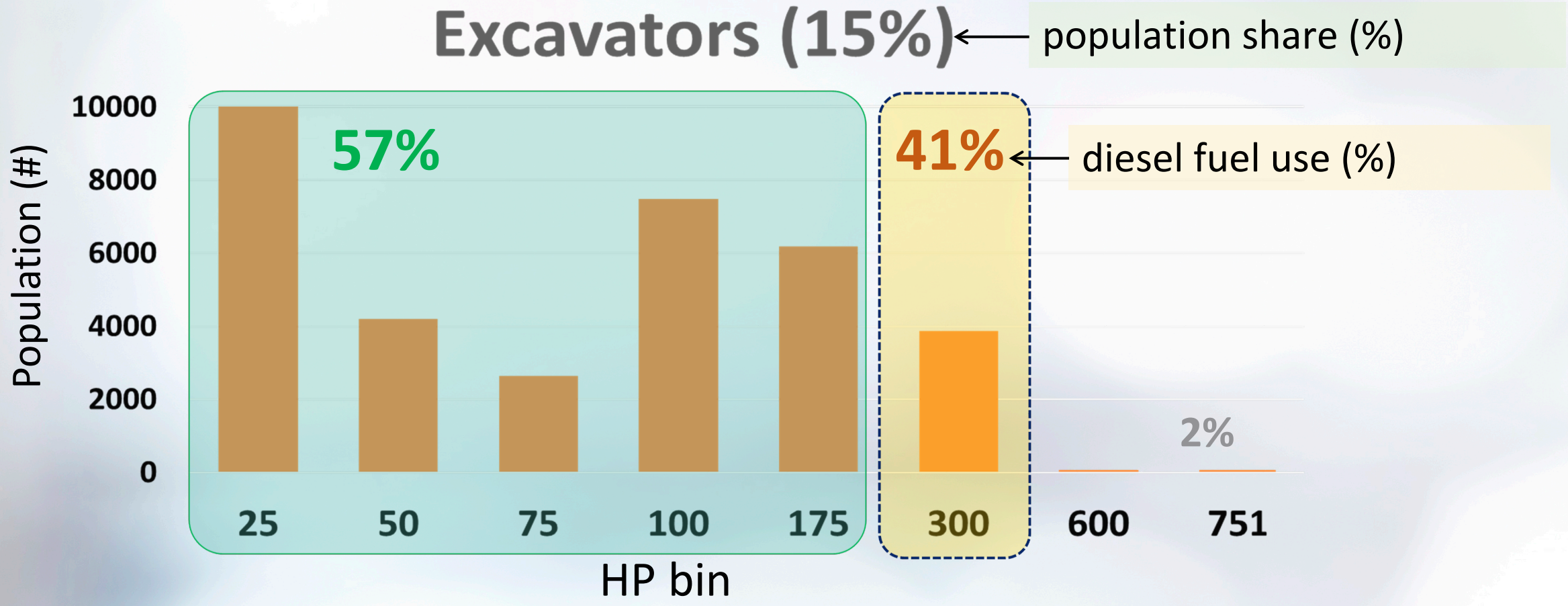
1. Assess power needs from ECU data, including peak power and daily energy use

Equipment Type	Equip. ID	HP Bin of the equipment	Total Operating Hours (hrs)	Mean Daily Fuel Use (gal/day)	Hours per Day
Excavator	3	175	256.1	20.21	1.75
Grader	4	300	13.3	0.98	0.15
Off-Highway Tractor	9	600	223.7	137.04	7.99

2. Determine battery size and charging times required to meet demand (in some cases, *current* technology has prohibitive battery size or charging needs for full electrification)

Equipment Type	Battery Size (kWh)		Charging Time with 50 kW Charger (Hour)	
	Minimum	Maximum	For Minimum Battery Size	For Maximum Battery Size
Excavator	387	420	8	8
Grader	54	60	1	1
Off-Highway Tractor	2,283	2,711	46	54

Horsepower Ranges for Existing Clean Technologies



HP ranges with higher **electrification** potential

HP ranges covered by **hybrid** CE demo projects

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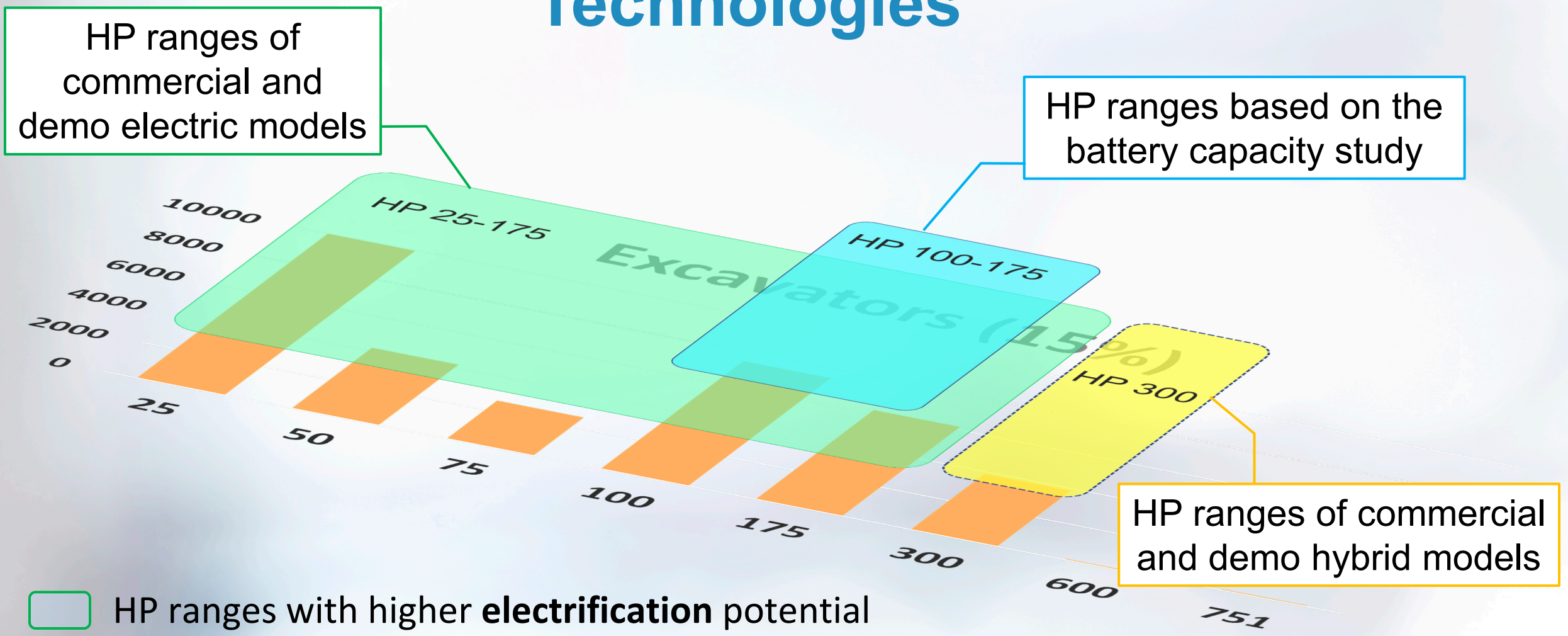
Horsepower Ranges for Existing Clean Technologies



HP ranges with higher **electrification** potential

HP ranges covered by **hybrid** CE demo projects

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Tractors/Loaders/Backhoes (24%)
Population (#)
30000
0
87%
9%
25 50 75 100 175 300 600 751
HP bin
Skid Steer Loaders (13%)
population share (%)
20000
0
0%
99%
diesel fuel use (%)
25 50 75 100 175 300 600 751
Excavators (15%)
10000
0
57%
41%
25 50 75 100 175 300 600 751
Rubber Tired Loaders (8%)
10000
0
28%
66%
3%
25 50 75 100 175 300 600 751
Graders (3%)
10000
0
32%
63%
25 50 75 100 175 300 600 751
Rough Terrain Forklifts (7%)
10000
0
79%
25 50 75 100 175 300 600 751
Off-Highway Trucks (2%)
10000
5000
0
5%
54%
15%
25 50 75 100 175 300 600 751
Rollers (6%)
10000
5000
0
22%
25 50 75 100 175 300 600 751
Scrapers (3%)
10000
5000
0
13%
25 50 75 100 175 300 600 751
HP ranges with higher electrification potential (identified by the battery capacity analysis)
Additional electrifiable HP range with multi-motor setup & higher charging power (150 or 200kW)
HP ranges covered by hybrid CE demo projects
Potentially electrifiable HP range (referred to electric CHE cases)

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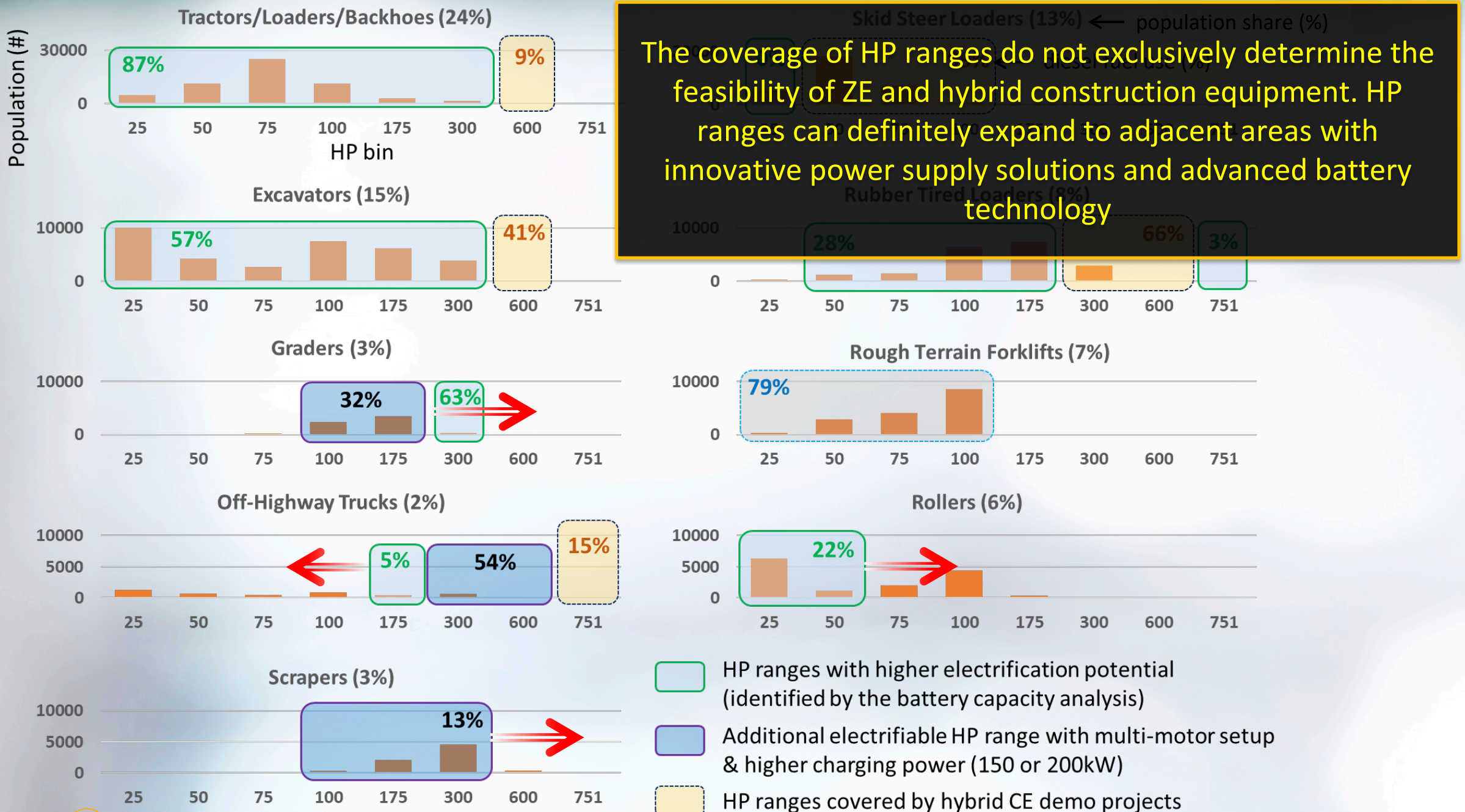

The coverage of HP ranges do not exclusively determine the feasibility of ZE and hybrid construction equipment. HP ranges can definitely expand to adjacent areas with innovative power supply solutions and advanced battery technology

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Potential Fuel Savings

Construction & Mining Equipment Type	Horsepower Range		Fuel Use by Segment (gpy)		Fuel Share (%)		Baseline Fuel Use (gpy)	Alt. Fuel Use (gpy)	Fuel Reduction (gpy)	% of Reduced Fuel Use
	Electrification	Hybridization	Electrification	Hybridization	**Elec.**	**Hybrid.**				
Crawler Tractors	-	-	-	-	**0%**	**0%**	15,853,308	15,853,308	-	0%
Excavators	25-300	600	16,332,089	11,607,735	**57%**	**41%**	28,525,577	3,487,686	25,037,891	88%
Graders	300 (100-175)	-	6,708,850		**95%**	**0%**	10,731,276	572,943	10,158,333	95%
Off-Highway Tractors	175 (300-600)	751 <	7,108,569	-	**59%**	**15%**	36,179,004	10,920,025	25,258,980	70%
Rollers	25-50	-	1,071,497	-	**22%**	**0%**	4,931,572	3,860,075	1,071,497	22%
Rough Terrain Forklifts	25-100	-	4,246,152	-	**79%**	**0%**	5,353,663	1,107,512	4,246,152	79%
Rubber Tired Loaders	50-175 & 751<	300-600	13,583,010	28,796,492	**31%**	**66%**	43,489,540	8,309,160	35,180,379	81%
Scrapers	(100-300)	-	-	-	**13%**	**0%**	28,325,209	24,659,142	3,666,067	13%
Skid Steer Loaders	25	50-100	-	5,111,444	**0%**	**99%**	5,185,890	1,352,307	3,833,583	74%
Tractors/Loaders/Backhoes	50-300	600 (300-600)	34,508,455	3,743,397	**87%**	**9%**	39,626,931	2,310,928	37,316,003	94%
Diesel use of the TOP 10 equipment types (gpy) (87% of the entire sector)							218,201,971	72,433,086	145,768,885	67%
Diesel use of the entire Construction and Mining sector (gpy)							251,421,757	105,652,873	145,768,885	58%

- If the entire population of the target segments are fully electrified or hybridized (i.e., by 2050), it is expected to achieve 58% fuel savings

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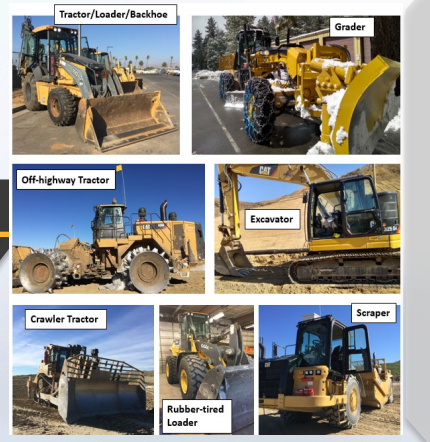
Need for Zero-Emission Infrastructure Planning

- A reliable infrastructure system is essential for zero emission technologies to achieve widespread growth
- Infrastructure needs, charging standards/connections, and power capacity needs vary widely, and are under various stages of development by source category
- In some off-road applications such as construction or agriculture, access to the grid may be nonexistent
- Innovative solutions are needed to overcome these barriers: mobile and ground power units
- Collaborate and engage facilities, utilities, and other agencies in zero-emission planning discussions

Mobile Battery Solution for Construction Equipment

- Much of the equipment is too heavy to make re-charging trips every day
- Various construction sites may not have stationary power supply
- Mobile batteries provide on-site charging solutions
- 7 mobile and ground power units are available through CORE

Charging station



Work-zone

Mobile battery pack on wheels

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Potential Mobile Power Supply Solutions

- Portable hydrogen fuel cell power generator
- Charging service van
- Portable off grid solar chargers
- Efficient fast charging strategy for peak-shaving in a limited grid connection condition
- Battery and tank swapping technologies

The Olav Vs Gate construction site in Oslo, Norway, is a zero-emissions project with ZERON ZE85US (9t) and ZE160LC (17.5t) electrified excavators built by NASTA AS. Courtesy of NASTA AS

CARB

Potential Strategies

Voucher Incentives for Clean Off-road Equipment

Expand eligibility for voucher incentives through Clean Off-Road Equipment. Funding for zero-emission off-road construction equipment.

Zero-Emission Forklift Requirements

(Board Date: 2022)

In-Use Requirements for forklifts to transition to zero emissions. Zero emissions equipment is option for replacement.

In-Use Off-Road Diesel Vehicle Amendments

(Potential Board Date: 2023)

Focused on phasing out Tier 0 to Tier 2 equipment

Potential Strategies (continued)

Green Fleet Recognition Program

(Action by: 2025)

Voluntary program for recognition of cleanest fleets, with an emphasis on zero emissions. Would allow public agencies and partnerships to choose fleets with minimal environmental impact.

Off-Road Tier 5 Engine Standards

(Potential Board Date: 2024)

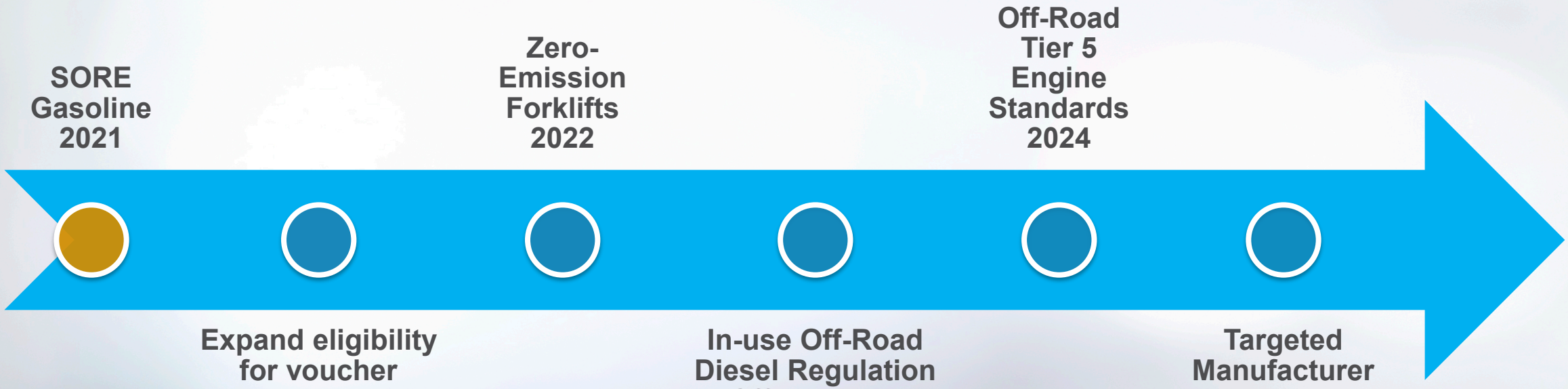
New NOx, PM, and GHG standards, and considering off-road diesel OBD requirements. May include powertrain certification, and/or credits.

Targeted Zero-Emission Off-Road Equipment Production

(Potential Board Date: 2025)

Manufacturer requirements for production of zero-emission off-road equipment. Sales/production mandate levels based on the projected feasibility of zero-emission technology in the various off-road equipment types.

Strategies Timeline



Questions, Comments, Feedback

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Los Angeles County
Metropolitan Transportation Authority

Metro's Green Construction Policy: Program Overview

April 7th, 2021

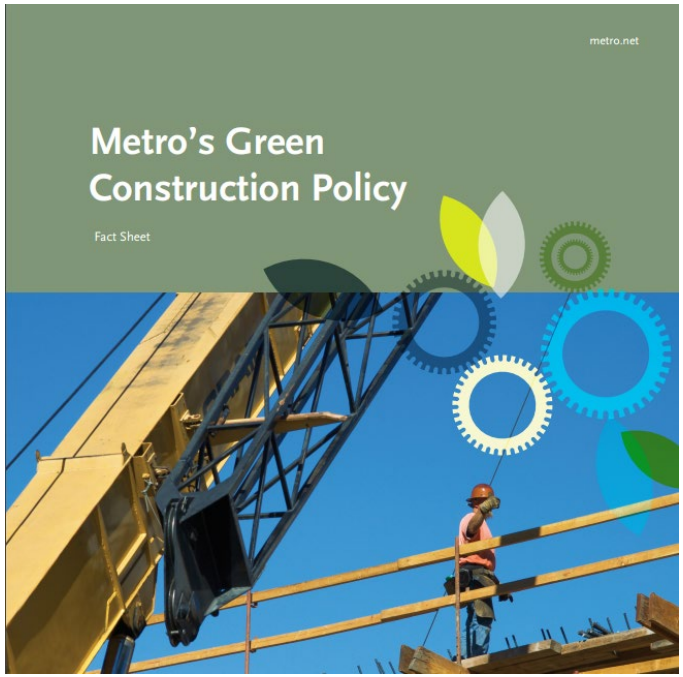
Shannon Walker, ENV SP
Senior Environmental Specialist, LA Metro

Metro

About the GCP

Why was the GCP created?

- Air quality impacts human health.
- The U.S. EPA and the International Agency for Research on Cancer (IARC) have classified diesel exhaust as a potential human carcinogen.
- Diesel engines are a major source of harmful air pollutants.
- Increased planned construction activity from passing of Measure R in 2008.



Metro

GCP Purpose and Goal

Purpose

- ***To identify and mitigate diesel exhaust emission impacts on human health and the environment to the greatest extent feasible.***

Application

- Applies to on-road vehicles, off-road equipment, and portable generators used for Metro Construction Projects and at Metro Rights-of-Way.
- Part of the requirements for funding capital projects for other jurisdictions when applying for transportation funds.

Goal

- To reduce harmful diesel exhaust emissions such as Particulate Matter (PM), Nitrogen Oxides (NO_x), and Carbon Dioxide equivalent (CO_2e) while minimizing impact to construction project costs and schedules.

Metro

GCP Regulatory Compliance

California Air Resources Board (CARB) Compliance

- Truck and Bus Regulations
- Off-Road Diesel Regulation
- Large Spark Ignition Fleet
- DOORS Reporting
- PERP

Metro

GCP Specification Requirements

Metro Construction Specifications

- The GCP was incorporated into Metro Construction Specifications in May 2012.

Key Requirements

Off-Road Diesel-Powered Construction Equipment
≥ 50 BHP, Must Meet Tier 4 Off-Road Emission Standards

On-Road Diesel-Powered Vehicles
GVWR ≥ 19,500 lbs.
Must Meet EPA 2010 or greater On-Road Emission Standards

Portable Generators
≥ 50 BHP, Permitted/Registered w/ BACT for PM Emissions

GCP Specification Requirements

Additional Requirement: Renewable Diesel

- Mandated use of Bulk Renewable Diesel (R-99) in lieu of Petroleum Diesel (exceptions may apply based on start date of project).
- Aligned with Department of General Services (DGS) MM 15-07.

Best Management Practices

- Use electric power instead of diesel power (when available).
- Limit idling to five (5) consecutive minutes.
- Maintain 1000 feet between Truck Traffic and Sensitive Receptors.

Metro

GCP Specification Requirements

Exceptions

- Construction equipment that is part of a small fleet (less than or equal to 2,500 HP).
- Construction equipment required for use at locations defined as “gassy” per Cal/OSHA (must contain lowest emitting MSHA-approved engines or technically feasible)
- On-road equipment or vehicles part of a small fleet (fleet size of 1-3 vehicles); must comply with CARB requirements for small fleets.
- The Contractor has attempted to lease the vehicle or equipment that would comply with this policy, but that vehicle or equipment is not available for lease or short-term rental within 200 miles of the project site
- Exceptions are valid for one year from time of equipment use on-site – updated exception letters must be annually resubmitted to Metro for review.

Metro

GCP Specification Requirements

Conformance

- Metro conducts periodic inspections of sites and construction equipment.
- Metro provides assistance to help contractors to meet requirements.

Key Submittals

- Certification of Compliance
- Construction Equipment Information List
- Monthly Fuel Use Log for all equipment used on-site.
- CARB Registration or SCAQMD Permits for Portable Equipment
- Notification within 14 days of new equipment and/or vehicles

Metro

GCP Specification Requirements

GCP On-Site Inspections

CARB EIN numbers

Gross Vehicle Weight Rating

Portable Equipment Registration Program

Metro

GCP Training

On-Site Training for Contractors

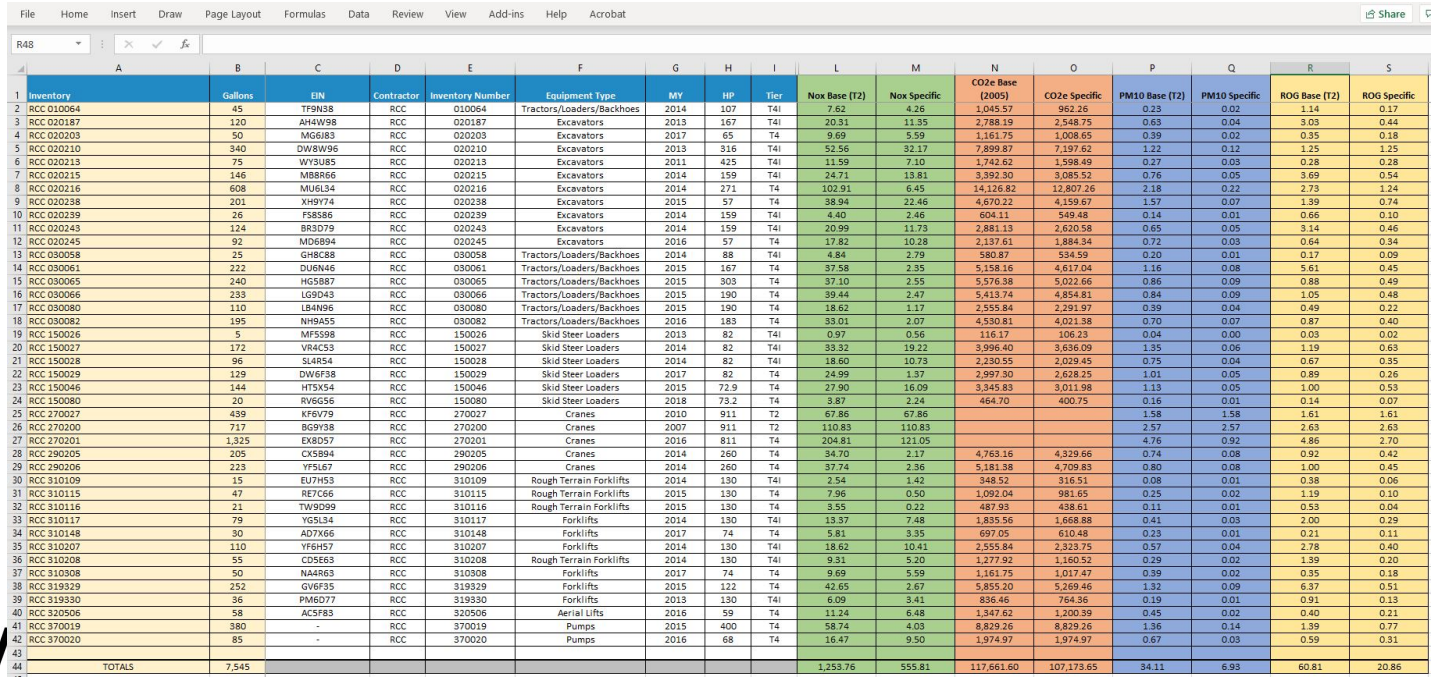
- Training is provided to contractors on Metro's GCP specification and applicable CARB regulations regularly and often.
- Training is always available on an as-needed basis and is determined by the project's assigned Metro Environmental PM.
- For all segments pertaining to CARB, a CARB representative conducts the training.

Metro

GCP Emissions Impacts

Emissions Calculations

- Fuel usage as reported by each project is compiled to calculate annual emissions of NO_x, PM, and CO_2e.
- Emissions are compared between baseline emissions (Tier 2) and specific/actual emissions (Tier 4).



Inventory	Gallons	EIN	Contractor	Inventory Number	Equipment Type	MY	HP	Tier	Nox Base (T2)	Nox Specific	CO2e Base (2005)	CO2e Specific	PM10 Base (T2)	PM10 Specific	ROG Base (T2)	ROG Specific
RCC 010064	45	TF9N38	RCC	010064	Tractors/Loaders/Backhoes	2014	107	T4I	7.62	4.26	1,045.57	962.26	0.23	0.02	1.14	0.17
RCC 020187	120	AH4W98	RCC	020187	Excavators	2013	167	T4I	20.31	11.35	2,788.19	2,548.75	0.63	0.04	3.03	0.44
RCC 020203	50	MG6J83	RCC	020203	Excavators	2017	65	T4	9.69	5.59	1,161.75	1,008.65	0.39	0.02	0.35	0.18
RCC 020210	340	DW8W96	RCC	020210	Excavators	2013	316	T4I	52.56	32.17	7,899.87	7,197.62	1.22	0.12	1.25	1.25
RCC 020213	75	WY3U85	RCC	020213	Excavators	2011	425	T4I	11.59	7.10	1,742.62	1,598.49	0.27	0.03	0.28	0.28
RCC 020215	146	MB8R66	RCC	020215	Excavators	2014	159	T4I	24.71	13.81	3,392.30	3,085.52	0.76	0.05	3.69	0.54
RCC 020216	608	MU6L34	RCC	020216	Excavators	2014	271	T4	102.91	6.45	14,126.82	12,807.26	2.18	0.22	2.73	1.24
RCC 020238	201	XH9Y74	RCC	020238	Excavators	2015	57	T4	38.94	22.46	4,670.22	4,159.67	1.57	0.07	1.39	0.74
RCC 020239	26	F58S86	RCC	020239	Excavators	2014	159	T4I	4.40	2.46	604.11	549.48	0.14	0.01	0.66	0.10
RCC 020243	124	BR3D79	RCC	020243	Excavators	2014	159	T4I	20.99	11.73	2,881.13	2,620.58	0.65	0.05	3.14	0.46
RCC 020245	92	MD6B94	RCC	020245	Excavators	2016	57	T4	17.82	10.28	2,137.61	1,884.34	0.72	0.03	0.64	0.34
RCC 030058	25	GH8C88	RCC	030058	Tractors/Loaders/Backhoes	2014	88	T4I	4.84	2.79	580.87	534.59	0.20	0.01	0.17	0.09
RCC 030061	222	DU6N46	RCC	030061	Tractors/Loaders/Backhoes	2015	167	T4	37.58	2.35	5,158.16	4,617.04	1.16	0.08	5.61	0.45
RCC 030065	240	HG5B87	RCC	030065	Tractors/Loaders/Backhoes	2015	303	T4	37.10	2.55	5,576.38	5,022.66	0.86	0.09	0.88	0.49
RCC 030066	233	LG9D43	RCC	030066	Tractors/Loaders/Backhoes	2015	190	T4	39.44	2.47	5,413.74	4,854.81	0.84	0.09	1.05	0.48
RCC 030080	110	LB4N96	RCC	030080	Tractors/Loaders/Backhoes	2015	190	T4	18.62	1.17	2,555.84	2,291.97	0.39	0.04	0.49	0.22
RCC 030082	195	NH9A55	RCC	030082	Tractors/Loaders/Backhoes	2016	183	T4	33.01	2.07	4,530.81	4,021.38	0.70	0.07	0.87	0.40
RCC 150026	5	MF5S98	RCC	150026	Skid Steer Loaders	2013	82	T4I	0.97	0.56	116.17	106.23	0.04	0.00	0.03	0.02
RCC 150027	172	VR4C53	RCC	150027	Skid Steer Loaders	2014	82	T4I	33.32	19.22	3,996.40	3,636.09	1.35	0.06	1.19	0.63
RCC 150028	96	SL4R54	RCC	150028	Skid Steer Loaders	2014	82	T4I	18.60	10.73	2,230.55	2,029.45	0.75	0.04	0.67	0.35
RCC 150029	129	DW6F38	RCC	150029	Skid Steer Loaders	2017	82	T4	24.99	1.37	2,997.30	2,628.25	1.01	0.05	0.89	0.26
RCC 150046	144	HT5X54	RCC	150046	Skid Steer Loaders	2015	72.9	T4	27.90	16.09	3,345.83	3,011.98	1.13	0.05	1.00	0.53
RCC 150080	20	RV6G56	RCC	150080	Skid Steer Loaders	2018	73.2	T4	3.87	2.24	464.70	400.75	0.16	0.01	0.14	0.07
RCC 270027	439	KF6V79	RCC	270027	Cranes	2010	911	T2	67.86	67.86			1.58	1.58	1.61	1.61
RCC 270200	717	BG9Y38	RCC	270200	Cranes	2007	911	T2	110.83	110.83			2.57	2.57	2.63	2.63
RCC 270201	1,325	EX8D57	RCC	270201	Cranes	2016	811	T4	204.81	121.05			4.76	0.92	4.86	2.70
RCC 290205	205	CX5B94	RCC	290205	Cranes	2014	260	T4	34.70	2.17	4,763.16	4,329.66	0.74	0.08	0.92	0.42
RCC 290206	223	YF5L67	RCC	290206	Cranes	2014	260	T4	37.74	2.36	5,181.38	4,709.83	0.80	0.08	1.00	0.45
RCC 310109	15	EU7H53	RCC	310109	Rough Terrain Forklifts	2014	130	T4I	2.54	1.42	348.52	316.51	0.08	0.01	0.38	0.06
RCC 310115	47	RE7C66	RCC	310115	Rough Terrain Forklifts	2015	130	T4	7.96	0.50	1,092.04	981.65	0.25	0.02	1.19	0.10
RCC 310116	21	TW9D99	RCC	310116	Rough Terrain Forklifts	2015	130	T4	3.55	0.22	487.93	438.61	0.11	0.01	0.53	0.04
RCC 310117	79	YG5L34	RCC	310117	Forklifts	2014	130	T4I	13.37	7.48	1,835.56	1,668.88	0.41	0.03	2.00	0.29
RCC 310148	30	AD7X66	RCC	310148	Forklifts	2017	74	T4	5.81	3.35	697.05	610.48	0.23	0.01	0.21	0.11
RCC 310207	110	YF6H57	RCC	310207	Forklifts	2014	130	T4I	18.62	10.41	2,555.84	2,323.75	0.57	0.04	2.78	0.40
RCC 310208	55	CD5E63	RCC	310208	Rough Terrain Forklifts	2014	130	T4I	9.31	5.20	1,277.92	1,160.52	0.29	0.02	1.39	0.20
RCC 310308	50	NA4R63	RCC	310308	Forklifts	2017	74	T4	9.69	5.59	1,161.75	1,017.47	0.39	0.02	0.35	0.18
RCC 319329	252	GV6F35	RCC	319329	Forklifts	2015	122	T4	42.65	2.67	5,855.20	5,269.46	1.32	0.09	6.37	0.51
RCC 319330	36	PM6D77	RCC	319330	Forklifts	2013	130	T4I	6.09	3.41	836.46	764.36	0.19	0.01	0.91	0.13
RCC 320506	58	AC5F83	RCC	320506	Aerial Lifts	2016	59	T4	11.24	6.48	1,347.62	1,200.39	0.45	0.02	0.40	0.21
RCC 370019	380	-	RCC	370019	Pumps	2015	400	T4	58.74	4.03	8,829.26	8,829.26	1.36	0.14	1.39	0.77
RCC 370020	85	-	RCC	370020	Pumps	2016	68	T4	16.47	9.50	1,974.97	1,974.97	0.67	0.03	0.59	0.31
TOTALS	7,545								1,253.76	555.81	117,661.60	107,173.65	34.11	6.93	60.81	20.86

GCP Emissions Impacts

Emissions Impacts

- It is estimated that the use of renewable diesel across multiple construction projects in 2019 resulted in a GHG emissions reduction of **98%** compared to petroleum diesel, preventing **2,421 MTCO$_2$e** of GHG emissions.
- Similarly, it is estimated that the deployment of renewable diesel at Metro projects reduces PM emissions by ~**25-35%** and NO_x emissions by ~**10%** on projects by deploying renewable diesel, compared to petroleum diesel (based on CARB estimates).

Metro

Thank you.

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Metro