Advanced Clean Transit

May 2015

Mobile Source Control Division

Air Resources Board

Agenda

* Introduction
* The importance of public transit
* Air quality and climate change goals
* Technology assessment
* Costs and funding
* Proposed amendments
* Discussion topics
* Timeline and contacts

Introduction

Transit Fleet Achievements

* Transit Fleet Rule originally adopted in 2000
  * Transit fleet vehicles & urban buses achieved significant PM and NOx emissions reductions
* Diesel fuel path fleets
  * More than 50% of the new purchase are hybrid
  * Zero emission bus demonstration and purchases
    * 12 fuel cell bus demonstration in Bay Area
* Alternative fuel path fleets
  * Converted to natural gas

Zero Emission Bus Technologies Have Matured

* Significant advancements for zero emission buses in the past few years
* Are commercially available
* Costs have come down substantially
* Have reliable performance
* Zero emission buses are operated in California successfully

Many Fleets Operating Zero Emission Buses in California

Bus Operator	Technology Type	Total Buses	Operating period (yrs)
Antelope Valley Transit	Battery	2	<1
Foothill Transit	Battery	15	4
LA MTA	Battery	5	--
San Joaquin RTD*	Battery	2	2
Stanford	Battery	13	1
SunLine Transit	Fuel Cell	4	4
UC, Irvine	Fuel Cell	1	--
ZEBA (AC Transit lead)	Fuel Cell	13	8
Total		53	--

*As of 4/1/2015 five more buses under contract for delivery

Driving Change

* Significant reductions needed to meet air quality and climate goals, and reduce dependence on depletable resources
* Achieving goals will require a transformational change in every sector
  * Zero emission technologies will be necessary where feasible
  * Near-zero emission technologies need to be applied everywhere else
* Transit fleets will play a major role

Leading the Way

* Transit buses are highly suitable for advanced technologies
  * Operate in congested areas where pollution is a problem
  * Centrally located and fueled
  * Government support
* Experiences aid other fleets in deploying heavy-duty zero-emission vehicles
* Zero-emission technology in buses can be transferable

Key Step to Zero and Near-Zero Emissions Begins with Transit

* Complete transition to a zero emission bus fleet by 2040 or sooner
* Require near-zero emission technology and fuels for conventional engines during transition
  * Low NOx engines with use of low carbon intensity fuels
* Provide regional flexibility for zero emission bus goals
* Encourage innovative transit beyond buses

The Importance of Public Transit

Transit Systems Provide a Critical Public Service

* Provides safe, reliable, affordable transportation to millions every day
* Transit reduces
  * Roadway congestion
  * Emissions
  * Reliance on petroleum and automobiles
* Supports sustainable communities goals and improves air quality
* Leads technology advancement

Modes of Transportation

* Buses
* Trains
* Ferries
* Trolley
* Other (shuttles, paratransit)

Bus Operation

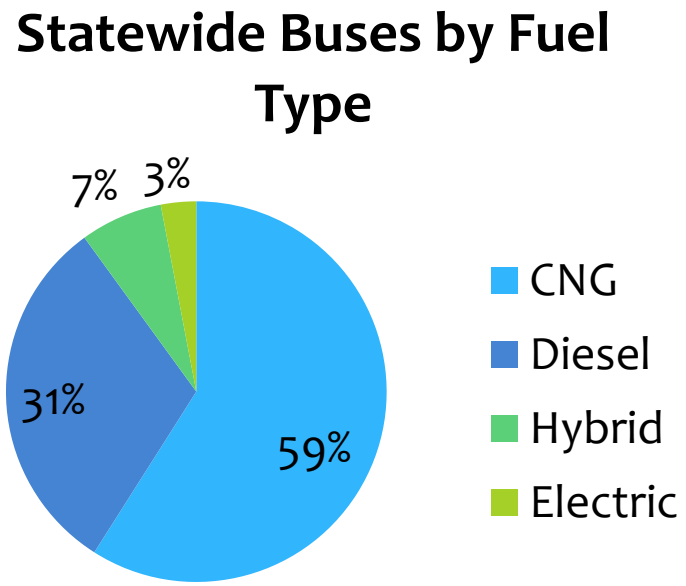
* Urban bus service
  * Short routes with frequent stops in urban centers
  * Typically served by low floor transit bus
* Commuter service
  * Travel between urban centers at peak times
  * Typically served by motor coaches
* Paratransit service
  * Flexible transportation, supplements fixed-route service

Role in Sustainable Communities and Climate Protection

* The Sustainable Communities and Climate Protection Act of 2008 (SB 375)
* Reduce GHG emissions through coordinated transportation and land use planning
* Improve transit system efficiencies while reducing passenger car use

Summary of California Transit Fleet

* Fleet size
  * 9,908 urban buses
  * 1,622 other transit fleet vehicles
* Urban buses by fuel type
  * 5,816 CNG, LNG, LPG
  * 3,084 diesel
  * 667 diesel-electric hybrid
  * 341 all-electric buses



Source: ARB Transit Fleet Rule Reporting database on 03/2015

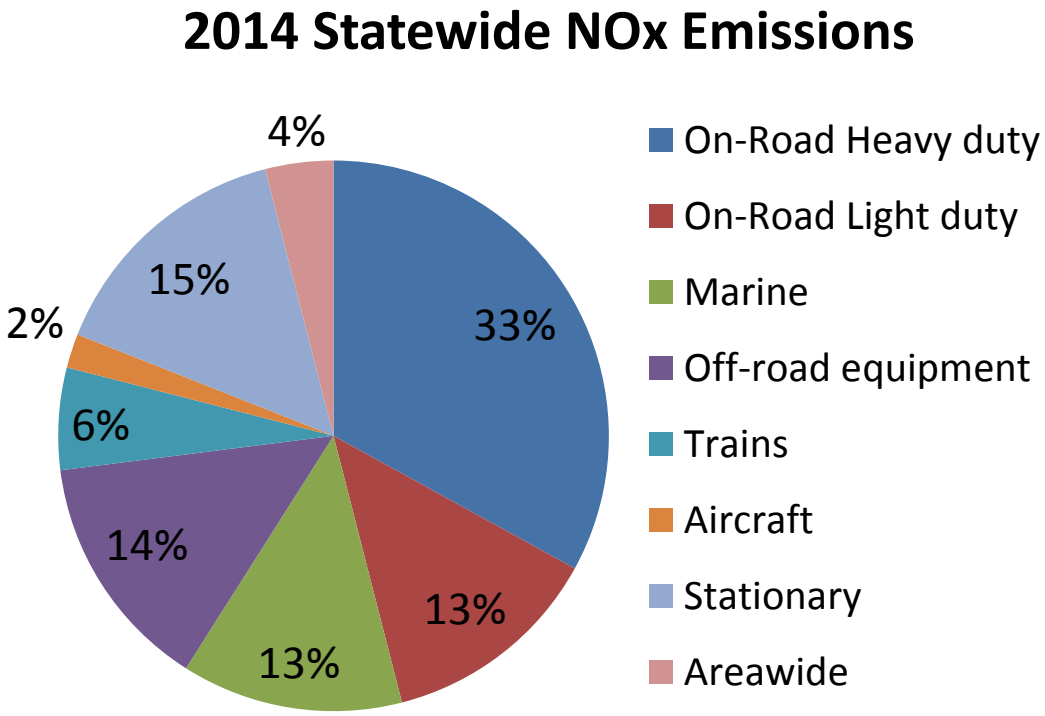
Air Quality and Climate Goals

Air Quality and Climate Change Goals

* Significant technology advancement needed to meet air quality, climate, petroleum reduction, and public health goals:
  * 40% reduction in GHG by 2030
  * 50 % reduction in petroleum use by 2030
  * 90% reduction in NOx by 2031
  * 80% reduction in GHG by 2050
  * Continued reductions in diesel PM and air toxics to protect public health

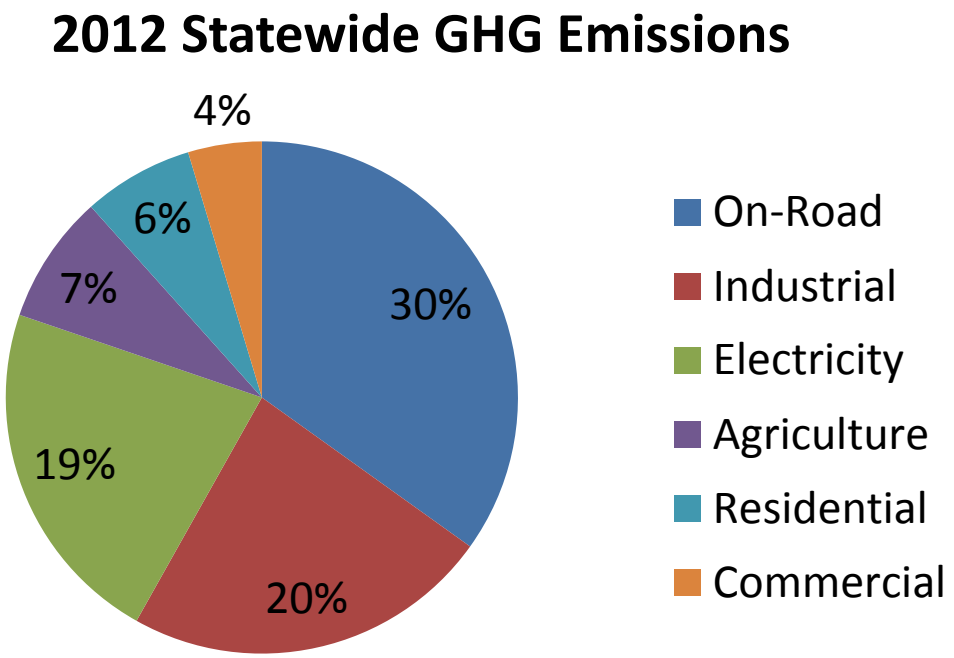
Statewide NOx Emissions

* On-road sector remains a large contributor to statewide emissions
* 46% of total NOx emissions in CA
  * 33% Heavy duty
  * 13% Light duty



Statewide GHG Emissions

* On-road sector contributes to 30% of total GHG emissions in CA



ARB Planning Strategies to Meet Goals

* Planning efforts focus on
  * Achieving climate change emissions reduction targets
  * Meeting ozone air quality standards
  * Technology development, deployment, and incentives
* Zero emission technologies will be needed everywhere feasible and near zero emission everywhere else as technology matures
* Zero emission buses are a key part of strategy

Technology Assessment

Existing Zero Emission Bus Requirements on Hold

* Zero emission bus purchase requirement on hold pending technology review
  * Resolution 09-49; (January 2010 mailout, MSC #10-04)
* Technology assessment conclusions
  * Over the past 5 years technology has matured
  * Costs have come down substantially
  * Both battery and fuel cell electric buses ready for transit applications

More information on the technical assessments can be found at: http://www.arb.ca.gov/msprog/tech/tech.htm.

Bus Technology and Fuel Options

* Zero emission technologies
  * Battery electric buses
  * Fuel cell electric buses
* Other advanced technologies
  * Hybrid buses
  * Low NOx engines
* Renewable fuels

Battery Electric Buses

* Commercially available
  * Battery lease options
  * 4 manufacturers, 8 models
* Multiple charging options
  * Slow charging with ~160-190 mile range
  * Fast charging for unlimited range on shorter routes
* Higher upfront cost compared to conventional diesel vehicles
* Total cost of ownership is similar to conventional diesel vehicles after federal funds utilized

Commercially Available Battery Electric Buses

Technology	Manufacturer	Bus Type	Charge/Fuel Time
Battery	BYD	30’	2-4 hours
Battery	BYD	35’	2-4 hours
Battery	BYD	*40’	2-4 hours
Battery	BYD	60’ Articulated	2-3 hours
Battery	Proterra	*35’	Fast Charge (<10 min.) Slow Charge (90 min.)
Battery	Proterra	*40’	Fast Charge (<10 min.) Slow Charge (90 min.)
Battery	Nova	40’	Fast Charge (6 min.)
Battery	New Flyer	40’	Slow Charge 96 min. Fast charge 4-6 min.

* Completed Altoona testing

Battery Electric Buses Currently Operating in California

Bus Operator	Total Active Buses	Operating Period (years)
Antelope Valley Transit	2	<1
Foothill Transit	15	4
LA MTA	5	--
San Joaquin RTD*	2	2
Stanford	13	1
Total	37	--

*As of 4/1/2015 five more buses under contract for delivery

Fuel Cell Electric Buses

* Early commercialization
  * Capital costs substantially higher than conventional and battery electric buses
    * Expect further cost reductions over time
  * Two manufacturers
* Performance, durability and availability similar to conventional buses
* Hydrogen fueling 4-6 minutes
* Range of ~300 miles
* Operational flexibility same as conventional buses

Fuel Cell Electric Buses

Technology	Manufacturer	Bus Type	Fuel Time
Fuel Cell	New Flyer	40’	4-6 min.
Fuel Cell	New Flyer	60’	4-6 min.
Fuel Cell	El Dorado National	41’	4-6 min.

Fuel Cell Electric Buses Operating in California

Bus Operator	Total Active Buses	Operating Period (years)
SunLine Transit	4	13
UC Irvine	1	--
ZEBA (AC Transit lead)	12	8
Total	17	--

Conventional Hybrid Buses

* About 50 percent of current diesel purchases
* Reduces GHG emissions with improved fuel efficiency
* Support supply chain for zero emission drivetrain and components
* Hybrids certified to same emission standards as conventional diesel and natural gas vehicles

Low NOx Engines

* Expected to be available for CNG buses in 2016-2017
  * Certified to ARB optional low NOx standards
  * Likely to be 90% lower NOx than existing engines
* Expect limited impact on bus cost

Renewable Fuels

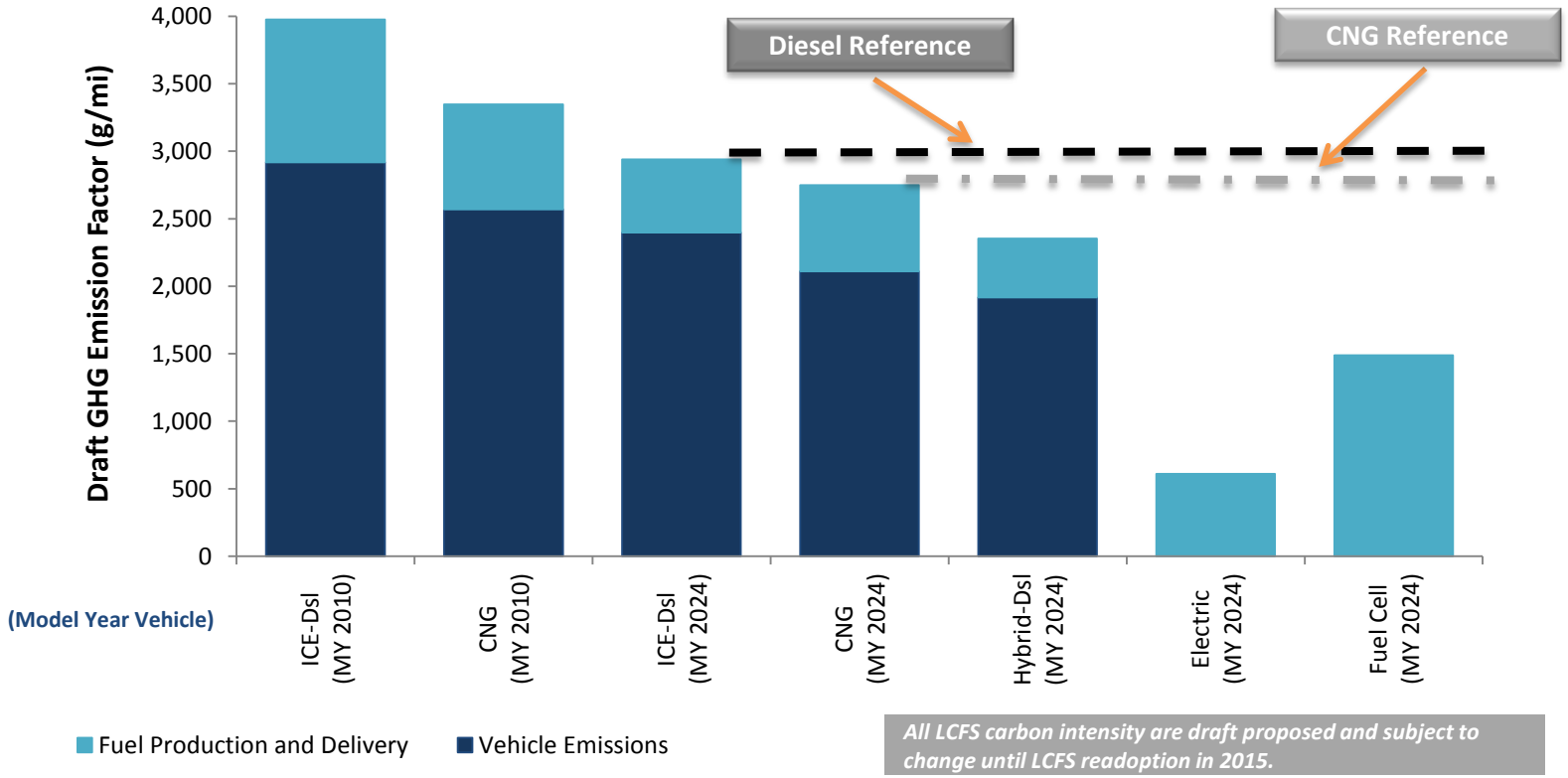
* Renewable fuels are commonly available
  * Renewable natural gas
  * Renewable diesel
  * Biodiesel
* Power to gas from renewables

Low Carbon Fuel Standard:
http://www.arb.ca.gov/fuels/lcfs/lcfs.htm

Emissions Comparison

* GHG emissions compared with a well-to-wheel analysis where the emissions associated with the vehicle use and fuel consumed
  * Regardless of where the activity occurs
* NOx emissions compared by engine certification standard
  * Reflects regional exposure where engine exhaust occurs
  * In-use comparison varies by a number of factors

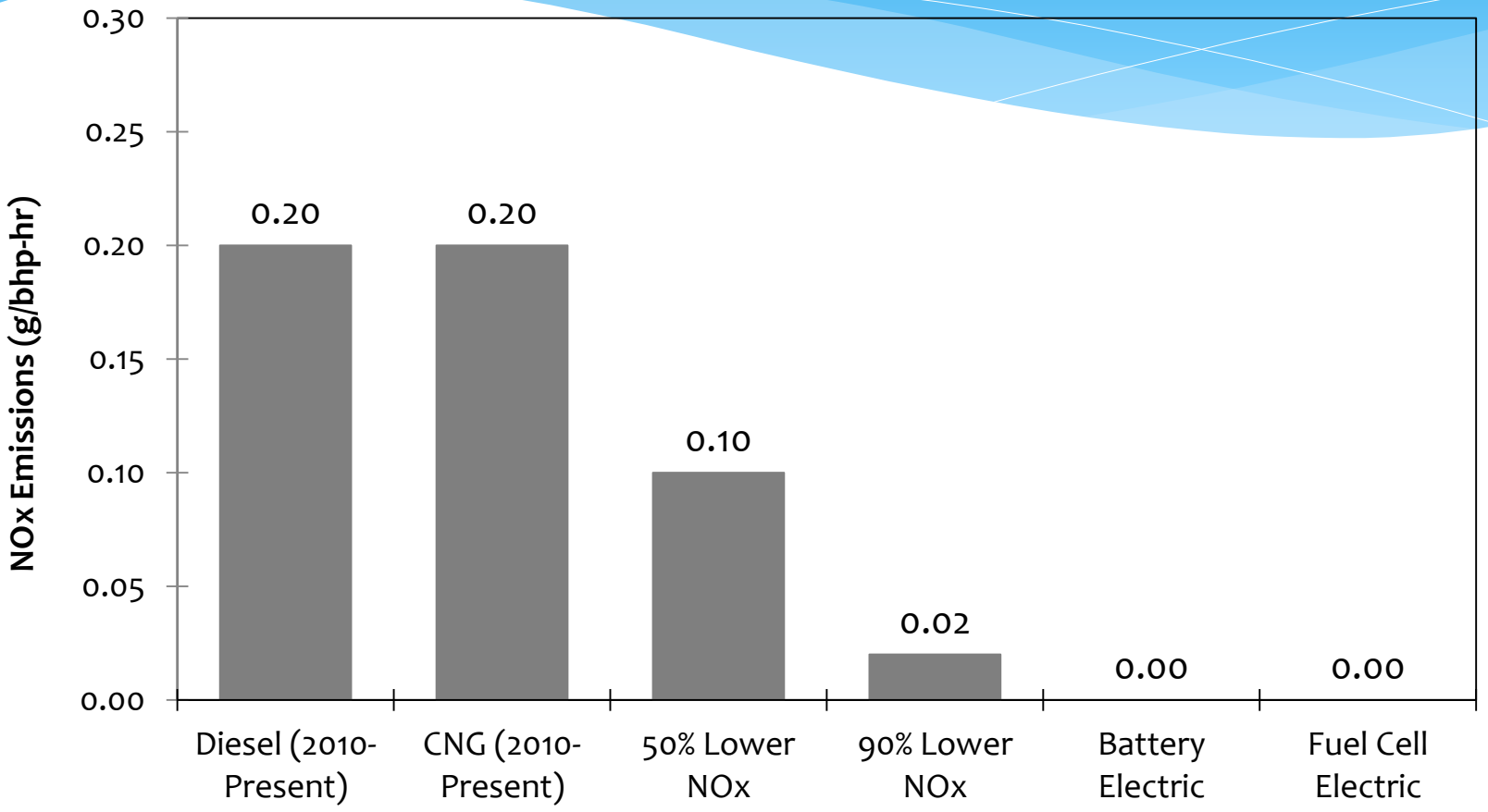
Urban Bus GHG Emission Comparison



All LCFS carbon intensity are draft proposed and subject to change until LCFS readoption in 2015.

Low Carbon Fuel Standard Carbon Intensity as of April 28, 2015

Engine Certification Standards for NOx Emissions



Costs and Funding

Normal Transit Funding Sources

* Federal Transportation Agency (FTA)
  * 80% of capital funding for buses (Section 5307)
  * Funds distributed by MPO/RTPA
  * Funding requirements for buses: Buy America, Altoona tested and have a 12 year minimum service life
  * Must maintain minimum spare ratio
* Operation and maintenance funded mainly through local funds
  * Ticket fares, sales tax, property taxes, bridge tolls, etc.

Bus Capital Cost Comparison

Technology	Purchase Price	Estimated FTA Section 5307 Funding	Transit Agency Cost Share	Incremental Cost to Transit Agencies above Diesel
Diesel	$485,000	$398,000	$87,300	---
Natural Gas	$525,000	$431,000	$95,000	$7,000
Diesel Hybrid	$758,000	$622,000	$136,000	$49,000
Battery Electric	$800,000	$656,000	$144,000	$57,000
Fuel Cell Electric*	$1,300,000	$1,066,000	$234,000	$147,000

Incremental Cost Example: Battery Electric Buses

	Diesel	CNG	Battery Electric
Bus Cost	$485,000	$525,000	$800,000
Charger and Installation	0	0	$40,000
FTA Formula Funds	-$398,000	-$431,000	-$656,000
HVIP[1]	0	0	-$110,000
Net Transit Agency Cost	**$87,000**	**$94,000**	**$74,000**

*Assume standard overnight charging
*Does not include $17,000 in annual fuel savings for battery electric
*Does not include maintenance bay upgrades and training

[1]Hybrid and Zero Emission Truck and Bus Voucher Incentive Project

Cost Analysis

* Analysis period 2018 to 2040
* Total cost of ownership comparison
  * Bus, fueling and maintenance facility infrastructure
  * Fuel and maintenance costs
* Cost analysis at transit fleet level
  * Normal replacement practices
  * Projection of likely actions with rule
* Information on type(s) of buses that can serve needs
* Annual mileage, fuel use, cost of fuel or electricity

Financing Options

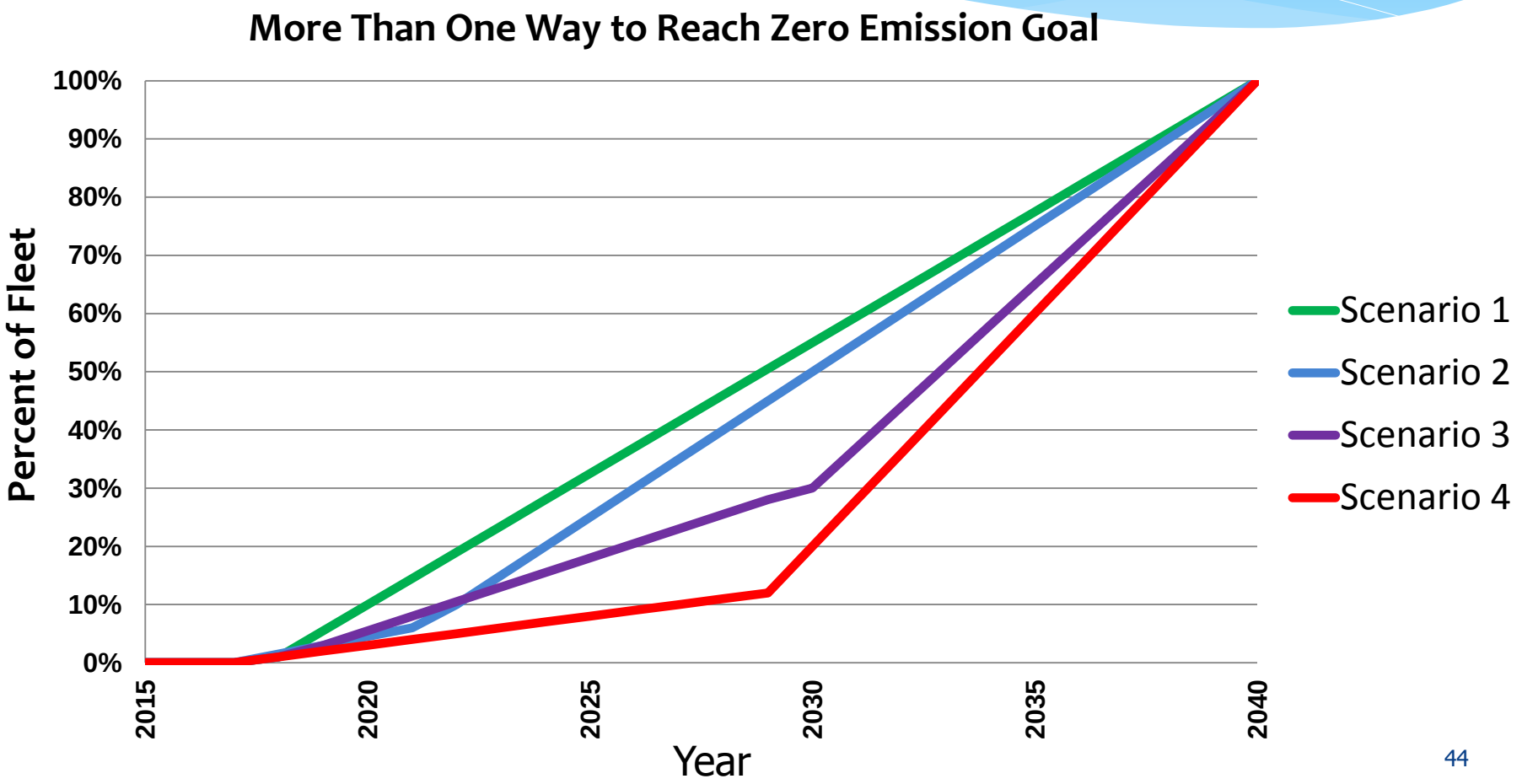
* Option to lease the high value components can reduce up-front cost similar to a conventional bus
  * Reduce the incremental capital cost and offset with operating and maintenance cost savings
  * FTA confirmed federal funds could be used for lease
* Manufacturers also offering extended warranty options for batteries (no mid-life cost)
  * Up to life of bus (12 years)

Proposed Amendments

Zero Emission Bus Targets

* Beginning January 1, 2018
* Low initial targets allow fleets to prepare and become familiar with technologies
* Requirements will increase over time, with goal to achieve full zero emission fleet by 2040
* Base requirements on percentage of bus purchases
  * Potentially higher initial credit for fuel cell electric buses
  * Potentially additional time for smaller transit fleets
    * Need to establish appropriate size threshold

2040 Zero Emission Bus Goal Requires Action Now



Minimize Emissions from Conventional Fleet

* Beginning January 1, 2017
* Purchase best available technology at time of replacement
* Purchase renewable diesel or CNG for entire fleet at time of fuel contract
* Need to discuss role of hybrid electric buses
  * Potential for zero emission miles
* All transit fleet vehicles must have PM filters

Regional Flexibility Options

* Option for transit fleets to pool bus purchases
  * Meet same total zero emission bus milestone
  * Allows for flexibility for vehicle and infrastructure deployment

Innovative Transit Beyond Buses

* Opportunity for transit fleets and regional planning agencies to transform passenger transportation with creative methods and new technologies
  * Result in additional GHG reduction
  * Beyond buses and conventional technologies
* Provide additional flexibility in zero emission bus requirements
* Potential to be recognized in meeting regional Sustainable Communities Strategies (SB375)

Areas Staff is Working On

* Incentives alignment with federal formula funding
* Role for hybrids (including plug-ins)
* Economic analysis data and assumptions
* Axle weight

Bus Axle Weight Status

* Bus purchases prohibited if exceeding axle weight limits
  * California: 20,500 lbs./axle
  * Federal: 24,000 lbs./axle
* Bus axle weight limits commonly exceeded when at capacity
* Higher axle weights result in greater road wear
* National study identified pros and cons of potential options[1]
  * American Public Transportation Association
* Continuing to monitor outcome

[1]http://www.apta.com/resources/reportsandpublications/Documents/An-Analysis-of-Transit-Bus-Axle-Weight-Issues-TCRP-J11-T20.pdf

Discussion Topics

Discussion Topics (1)

* How to phase-in requirements for zero emission bus purchases in a manner that is consistent with existing purchase patterns?
* How existing funding programs could be improved to provide more certainty about available funding and funding levels?
* Should smaller transit fleets be given more time to phase-in zero emission buses?

Discussion Topics (2)

* How to encourage deployments of fuel cell buses to bring them into broader commercialization?
* How should conventional and plug-in hybrid (PHEV) buses be included in the strategy?
* What are the approaches to build innovative transit beyond buses?

Timeline

* Summer 2015: Public workshops
* September 2015: Update to Board on progress
* Winter 2015: Public workshops
* Spring 2016: Board hearing

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