The National Academies of
SCIENCES • ENGINEERING • MEDICINE

TRANSPORTATION RESEARCH BOARD

Technology Changes Influencing the Decline of Vehicle Emissions

Wednesday, April 25, 2018
2:00-3:30 PM ET

The Transportation Research Board has met the standards and requirements of the Registered Continuing Education Providers Program. Credit earned on completion of this program will be reported to RCEP. A certificate of completion will be issued to participants that have registered and attended the entire session. As such, it does not include content that may be deemed or construed to be an approval or endorsement by RCEP.

RCEP

REGISTERED CONTINUING EDUCATION PROGRAM

Purpose

Discuss emerging technologies and programs that are designed to mitigate emissions from vehicles.

Learning Objectives

At the end of this webinar, you will be able to:

- Identify technologies being introduced that are intended to reduce vehicle emissions
- Identify programs that are implemented that are intended to reduce vehicle emissions
- Understand the possible emission quantities that may be reduced as a result of adoption of these technologies and programs

The Three Transportation Revolutions

Daniel Sperling

Distinguished Blue Planet Professor and Founding Director
Institute of Transportation Studies
University of California, Davis

and

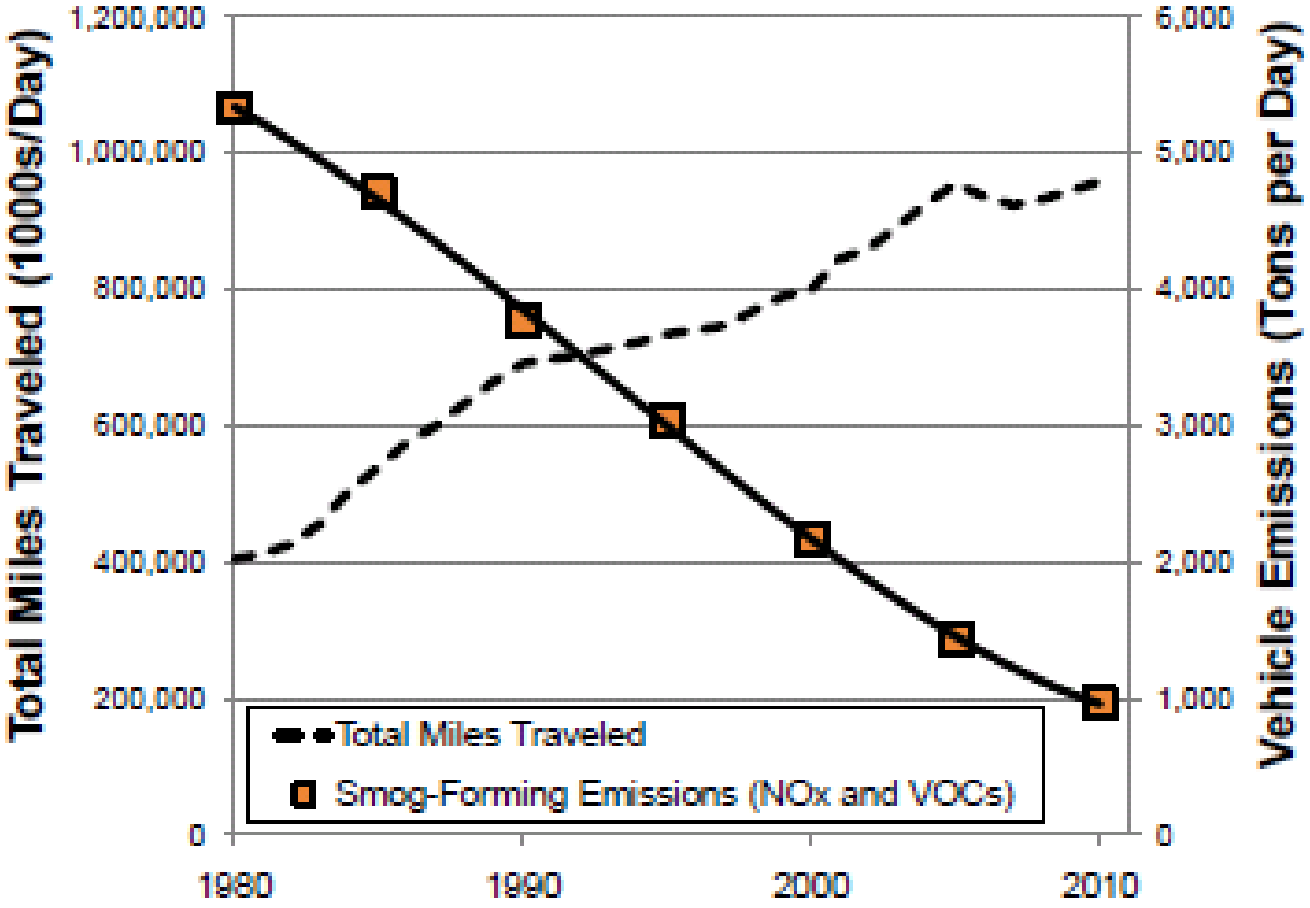
Board Member, California Air Resources Board

TRB Webinar on Technology Changes Influencing the Decline of Vehicle Emissions

25 April 2018

Huge Environmental Success Story

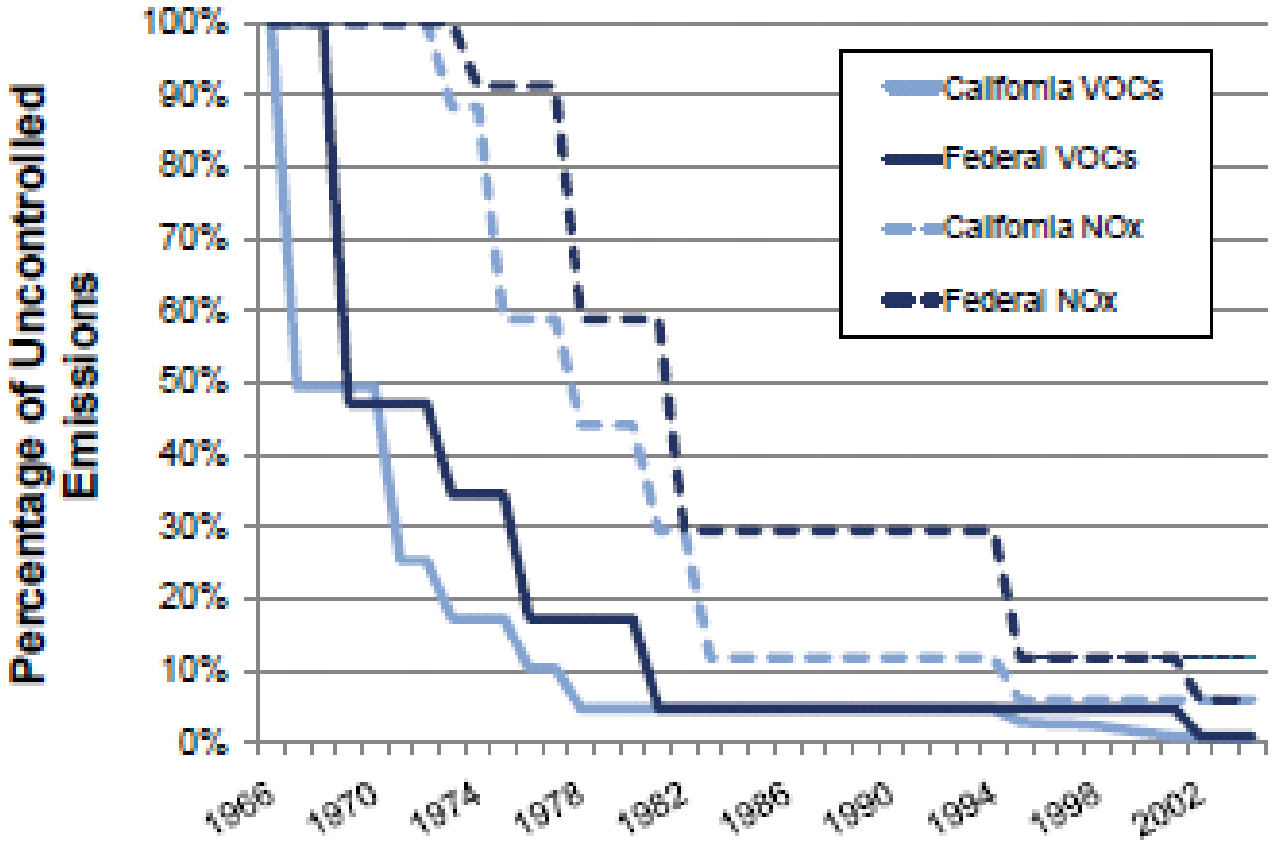
Dramatic Reduction in "Criteria" (Local) Emissions, Despite Large Increase in VMT (California)



Clean Cars in California (2010), Environment California & Environment California Research & Policy Center www.environmentcalifornia.org

New Cars are 99% Cleaner than in 1960s

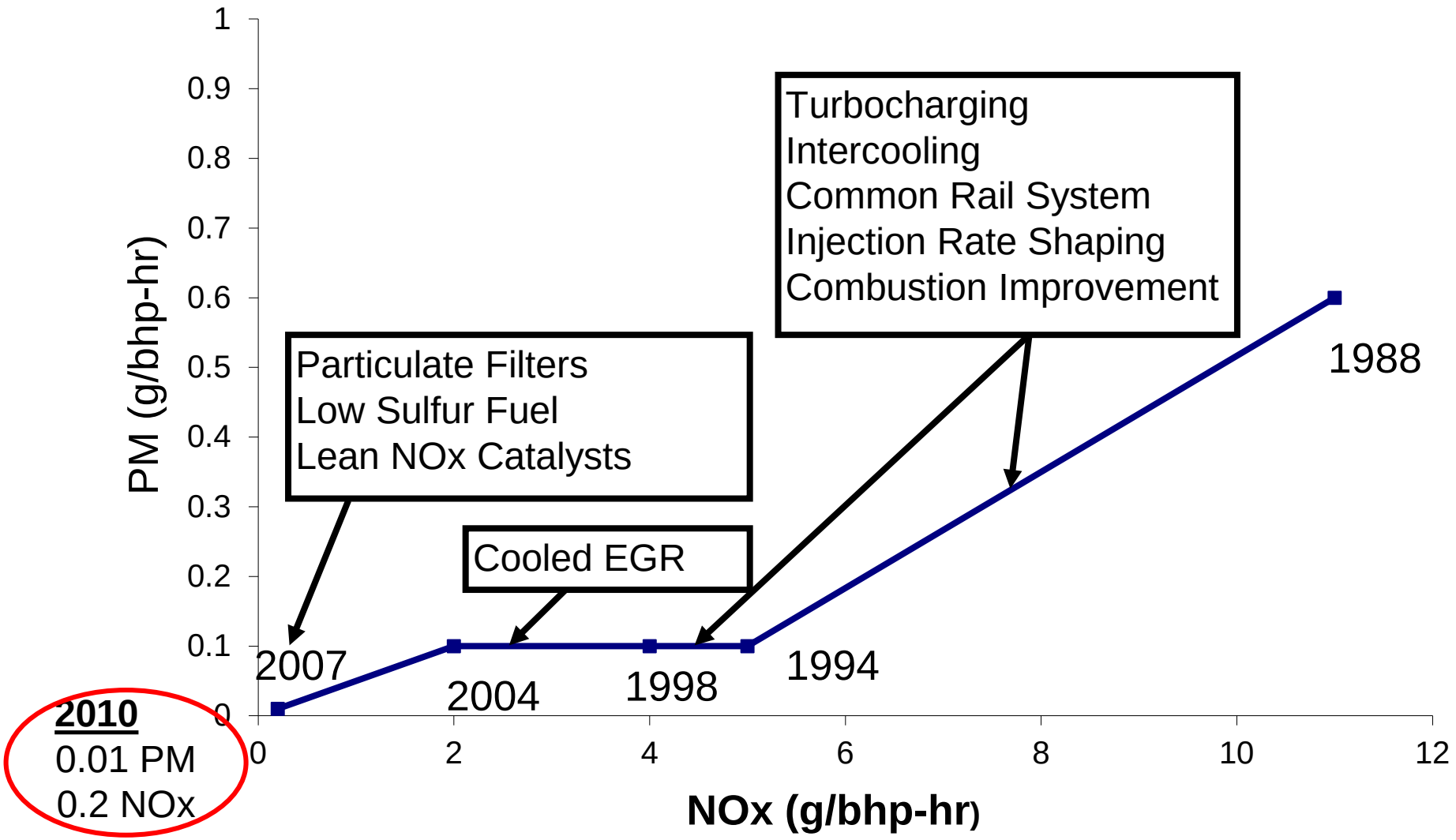
Tailpipe Standards—as % Reduction from Uncontrolled Emissions



Clean Cars in California (2010), Environment California & Environment California Research & Policy Center www.environmentcalifornia.org

New Trucks are 98% Cleaner Than 30 Years Ago

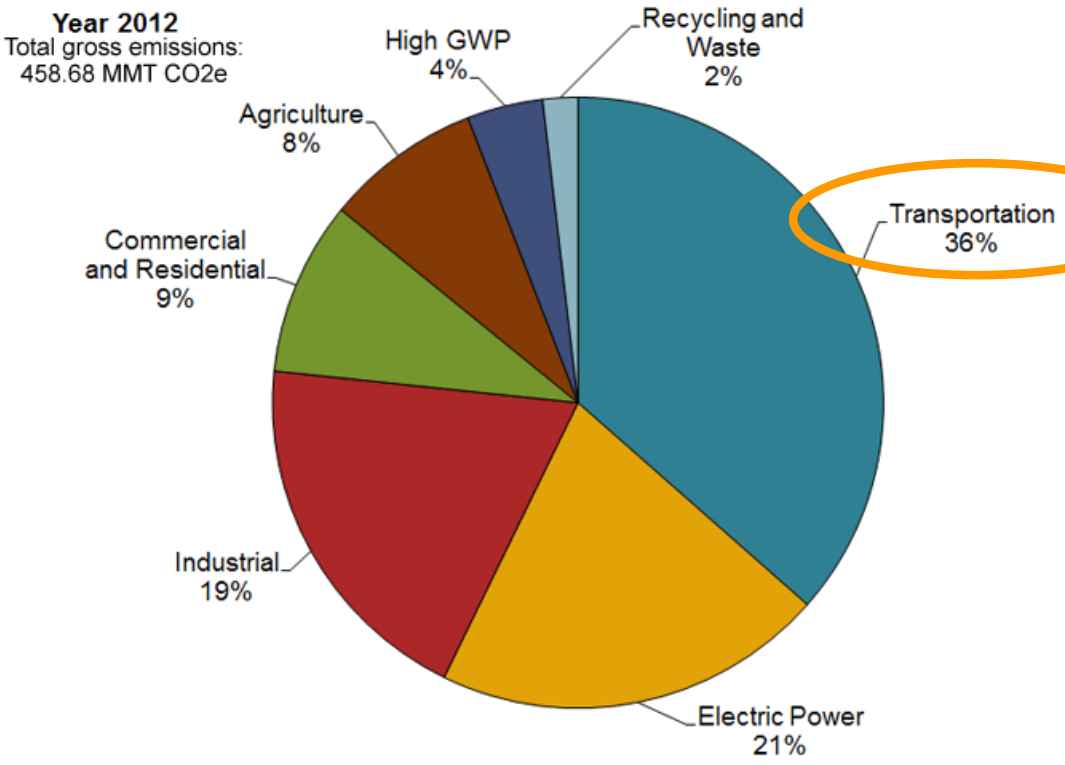
(aided by simultaneous cleanup of diesel fuel)



Bigger Challenge Now is Reducing Greenhouse Gas (GHG) Emissions

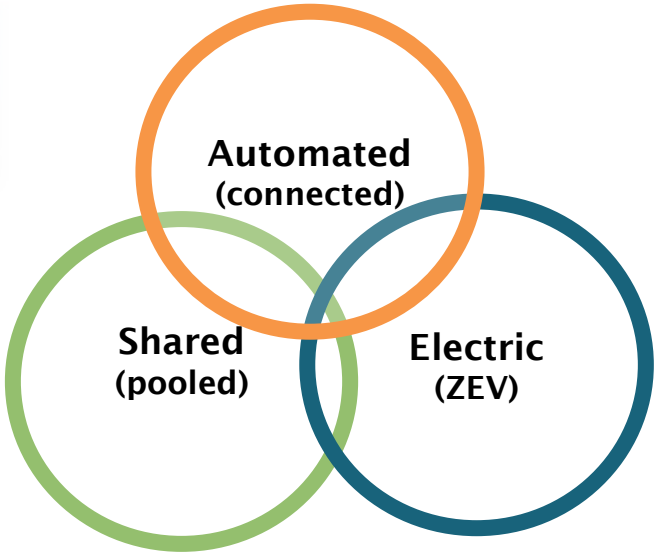
- **Greenhouse gas emissions**
  - U.S.: transport is ~28% GHG emissions (roughly equal to electricity generation)
  - CA: transport is >40% GHG emissions (if include refinery emissions)
  - Emissions: Carbon dioxide (CO_2), nitrous oxide (N_2O), hydrofluorcarbons (HFC), plus methane, ozone precursors

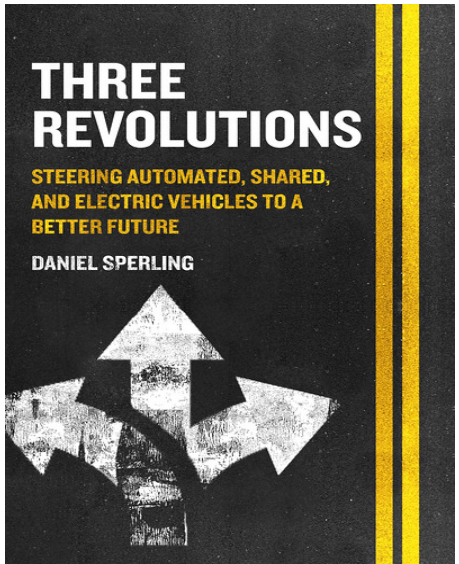
California greenhouse gas emissions



Source: California Air Resources Board

Electrification + Automation + Pooling





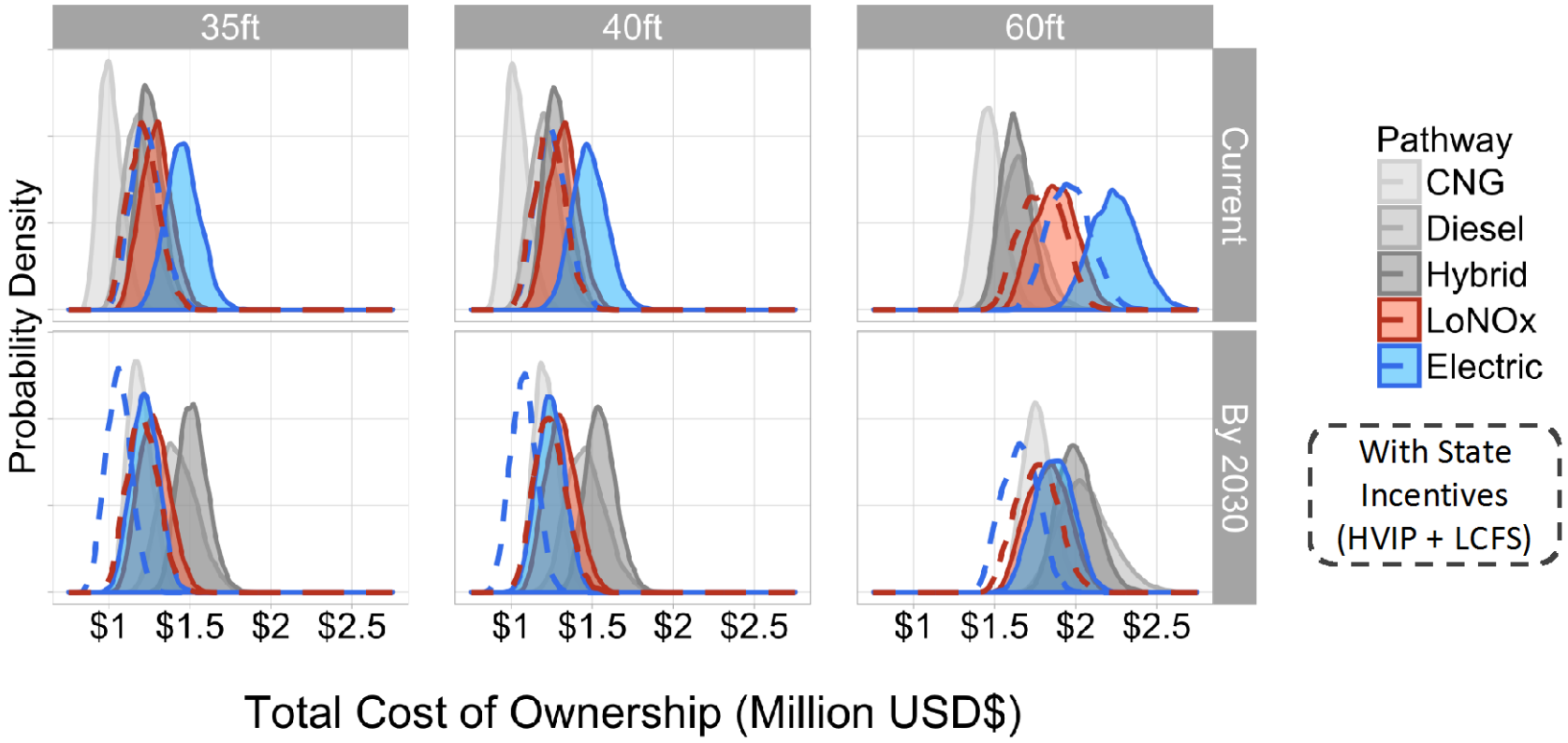
What is Certain

- Almost all cars and urban buses will be electric
  - All automakers well prepared for EVs
- Most “urban” trucks will be electric
- Eventually almost all road vehicles will be automated (AVs)

<u>What is less certain</u>

- How much increase in pooling (multiple riders/vehicle), especially for AVs
  - Sensitive to local policy

Electric Buses Will Be Low-Cost Option by 2030?



Ambrose et al, *Exploring the Costs of Electrification for California's Transit Agencies*, ITS-Davis (2017)

Likely Impacts of Each “Revolution” By Itself

- EVs

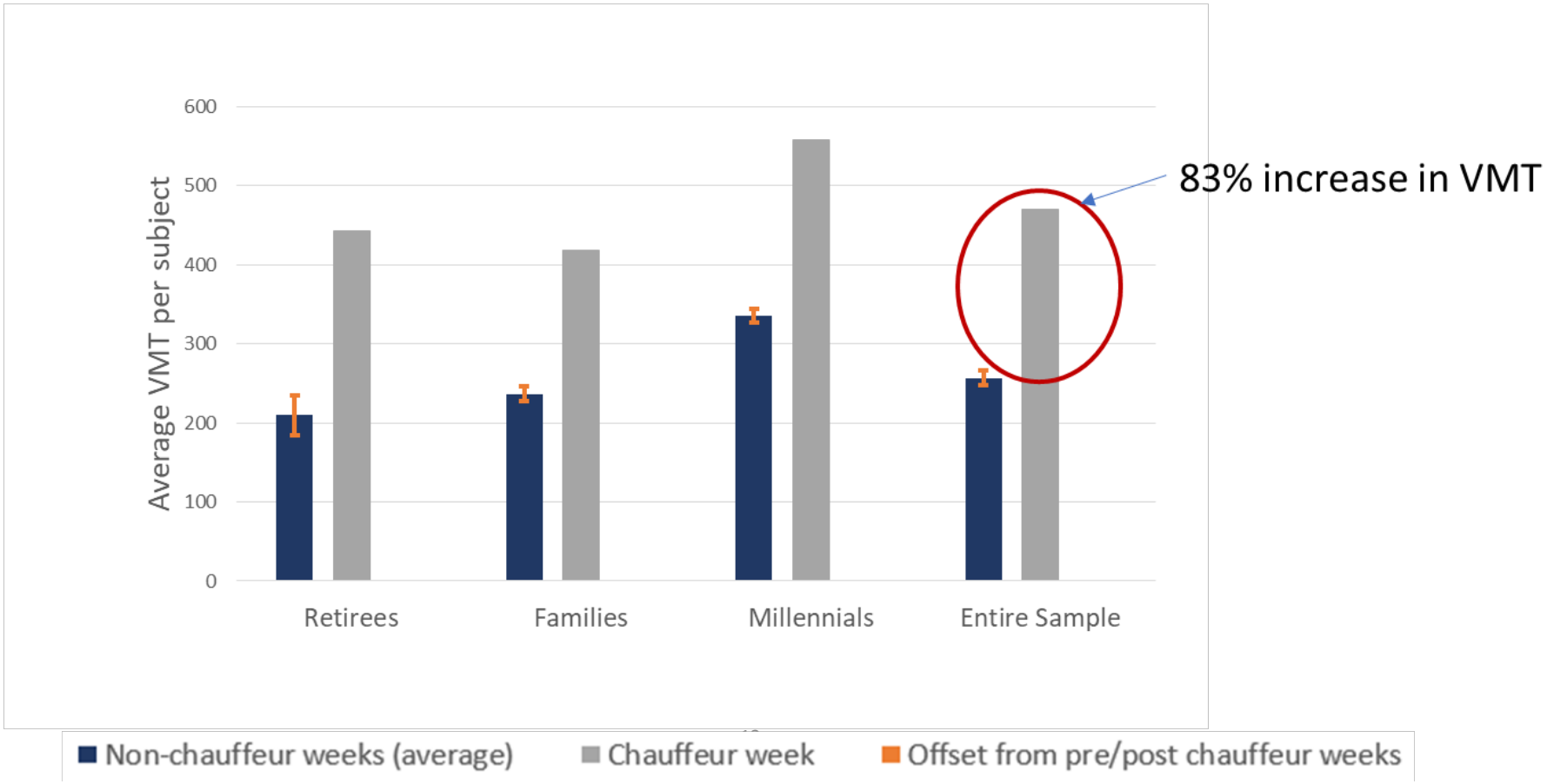
  Reduce criteria (local) pollutants and GHGs

- Shared Mobility Services
  - Single-passenger ride-hailing services increase VMT (and all emissions)
  - Pooled services reduce VMT and all emissions
- Automated Vehicles (aka “autonomous”)
  - Increase VMT if personally owned
  - Reduce VMT and emissions if “pooled” (operated by mobility service companies)

Car of the future?

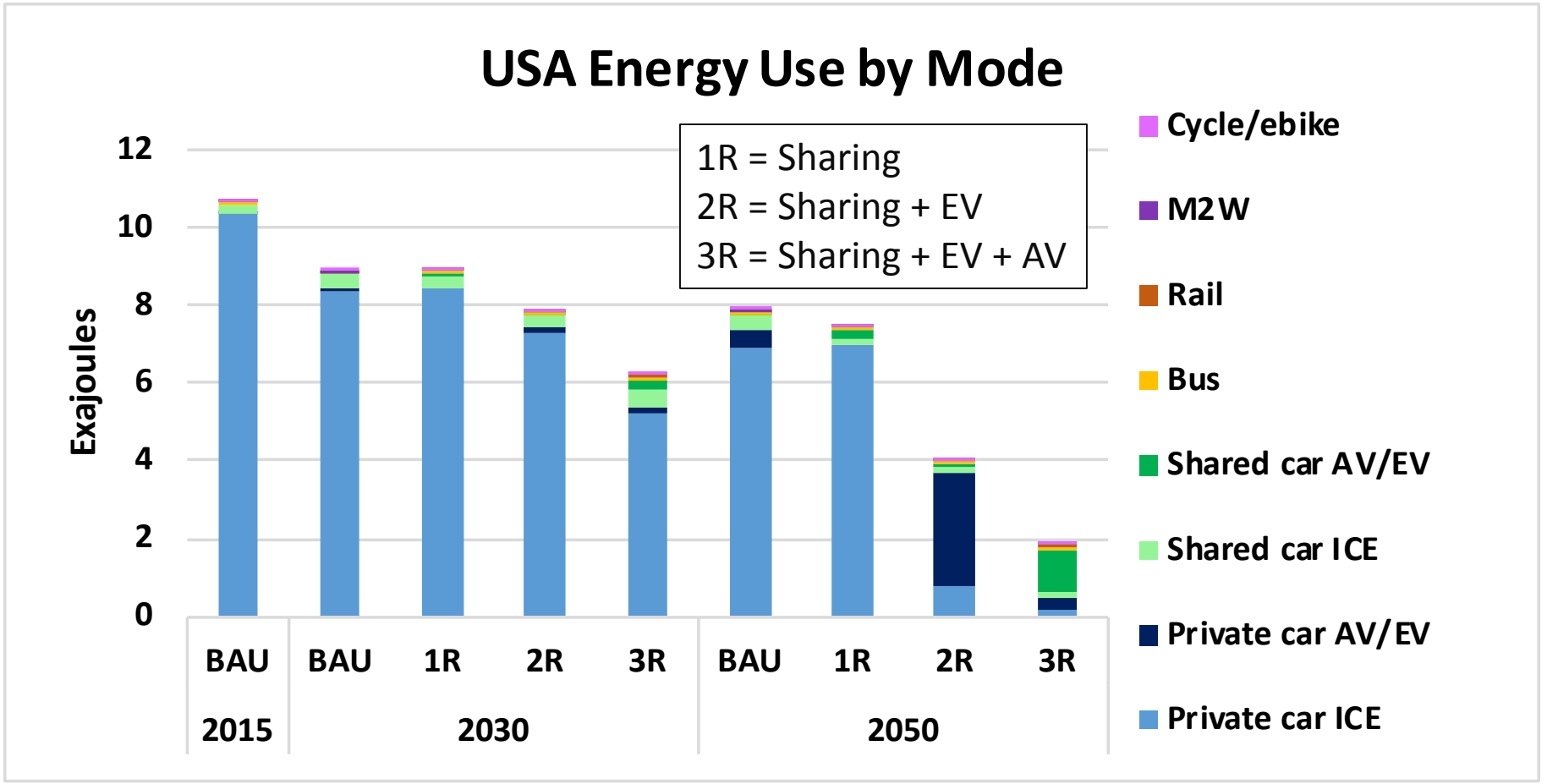
Or this?

Automated Vehicles = Huge Increase in VMT … if No Pooling ("Hell Scenario")



Source: Early findings from UC Davis/Berkeley "chauffer" study: *Harb, M., Xiao, Y., Circella, G., Mokhtarian, P., & Walker, J., presented at TRB Meeting, Washington D.C., January 8, 2018.*

Electrification + Automation + Pooling = Huge Reduction in Energy Use (and GHGs)



Fulton et al, *Three Revolutions in Urban Transportation*, ITS-Davis (2017)

Will Travelers Embrace “Pooling” and Relinquish Auto Ownership?

NO?!

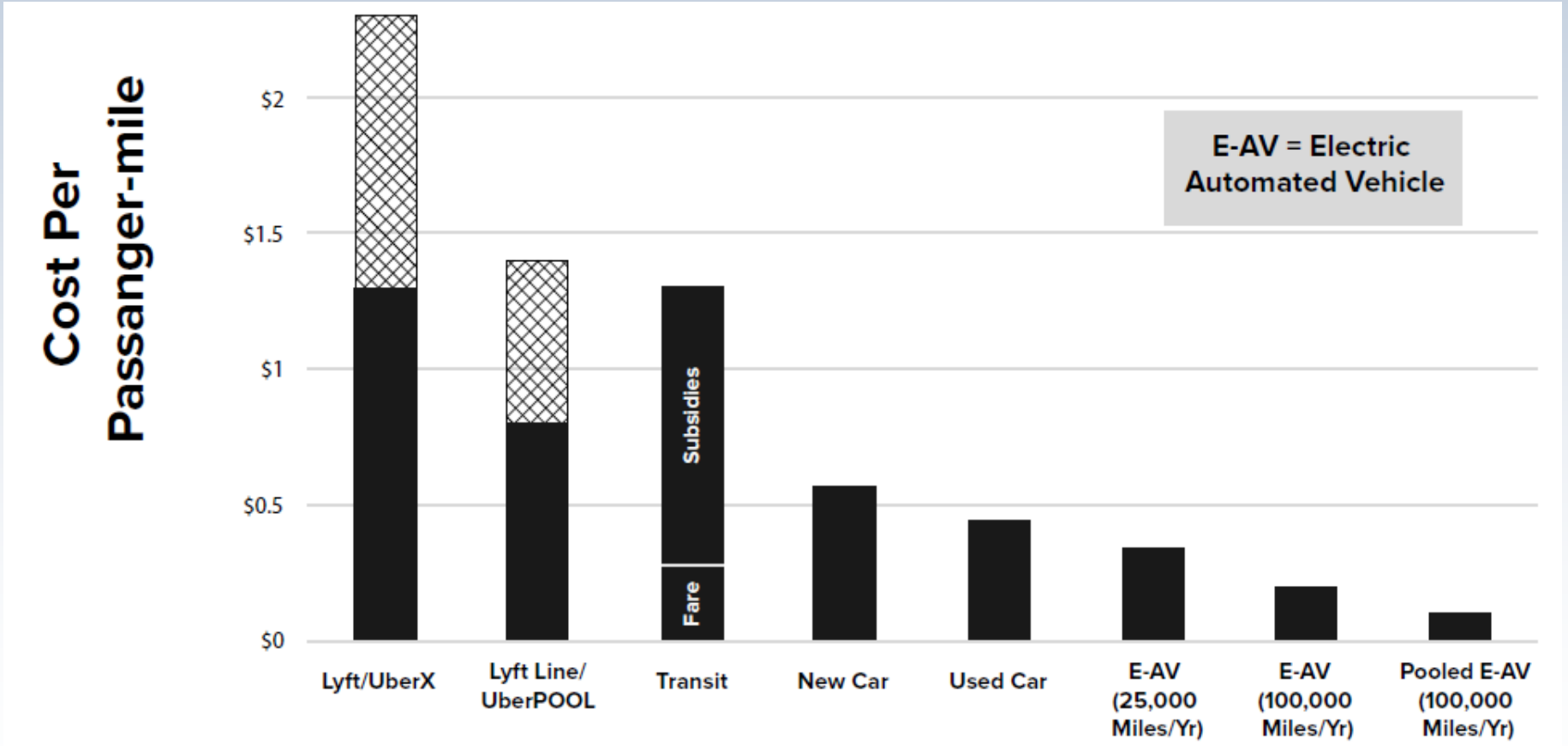
- Large in-car time savings ($3000-$10,000/year) ($10-30/hr x 300 hours)
  - Why bother sharing?
- Concerns about:
  - Personal security (no “adult” in car)
  - Longer and uncertain trip times
- Functional needs
  - Families, sports gear, dogs, business/equipment
- Non-functional “needs”
  - Status and image, entertainment, investment

Yes! If…

- Cars redesigned for privacy and security (passenger-centric)
- High “tax” on single-occupant vehicles (and ZOVs)
  - Usage, reg fees, incentives for pooling (curbspace, HOV lanes…)

Pooling + Electric + Automated = Very Cheap Mobility

(less than $0.20/passenger mile)



Sperling et al, *Three Revolutions,* Island Press (2018)

When the 3 revolutions are Integrated (Vehicles are Pooled, Electric, Automated—Huge Benefits ("Heaven Scenario")

Better for economics, environment, and equity

- Less local pollution
- Less GHGs and energy use (electrified + less VMT)
- Safer (automated)
- Access for mobility disadvantaged (young, elderly, poor, physically disabled)
- Less personal cost
- Less infrastructure cost (pooled AVs need less space)
- Less congestion/VMT (because of pooling and automation)
- More urban space (less parking, roadspace)
- More jobs

Supportive Policies Needed to Steer Revolutions to the Public Interest

- Efficient parking and urban development policies
- VMT incentives and disincentives
- Merging of transit and other modes (remove silos)


Thank You

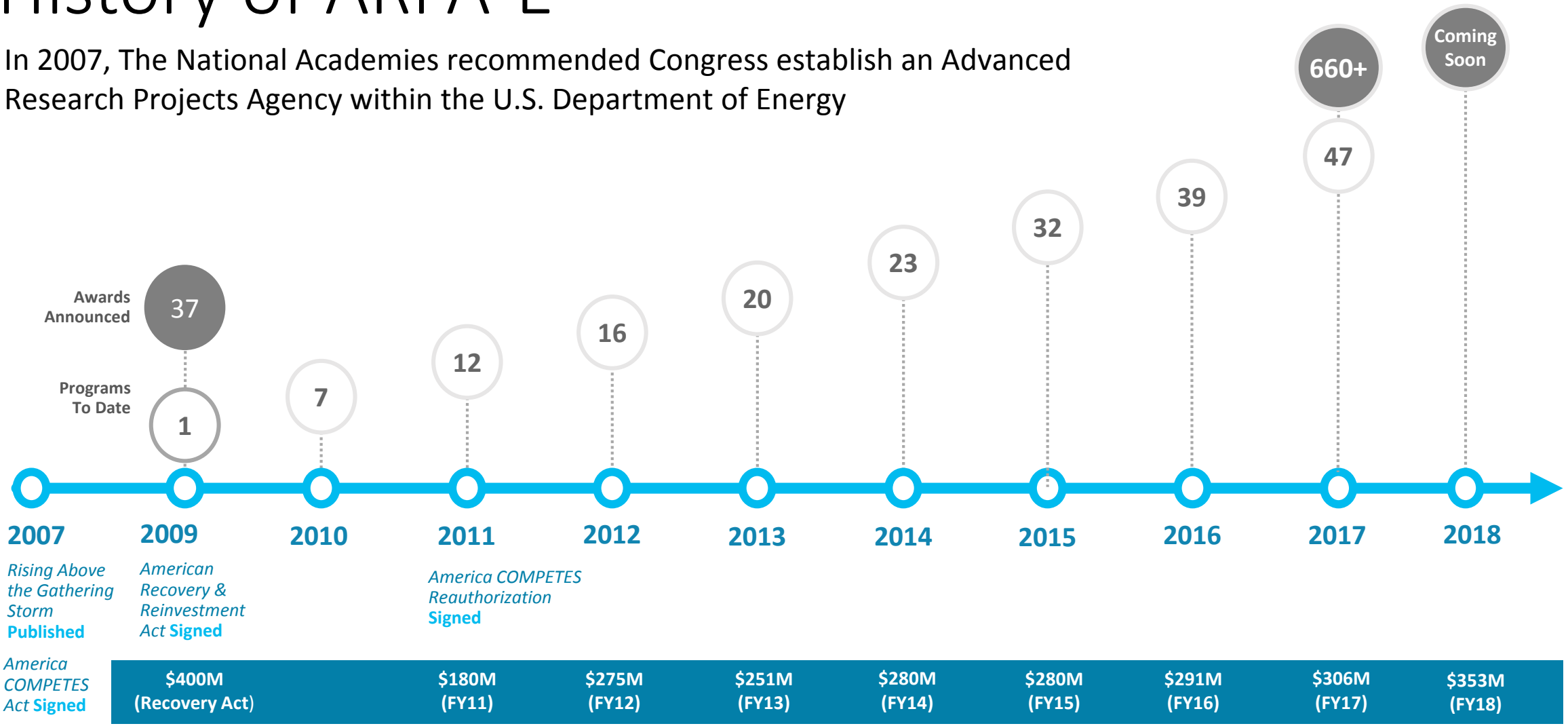
ARPA-E:
Changing What's Possible in Transportation Energy Technologies

Ann Xu
Yanzhi.Xu@hq.doe.gov

www.arpa-e.energy.gov

History of ARPA-E

In 2007, The National Academies recommended Congress establish an Advanced Research Projects Agency within the U.S. Department of Energy



ARPA-E Mission

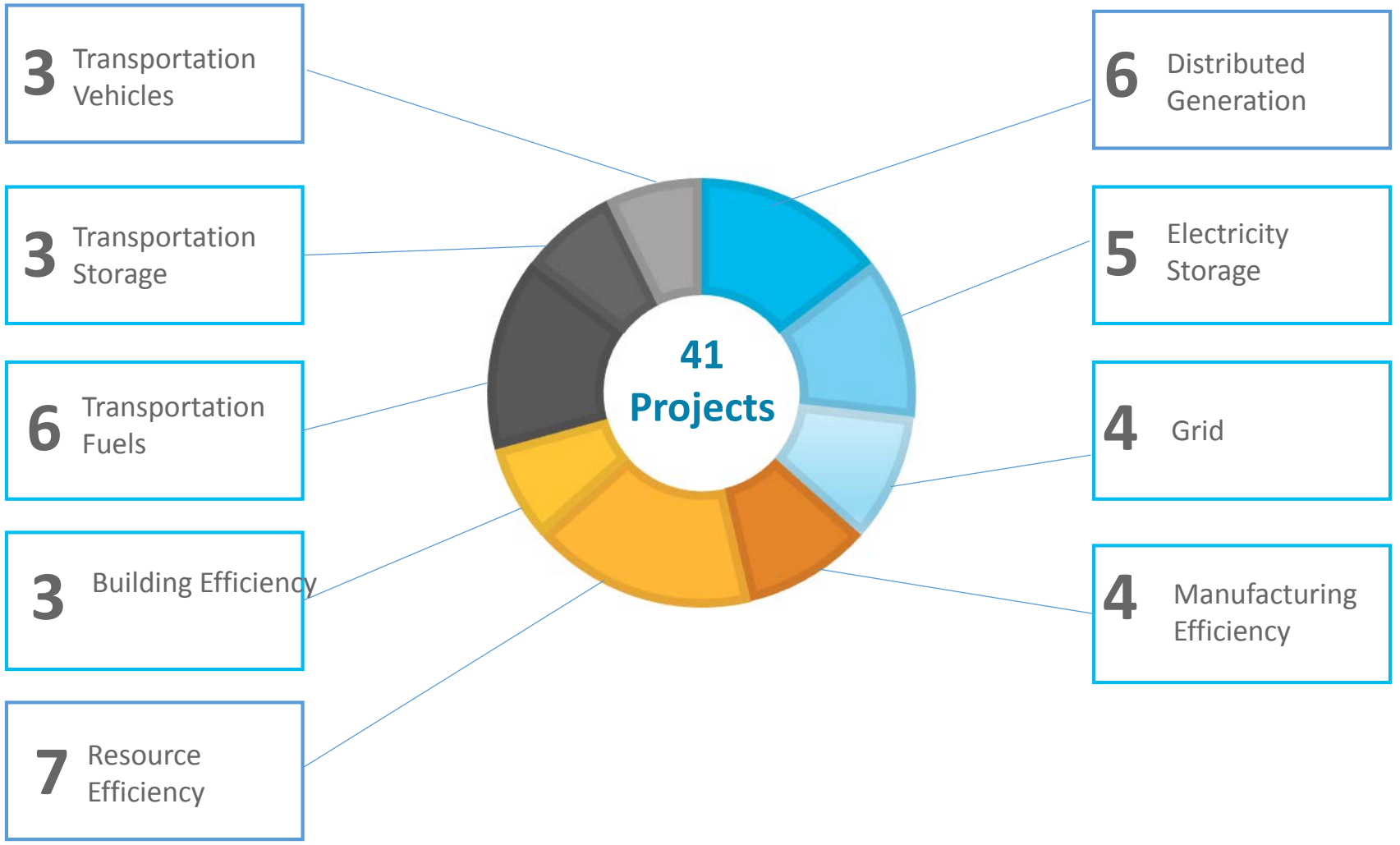
Mission: To overcome long-term and high-risk technological barriers in the development of energy technologies

Means:

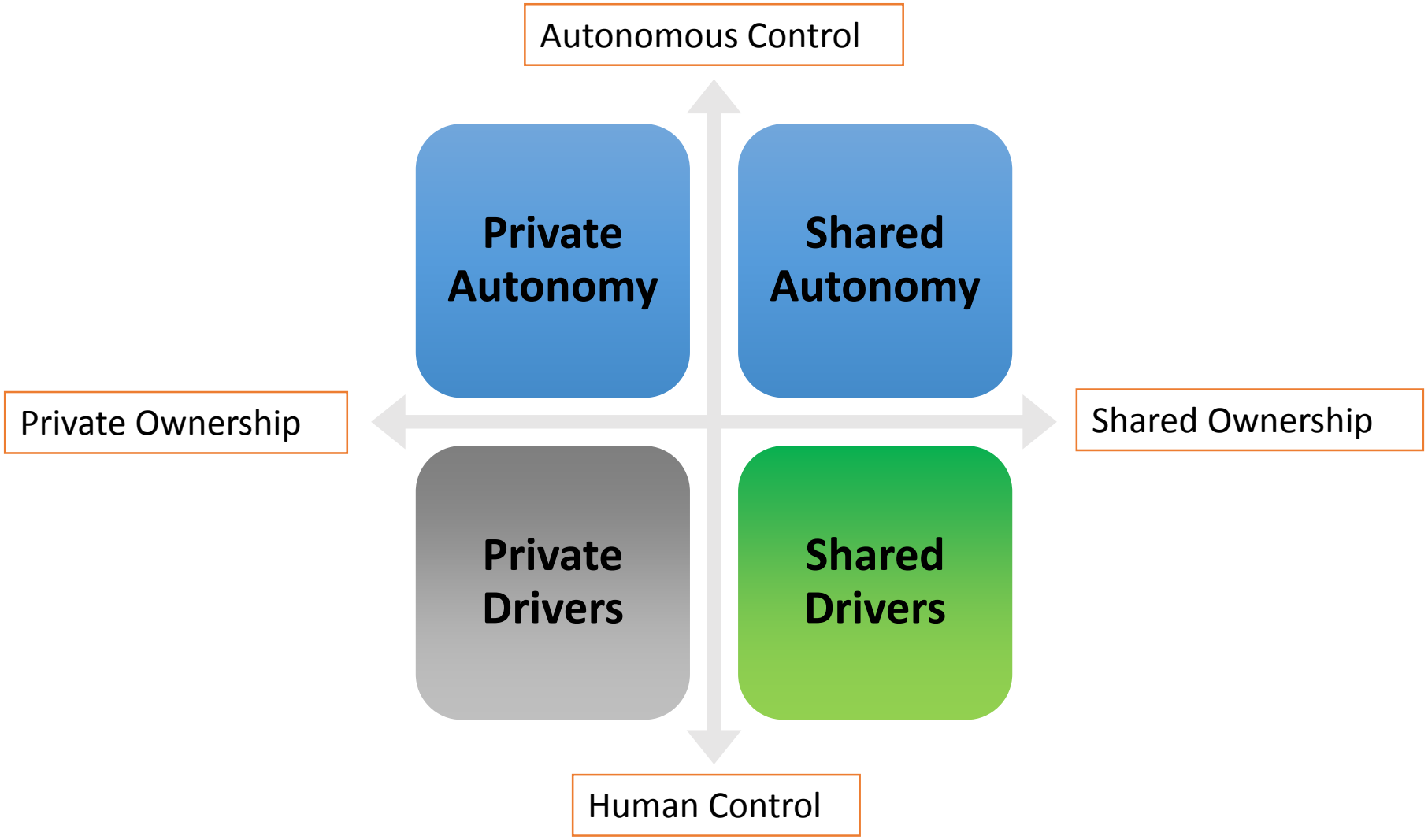
- Identify and promote revolutionary advances in fundamental and applied sciences
- Translate scientific discoveries and cutting-edge inventions into technological innovations
- Accelerate transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty

ARPA-E Program Portfolio

OPEN 2015: 41 Projects, 21 States, 9 Areas



Future of Mobility: Optimized, Shared Transportation?

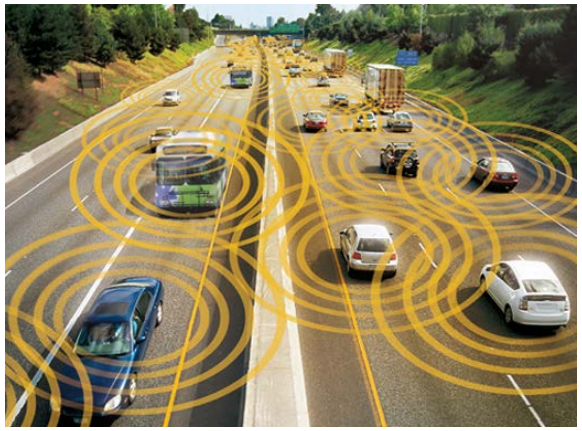


Trends in Automotive Transportation

Trend 1

Future **fuel economy** of the vehicle fleet will be required to be significantly higher than today (54.5 mpg CAFE by 2025 & EPA Phase 2 GHG HD regulations).

Trend 2



Future vehicles will utilize greater levels of **connectivity** – V2V, V2I, V2X – driven primarily by road traffic safety considerations.

Trend 3

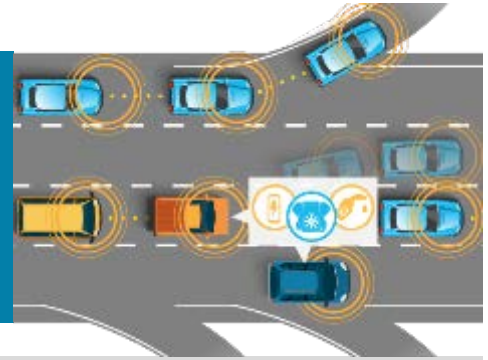
Future vehicles will display greater levels of **automation**.

- L1-L2: advanced driver assistance systems
- L3-L4: automated operation with a driver present
- L5: full automation – no driver required

Source: Trend 1 Image from CruzTalk.com

NEXTCAR

NEXT-Generation Energy Technologies for Connected and Automated on-Road vehicles



- **Mission**
- Fund the development of new and emerging vehicle dynamic and powertrain control technologies (VD&PT) that can reduce the energy consumption of future Light-Duty (LD), Medium-Duty (MD) and Heavy-Duty (HD) on-road vehicles through the use of connectivity and vehicle automation.

Program Director	Dr. Chris Atkinson
Year	2016
Projects	11
Funding Amount	$30 Million

Goals:

- **Energy consumption:** 20% reduction over a 2016/2017 baseline vehicle
- **Emissions:** No degradation relative to baseline vehicle
- **Utility:** Must meet current Federal Vehicle regulatory and customer performance requirements
- **Customer Acceptability:** Technology should be transparent to the driver
- **Incremental System Cost:** $1,000 for light-duty vehicle, $2,000 for medium-duty vehicle, and $3,000 for heavy-duty vehicle

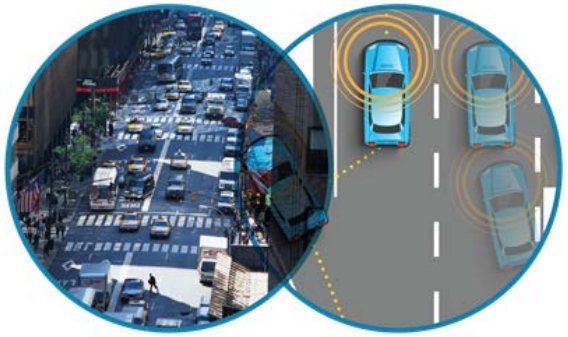
Potential Impact:

- **Energy Consumption Reduction:** 4.4 quads/year
- **CO_2 emissions:** 0.3 GT/year

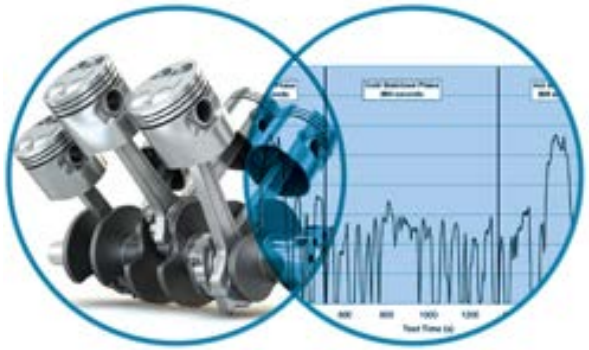
Collaborative Vehicle and Powertrain Solution

STATUS QUO

Two separate and independent efforts for improving vehicle energy efficiency



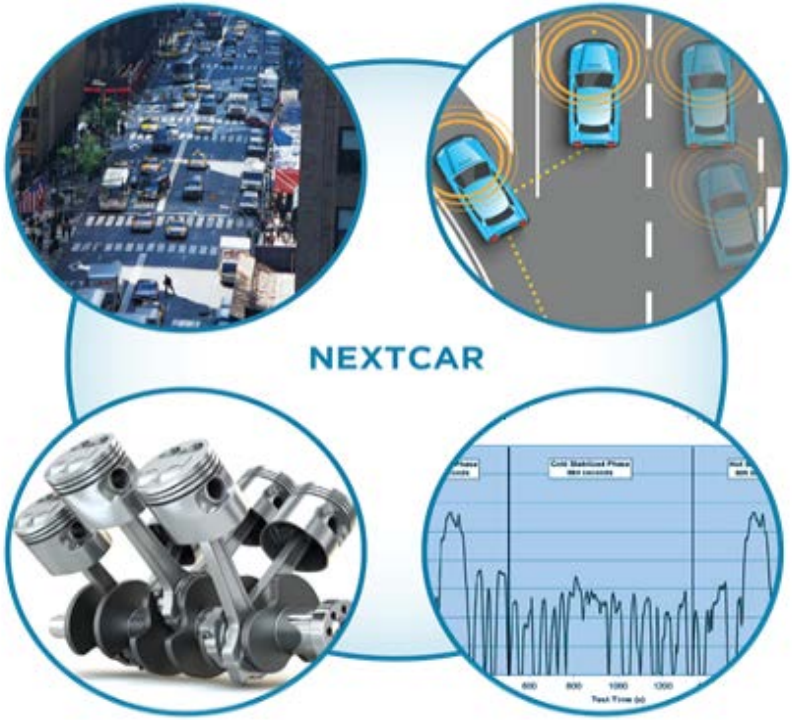
Independent Vehicle Dynamic Control



Powertrain Optimization

NEXTCAR

Program vision is to maximize energy efficiency through a cooperative effort from all communities including Transportation, Vehicles and Powertrain



TRANSNET

Traveler Response Architecture using Novel Signaling for Network Efficiency in Transportation

Mission

Develop new network control architectures, coupled with incentive strategies, to encourage individual travelers to take specific energy-relevant actions to minimize system wide energy consumption.

Program Director	Dr. Ann Xu
Year	2015
Projects	5
Funding Amount	$14.5 Million

Goals

- Demonstrate that system-wide reductions in energy use for personal transportation are possible through implementable control architectures
- Design two interacting components: a system model that simulates the transportation network and calculates individual energy use, and a control architecture, which uses incentives and personalized signals to achieve real-time energy reductions
- Reduce energy use in transportation without requiring improvements to infrastructure or vehicle technologies

What Is The Problem To Be Solved?

- Optimize the *energy efficiency* of urban, multi-modal transportation, while maintaining expected quality-of-service
  - Embed system-level energy optimization into the daily commute and emerging urban mobility services
  - Provide accurate predictive mobility and energy simulations for planning and evaluation purposes

Traveler **Information & Incentives** **Urban Transportation System**

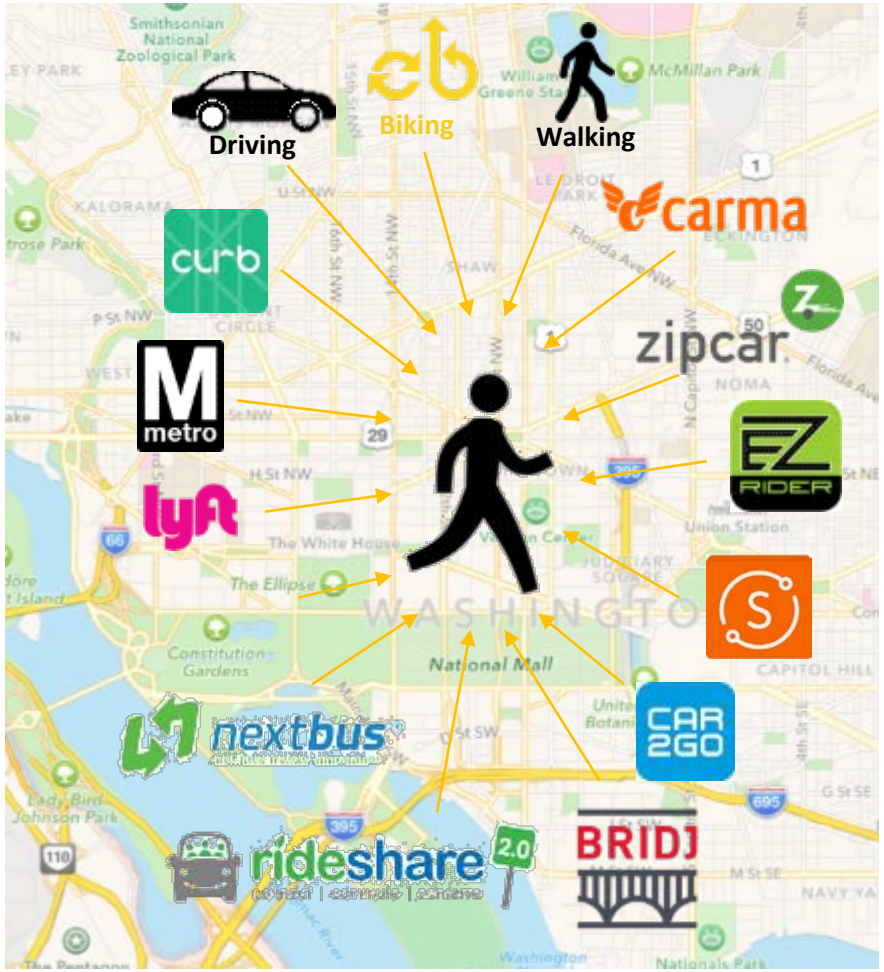
Program Structure

- **TRANSNET:**
  - System Model (SM): A parameterized model of a multi-modal urban transportation network with accurate energy estimation per traveler
  - Control Architecture (CA): Network control that enables system-level energy reductions via personalized information and incentives to individual travelers

- **Approach (initial phase):**

  Build SM and use it to benchmark the energy effects of the CA *in silico*, for various scenarios

- **Some challenging problems:**
  - Quality-of-Service Combining unconstrained & constrained modes (e.g., car ➔ transit)
  - Integration across scales Macro-, meso-, and micro-scale, computed concurrently & dynamically
  - Influencing traveler behavior What can really motivate significant behavioral shifts?



Washington, D.C. Travel Network: Modes and transport options available to personal travelers

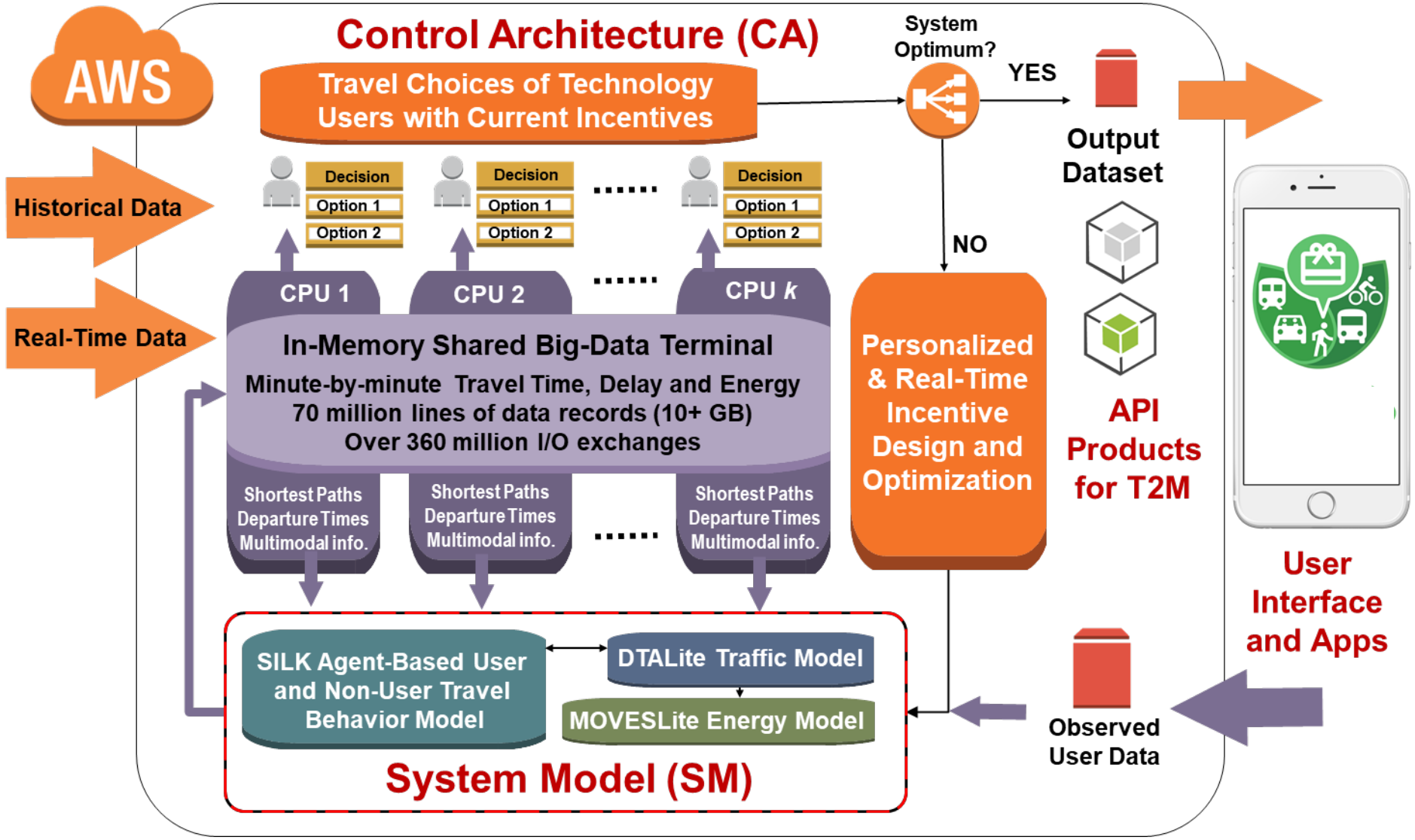
TRANSNET: 5 Projects; $14.5M

- **Teams:**
  - MIT: Boston, MA
  - University of Maryland: DC-Baltimore
  - Georgia Tech: Atlanta, GA
  - National Renewable Energy Laboratory/Metropia: Austin, TX
  - PARC: Los Angeles, CA
- **Modes:** Walk, Bicycle, Car, Bus, Rail, Rideshare
- **Variables:** Departure Time & Location, Route, Arrival Time & Location, Travel Mode, Number of Travelers, Traffic Incidents, Congestion, Events, Parking, Weather, etc.
- **Data:** INRIX, Google/Waze, RITIS, Metro Services, DOT, Vehicles, Smartphones, other Intelligent Transportation Systems
- **Controls:** Departure Times, Routing, Travel Modes
- **Traveler Incentives:** Personalized info, Rewards, Points

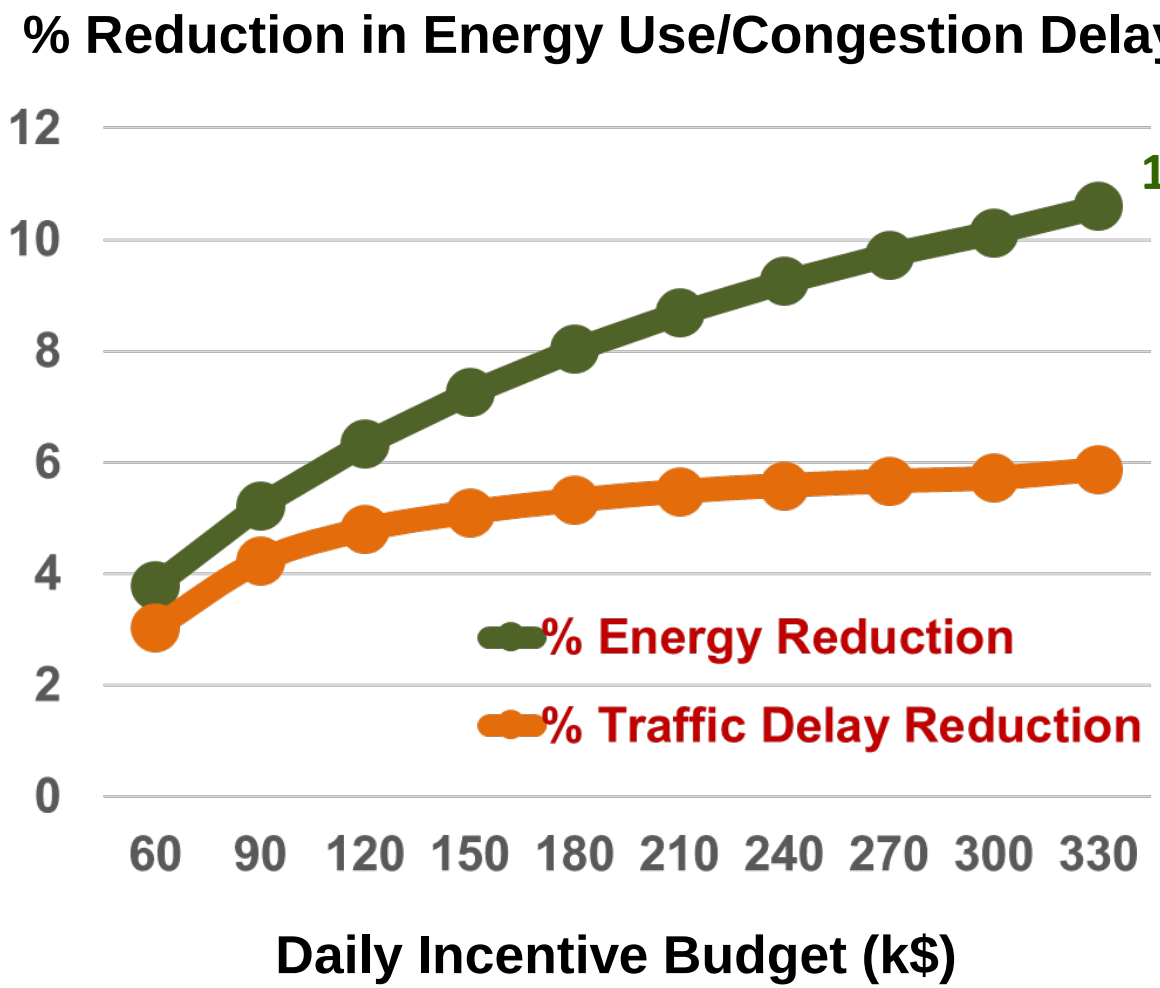
Program Outcomes

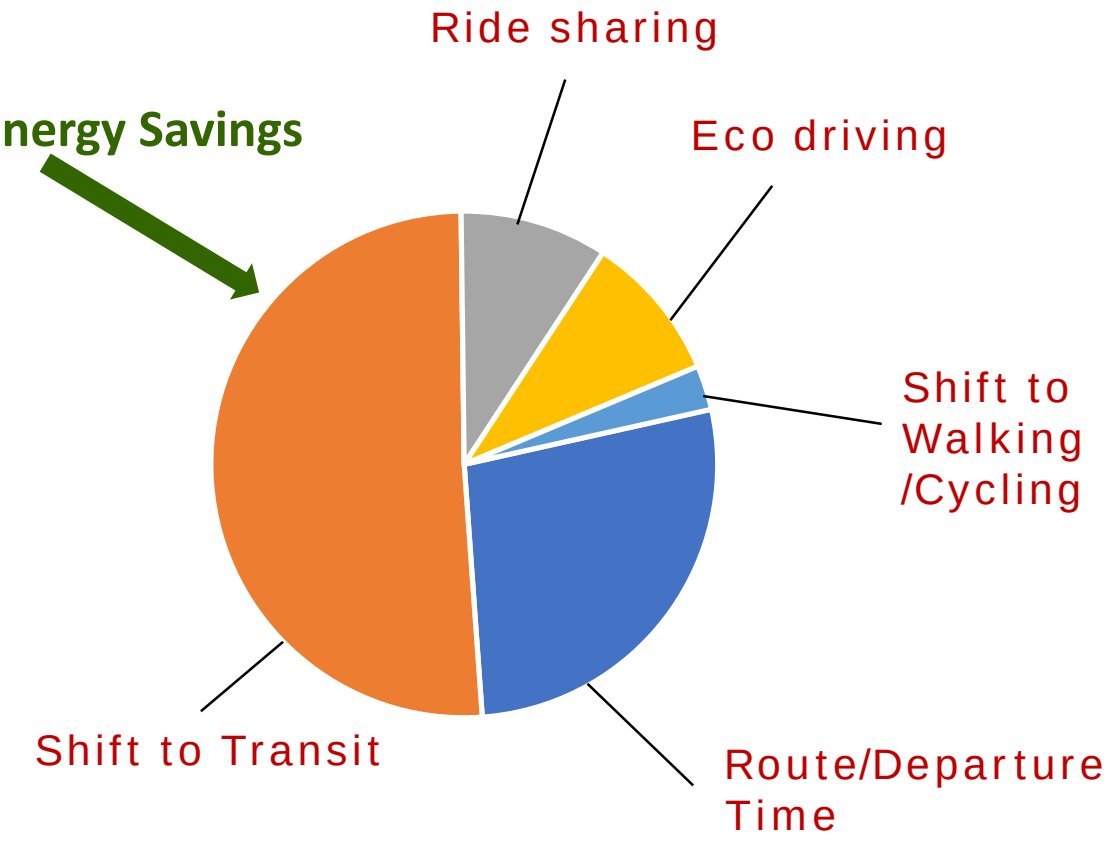
- **TRANSNET will address control architectures, traveler behavior, and the identification of technology gaps**
- **The primary objectives are:**
  - To demonstrate that energy efficiency gains are possible through implementable control architectures
  - To identify key technology gaps that limit such implementation
- **Primary stated deliverables:**
  - The system model (open source) that will be of interest for use by local and regional transportation authorities
  - The control architecture (proprietary) that will be implemented via smart phone apps
- **Several TRANSNET teams are accelerating development and implementation of smart phone apps to begin evaluation demonstrations in collaboration with state and local transportation authorities, commuter groups, or companies**

UMD incenTrip Technology Overview



Preliminary Results at 20% Penetration (U. Maryland)





Join the Team that is Transforming the Energy of Tomorrow

PROGRAM DIRECTOR

- ✓ Program development
- ✓ Active project management
- ✓ Thought leadership
- ✓ Explore new technical areas

TECHNOLOGY-TO-MARKET ADVISOR

- ✓ Business development
- ✓ Technical marketing
- ✓ Techno-economic analyses
- ✓ Stakeholder outreach

FELLOW

- ✓ Independent energy technology development
- ✓ Program Director support
- ✓ Organizational support

Learn more and apply: **arpa-e-jobs@hq.doe.gov**.

https://arpa-e.energy.gov

Contact: Dr. Ann Xu: Yanzhi.Xu@hq.doe.gov

TRB Webinar:
Reducing Transportation Emissions—Recent EPA Initiatives

Susan Burke
Office of Transportation and Air Quality
United States Environmental Protection Agency

April 25, 2018

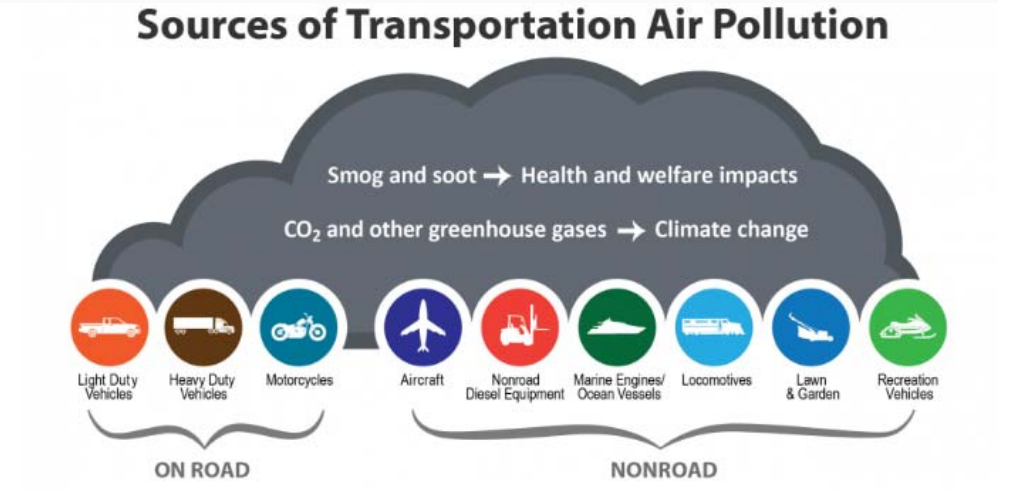
Overview

- EPA Office of Transportation and Air Quality
- Clean Diesel Funding Assistance Program
- Ports Initiative
- Volkswagen Clean Air Act Civil Settlement
  - Mitigation Trust
  - Zero Emission Vehicle Investment
- Resources
- Questions for Consideration

EPA Office of Transportation and Air Quality (OTAQ)

OTAQ's mission is to protect human health and the environment by:

- reducing air pollution from mobile sources and the fuels that power them
- advancing clean fuels and technology and
- encouraging business practices and travel choices that minimize emissions



OTAQ's Programs

Assessment and Standards

Compliance

Vehicle and Engine Testing

Transportation Activity and Planning

Clean Diesel Funding Assistance Program

- Enables EPA to offer funding assistance for projects that achieve significant reductions in diesel emissions and exposure, particularly from fleets operating at or servicing goods movement facilities located in areas designated as having poor air quality.

- Diesel Emissions Reduction Act (DERA) originally authorized under the Energy Policy Act of 2005. Amended by the Diesel Emissions Reduction Act of 2010.

Clean Diesel Funding Assistance Program

- National Funding Assistance Program
  - Fiscal Year 2018 funding: $40 Million
  - RFP posted at: www.epa.gov/cleandiesel/clean-diesel-national-grants#rfp
  - Deadline for Proposals: June 12

- Eligible Entities
  - Regional, state, local, tribal or port agency with jurisdiction over transportation or air quality; and
  - Nonprofit organization or institution which
    - Represents or provides pollution reduction or educational services to persons or organizations that operate diesel fleets; or
    - Has, as its principle purpose, the promotion of transportation or air quality
  - Private entities and individuals can benefit through partnerships with eligible entities

Clean Diesel Funding Assistance Program

Eligible Vehicles, Equipment & Engines

May include, but are not limited to

- Buses;
- Class 5 – Class 8 heavy-duty highway vehicles;
- Marine engines;
- Locomotives engines; and
- Non-road engines, equipment or vehicles used in:
  - Construction; Handling of cargo (including at a port or airport); Agriculture; Mining; or Energy production (including stationary generators and pumps)

Eligible Projects

- Verified Exhaust Control Technologies
- Verified/Certified Engine Upgrades and Remanufacture Systems
- Verified Cleaner Fuels
- Verified Idle Reduction Technologies
- Verified Aerodynamic Technologies & Low Rolling Resistance Tires
- Certified Clean Alternative Fuel Conversion
- Certified Engine Replacement
- Vehicle and Equipment Replacement

Clean Diesel Funding Assistance Program

- Certified Engine Replacement:
  - EPA will fund up to 60% of the cost (labor and equipment) of replacing a diesel engine with a zero emission power source for the following applications
    - Highway Diesel Vehicles
    - Locomotive
    - Marine
    - Nonroad Vehicles and Equipment

- Vehicle and Equipment Replacement
  - EPA will fund up to 45% of the cost of
    - new, zero emission nonroad vehicle or piece of equipment
    - an all-electric replacement vehicle for highway vehicles (other than drayage trucks)
- Note that hydrogen fuel cells are only eligible for engine, vehicle, and equipment replacements for certain applications

Ports Initiative

Why focus on ports?

- Port-related diesel emissions impact public health and the climate
- Important part of U.S. economy
- Expected to grow
- Need for better data, emission inventories, and other support for environmental planning and decision-making

Funding

Helping Ports Capitalize on Funding for Clean Technologies

Technical Resources

Providing Tools to Help Identify Smart Infrastructure Investments

Collaboration

Promoting Port-Community Collaboration for Effective Planning

Coordination

Increasing Efficiency in Federal Government and Port Operations

Communications

Creating a Knowledge Clearinghouse

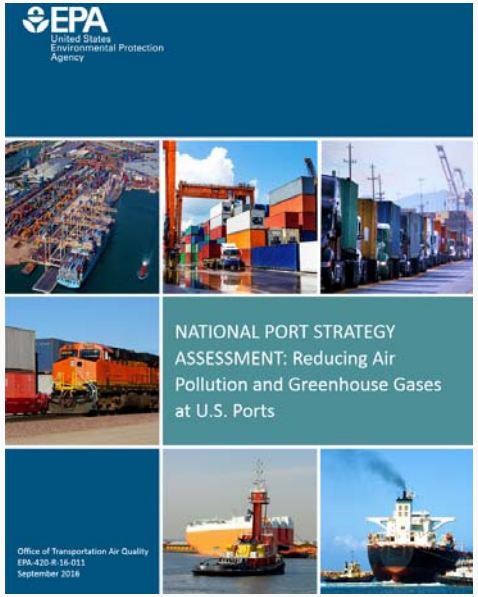
Ports Initiative

- We are working to advance clean technologies at ports, including low and zero emission vehicles and equipment.

  One example:

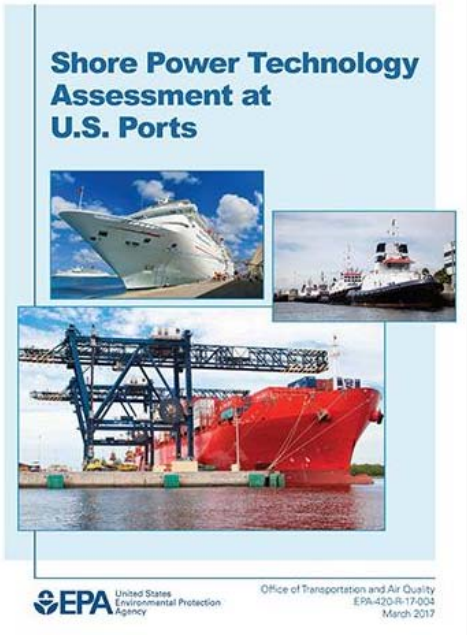
  - DERA funding helped support the replacement of a1987 diesel ship-loading crane with a new all-electric crane at the Port of Los Angeles
    - Reduces direct emissions of NOx, PM, HC, CO, and GHGs by 100%
    - Over the crane's lifetime, PM reductions equivalent to taking 3,400 heavy duty trucks off the road for a year.
    - Reduces noise
- We are performing a case study on the ports of Long Beach and Los Angeles jointly developed Clean Air Action Plan, which includes ambitious ZEV goals, to inform other ports

Ports Initiative



National Port Strategy Assessment: Reducing Air Pollution and Greenhouse Gases at U.S. Ports

Released 2016



Shore Power Technology Assessment at U.S. Ports

Released 2017

www.epa.gov/ports-initiative

Volkswagen Partial Clean Air Act (CAA) Settlements

- On October 25, 2016, the court approved a settlement partially resolving allegations that Volkswagen violated the Clean Air Act by the sale of vehicles containing 2.0 liter diesel engines equipped with defeat devices.

  Under this settlement, VW is required to:
  - Buyback or perform an emissions modification on at least 85% of the affected vehicles
  - Invest an additional $2 billion to promote the use of zero emission vehicles and infrastructure
  - $2.7 billion to fully remediate the excess NO_x emissions from the affected vehicles through mitigation trust fund

- On May 17, 2017, the court approved a second partial settlement addressing vehicles containing 3.0 liter diesel engines
  - Required buyback or perform an emissions modification on at least 85% of the affected vehicles
  - Required an additional $225 million to mitigation trust fund

- A third partial settlement addressing civil penalties and injunctive relief was approved on April 13, 2017.

Mitigation Trust Fund

- Volkswagen must fund a $2.7 billion mitigation trust fund to fully mitigate the total, lifetime excess NO_x emissions from the 2.0 liter vehicles and an additional $225 million to fully mitigate emissions from the affected 3.0 liter vehicles

- All 50 states, DC, and Puerto Rico have certified as beneficiaries to the trust. All federally recognized tribes can also become beneficiaries.

  – Each beneficiary will receive a specific allocation of funds that can be used for any of the listed eligible mitigation actions

  – The allocation structure is primarily based on the number of registered illegal Volkswagen vehicles within the boundaries of the beneficiary

Mitigation Trust Fund

Eligible Mitigation Projects

1. Class 8 local freight trucks and port drayage trucks
2. School/shuttle/transit bus
3. Locomotive switchers
4. Ferries/tugboats
5. Ocean going vessels shorepower
6. Class 4-7 local trucks
7. Airport ground support equipment
8. Forklifts and cargo handling equipment at ports
9. Light-duty ZEV supply equipment (up to 15% of allocation)

DERA Option (#10)

- Option to use Trust Funds for actions not specifically listed but otherwise eligible under DERA
- Beneficiaries may use Trust Funds for their DERA non-federal voluntary match
- State and tribal DERA grants only

Zero Emission Vehicle (ZEV) Investment

- Volkswagen required to invest $2 billion over 10 years in four 30-month cycles
  - $1.2 billion National ZEV Investment (excludes CA)
  - $800 million California ZEV Investment

- Electrify America (EA), a wholly-owned subsidiary of Volkswagen Group of America, was established to fulfill the ZEV Investment requirements of the settlement

- EA must submit ZEV Investment Plans to the EPA and California Air Resources Board (CARB) for their approval for each cycle, and must provide annual reports on progress

Zero Emission Vehicle Investment

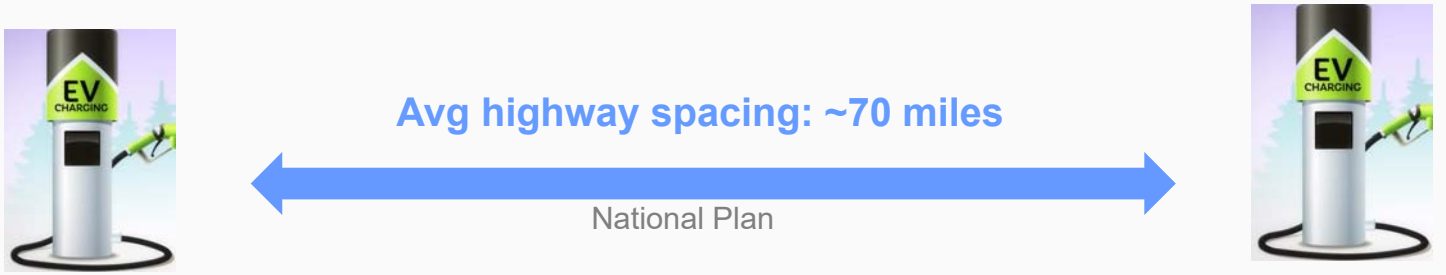
- What types of ZEV Investments can be funded under the settlement?

Infrastructure	Education	Access
• Level 2 charging at multi-unit dwellings, workplaces, and public sites • DC fast charging facilities • Later generations of charging infrastructure • Hydrogen fueling stations	• To build or increase public awareness of ZEVs • Brand-neutral media activities such as print, television, radio, websites, and social media	• Programs to increase public exposure and/or access to ZEVs without requiring the consumer to purchase or lease a ZEV at full market value, e.g., car share and ride hailing services, ride and drive events

- California investment additionally allows investments in: heavy-duty fueling infrastructure, scrap and replace with ZEV vehicles, “Green City” initiative.

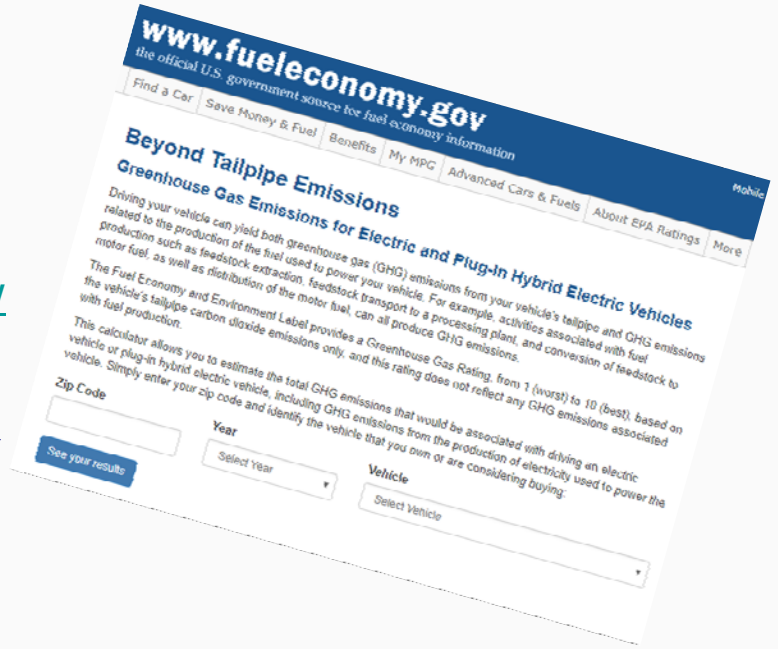
Zero Emission Vehicle Investment

- National and California ZEV Investment plans for the first 30-month cycle have been approved. Infrastructure investments in the plans include:
  - Installation of over 200 fast charging highway stations accessible to all vehicles using non-proprietary connectors
  - And 650 charging stations in seventeen communities at workplaces, retail locations, multifamily dwellings, municipal lots and garages, and community depots



Resources

- OTAQ's Main Page: www.epa.gov/aboutepa/about-office-air-and-radiation-oar#otaq
- State and Local Transportation Resources: www.epa.gov/state-and-local-transportation
- MOVES model: www.epa.gov/moves
- SmartWay: www.epa.gov/smartway
- DERA: www.epa.gov/cleandiesel
- Ports Initiative: www.epa.gov/ports-initiative
- Volkswagen Settlement information: www.epa.gov/vw
- Green Vehicle Guide: www.epa.gov/greenvehicles
- DOE-EPA website: www.fueleconomy.gov



Questions for Consideration

- Are there opportunities to shift autonomous and shared vehicles toward low carbon fuel sources, including electrification? How will this impact charging infrastructure needs?
- Will autonomous vehicles and mobility on demand services make travel so easy that we end up spending more time in the car, driving or riding further?
- Can these new mobility options change the ways we build our cities and towns around us?
- What are the opportunities for vehicle right sizing, maximizing occupancy, and reducing deadhead miles in mobility on demand?
- How will these trends affect transportation planning and forecasting?


TPO
Miami-Dade Transportation
Planning Organization
IMPACT OF FUTURE TECHNOLOGY
IN THE 2045 LRTP

STUDY BACKGROUND

- **Technology changes *influencing the decline of vehicle emissions* was a subset of our evaluation.**
- *"What will our community look like in 20 – 25 years?"*
- Technology advancements are causing a shift in the way automotive vehicles are manufactured
- **HB 7061 compliance**
- Florida Planning Emphasis Areas: Automated/Connected/Electric/Shared-use Vehicles (ACES)

STUDY METHODOLGY

- Literature Review
  - AV/CAV
    - Cars
    - Transit/Emergency Vehicles
    - Ridesharing/Car sharing
    - Marine and Freight
  - SMART City concepts
  - Solar Solutions
  - Integration of AV/CAV in Travel Demand Modeling
  - Effects of Telecommuting and Drone deliveries
- **More than 200 sources reviewed and documented**

EVALUATION

- Feasibility based on **two criteria :**

1. Technology able to be deployed as a **Pilot Program**

2. Technology able to be deployed in a **specific future time period within the 2045 LRTP**

Table 2: Preliminary Evaluation of Technologies (continued)

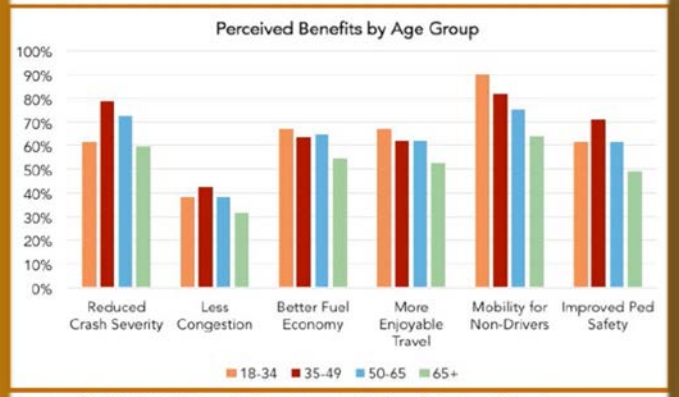
CATEGORY	SUBCATEGORY	TOPIC	Possible in Pilot Program	Possible in 2045 LRTP		
				2020-2025	2026-2035	2036-2045
E. BRT (Bus Rapid Transit)		49. Cape Town, South Africa BRT (BRT)	●	●	●	●
E. BRT (Bus Rapid Transit)		50. Healthline serving the Euclid Corridor	●	●	●	●
F. Solar		51. Solar Roadways – Missouri DOT Pilot Project on Route 66	◔	○	◔	◑
F. Solar		52. Solar Energy Present and Future	◑	◔	◑	●
G. Energy		53. Energy	◑	◔	◑	●
H. 3D Printing		54. The Future Impact of 3D Printing on the Freight Transportation Industry and Retailers	◔	◔	◑	●
I. Parking		55. How Driverless Cars Spell the End of Parking as We Know It	○	○	◔	◕
J. Bikes		56. Bikes	●	●	●	●
K. Drones		57. FAA Expects 600,000 Commercial Drones in the Air (by 2017)	●	◕	●	●
K. Drones		58. Drone Use for Transportation Purposes	●	◕	●	●
L. IoT/Data Management		59. What is the Internet of Things (IoT)?	●	◔	◕	●
L. IoT/Data Management		60. Internet of Things in Healthcare: Information Technology in Health	●	◔	◕	●

LEGEND

○ HIGHLY UNLIKELY	◔ POSSIBLE, BUT UNLIKELY	◑ POSSIBLE	◕ LIKELY	● HIGHLY LIKELY
○ HIGHLY UNLIKELY	◔ POSSIBLE, BUT UNLIKELY	◑ POSSIBLE	◕ LIKELY	● HIGHLY LIKELY

MARKET PENETRATION

Figure 2: Variations in Perceptions of Benefits of Autonomous Vehicle Technology by Major Age Groups



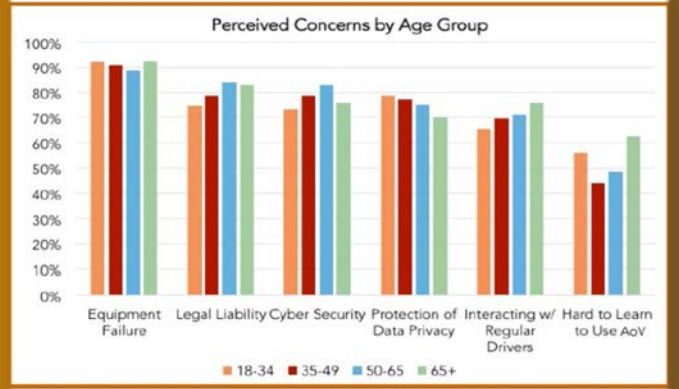
Source: Florida State University Department of Urban & Regional Planning

Table 4: Predictions of Availability of AV Cars

COMPANY	DRIVERLESS VEHICLE PREDICTION
Baidu	by 2019
BMW	by 2021
Delphi	by 2019
Ford	by 2021
GM	by 2020
NuTonomy	by 2020
Tesla	by 2018
Toyota	in 2020
Uber	Entire fleet by 2030
Volkswagen	by 2019

Source: http://www.driverless-future.com/?page_id=384

Figure 3: Variations in Perceptions of Concerns of Autonomous Vehicle Technology by Major Age Groups



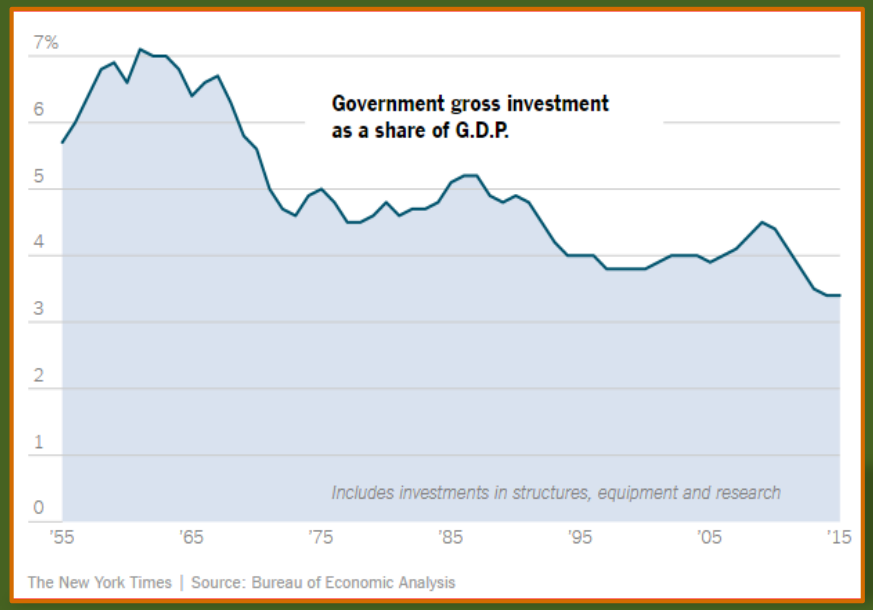
Source: Florida State University Department of Urban & Regional Planning

Table 5: Period in which AVs Will Reach Certain % of All Vehicles Purchased in U.S.

PERIOD	CONSULTANT	MPO SAC
2020–2025	NA	NA
2026–2035	25%	25%
2036–2045	50%	50%
> 2045	75%	75%

- Imperative to know **WHAT & WHEN** the Technology is coming
- Reviewed variations in Autonomous Vehicle Technology **Perceptions**
- Reviewed Predictions of **Availability** of AV Cars

FUNDING



- **Dwindling resources** from Highway Trust Fund (Federal Funds)
- Greater emphasis on Local Funds and **Local Options**

- **Vehicle Miles Travelled (VMT) Tax**

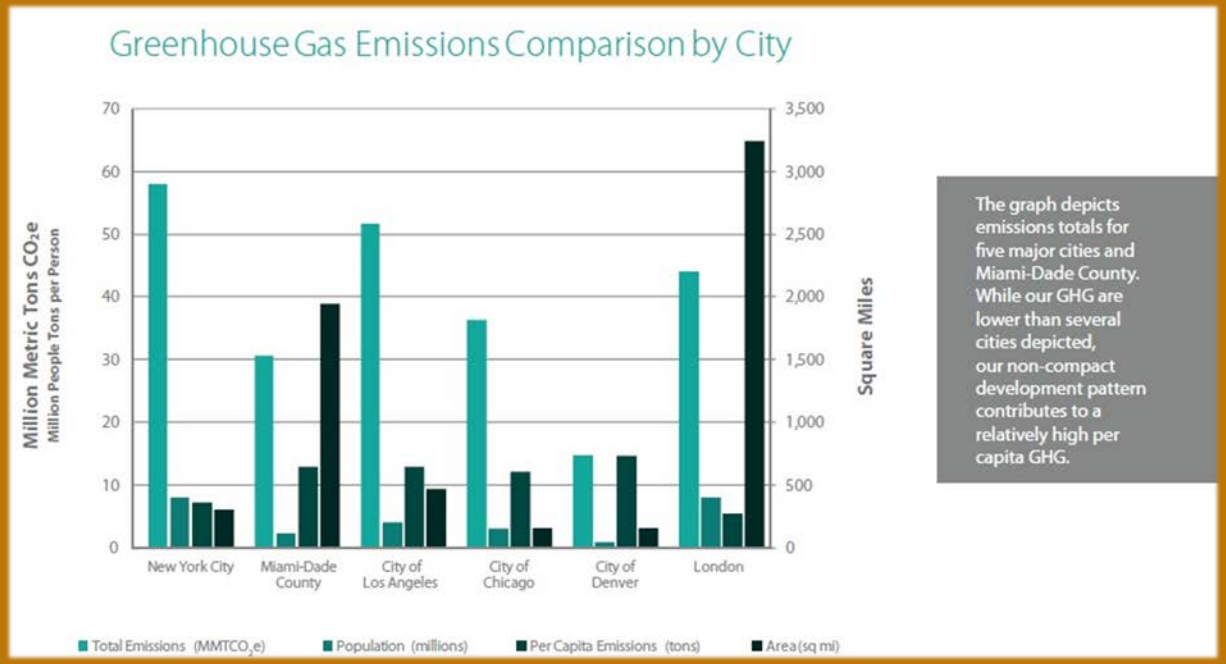
Table 3: Quick Reference to 2016 Fuel Taxes

LEVEL/TAX	AMOUNT	USE
Federal		
Fuel Excise Tax	Gasohol = 18.4¢/gal Gasoline = 18.4¢/gal Diesel = 24.4¢/gal	2.86¢ for mass transit 0.1¢ for leaking tanks Remainder for roads and bridges
State (Distributed to DOT)***		
Fuel Sales Tax	All fuels = 13.3 ¢/gal	At least 15.0% of DOT receipts** dedicated for public transportation. Remainder for any legitimate state transportation purpose.
SCETS* Tax	Gas/Gasohol = 6.1¢ – 7.4¢/gal Diesel = 7.4¢/gal	Net receipts must be spent in the district where generated.
State (Distributed to Local Governments)***		
Constitutional Fuel Tax	All fuels = 2¢/gal	Acquisition, construction, and maintenance of roads
County Fuel Tax	All fuels = 1¢/gal	Any legitimate county transportation purpose
Municipal Fuel Tax	All fuels = 1¢/gal	Any legitimate municipal transportation purpose
Local***		
Ninth-cent Fuel Tax	Gas/Gasohol = 0¢ – 1¢/gal Diesel = 1¢/gal	Any legitimate county or municipal transportation purpose
Local Option Fuel Tax	Gas/Gasohol = 5¢–11¢/gal Diesel = 6¢/gal	Local transportation; small counties may also use funds for other infrastructure needs.

GREENPRINT

- In 2009 Miami Dade was selected to participate in **Sustainability Planning Pilot Program**
- Result was a sustainability plan known as **GreenPrint**
- Uses a “Big Picture” collaborative and long term approach

- Reducing GHG emissions to **80% of 2008 levels by 2050**
- **20% of Florida’s Energy from Renewable sources by 2020**

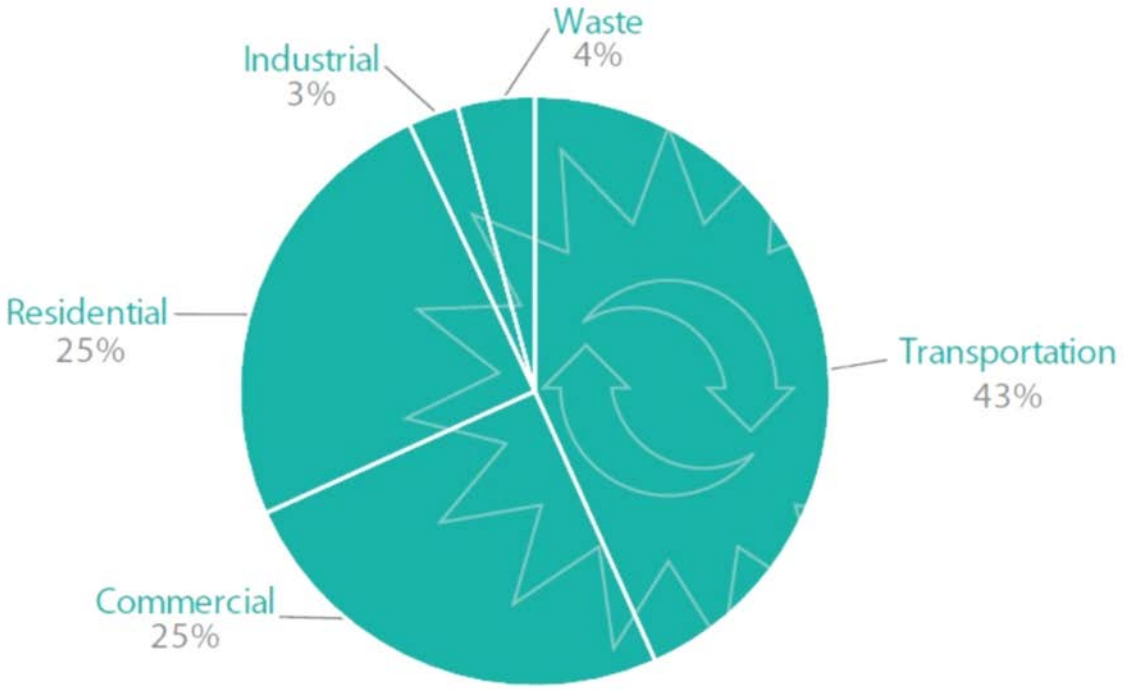


GREENPRINT

- Action Plan with **5 – Year Cycles**
- Focused on measurable goals and specific targets within its **7 interconnected** goal area
- All **GreenPrint** goals are related to specific goals and objectives outlined in the LRTP
- Details **137 specific sustainability initiatives** – 27 of which directly impact **CO2 emissions**, resulting in:
  - ✓ 1.5 Million Metric Tons of CO2 equivalent reductions
  - ✓ 2.9 Million Metric Tons of CO2 equivalent avoidances

TRANSPORTATION STATISTICS

Miami-Dade County 2005 Community-wide Emissions Inventory by Community Sector

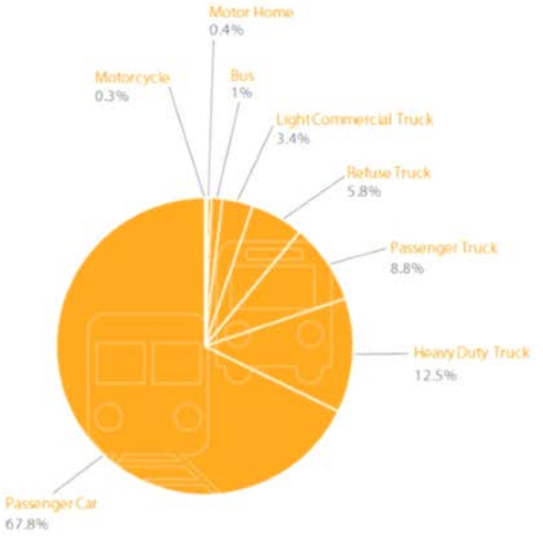


30.7 Million Metric Tons of CO_2e

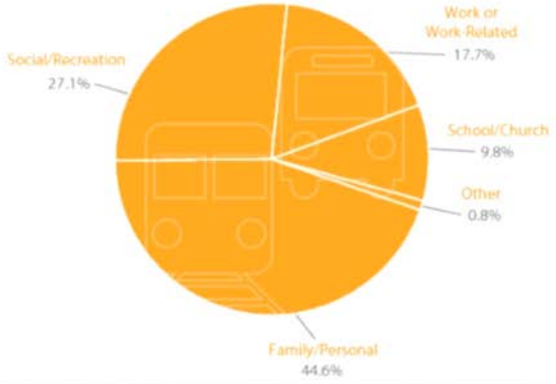
This chart illustrates total community-wide GHG. Clearly transportation, commercial and residential sectors are major contributors with significant potential for reductions.

2015 Estimated Daily Greenhouse Gas Emissions by Vehicle Type

The personal automobile is expected to continue to be the largest source of GHG emissions within the transportation sector in 2015, contributing 68 percent of the GHG emissions . This estimate is based on transportation modeling, which includes transportation projects planned through 2015. (MPO, "Emissions Scenarios" Figure 12)



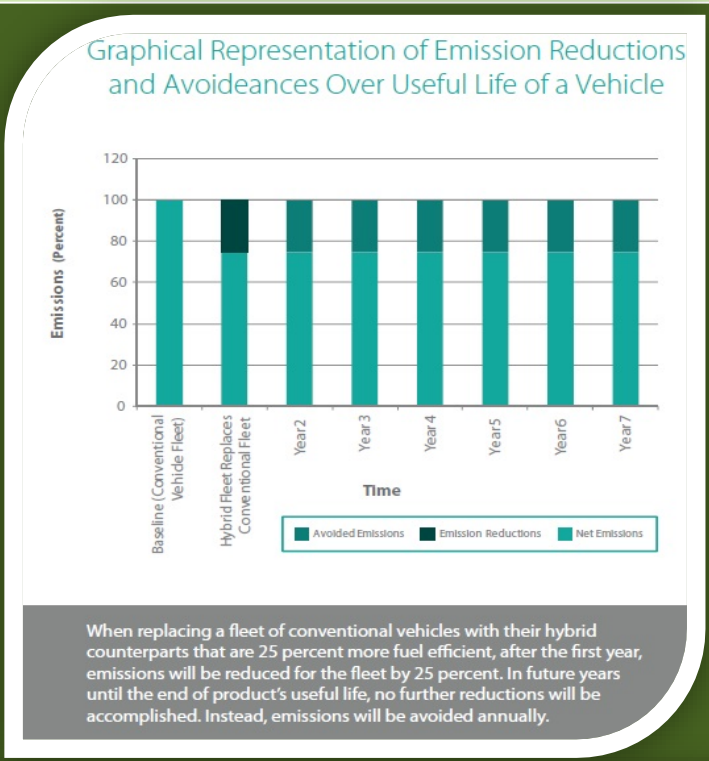
Breakdown of Trips by Purpose



Most trips are not work-related. Compact development can help people reduce car use for errands, shopping , and other personal trips. (Urban Land Institute 5)

SOLUTIONS

- County converting fleet from **Diesel to CNG**
- **EV Charging Stations** for general public county wide
- **Incentives** for user Carpooling ,Vanpooling and Commuter services
- Increasing Bicycle and Pedestrian Miles **(Underline Project)**



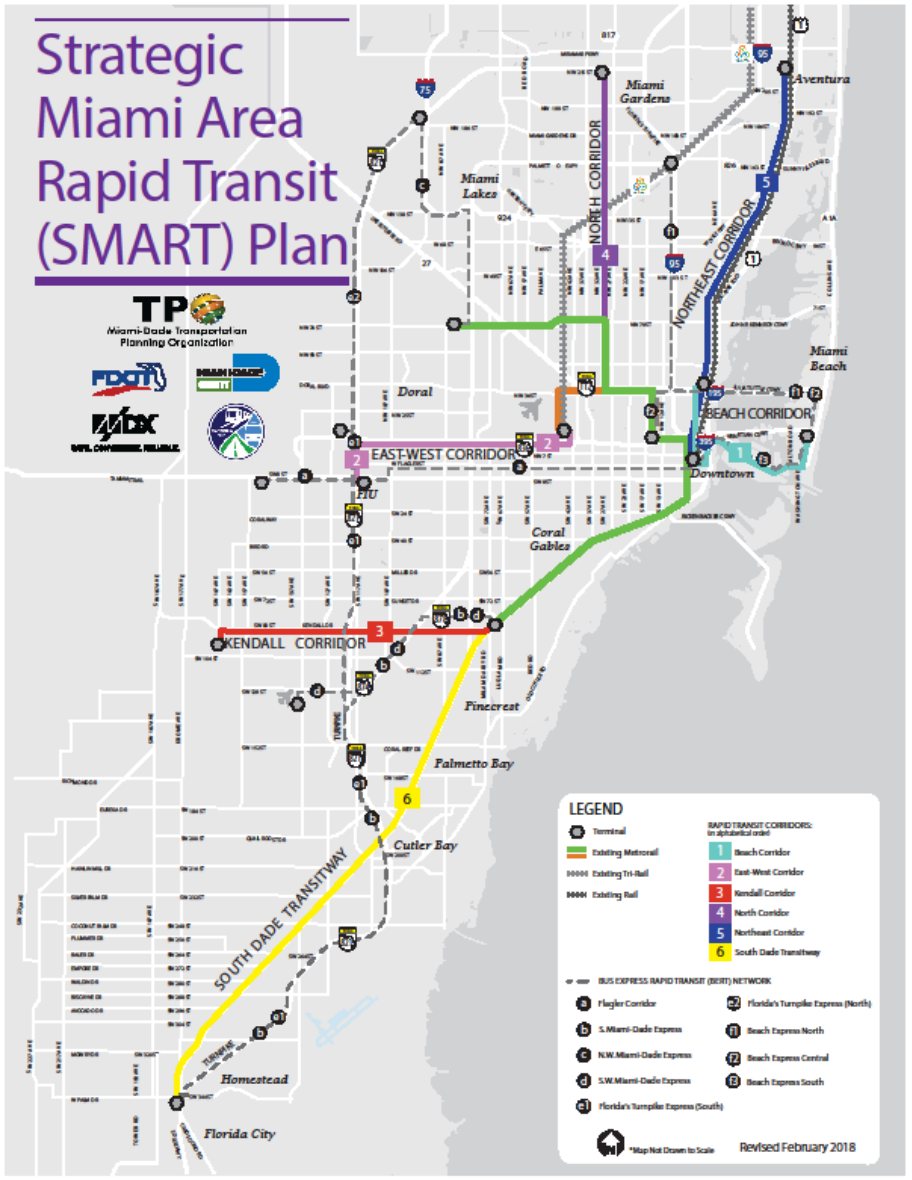
Quantified Emission Reductions Associated with Strategy

Initiative	Total Projected Reduced Emissions (mt CO_2e)
Work in partnership with the Metropolitan Planning Organization (MPO) and South Florida Commuter Services to expand carpooling and vanpooling programs Increase carpool participation by five percent/year Increase Vanpool fleet by 12 vans/year	Carpooling 3,892
	Vanpooling 1,613
Expand the express bus service between Miami-Dade and Broward counties through extending the I-95 managed/express lanes from Golden Glades Interchange to I-595 (expected completion of construction by December 2013)	337
Total	5,842

Quantified Emission Reductions Associated with Strategy

Initiative	Total Projected Reduced Emissions (mt CO_2e)
Increase the percentage of total trips taken by walking or bicycling from 10 percent to 16 percent of all travel trips *(over plan period of 5 years)*	128,622
Fund & Construct Priority non-motorized multi-use trails 8.4 miles of Black Creek Trail *(expected completion by July 2012)*	643
Include designated bicycle space within Metrorail cars *(1,750 bikes on trains/year beginning in 2014)*	984
Total	130,249*

TRANSIT ROLE – (SMART PLAN)



- 6 RAPID TRANSIT CORRIDORS
- Bus Rapid Transit Network (9 Routes)
- 50 % of Future growth

Table 8: Fuel Savings (in US dollars)

	Present Value	2020	2025	2030	2035	2040	2045	30-year Cumulative
Fuel Savings (in gallons)		226,856	222,420	222,778	227,210	225,615	224,557	6,753,016
Fuel Savings (in US dollars)	$12,635,345	$803,071	$825,178	$851,012	$883,847	$937,569	$992,544	

Note: Present Value in real 2013 dollars. Annual values in nominal amounts.

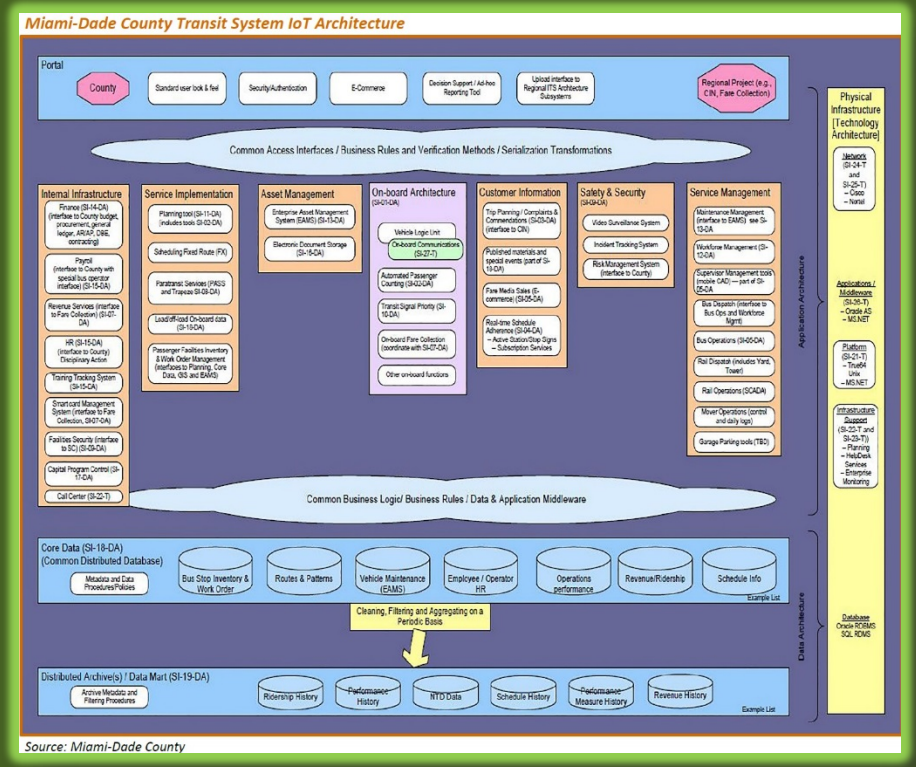
Source: Parsons Brinckerhoff

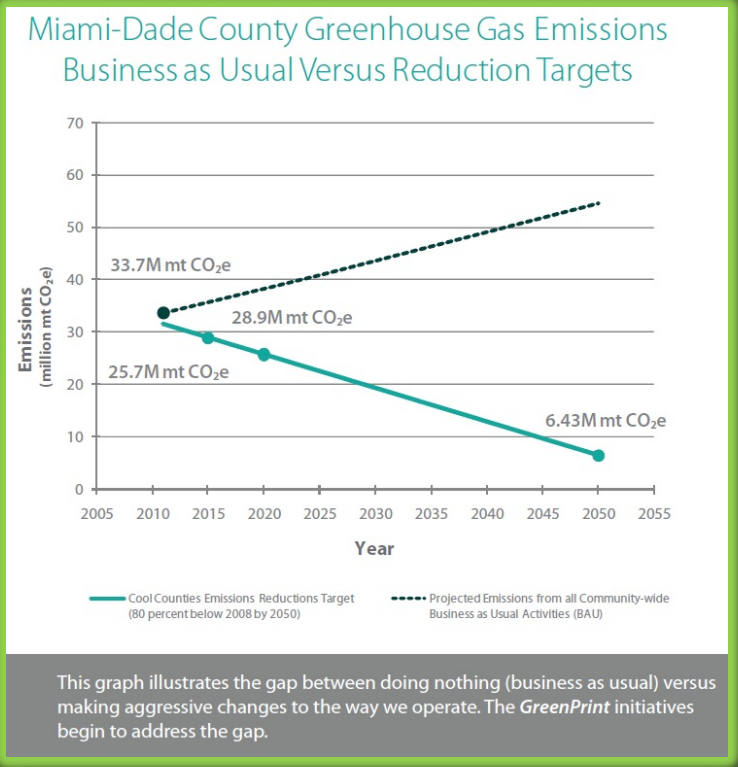
Emission Reductions from Increasing Transit Ridership

Miami-Dade County	Metro Bus	Metrorail	Metro Mover	Total
If we increase transit ridership by	Reduced emissions from ridership increase in mt CO_2e			mt CO_2e
10 percent	18,747	7,238	463	26,448
20 percent	37,495	14,476	926	52,897
30 percent	56,242	21,714	1389	79,345
40 percent	74,990	28,952	1852	105,794
50 percent	93,737	36,191	2315	132,242

NEXT STEPS

- Study was integrated into the **Guiding Principles in the 2045 LRTP**
- Ensure **Systems Architecture** is ready for deployment of New Technology
- Continue working towards **GreenPrint** goals and objectives
- Continue to promote and grow Bicycle, Pedestrian and **TRANSIT** usage





This graph illustrates the gap between doing nothing (business as usual) versus making aggressive changes to the way we operate. The ***GreenPrint*** initiatives begin to address the gap.

Thank you!

Questions/Comments?

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Kevin Black

Mr. Kevin Black is an Air Quality Specialist with the Federal Highway Administration's Resource Center in Baltimore, Maryland. In his position, he works on issues pertaining to air quality impact associated with highway programs and projects, air quality monitoring. and other transportation-related air quality issues. He is a member of several TRB subcommittees or committees including the committee sponsoring this webinar. Kevin holds a B.A. in Geography from George Mason University, a B.S. in Civil Engineering from Virginia Tech, and an M.S. in Civil and Environmental Engineering from George Mason University.

Dr. Daniel Sperling

Dr. Daniel Sperling is Distinguished Professor of Civil Engineering and Environmental Science and Policy, and founding Director of the Institute of Transportation Studies at the University of California, Davis (ITS-Davis). He holds the transportation seat on the California Air Resources Board and served as Chair of the Transportation Research Board of the National Academies in 2015-16 (and is current member of the Executive Committee). Among his many prizes are the 2013 Blue Planet Prize from the Asahi Glass Foundation Prize for being "a pioneer in opening up new fields of study to create more efficient, low-carbon, and environmentally beneficial transportation systems." He served twice as lead author for the IPCC (sharing the 2007 Nobel Peace Prize), has testified 7 times to the US Congress, and provided 10 keynote presentations in the past 4 months. He has authored or co-authored over 250 technical papers and 13 books, including, Three Revolutions: Steering Automated, Shared and Electric Vehicles to a Better Future (Island Press, 2018), is widely cited in leading newspapers, been interviewed many times on NPR radio, including Science Friday, Talk of the Nation and Fresh Air, and in 2009 was featured on The Daily Show with Jon Stewart.

Dr. Ann Xu

Dr. Ann Xu is Senior Technical Advisor for Impact and Assessment at the Advanced Research Projects Agency – Energy, or ARPA-E, a unit of the U.S. Department of Energy. She is Program Director for ARPA-E's TRANSNET program, which seeks to demonstrate that system-wide reductions in energy use for personal transportation are possible through implementable incentive architectures. Dr. Xu is chairs the Technology and Behavior subcommittee of TRB's Air Quality Committee. She is also Session Planning subcommittee chair of the Transportation and Sustainability Committee. She holds a PhD in Civil Engineering from Georgia Institute of Technology.

Dr. Susan Burke

Dr. Susan Burke is a scientist in the Transportation and Climate Division of U.S. EPA's Office of Transportation and Air Quality. She works on a variety of initiatives related to electric vehicles (and hydrogen fuel cell vehicles) including consumer information and, most recently, the Zero Emission Vehicle (ZEV) Investment component of the Volkswagen settlement. She has a Ph.D. in physics from the University of Arizona.

Tewari Edmonson

Mr. Tewari Edmonson serves as a Transportation Planner for the Miami-Dade Transportation Planning Organization (TPO) and graduated from Florida International University with a Bachelors and a Masters of Science in Civil Engineering with a specialization in Transportation.

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