

Greenhouse Gas Emission Reduction Strategies

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“We know that our dependence on foreign oil endangers our security and our economy.
We know that climate change poses a threat to our way of life – in fact we are already beginning to see its profound and costly impact.
And we know that our economic future depends on our leadership in the industries of the future.”
--President Obama May 21, 2010



Presidential Directive of May 21, 2010

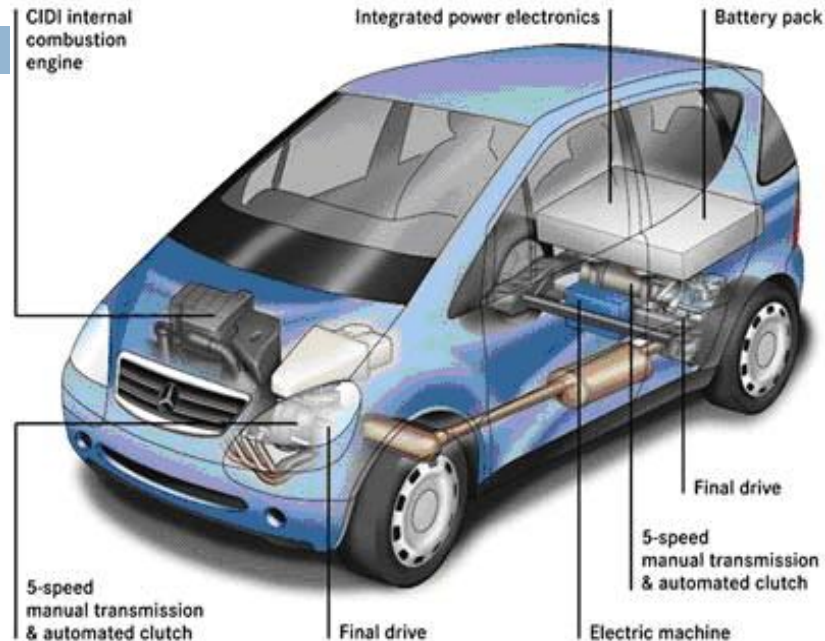
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- President Obama ordered tougher fuel-efficiency standards for cars and trucks, advancing the fight against climate change
- Under new Corporate Average Fuel Economy (CAFÉ) standards, new cars must get at least 35.5 miles to a gallon of fuel by 2016
- The president's new plan would order further improvements in fuel efficiency for cars and light trucks made in 2017 and beyond, and in medium and heavy trucks made in 2014 through 2018
- The directive orders more federal support for new vehicles like advanced electric cars, and it instructs the EPA to reduce emissions of other kinds of pollutants by motor vehicles, besides greenhouse gases

Source: New York Times

Current State of Hybrid-Electric Cars

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- Hybrid sales dropped along with car sales in general from 2008 to 2009, but remained steady at 2.5% of the market
- About 250,000 hybrid cars were sold in 2009; New York is the third largest hybrid market in the country
- Potential GHG reductions from hybrid-electric light-duty vehicles range from 26-54% by 2030
- Currently hybrid cars cost approximately \$3,700-\$5,700 more than a comparable conventional vehicle
- Toyota plans to offer a full line of regular hybrids by 2020

Incentives for Hybrid-Electric Cars

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- Federal tax credits are available for advanced vehicle technologies ranging from \$250 to \$3,400 depending on the vehicle's level of fuel economy improvement. The full tax credits are available until December 31, 2010, or until a manufacturer reaches 60,000 vehicles sold
- HOV lane occupancy requirements on the Long Island Expressway are waived for passenger vehicles that meet strict emissions standards and average a least 45 mpg highway
- Two bills in the Assembly Ways and Means Committee would exempt hybrid vehicles from the state sales.

Current State of Plug-In Hybrid Electric Cars (PHEV's)

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- Plug-in hybrid cars run on an electric motor for a certain range, then a gasoline engine kicks in and the car runs as a hybrid
- PHEVs reduce lifecycle GHG emissions by 12-54% compared to conventional automobiles depending on the source of the electric power
- Cars can be plugged into regular electrical sockets, but take 8-16 hours to recharge
- The plan is for electric cars to use “quick chargers” hardwired directly into high-power lines that would take just a few hours to recharge a car battery
- The projected level of adoption of EVs should not threaten the stability of the electric grid as long as most chargers are “smart”, allowing charging to take place during off-peak hours. Two examples of PHEV's are:
- Chevrolet Volt in October 2010
 - The Volt takes 8 hours to charge, or 3 hours if a 240-volt outlet is installed
 - Has a range of 40 miles
 - GM plans to build 60,000 a year
- Toyota Plug-in Hybrid Prius in 2011
 - Can travel 14.5 miles on a single electric charge before gasoline engine kicks in
 - Takes about 100 minutes to charge at a quick-charger

Sources: Cost-Effectiveness of Greenhouse Gas Emission Reductions from Plug-in Hybrid Electric Vehicles, PlaNYC, HybridCars.org, US DOT Report to Congress on Transportation's Role in Reducing US GHG Emissions

Cost Considerations for Plug-In Hybrid-Electric Cars

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- Both Volt and Prius will cost \$35,000-\$40,000, approximately \$10,000-\$15,000 more than a comparable conventional vehicle
- If the Chevrolet Volt is driven 40 miles or less, the electricity costs \$1.00
- The Toyota Prius plug-in hybrid costs about half as much to operate as does a regular Prius

Fuel Costs of Plug-In Hybrid vs. Conventional Vehicles by Vehicle Type (in dollars per mile):

	Conventional Vehicle	PHEV in Electric Mode	PHEV in Hybrid Mode
Passenger Car	0.15	0.04	0.09
SUV	0.19	0.05	0.12

Assumption: gasoline price of \$3.50, 0.14 cents/watt electricity

Assumption: all PHEVs have all-electric range of 40 miles

Sources: EPRI/NRDC, 2006

Current State of Battery Electric Cars

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“The electric car is likely to emerge as one of the most transformational products of the current era, as important, perhaps, as the personal computer and the Internet.”

--Business Week, October 19, 2009



- Electric vehicles are expected to reduce per-vehicle GHG emissions by 68-80% by 2030
- In March 2009, the U.S. Department of Energy released a \$2 billion solicitation in federal funding for EV batteries and related drive-train components, and a \$400 million solicitation for transportation electrification demonstration projects; There is a federal tax credit of up to \$2,500-\$7,500 per vehicle for electric vehicles of 10,000 lbs. or less, with a credit of up to \$10,000 for vehicles 10,000-14,000 lbs
- Nissan Leaf, debuts late in 2010, mass production begins in 2012
 - Range of about 100 miles
 - Will cost \$32,780, or \$10,000-\$15,000 more than a comparable gasoline vehicle
 - Battery would take 4-8 hours to charge on a 220-volt home charging unit; could charge to 80% in 26 minutes at a quick-charge station
 - Sources: PlaNYC, US DOT Report to Congress on Transportation's Role in Reducing US GHG Emissions, Nissan.com

Potential Role for Government in Facilitating Transition to Plug-In Vehicles

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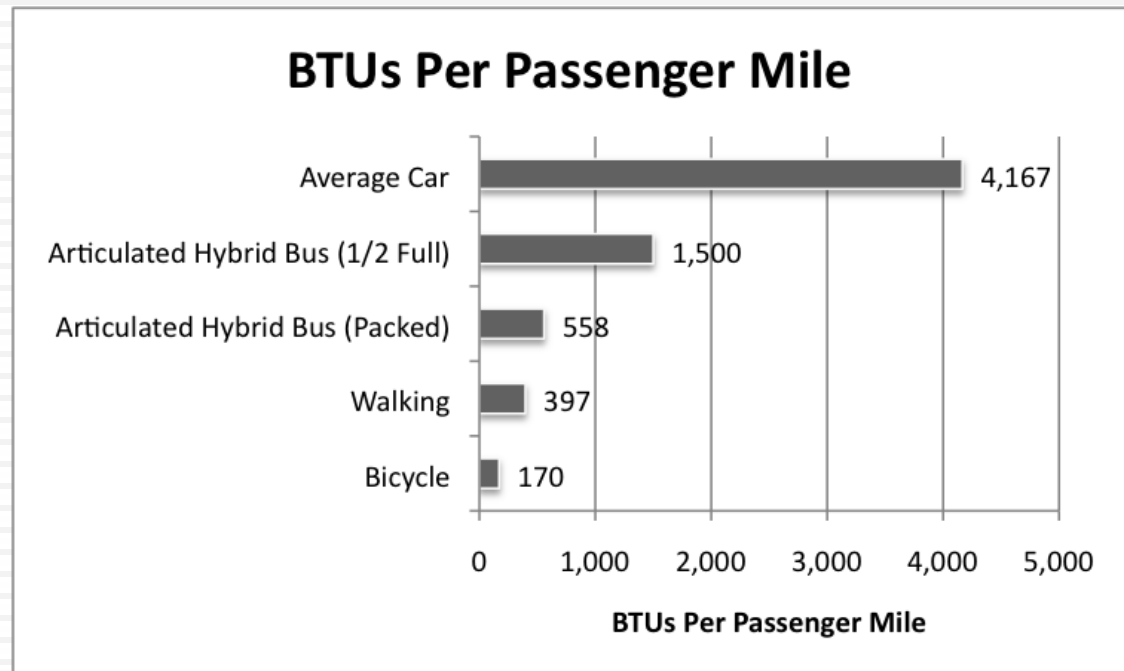
- Subsidizing research and development of battery and charger technology
- Subsidizing purchase of plug-in hybrid and electric vehicles and chargers
- Installing charging stations throughout the region
- Preparing the electric grid for the burden of charging plug-in vehicles

Typical Charging Facilities for Plug-In Hybrid and Fully Electric Cars

Parking Type	Benefits	Challenges	Installation Cost
Private Garage	<ul style="list-style-type: none"> • Inexpensive to install • Convenient to use • Available for nighttime charging 	<ul style="list-style-type: none"> • Not all car owners have private home garages 	\$1,500 - \$2,500
Commercial Garage	<ul style="list-style-type: none"> • Convenient to use • Available for nighttime charging 	<ul style="list-style-type: none"> • Not all car owners have access to commercial garages near their homes 	\$2,000 - \$3,500
Surface Parking Lot	<ul style="list-style-type: none"> • Visible location would create confidence in EV technology 	<ul style="list-style-type: none"> • Not all car owners have access to surface parking lots near their homes • Limited time to charge if parking hourly • Vandalism is possible 	\$3,000 - \$6,000
On-Street Parking	<ul style="list-style-type: none"> • Widely available • Visible location to create confidence for EV technology 	<ul style="list-style-type: none"> • Vandalism is possible • Enforcement challenges if reserved for EVs only 	\$4,500 to \$7,500
Rapid Charger and Battery Swap Stations	<ul style="list-style-type: none"> • Fast charging time 	<ul style="list-style-type: none"> • Technological challenges • Expensive to implement 	\$40,000+

Lower Emission Buses

Hybrid-Electric
Natural Gas
Electric
Ultracapacitor



Hybrid-Electric Buses

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- Suffolk County Transit, Huntington Area Rapid Transit, and Transport of Rockland have begun incorporating hybrid buses into their fleets
- New York City Transit has 1,171 hybrid buses, the largest fleet in the world
- From 1995 – 2006, diesel particulate emissions — also known as soot — dropped 97% per bus, while emissions of nitrogen oxides dropped 58% per bus
- A typical hybrid bus gets about 4 miles per gallon, compared to 2.75 mpg for a conventional diesel bus, a 45% improvement in fuel economy, with corresponding savings in GHG emissions
- Hybrid buses are approximately twice as expensive to purchase as conventional diesel buses, largely because their lithium-ion batteries cost \$60,000. While a conventional bus costs \$325,000, a hybrid-electric bus costs \$530,000.



Natural Gas Buses

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- The California Air Resources Board (CARB) has determined that burning compressed natural gas (CNG) produces about 22% less GHGs than burning diesel.
- Together, MTA NYC Transit, MTA Bus, and MTA Long Island Bus have 1,112 CNG buses as of summer 2009.
- Natural gas buses cost \$25,000-\$40,000 more than conventional diesel buses
- Agencies that have adopted natural gas technology have been able to recoup the higher cost of the vehicles through saving money on fuel.
- Noise levels and engine vibration are significantly lower on CNG buses than on internal combustion vehicles



All-Electric Buses

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- Proterra is promoting its new 35 feet long transit buses, with seating capacity of 37, and standing room capacity for 31 additional passengers, claiming it provides a range of 30 to 40 miles before the buses need to be recharged. High voltage can recharge the bus in 10 minutes.
- Electric buses cost \$1 Million, about twice the cost of a hybrid-electric bus.
- Once full production is achieved, the cost of the electric bus will be comparable to a diesel hybrid bus.
- Up to 40% more energy efficient than conventional buses
- According to Proterra, the bus can obtain a \$310,000 savings in fuel expenses of a lifetime, that is the differential in the cost of using diesel versus electricity.

Potential for Ultracapacitor Buses

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A bus that runs entirely on ultracapacitors charges up at a bus stop in Shanghai.



- The buses can only travel three to five miles between charges, but the ultracapacitors allow for fast recharging at designated bus stops.
- The trick is to turn some bus stops along the route into charging stations
- Unlike a conventional trolley bus that has to continually touch an overhead power line, Sinautec's ultracapacitor buses take big sips of electricity every two to three miles at designated charging stations, which double as bus stop.
- When at these stations, a collector on the top of the bus rises a few feet and touches an overhead charging line. Within a couple of minutes, the ultracapacitor banks stored under the bus seats are fully charged.
- "It's not well suited for electric-only cars, but it is practical to stop a bus every few city blocks"- Ultracapacitor expert and professor of engineering and computer science at MIT, Joel Schindall.
- Source: www.technologyreview.com/energy/23754/

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Further Greenhouse Gas Emissions Reduction Strategies

Speed Limit Reductions

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- The fuel economy of a vehicle varies with the speed of the vehicle
- The fuel economy of current vehicles is maximized at speeds between 50 and 90 km/h (31-56 mph)
- At higher speeds increased aerodynamic forces reduce fuel economy, and at lower speeds the fuel required to keep the engine running is greater.
- Reducing highway speed limits would involve substantially higher enforcement costs, as a greater proportion of vehicle operators would be affected
- Enforcement costs estimated at \$10-\$40 per ton of CO₂ equivalents reduced

Sources: Alberta (CA) Department of Transportation, US DOT Report to Congress on Transportation's Role in Reducing US GHG Emissions

Eco-Driving



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Eco-driving is a set of practices by which individual drivers can improve their fuel mileage

Lessons cost \$60 each, or \$450 for ten

The average long-term reduction in fuel consumption and GHG emissions is 10-20% for participants

Eco-driving simulators are a lower cost substitute for actual on-road lessons, and cost about \$105

Advertising campaigns can be targeted toward drivers by using rush hour drive-time radio, or placing ads on the backs of buses

Sources: Eco-driving school; Intelligent Energy Europe, ECODRIVEN Campaign Catalogue for European Eco-driving & Traffic Safety Campaigns; Climate Change 101: An Overview of Climate Change for State DOTs. From the Transportation and Climate Change Resource Center at AASHTO.

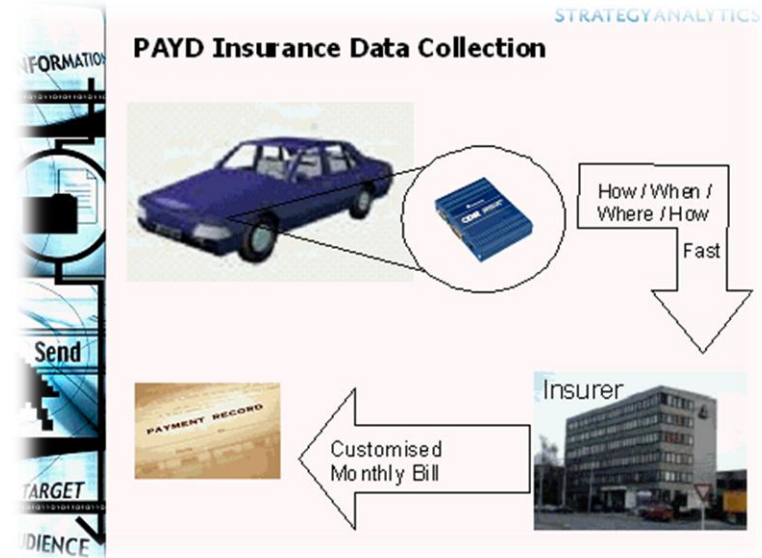
Selected Tips for Saving Fuel through Eco-Driving

- ❑ Avoid rapid starts and stops
- ❑ Keep moving slowly rather than stopping the car then moving fast
- ❑ Drive at the speed limit to take advantage of synchronized traffic lights
- ❑ Open windows to cool the car before turning on air conditioning, and when driving under 40 mph
- ❑ Use air conditioning and close windows when driving faster than 40 mph
- ❑ Drive 60 mph on the highway
- ❑ Use maps to plan the shortest route for every trip
- ❑ Avoid idling
- ❑ Use an automated pass for toll roads
- ❑ Use the highest gear possible
- ❑ Warm up your vehicle by driving it rather than idling
- ❑ Obey “check engine” light

Pay-As-You-Drive Insurance

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- Under pay-as-you-drive insurance, car insurance rates are tied to the number of miles you drive
- Can be implemented by pay-at-the-pump system or GPS monitoring of vehicles
- A national pay-as-you-drive insurance policy would decrease vehicle miles traveled by about 8% nationally
- Pay-as-you-drive insurance would require subsidies, since the cost of monitoring miles traveled would outweigh the benefits accrued to insurers through the program (but not the societal benefit)
- Cost to insurance companies and/or state of \$30-\$90 per ton of CO₂ equivalents reduced
- Other distance-based pricing programs:
 - ▣ Mileage-based vehicle registration fees
 - ▣ Mileage-based vehicle purchase taxes



High Occupancy/Toll Lanes (HOT Lanes)

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HOT lanes are highway lanes designated for use by multiple-occupancy vehicles, or single-occupancy vehicles whose drivers pay a toll

- HOT lanes can be converted from existing HOV lanes, or added as a highway expands
- Current HOV lanes are underused – only 9% of work trips are made in multi-occupant vehicles today, compared with 16% in the 1980s
- Tolls can vary with the time of day to ensure that lanes are uncongested but in use at all times
- Toll revenues can be used to provide Bus Rapid Transit service in the HOT corridor
- The Bay Area HOT lane network cost \$1.4 million to \$3.7 million per lane per mile depending on existing conditions, for a total of \$4.7 billion for construction
- NY's CleanPass program, which allows AFVs in HOV lanes, will result in an estimated reduction of 6,000 tons of GHG emissions

□ Sources: Robert Poole and Kenneth Orski. HOT Lanes: A Better Way to Attack Urban Highway Congestion. Cato Institute. Reducing GHG through Traffic Operations, Construction, Maintenance, and Agency Operations. From the Transportation and Climate Change Resource Center at AASHTO. April 19, 2010.)

Roundabouts

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- US cities and states are installing roundabouts for the benefits they provide in reduced emissions, better safety, and improved traffic flow
- A Kansas study found a 55-61% GHG emissions reduction at controlled intersections replaced with roundabouts
- Hamilton, Ontario found that replacing signals with roundabouts reduced GHG emissions by 60%
- Vermont estimated that replacing signals with roundabouts at 100 busy intersections would result in an 8% statewide reduction in motor vehicle fuel use
- Average cost of intersection conversion is \$750,000

Traffic Management Strategies

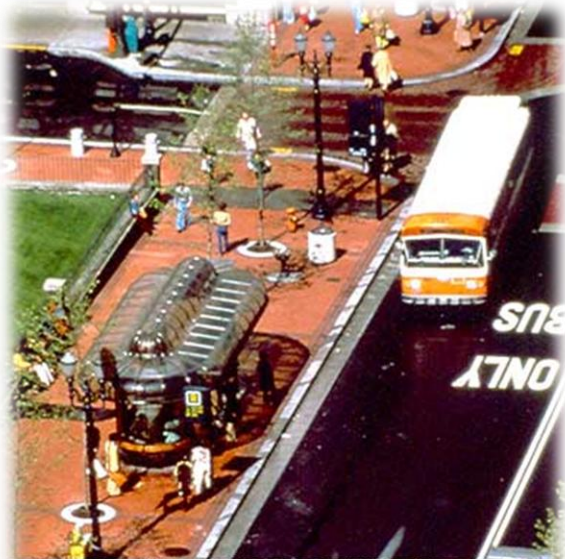
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- Signal optimization and coordination
 - ▣ Retiming signals to reduce intersection delay
 - ▣ Coordinating control of traffic signals along a corridor or network
 - ▣ Adaptive signal control: use of advanced software that continuously updates signal timing based on demand
 - Retiming signals costs \$2,500-\$3,100 per intersection
- Active traffic management: emerging strategies to squeeze extra capacity out of the system and prevent flow breakdown, such as lane control, speed harmonization, and queue warning

Source: US DOT Report to Congress on Transportation's Role in Reducing US GHG Emissions

Transit Oriented Development Guidelines

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- The transit-oriented development lies within a five to ten minute walk of the transit stop, or about a quarter-mile from stop to edge
- A balanced mix of uses generates 24-hour ridership
- There are places to work, to live, to learn, to relax and to shop for daily needs
- A place-based zoning code generates buildings that shape and define memorable streets, squares, and plazas, while allowing uses to change easily over time
- The average block perimeter is limited to no more than 1,350 feet, generating a network of streets that disperse traffic

Transit Oriented Development Guidelines

Continued

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- Minimum parking requirements are abolished, and maximum parking requirements are instituted
- Full market rates are charged for parking costs
- Bicycle parking provided at every transit stop
- Transit service is fast, frequent, reliable, and comfortable, with headways of 15 minutes or less
- Roadway space is allocated and traffic signals timed primarily for the convenience of walkers and cyclists
- Automobile level-of-service standards are met through congestion pricing measures, or disregarded entirely
- Roads designed to limit speed to 30 mph on major streets and 20 mph on lesser streets

Commuter Choice Programs

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Transportation Benefits Programs

Employer-paid transportation benefits:

Employers can pay for their employees to commute by transit or vanpool tax-free, up to a limit of \$100/month

Employee-Paid, Pre-Tax Transportation Benefits:

Employers can allow employees to set aside up to \$100/month of pre-tax income to pay for transit or vanpooling

Shared-Cost Transportation Benefits: Employers can provide a portion of the cost of taking transit or vanpooling as a tax-free benefit and allow the employee to set aside pre-tax income to pay for the remaining amount (up to the specified limits)

Parking Cash-Out

Employers can offer their employees the option to accept increased salary or tax-free transportation benefit in place of their subsidized parking space

Parking cash-out typically reduces automobile commuting 15-25% at companies where it is implemented

Parking Pricing

Entails charging directly for the use of a parking space

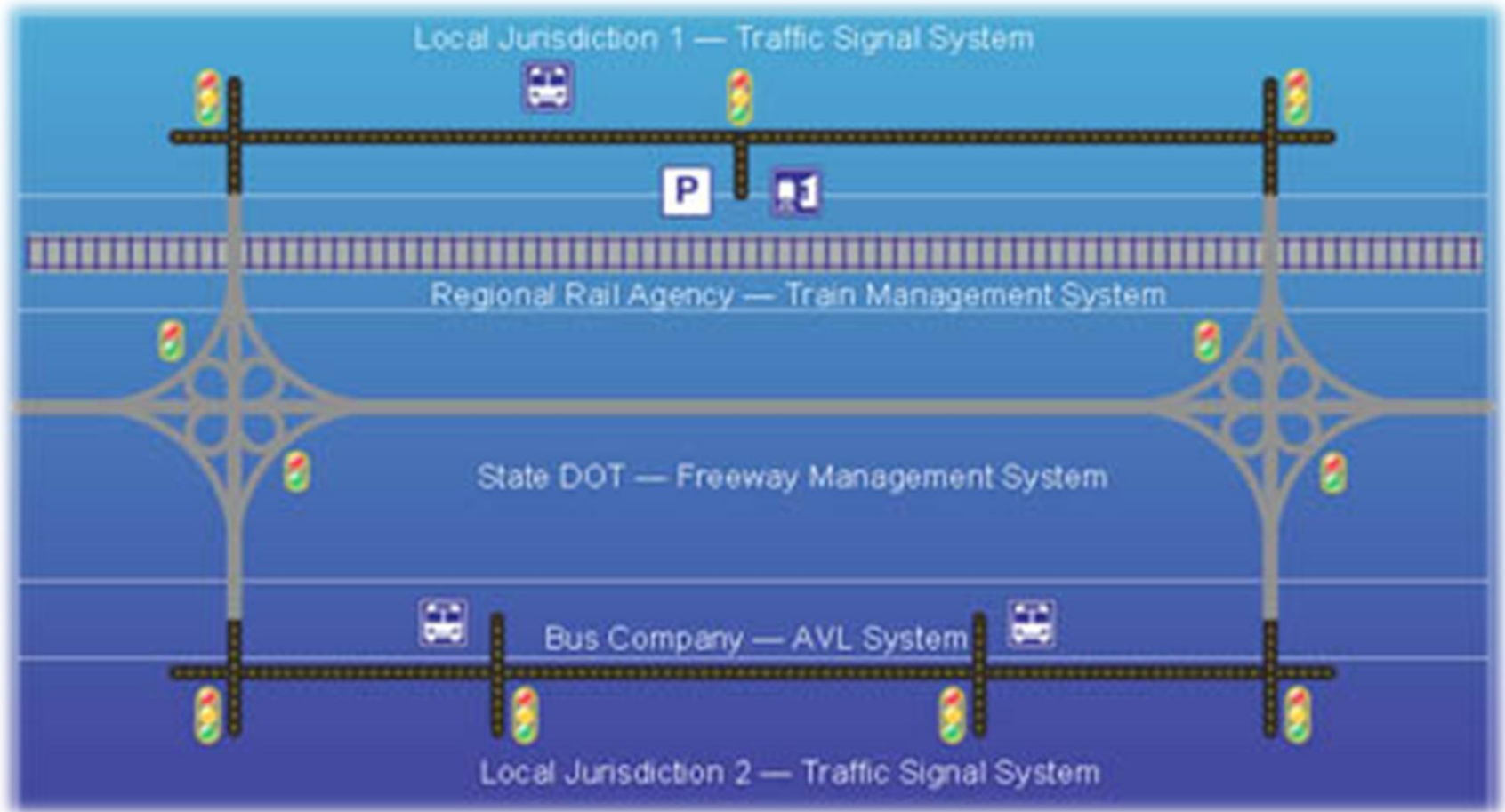
Over 95% of commuters park for free at work in the US, and almost all of them drive alone (91% of total commuters)

Sources: Federal Highway Administration Travel Demand Management Toolbox; Victoria Transport Policy Institute Win-Win Emissions Reduction Strategies



Integrated Corridor Management

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Integrated Corridor Management Continued

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- Integrated Corridor Management (ICM) and Active Traffic Management (ATM) are in their infancy in the U.S.
- Transportation corridors often contain unused capacity in the form of parallel routes, the non-peak direction on freeways and arterials, single-occupant vehicles and transit services that could be leveraged to help reduce congestion
- With ICM, the various institutional partner agencies manage the transportation corridor as a system, rather than as individual assets
- While driving in a future ICM corridor, a traveler could be informed in advance of congestion ahead on that route and be informed of alternative transportation options such as a nearby transit facility's location, timing and parking availability
- The program would cost \$11-\$26 billion to implement on a nationwide basis

Freight Efficiency Improvements

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- Freight route management systems that help carriers make more efficient routing and scheduling decisions in order to avoid congestion, reduce freight vehicle mileage, and increase load factors (e.g., avoiding empty backhauls)
- More fuel-efficient vehicles
 - ▣ Hybrid trucks
 - ▣ Low carbon fuels
- Anti-idling programs
- Truck stop electrification
- Engine efficiency improvements
 - ▣ Low-viscosity lubricants
 - ▣ Single wide-base tires
 - ▣ Automatic tire inflation systems



- Speed limit enforcement
- Freight villages/consolidation centers
- Feeder barge container service
- Traffic flow improvements
- “Black carbon” control technologies
- Pre-clearances at scale houses
- Truck driver eco-training
- EPA SmartWay up-grade kits & loans
- Incentives to retire older trucks
- Freight logistics improvements
- Shifting freight from truck to rail

VMT Reduction Strategies

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Strategy	2030 Reduction	Key Assumptions
Pay-As-You-Drive Insurance	1.1-3.5%	Require States to Allow (low) Require companies to offer (high)
Congestion Pricing	0.4-1.6%	LOS D on all roads (avg. 65c/mi for 29% of urban and 7% of rural VMT)
Public Transportation	0.2-0.9%	2.4-4.6% annual increase in service
Non-Motorized Travel	0.2-0.6%	Comprehensive urban bike/ped improvements 2010-2025
Land Use	1.2-3.9%	60-90% of new urban growth in approx. >5 units/acre
Parking Management	0.2%	Downtown workers pay for parking (\$5/day avg. for those not already paying)
Commuter / worksite trip reduction	0.1-0.6%	Widespread employer outreach and alternative mode support
Telework / compressed work week	0.5-0.7%	Doubling of current levels
Individualized marketing	0.3-0.4%	Reaches 10% of population
Eco-driving	0.8-4.3%	10-50% of drivers reached, half implement
Combined Strategies	5-17%	