

# **Air Quality In Vermont: With a Focus On Transportation and Air Quality**

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Agency of Natural Resources

REV Conference  
21 September 2005

# Air Pollution Control In Vermont:

- *“Criteria Air Pollutants”*
- *Visibility/Haze*
- *Airborne Toxins*
- *Climate Instability/Global Warming*

# National Ambient Air Quality Standards

§ 109 CAA: "... to protect human health.."

six air contaminants:

**Carbon Monoxide (CO)**

**Sulfur Dioxide (SO<sub>2</sub>)**

**Lead (Pb)**

**Nitrogen Dioxide (NO<sub>2</sub>)**

**Particulate Matter (PM)**








**Ozone (O<sub>3</sub>)**

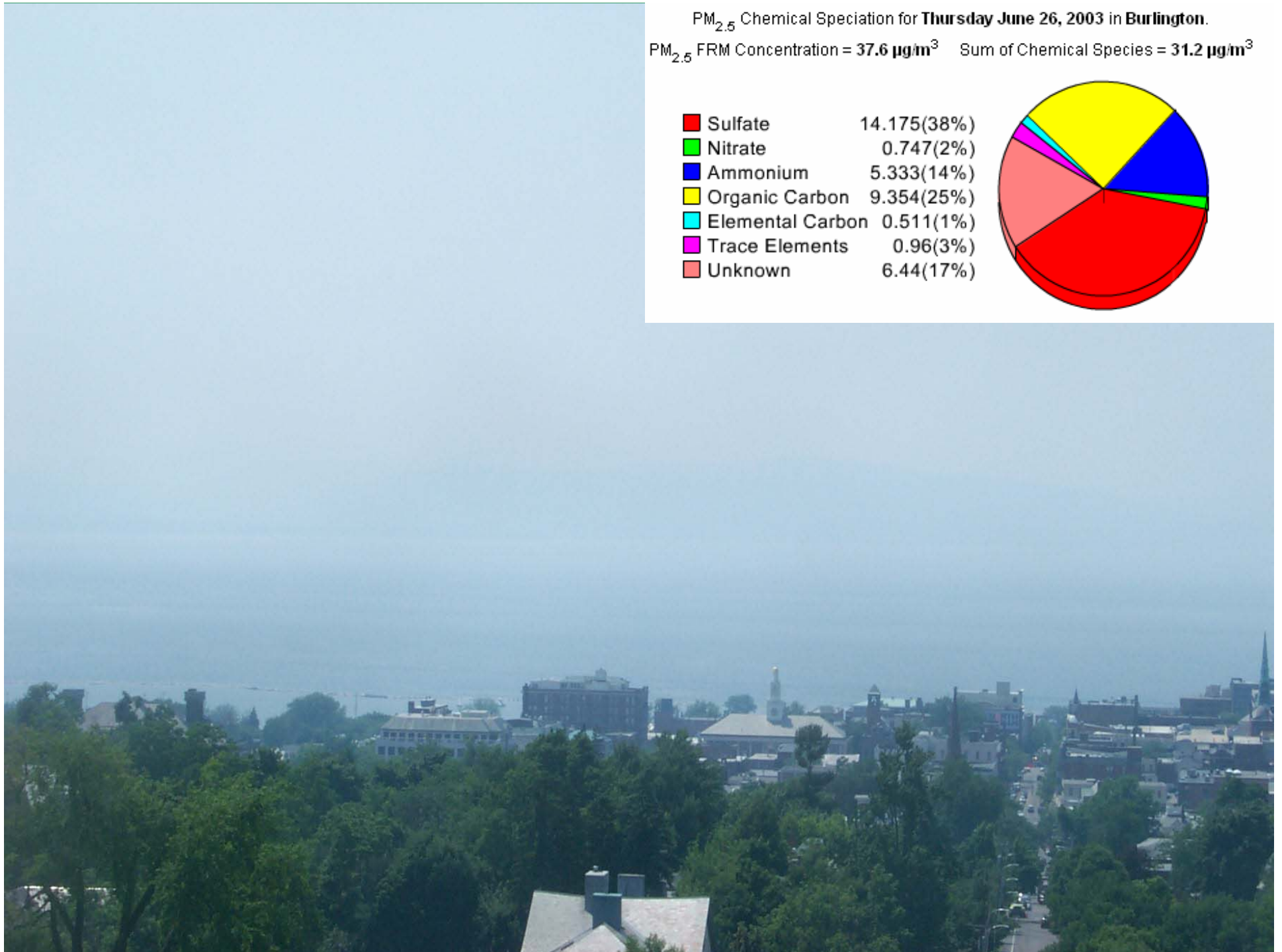
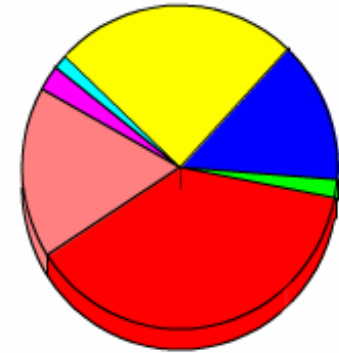
# PM<sub>2.5</sub> -- Visibility/Haze:



PM<sub>2.5</sub> Chemical Speciation for **Thursday June 26, 2003** in **Burlington**.

PM<sub>2.5</sub> FRM Concentration = **37.6 µg/m<sup>3</sup>**    Sum of Chemical Species = **31.2 µg/m<sup>3</sup>**








	Sulfate	14.175(38%)
	Nitrate	0.747(2%)
	Ammonium	5.333(14%)
	Organic Carbon	9.354(25%)
	Elemental Carbon	0.511(1%)
	Trace Elements	0.96(3%)
	Unknown	6.44(17%)

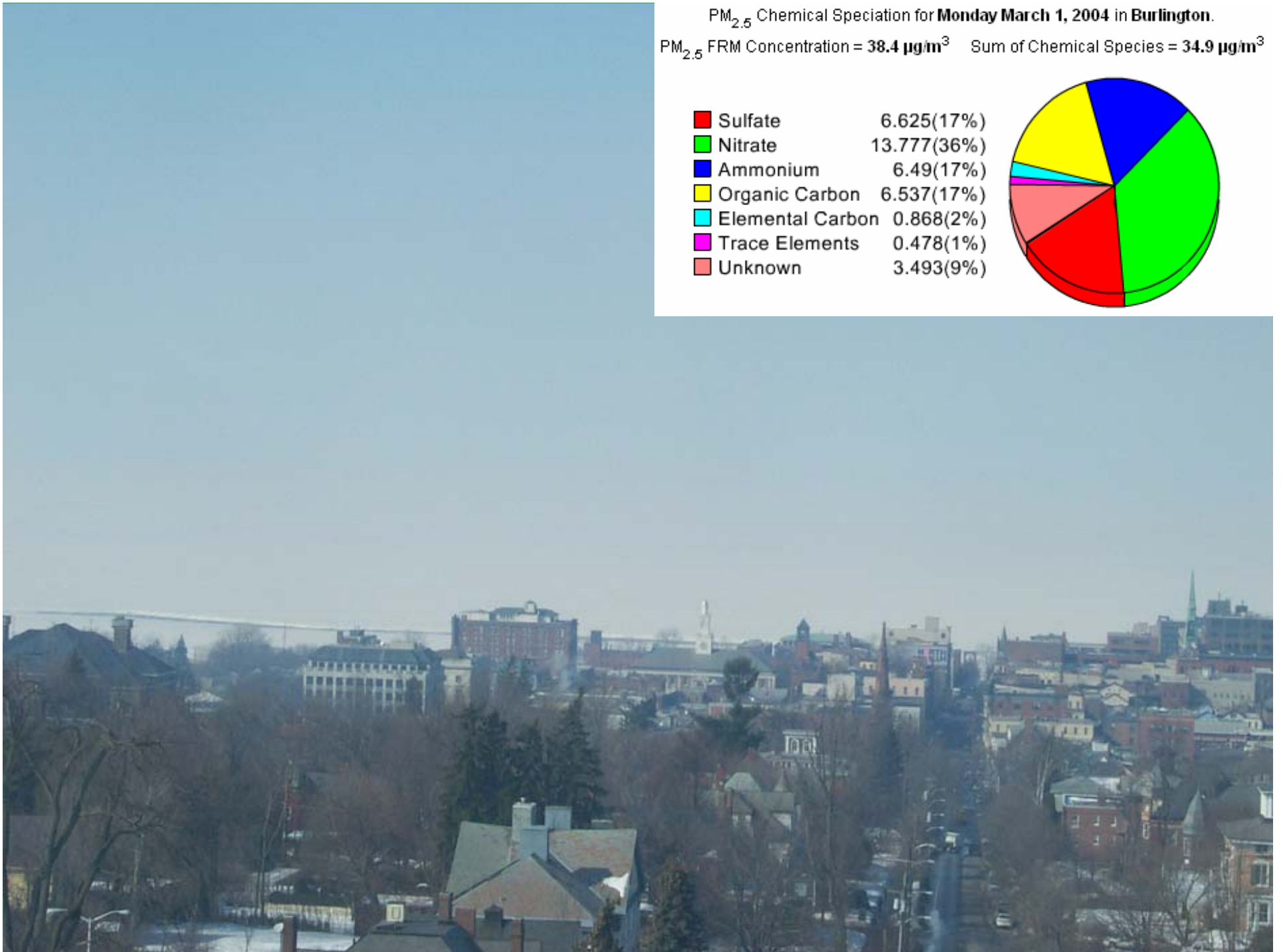




PM<sub>2.5</sub> Chemical Speciation for **Monday March 1, 2004** in **Burlington**.

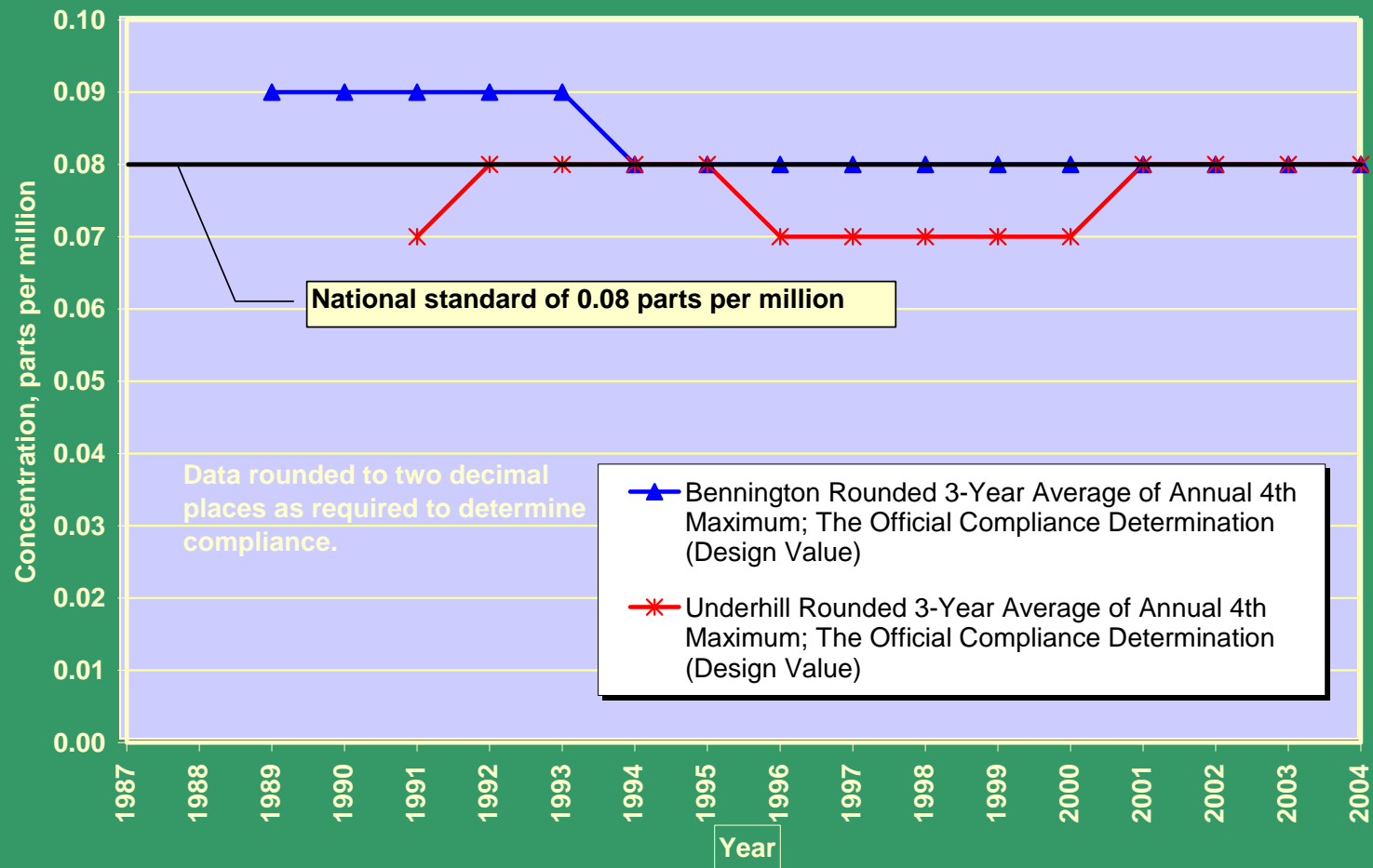
PM<sub>2.5</sub> FRM Concentration = **38.4 µg/m<sup>3</sup>** Sum of Chemical Species = **34.9 µg/m<sup>3</sup>**

	Sulfate	6.625(17%)
	Nitrate	13.777(36%)
	Ammonium	6.49(17%)
	Organic Carbon	6.537(17%)
	Elemental Carbon	0.868(2%)
	Trace Elements	0.478(1%)
	Unknown	3.493(9%)

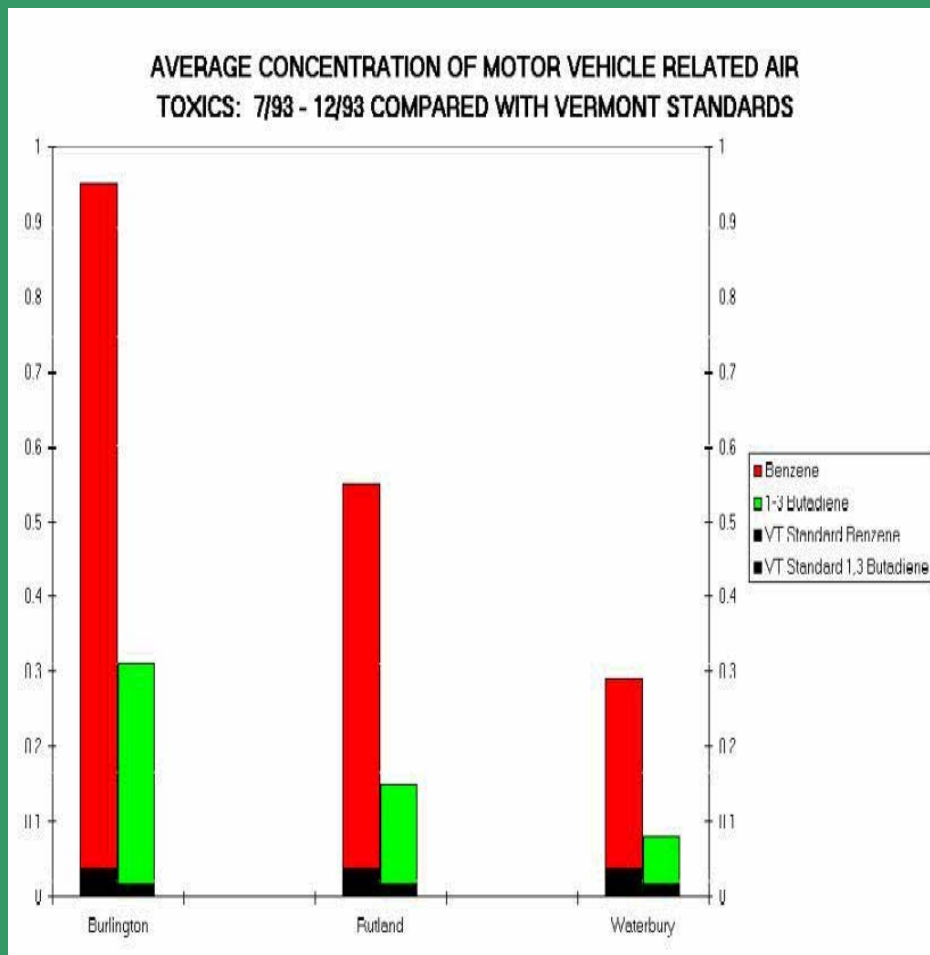


# Ozone in Vermont:

Ozone Three-Year Averages of Annual Fourth Maximum Daily Maximum 8-Hour Averages



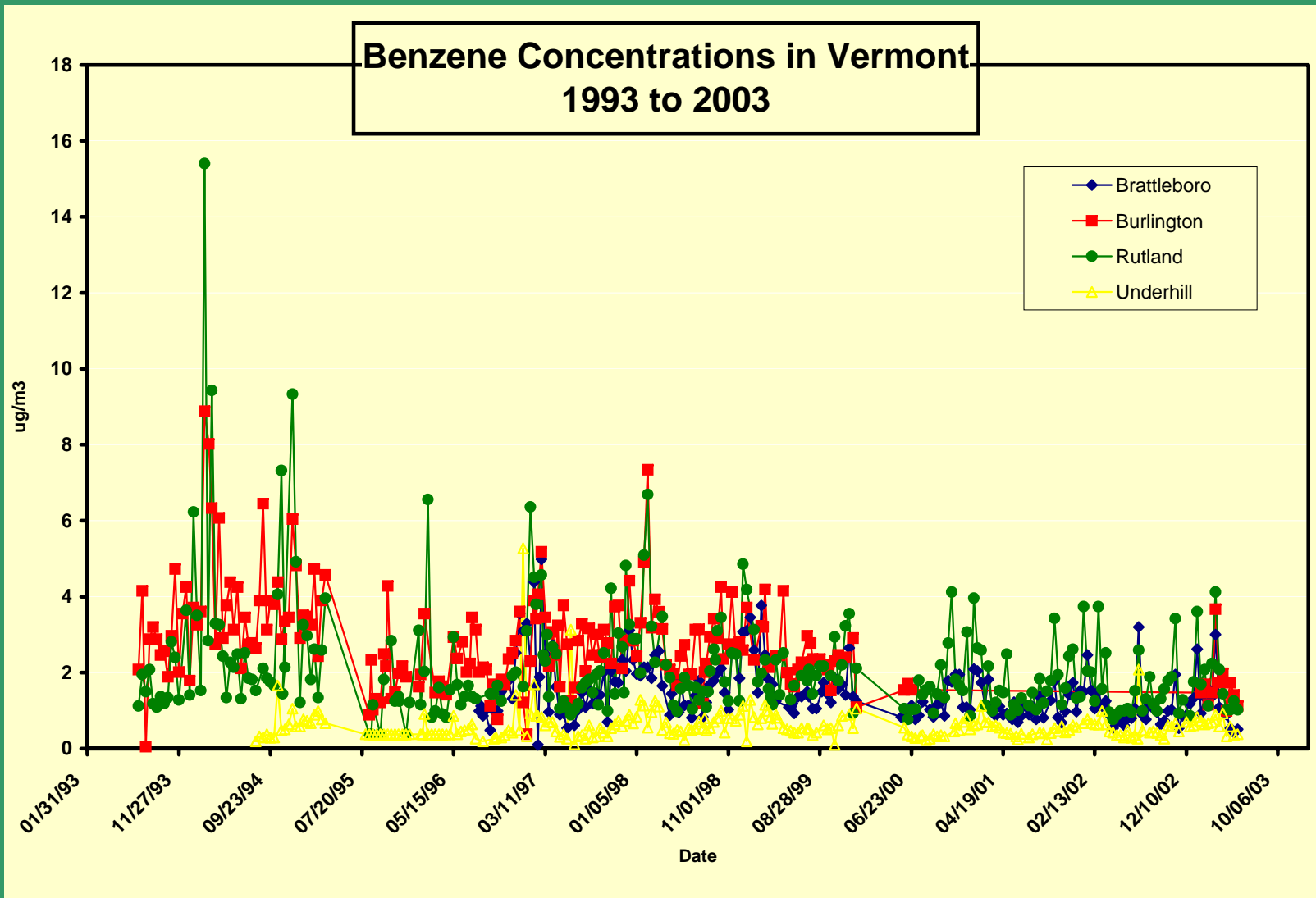
# Air Toxics:



**Levels of certain Toxic Air Pollutants do exceed state standards and recognized risk levels.**



# Air Toxics:



# Air Toxics:



**Diesel Smoke is –**

- Noxious,**
- Toxic,**
- Carcinogenic, and**
- Very small in size**

# Improving Air Quality

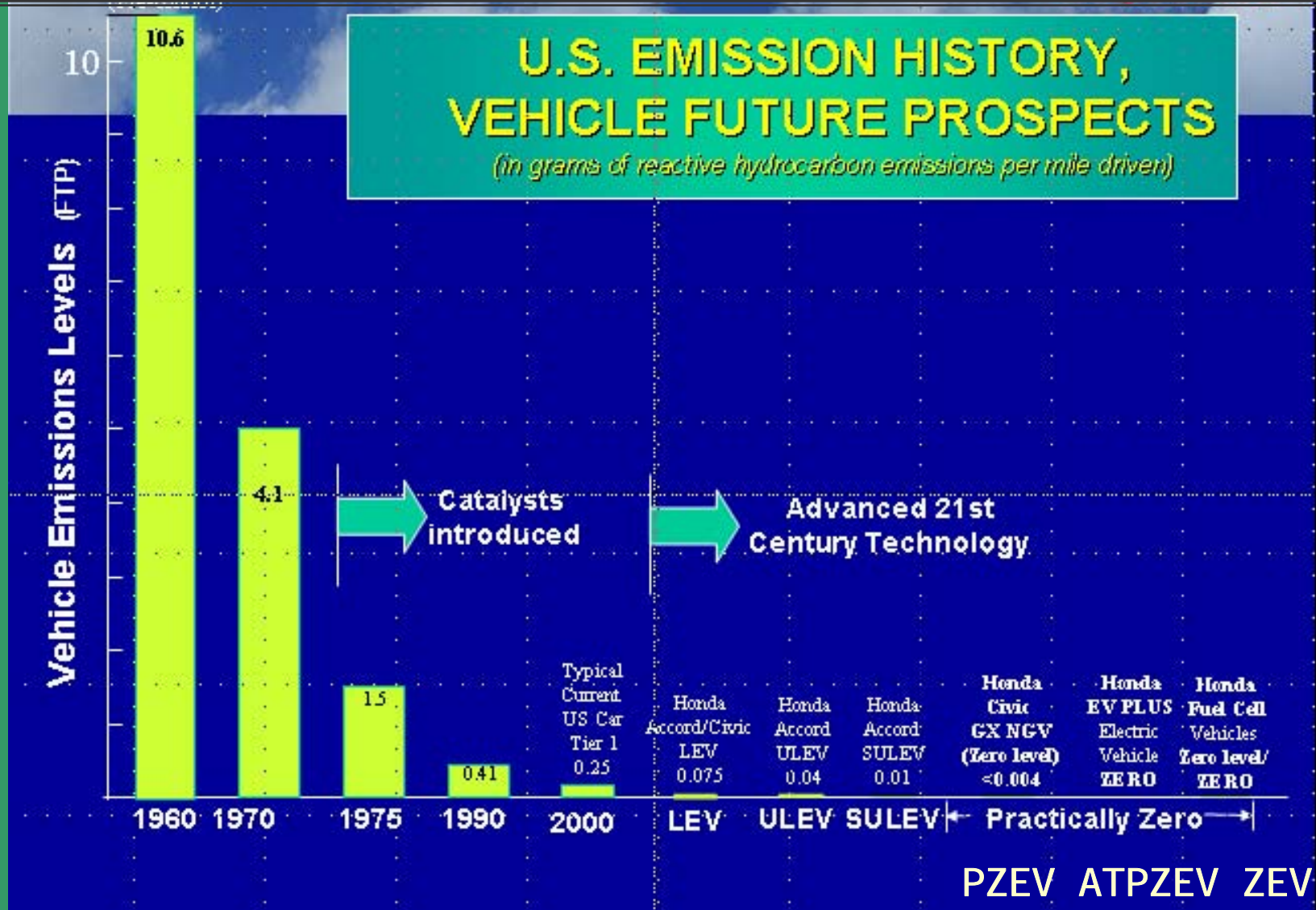
## Therefore if the Public Policy of Vermont is to:

- Remain in Attainment of National Ambient Air Quality Standards
- Improve Visibility
- Reduce levels of Airborne Toxins
- Manage Greenhouse Gases

## We Need a Four Part Strategy:

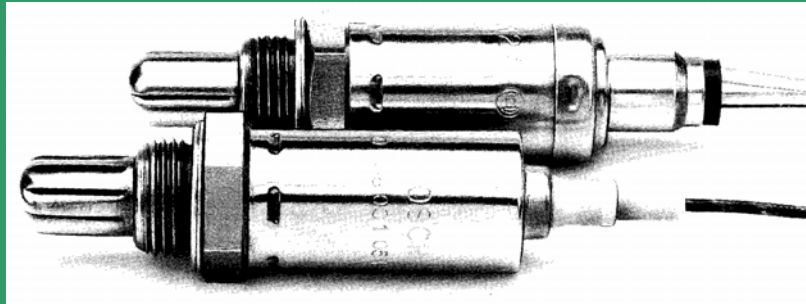
Improved Air Quality = “Clean Cars” + “Good Maintenance”  
+ “Clean Fuels” + “Efficient Use”

# Air Pollution Control In Vermont: "Clean Cars"



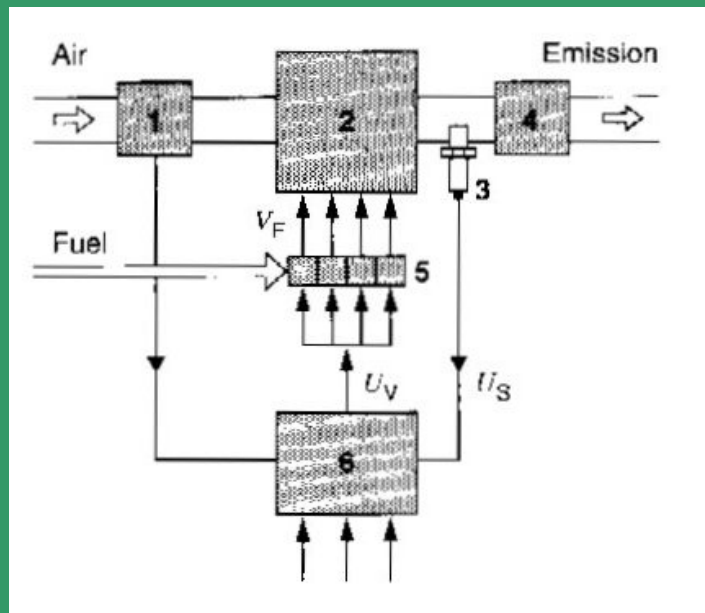
# Air Pollution Control In Vermont: "Clean Cars"

## Oxygen Sensor



O<sub>2</sub> Sensor Control Operation:

- 1) Air Flow Sensor
- 2) Engine
- 3) O<sub>2</sub> Sensor
- 4) Catalytic Converter
- 5) Fuel Injectors
- 6) Control Unit



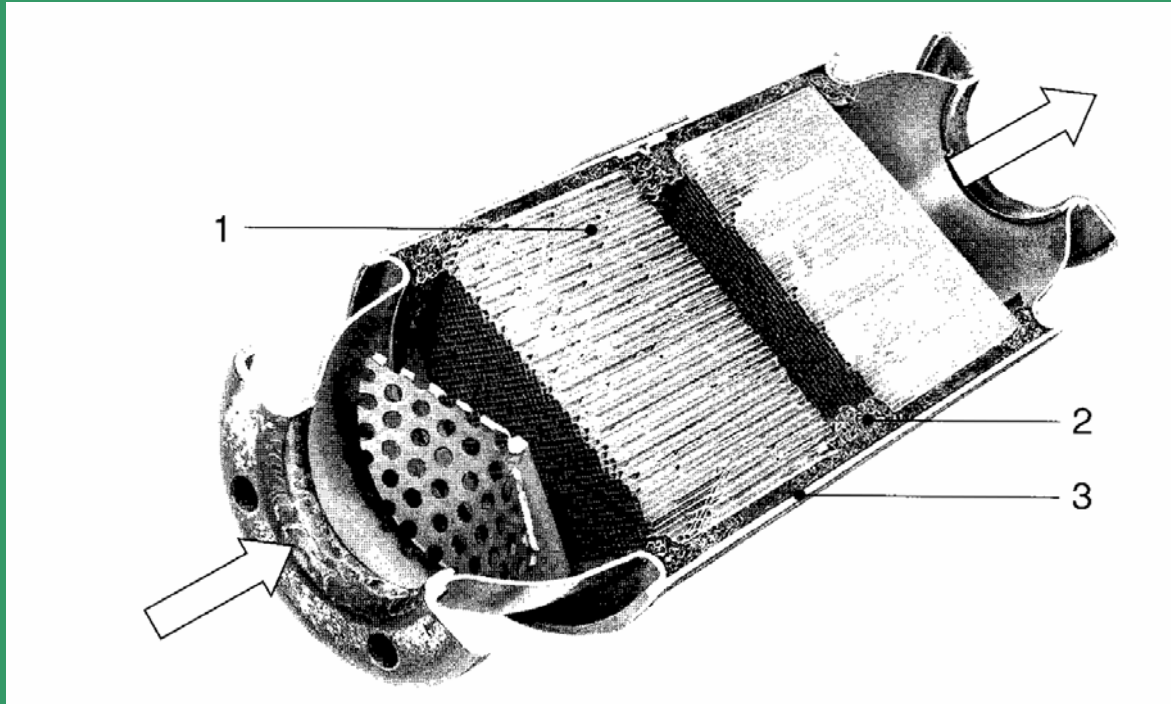
$U_S$  – Sensor Voltage

$U_V$  – Valve Actuation Voltage

$V_F$  – Injected Fuel Quantity

## Air Pollution Control In Vermont: “Clean Cars”

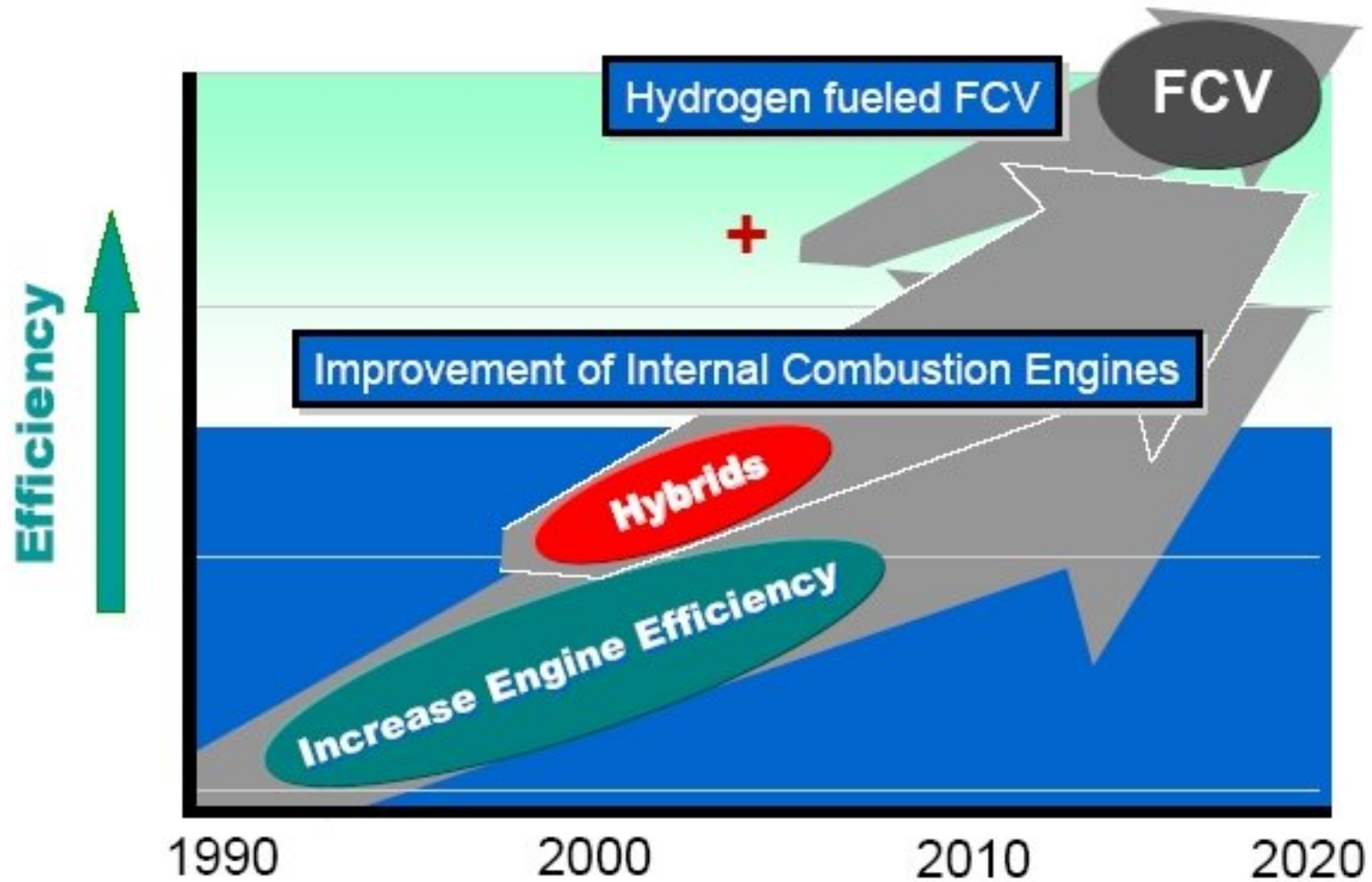
### Catalytic Converter



1. Ceramic material coated with catalytically active substances
2. Retaining material
3. Housing



# Honda's Power Plant Roadmap



Ben Knight Honda R&D

CARB International Vehicle Technology Symposium

March 12, 2003





# Available Technologies (Near-Term)

- Variable valve timing and lift
- Turbocharging
- Cylinder deactivation
- Improved multi-speed transmissions
- Electric power steering
- Improved alternator
- Gasoline direct injection
- More efficient, low-leak air conditioning



# Available Technologies



Cylinder Deactivation

6%\*

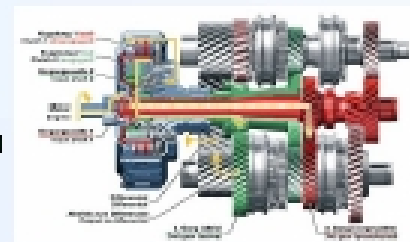


2005 Chrysler 300C Hemi



Audi TT 3.2 V6

7%



Automated Manual Transmission

\* % CO<sub>2</sub> reduction, large car



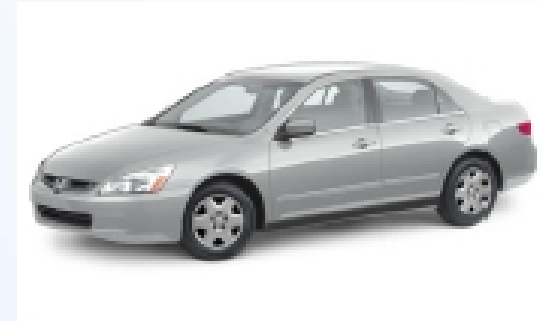
# Available Technologies



Acura RSX



Variable valve timing and lift



Honda Accord



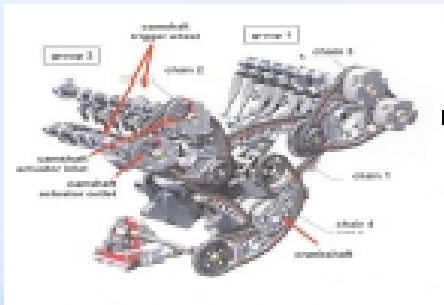
Toyota Matrix

↑ 4%



# Available Technologies

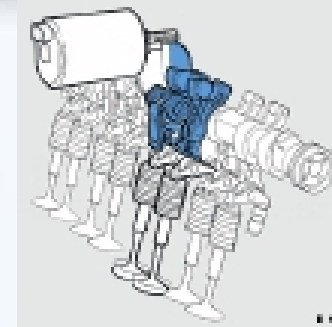
Gasoline Direct Injection  
w/dual cam phasers



5%



2005 Audi A4



BMW Valvetronic  
(continuously variable valve timing and lift)

6%



Volvo S60

8%



Turbocharger



BMW 5 Series

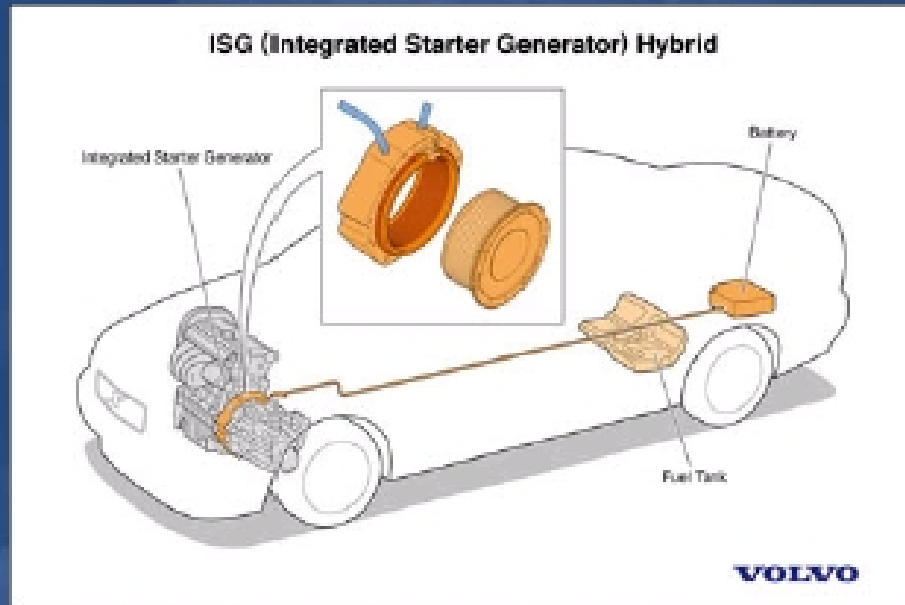


## Emerging Technologies (Mid-Term)

- Integrated starter/generator
- Camless valve actuation
- Gasoline homogeneous charge compression ignition
- More efficient, low-leak R-152a air conditioning system



# 42v Integrated Starter/Generator



Provides stop/start capability and some motor assist



Substantial CO<sub>2</sub> reductions  
at modest cost

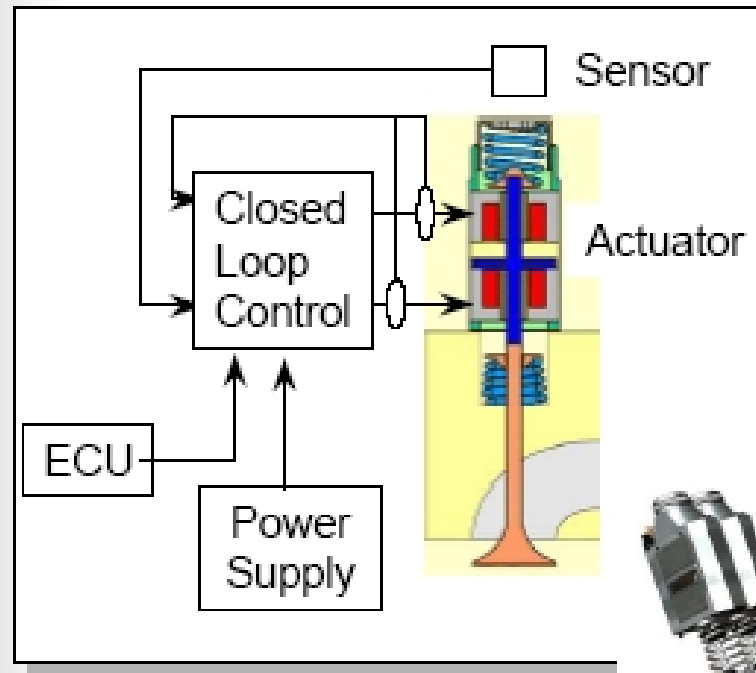
California Environmental Protection Agency

Air Resources Board

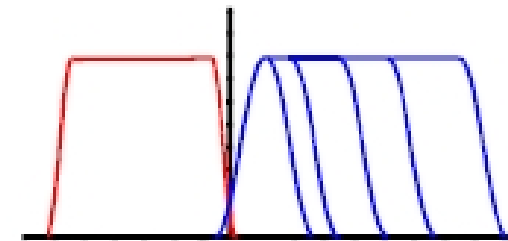
Steve Albu, CARB

# Electromechanical Valve Train EMVT

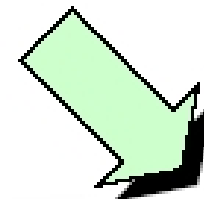
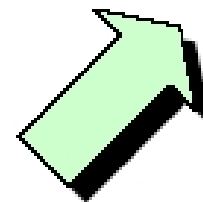
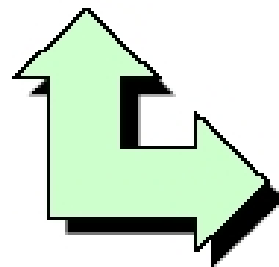
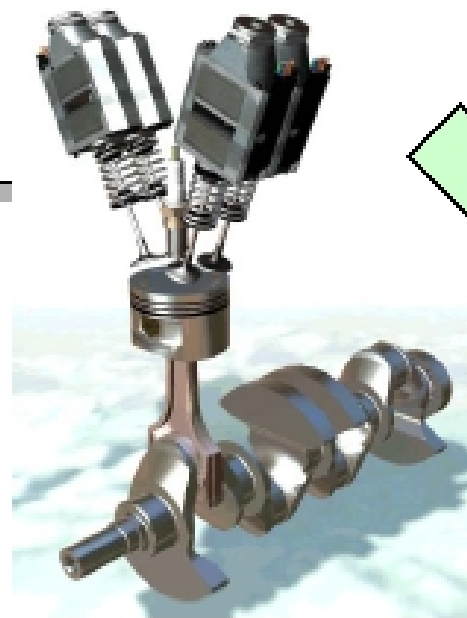
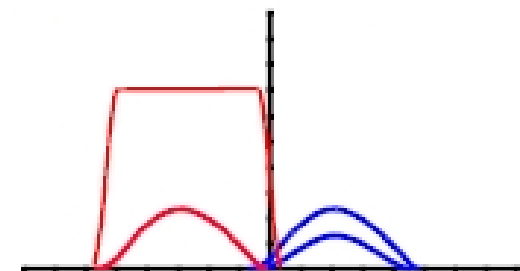
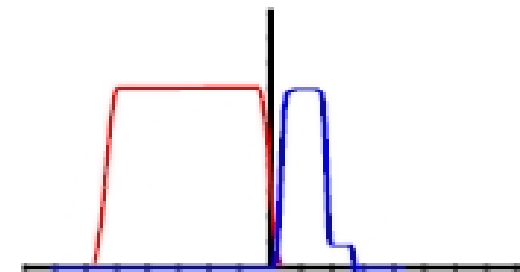
## Load Exchange Optimization - Valve Lift Curve Shaping (VLC)



EMVT- Load and Load Exchange Control



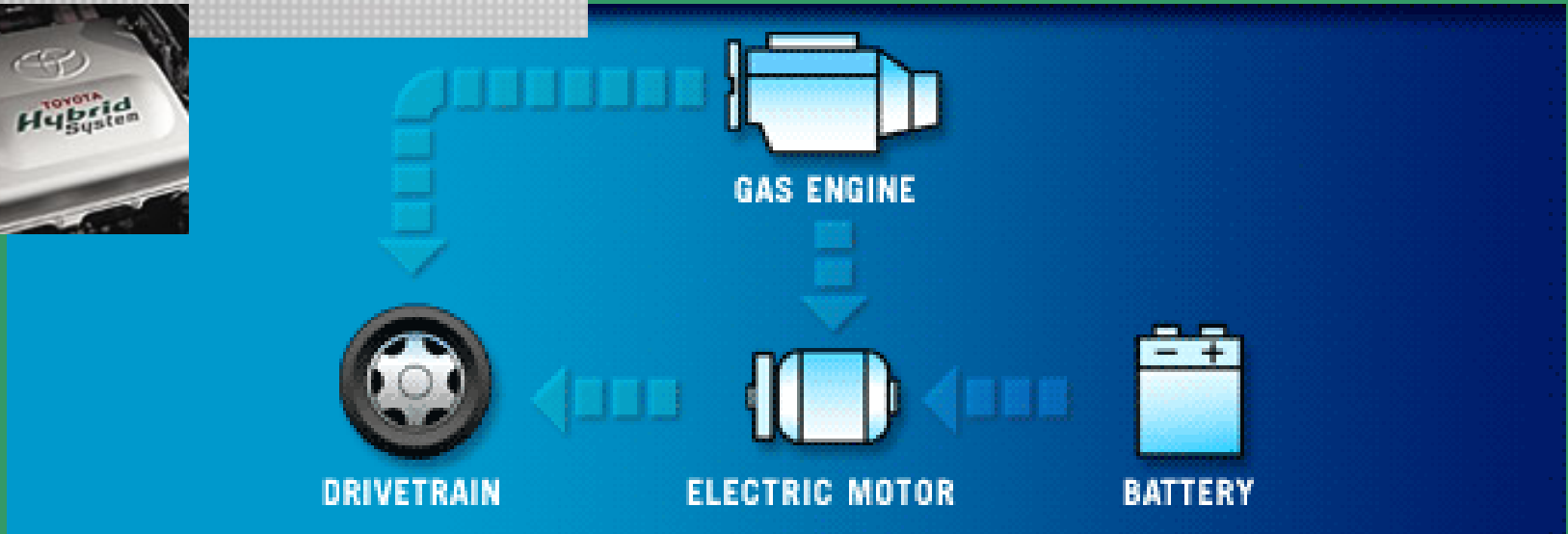
EMVT- Valve Lift Curve Shaping (VLC)







# Hybrid Electric Vehicles



for example, Toyota Prius

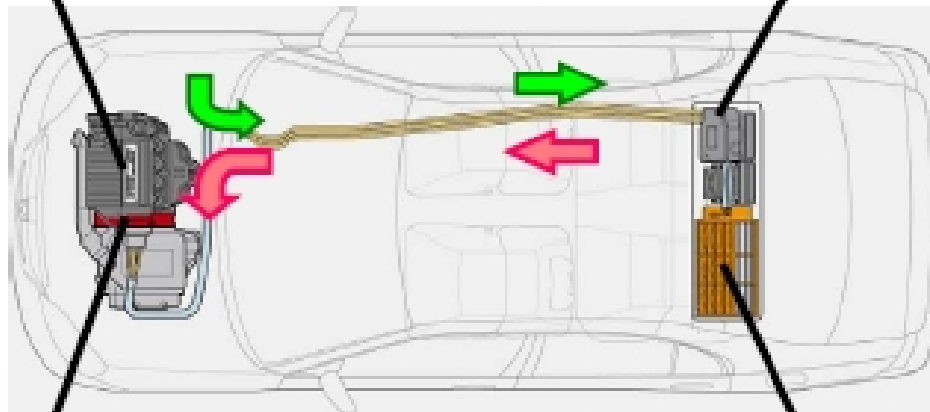
Fuel Economy: 52 City/45 Highway/48 Combined

Emissions: 89% fewer smog forming emissions than most new cars. SULEV → ATPZEV

# Major Technologies in the CIVIC HYBRID

1.3L i-DSI Engine  
(with VTEC Cylinder Idling System)

Power Control Unit



← motor assistance  
→ regeneration

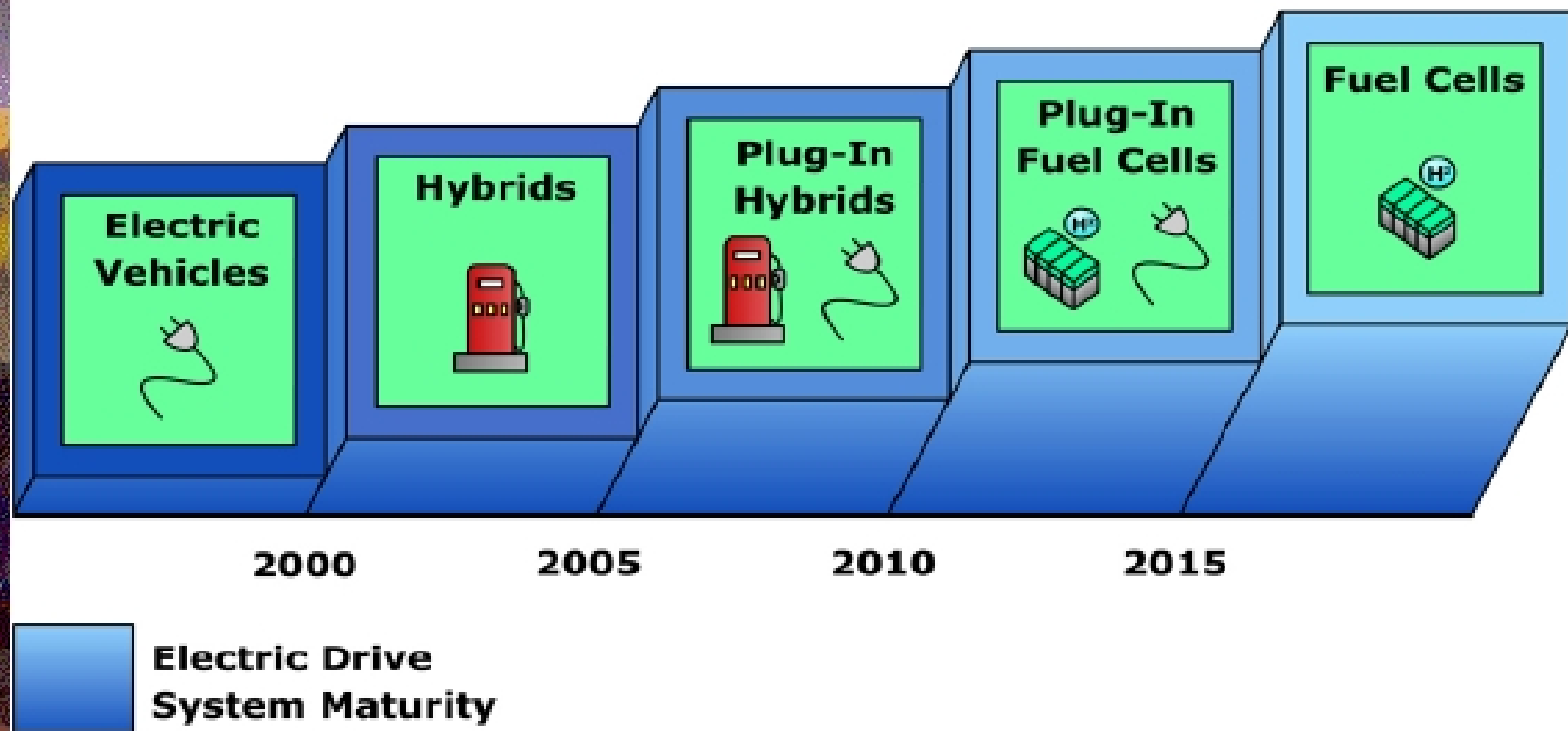


10 kW Perm. Magnet Motor

NiMH Battery

# Electric Drive System Commercialization Path

## Non-Competing - Non-Redundant Vehicle Technologies

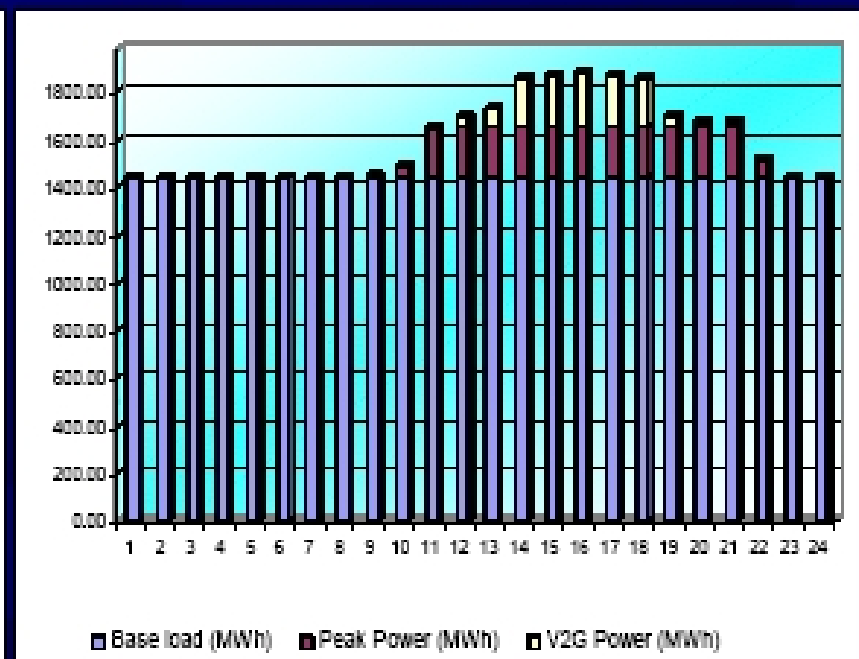
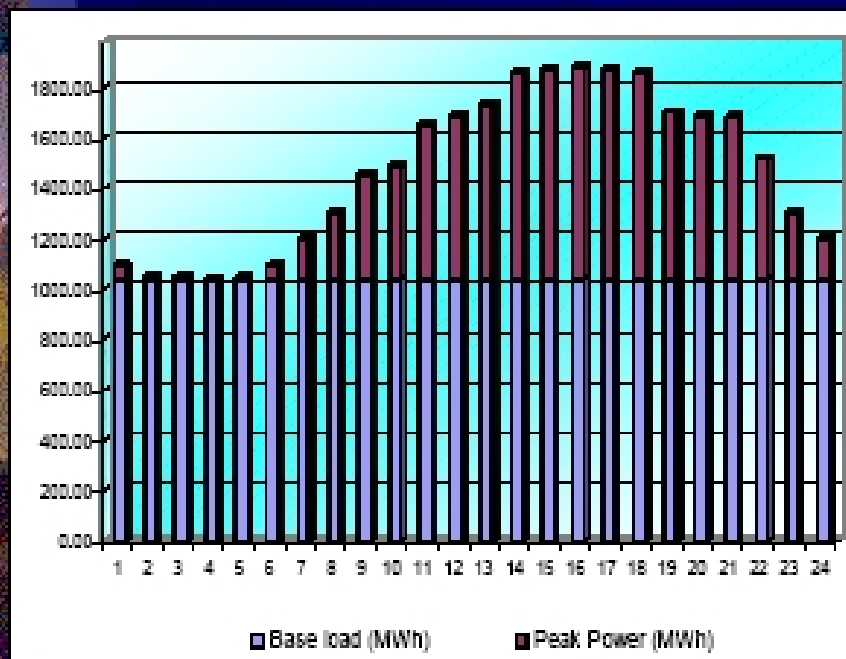




# Path to advance technology including fuel Cell

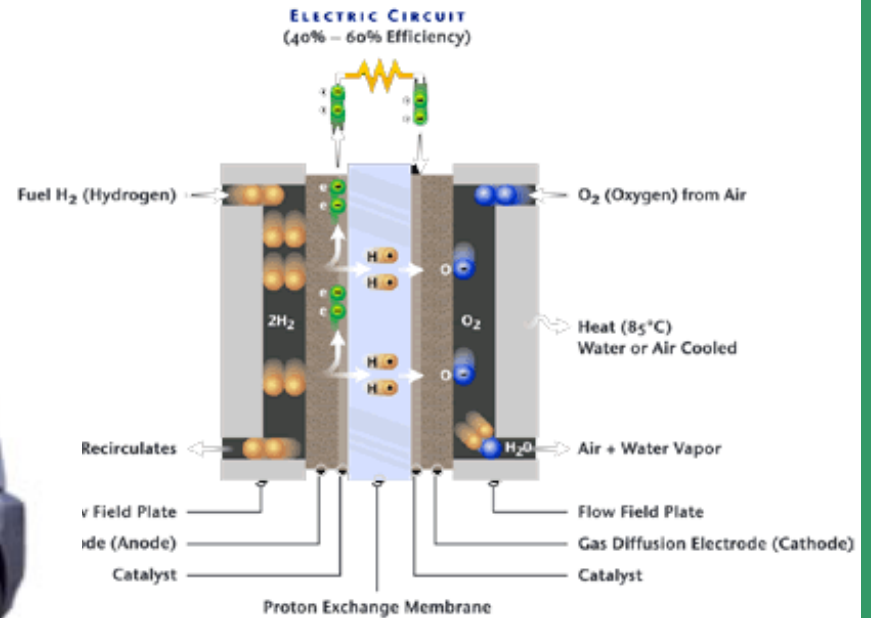
- ☀ PIHEV allows engine development with efficiency higher than the Prius engine using gasoline.
- ☀ PIHEV allows infrastructure on alternative fuels to evolve while using our current well developed gasoline and electricity infrastructures.
- ☀ PIHEV allows the stationary energy sector to integrate with the mobile energy sector.

# The PIHEV can be used to balance the Electric Grid-Integrating electric power and transportation energy sectors



Energy available for the grid (V2G)	0	Mwh	Consumption without V2G	35300	Mwh	Total Base load before	24960	Mwh	Total Peak Power before	10340	Mwh
Energy use for recharging vehicles	4	Mwh	Consumption with V2G	37068	Mwh	Total Base load after	34560	Mwh	Total Peak Power after	2508	Mwh
Nb of vehicles	125000	#	Consumption increase	5.01	%	Base load increase	38.46	%	Peak Power decrease	75.74	%

# Fuel Cell Cars

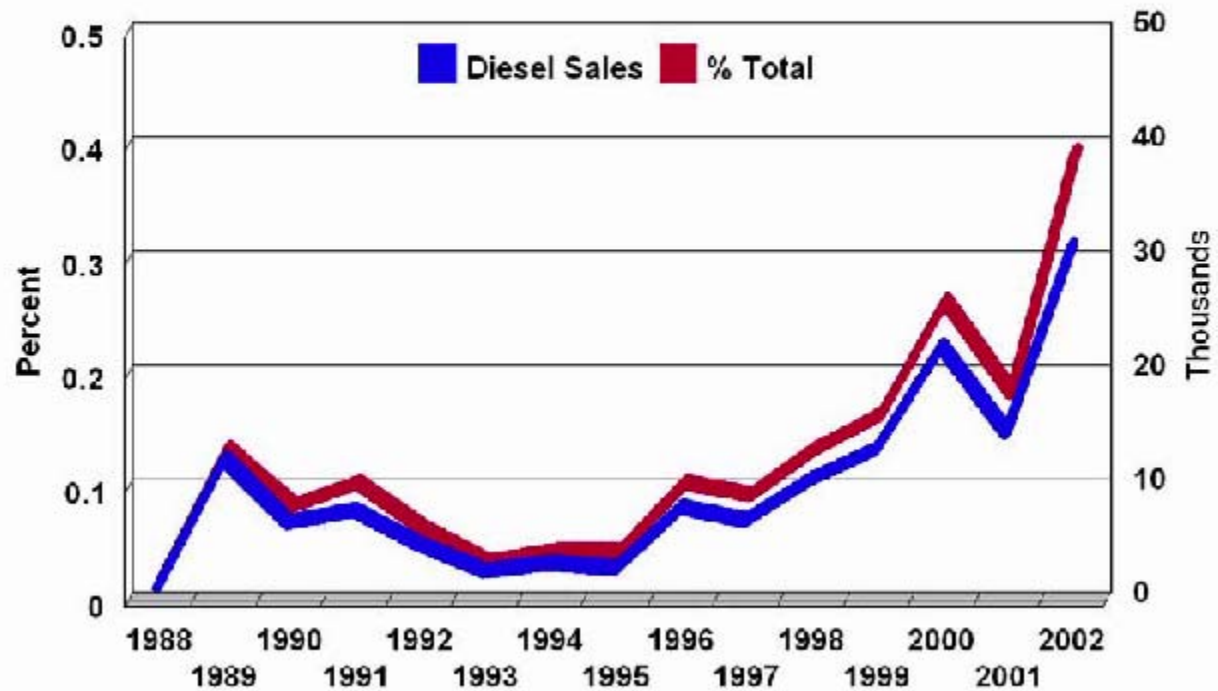


## Issues:

- Efficiency
- Water Management/Cold Weather
- Where will the  $H_2$  come from?

# Diesels

## Sales of Diesel Cars in the US





# Air Pollution Control In Vermont: "Clean Cars"



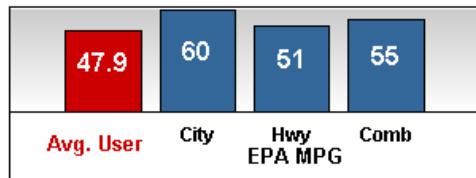
## 2005 Toyota Prius

**DISCLAIMER:**

Average user estimates are based on data from Your MPG users rather than official sources. Since the source data cannot be verified, neither DOE nor EPA guarantees the accuracy of these estimates.



4 Cylinder, 1.5 Liter, Automatic (fully variable gear ratios)



**Number of Vehicles:** 38  
**Average User MPG:** 47.9  
**Range:** 36 - 58 MPG  
**Updated On:** 09/06/2005

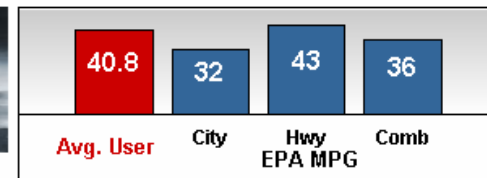
## 2005 Volkswagen Jetta

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4 Cylinder, 1.9 Liter, Auto (S5)



**Number of Vehicles:** 3  
**Average User MPG:** 40.8  
**Range:** 38 - 42 MPG  
**Updated On:** 09/06/2005

Emissions Certification (g/mi):

CA: ATPZEV/SULEV

HC	CO	NO <sub>x</sub>	PM
0.01	1.0	0.02	0.01

30x

Emissions Certification (g/mi):

EPA: Tier2 Bin 10

HC	CO	NO <sub>x</sub>	PM
0.156	4.2	0.6	0.08

# Air Pollution Control In Vermont: "Clean Cars"



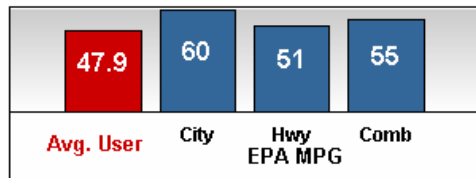
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4 Cylinder, 1.9 Liter, Auto (S5)

**For Model Year 2007/8**



**Number of Vehicles:** 3  
**Average User MPG:** 40.8  
**Range:** 38 - 42 MPG  
**Updated On:** 09/06/2005

### Emissions Certification (g/mi):

**CA: ATPZEV/SULEV**

<b>HC</b>	<b>CO</b>	<b>NO<sub>x</sub></b>	<b>PM</b>
<b>0.01</b>	<b>1.0</b>	<b>0.02</b>	<b>0.01</b>

### Emissions Certification (g/mi):

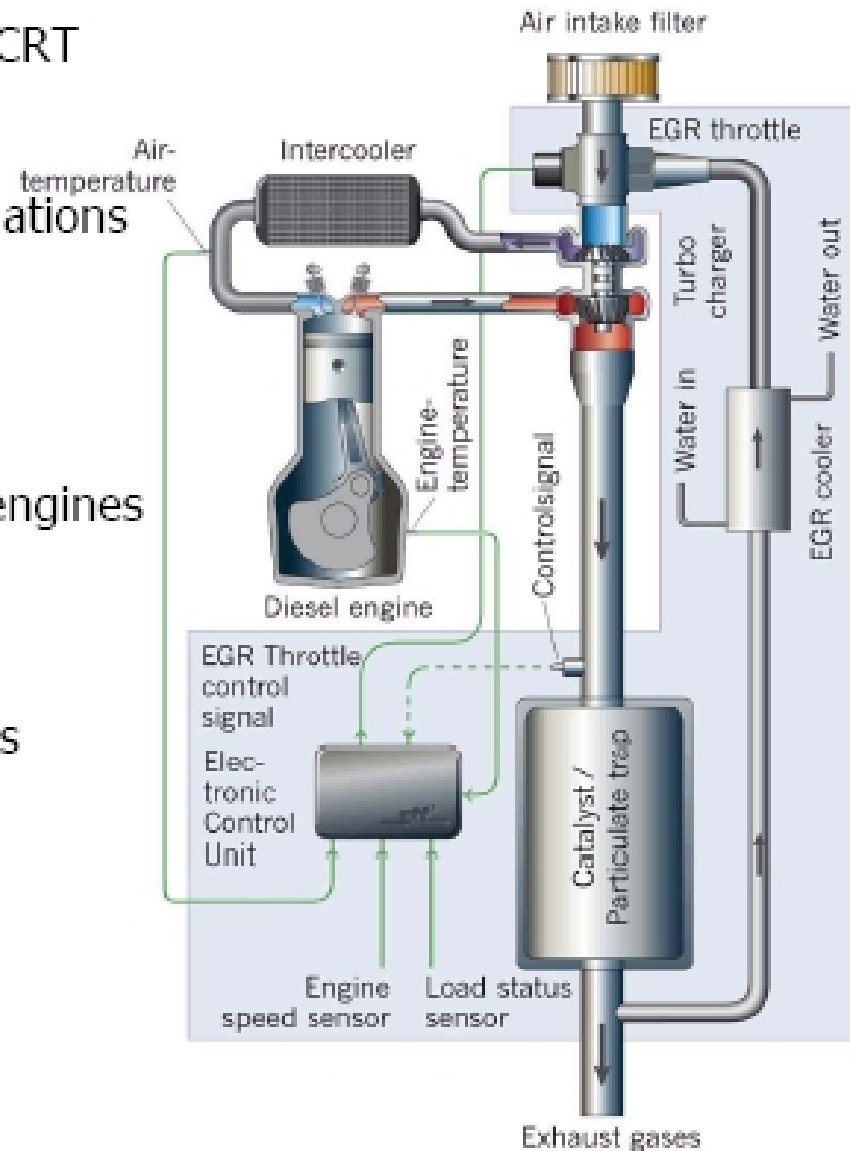
**CA: LEV = EPA: Tier 2 Bin 5**

<b>HC</b>	<b>CO</b>	<b>NO<sub>x</sub></b>	<b>PM</b>
<b>0.09</b>	<b>4.2</b>	<b>0.07</b>	<b>0.01</b>

# EGRT System

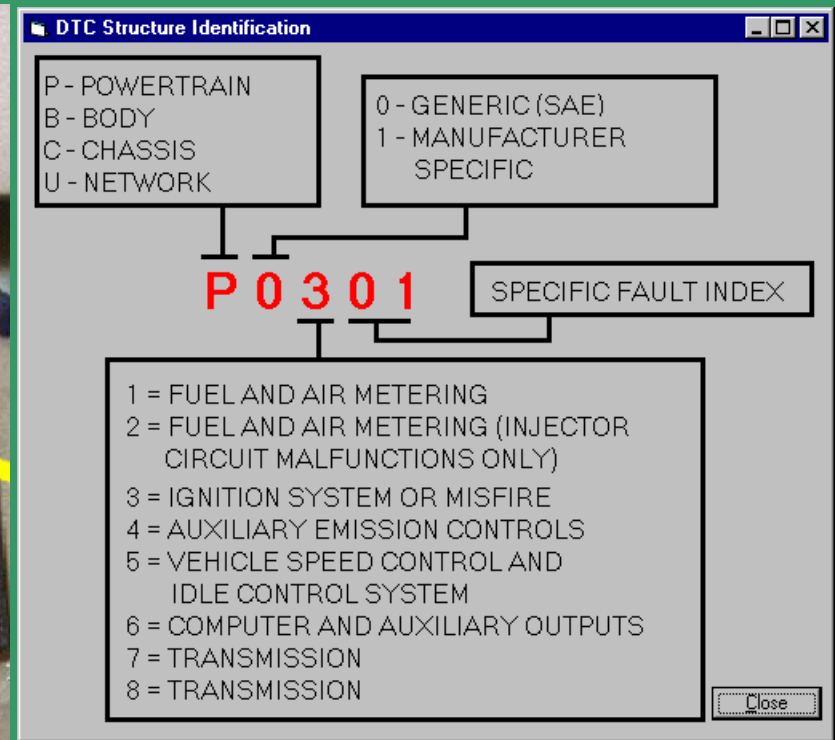
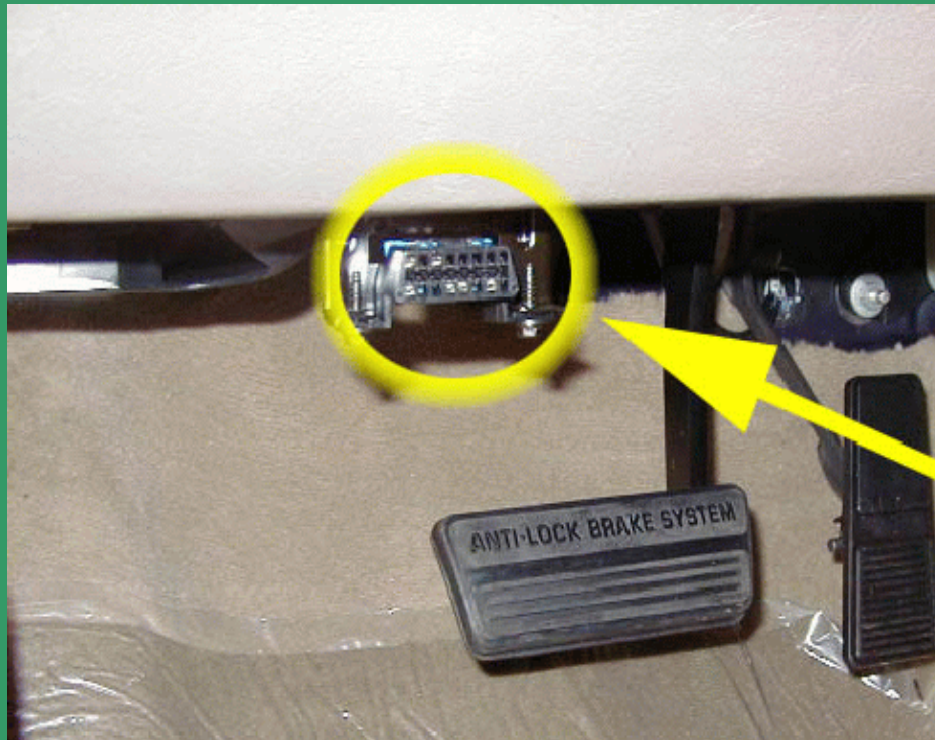
- Low pressure EGR-system with CRT particulate filter
- Used for OEM and retrofit installations
- For trucks, buses, and off-road machinery
- Over 1200 installed on various engines
- Use Ultra Low Sulfur Diesel
- Reduction of legislated emissions

CO	> 90 %
HC	> 90 %
PM	> 90 %
NO <sub>x</sub>	> 40 %



# Air Pollution Control In Vermont: "Good Maintenance"

OBDII



## Air Pollution Control In Vermont: “Clean Fuels”

### Clean Fuels

- *Unleaded Gasoline*
- *Oxygenated Gasoline*
- *Reformulated Gasoline/Low Sulfur*
- *Reformulated Diesel/Low Sulfur*

...

## Air Pollution Control In Vermont: “Clean Fuels”

### *Alternative Fuels*

- *Natural Gas*
- *Propane*
- *Ethanol*
- *Bio Diesel*
- *Electricity*
- *Hydrogen*

# Air Pollution Control In Vermont: "Clean Fuels"

## Alternative Fuels: EVERmont Sustainable Transportation Project



Grid



Proton Energy hydrogen generator



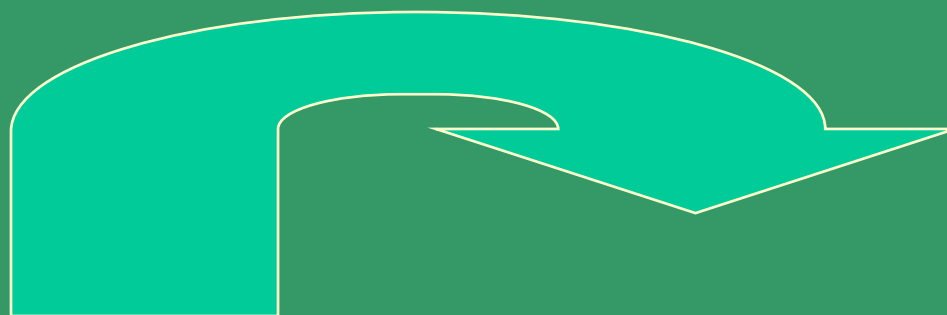
Compression and storage



Air Products fueling station



BED Wind Turbine (next door)



*Energy Flow*



2005 Toyota Prius Converted to H<sub>2</sub>

## Air Pollution Control In Vermont: “Efficient Use”











# Air Pollution Control In Vermont:

In conclusion:

*Clean Vehicles*

+ *Good Maintenance*

+ *Clean Fuels*

+ *Efficient Use*

= *Improved Air Quality*

# Air Pollution Control In Vermont:

Thank you for this opportunity to talk with about air quality in Vermont.

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