

International Best Practices on Methanol Fuel Blending

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Presentation Overview

- **History of Methanol Fuel Blending**
- **Benefits of Methanol Blending**
- **Materials Compatibility Considerations**
- **Gasoline Distribution System Best Practices**
- **Environmental Benefits**

Decades of Methanol Blending In Gasoline

Fuel Standards Used to Maintain Gasoline Performance Quality

1970's / 1980's	Substitute for Some Crude Oil in On-Road Vehicles
1990's	Clean Burning Octane and Oxygen in Fuel
2000's	Substitute for Some Crude Oil in On-Road Vehicles
Future	Methanol supplies expanding via Lower Cost Natural Gas Supplies

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35 Years of Global Experiences with M15 Gasoline Blends

- German Automakers and Oil Refiners conducted small vehicle fleet trials of M15 fuels in mid-1970's
- Germans selected M15 as highest methanol content for use in vehicles with 1980's carburetor fuel systems and material compatibility
- Number of larger M15 fleet trials conducted in late 1970's / early 1980's

<i>Germany</i>	<i>~ 1,000 vehicles</i>
<i>Sweden</i>	<i>~ 1,000 vehicles</i>
<i>New Zealand</i>	<i>~ 950 vehicles</i>
<i>China</i>	<i>~ 500 vehicles</i>

M15 with corrosion inhibitors and co-solvent alcohols provided stable gasoline fuel, and protected fuel system metals in vehicles

- Society of Automotive Engineers (SAE) established M15 as fuel standard for selecting materials used in vehicle fuel systems starting 1990
- Some China Provinces initiated commercial M15 market trials in 2004

Newer Fuel Standards Raises Allowable Methanol Content

Earlier commercial Fuel Standards started with nominal 3 vol % methanol in gasoline

Higher methanol content in gasoline allowed as global automotive fuel system technology and materials continues to improve in global vehicle fleets

Approved Methanol Gasoline Blends with Requirements for Co-solvent Alcohols and Additives						
Market Region		Introduction Year	Maximum Volume % Methanol	Minimum Volume % Co-solvent	Maximum Wt % Oxygen	Corrosion Additives
Europe	EC Directive	1985	3.0	≥ Methanol	3.7 %	
U.S.A	Sub Sim *	1979	2.75	≥ Methanol	2.0 %	
U.S.A	Fuel Waiver	1981	4.75	≥ Methanol	3.5 %	Required
U.S.A	Fuel Waiver	1986	5.0	2.5	3.7 %	Required
China, Shanxi	M15 Standard	2007	15.0	For Water Tolerance	~7.9 %	Required

* U.S. EPA's Substantially Similar Regulation for commercial gasoline

Other countries evaluating introduction of methanol blending standards in gasoline:

Pakistan, Israel, Australia, and Trinidad

Use of Oxygenates Is Expanding in Global Gasoline Markets

- U.S. moving to 100% E10 (10% ethanol with 3.7 wt% oxygen and 8 kPa RVP waiver) nationwide, and now allowing some E15 for newer vehicles in U.S. fleet

5 % methanol blends with up to 3.7 wt % oxygen allowed under a number of EPA waivers since 1981, and updated by EPA in 2012 with new corrosion inhibitors

Commercial methanol blends discontinued by 1987 due to unfavorable economics with period of low crude prices

- Europe started using 3 % methanol blends with co-solvents in late 1970's, but discontinued commercial use in late 1980's, but then restarted in 2011 with bio-methanol.

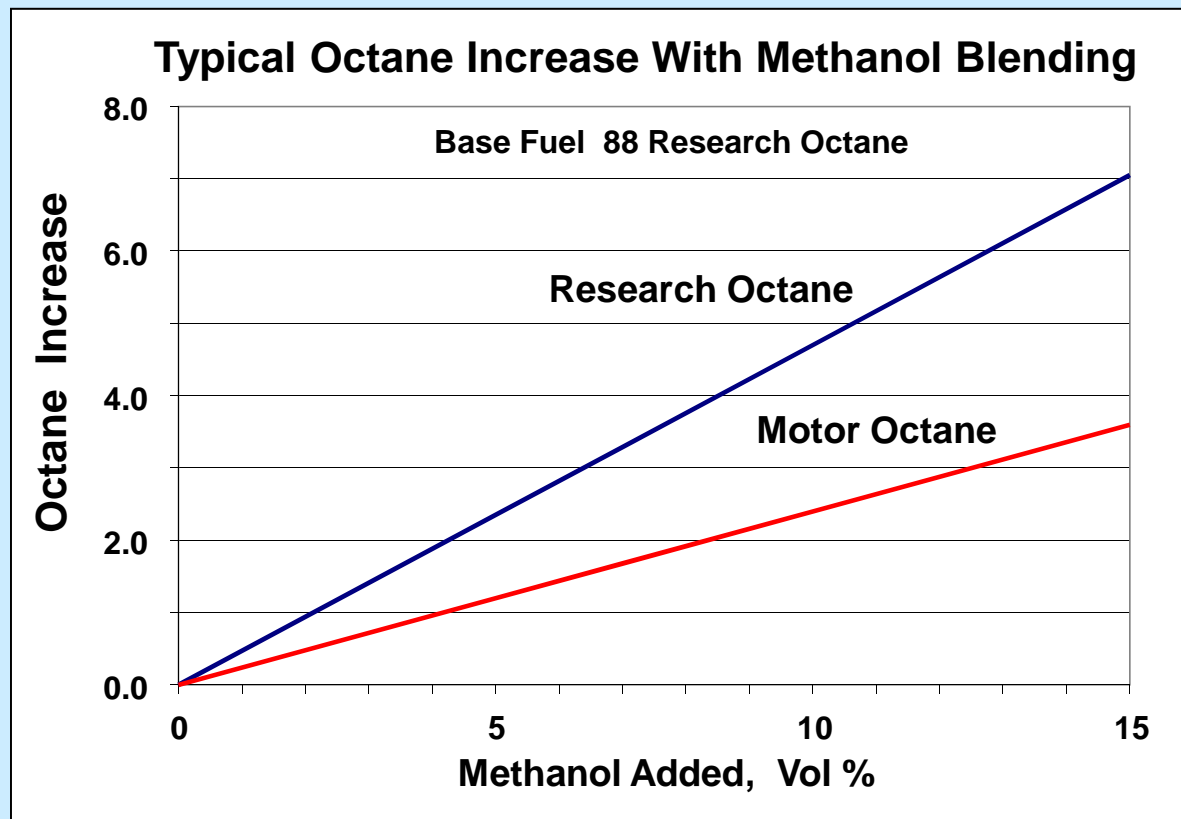
Moved oxygen limit from 2.7 wt% oxygen to 3.7 wt % to allow more bio-alcohol and bio-ether blending.

- Some China Provinces successfully introduced M5 and M15 methanol blend programs in 2004. M15 now expanding into additional Provinces.

Fuel oxygen level is effectively 7.5 wt %. National M15 standards with RVP waivers are under consideration.

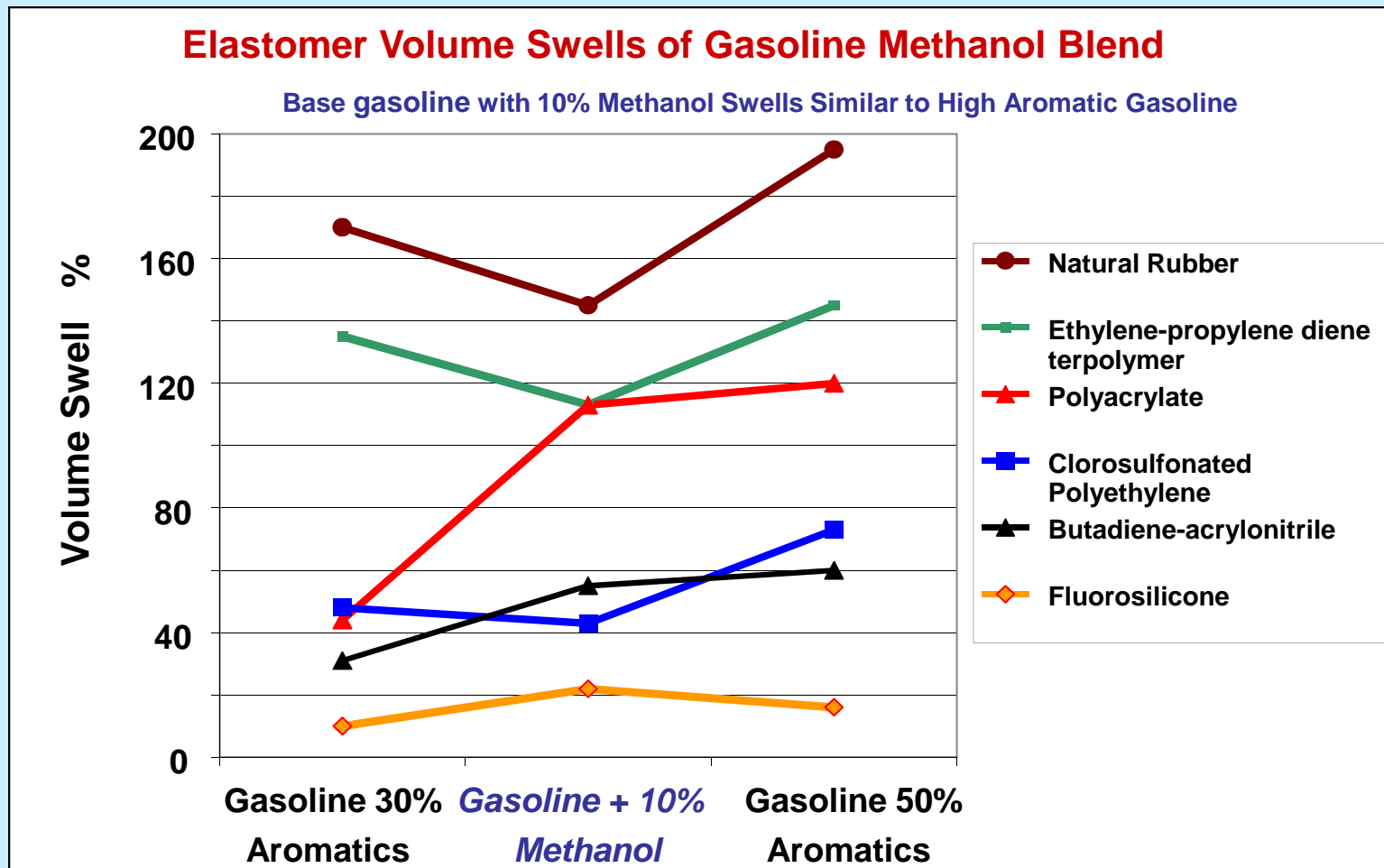
Methanol Blending Provides Multiple Savings of Petroleum Energy

- Methanol's energy made from non-petroleum energy sources (Gas and Coal)
- Methanol's oxygen in gasoline improves engine combustion efficiency which reduces vehicle's energy consumption
- Gasoline yield from refining crude oil improves by using external octane sources
Methanol provides the highest octane contribution per unit of contained energy



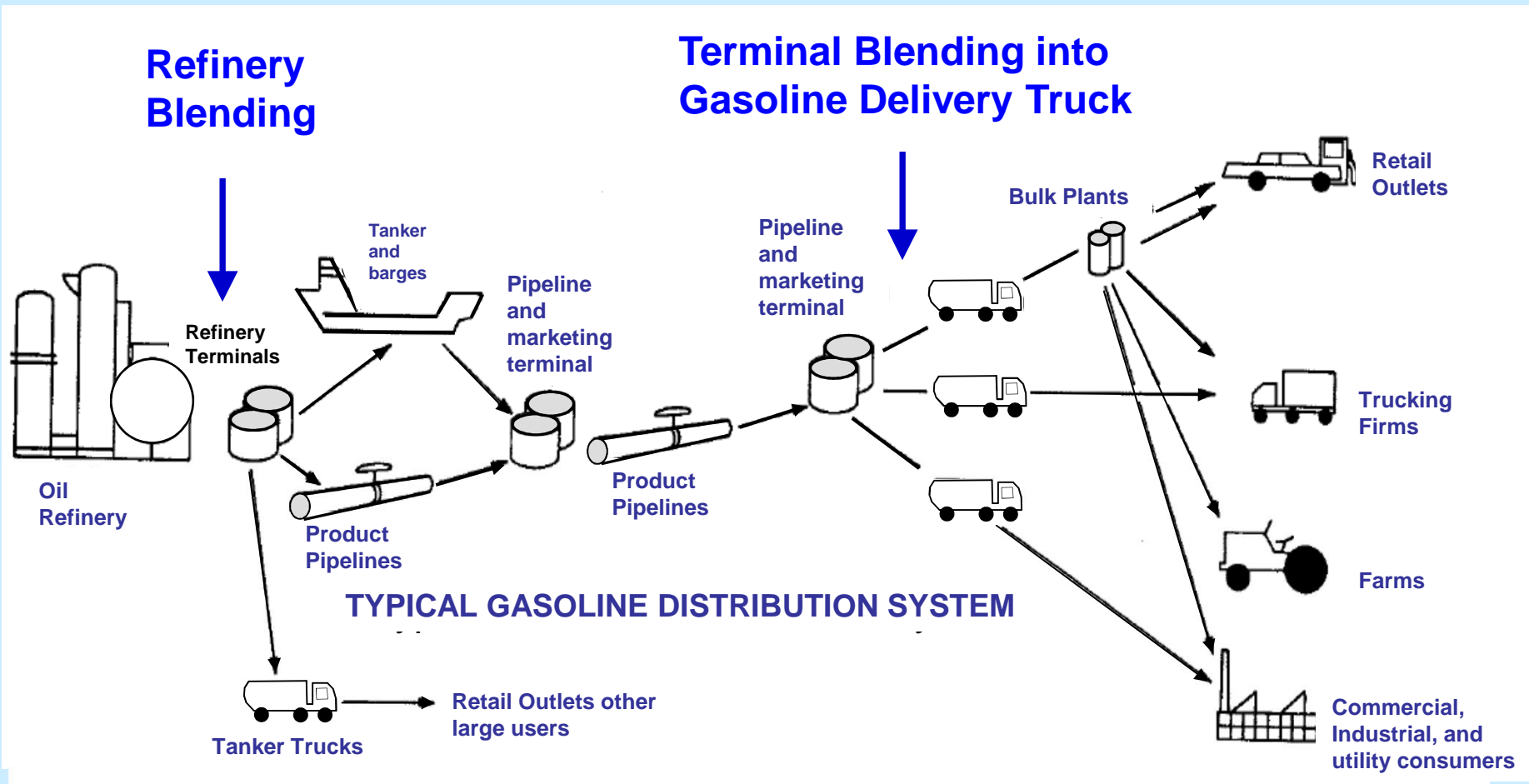
Material Compatibility With Methanol Blends Well Understood

- Elastomer Compatibility with Methanol Blends well studied in the 1980's
- Society of Automotive Engineers (SAE) established M15 as fuel standard for selecting materials used in vehicle fuel systems starting 1990



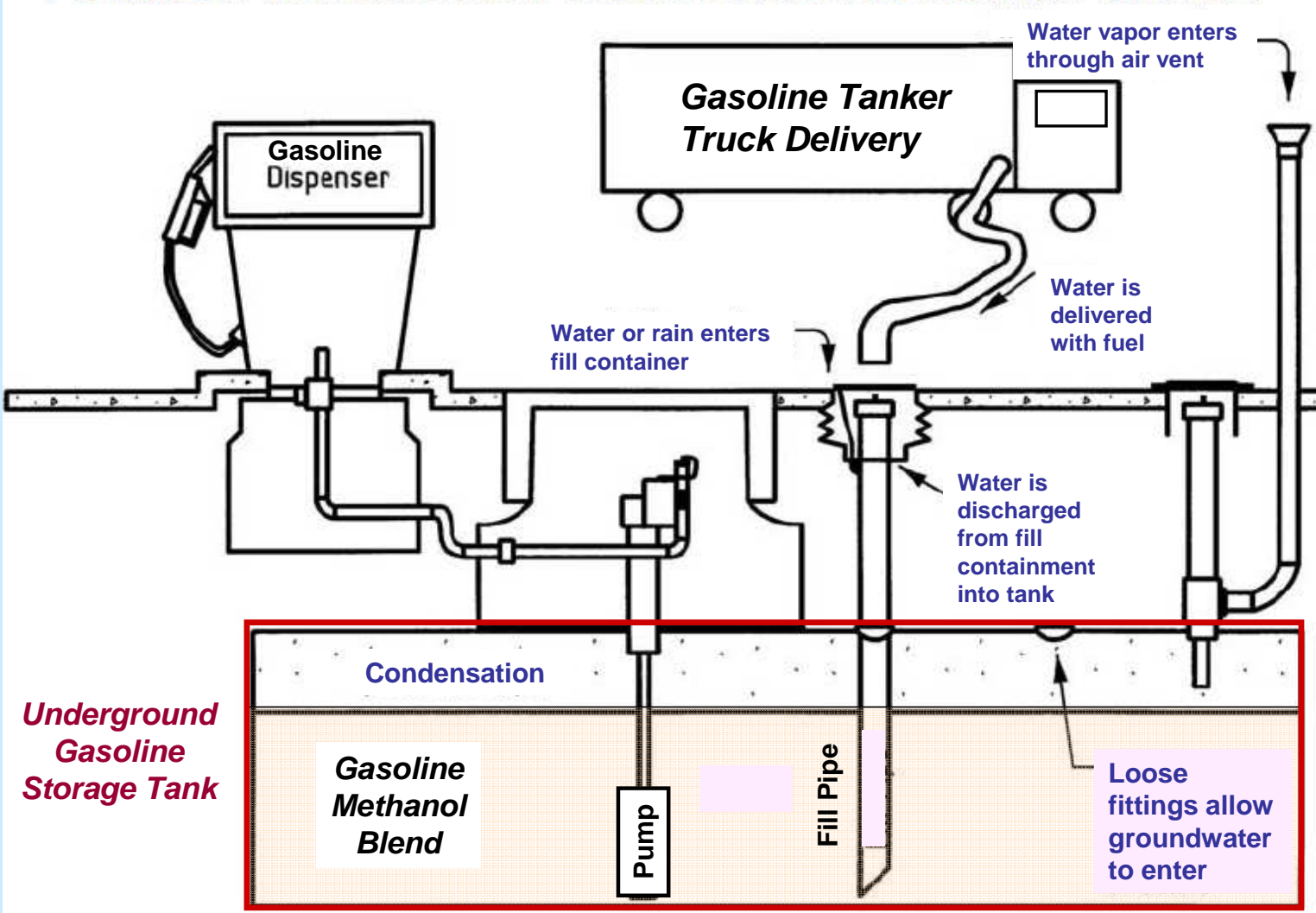
Methanol Blend Production at Two Locations for Fuel Quality Controls

- Global blending experience developed procedures for maintaining fuel quality in gasoline distribution systems



Monitoring For Water Maintains Quality / Stability of Methanol Blends

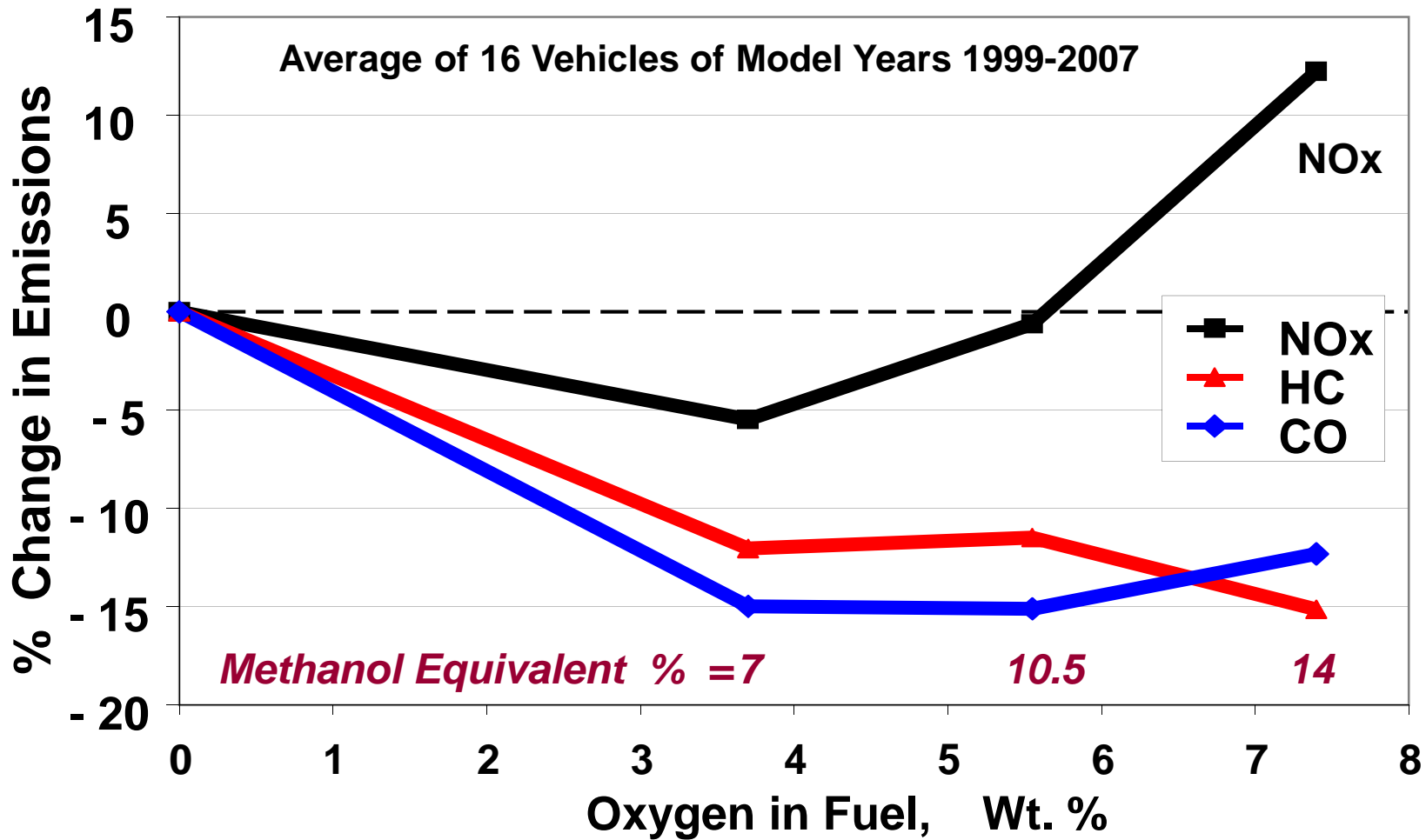
- Good operating practices in gasoline distribution system maintain quality gasoline



Methanol Provides Environmental Benefits with Low Risk

- Adding oxygen to gasoline reduces vehicle exhaust emissions which reduces air pollution

Vehicle Exhaust Emission Changes versus Fuel Oxygen Content



Methanol Provides Environmental Benefits with Low Risk

- Methanol has relatively short environmental life in water and in soil which reduces exposure risk in the environment

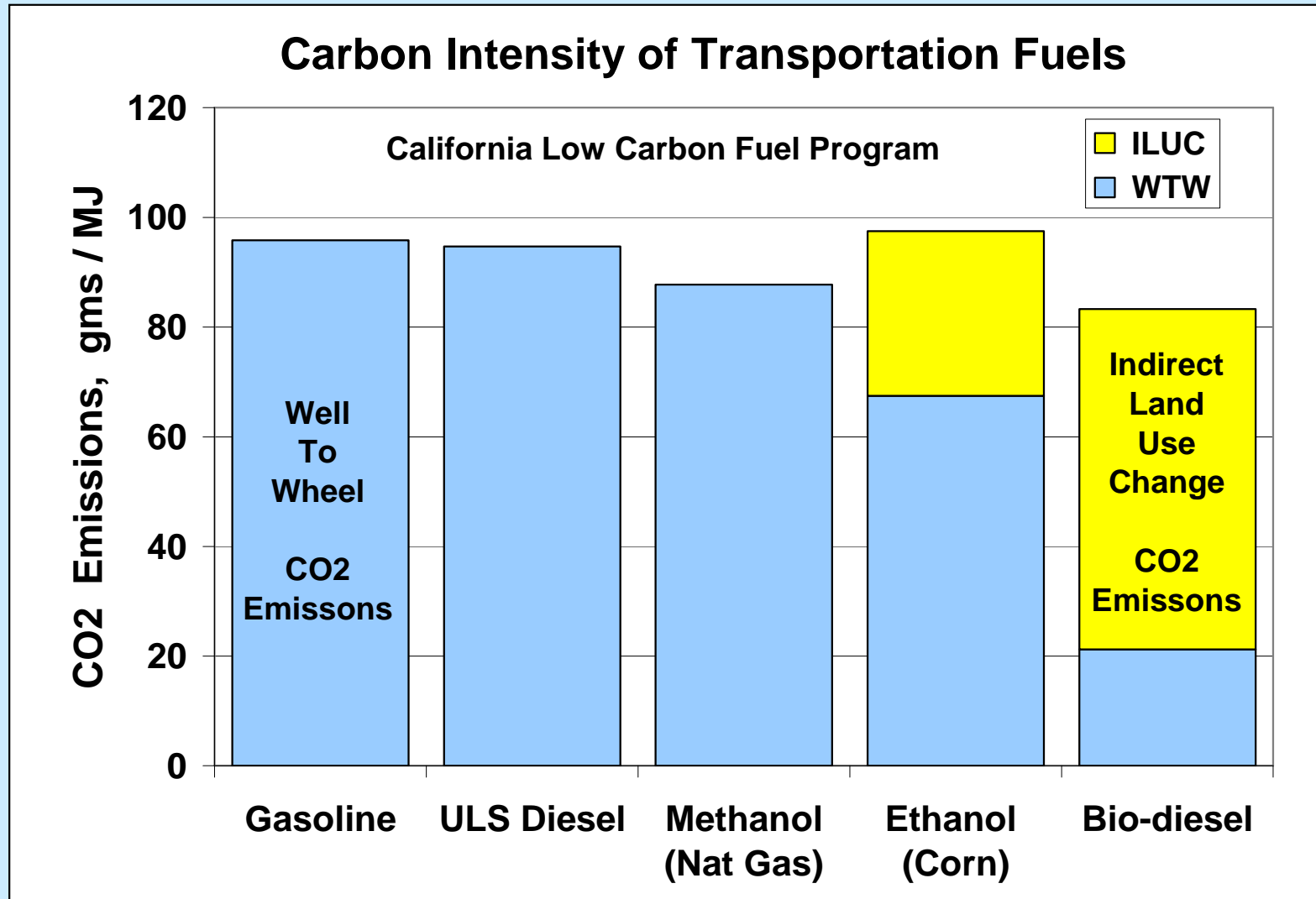
Environmental Half-Lives as Days

	Soil	Air	Surface Water	Ground Water
Methanol	1 - 7	3 - 30	1 - 7	1 - 7
Ethanol	0.1 - 1	0.5 - 5.1	0.25 - 1	0.5 - 2.2
Benzene	5 - 16	2 - 21	5 - 16	10 - 720
Toluene	4 - 22	0.4 - 4.3	4 - 22	7 - 28

Methanol as an alternative transportation fuel in the US: Options for sustainable and/or energy-secure transportation, MIT, Nov 2010

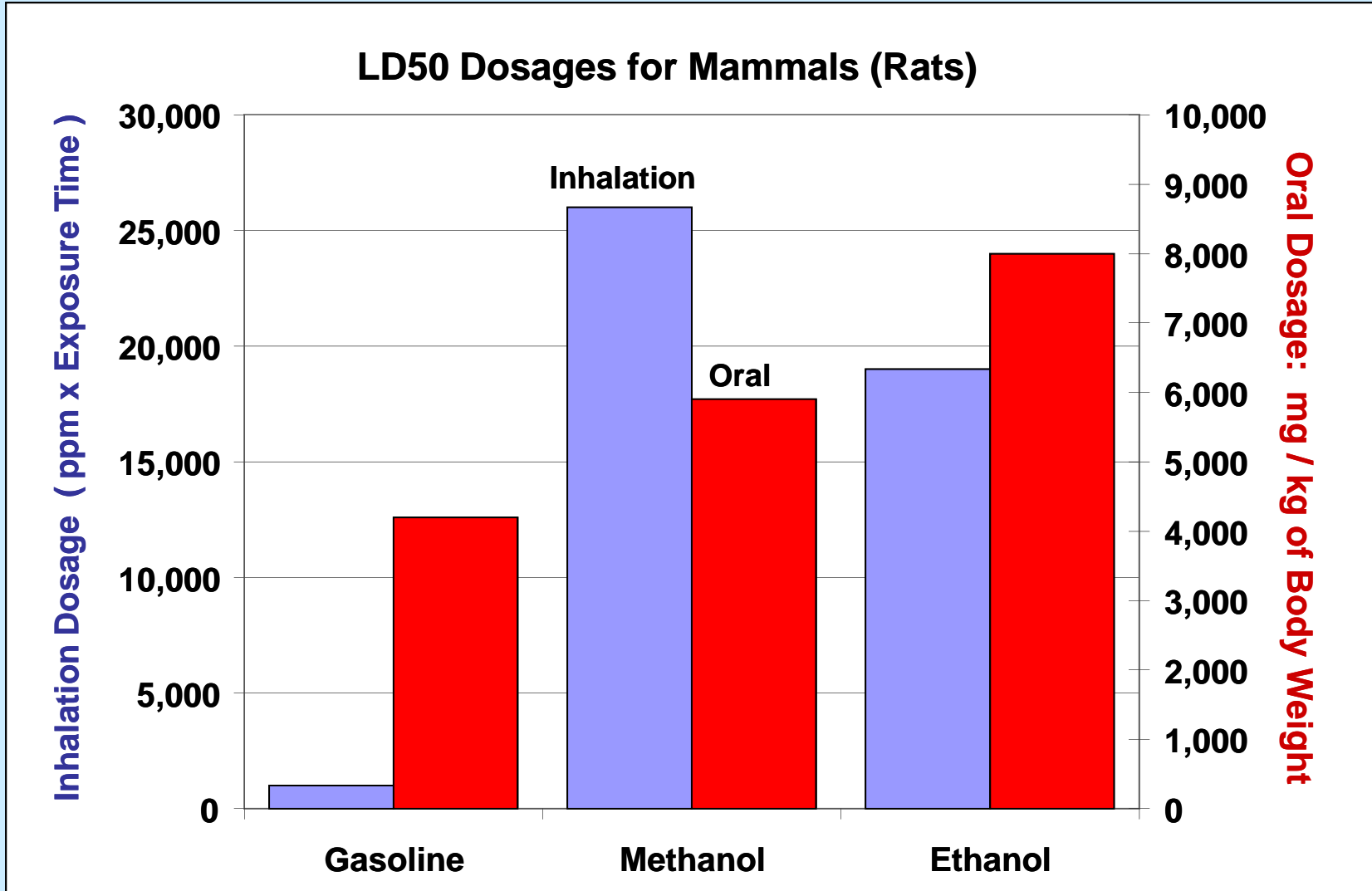
Methanol Provides Environmental Benefits with Low Risk

- Methanol made from Natural Gas has relatively lower CO₂ intensity for Green House Gases



Methanol Provides Environmental Benefits with Low Risk

- Methanol has relatively low acute toxicity for some mammals



35 Years of Global Experiences with Methanol Gasoline Blends

- **M15 Vehicle Fleet Trials began by German Automakers in mid-1970's**
- **Besides being made from natural gas energy, methanol also provides oxygen in fuel to improve engine combustion efficiency and high octane contribution which increases gasoline yield from refining crude oil**
- **M15 blends with corrosion inhibitors and co-solvent alcohols produces stable gasoline fuel, and protects fuel system metals in vehicles**
- **Modern vehicle fuel systems use materials compatible with M15**
- **Water monitoring in gasoline distribution system maintains performance equality of methanol gasoline blends**
- **Methanol blends provide air pollution reduction
with low exposure risks in the environment**

Thank you!

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