Assessing Effects of Mid-Level Ethanol Blends

Mobile Sources Technical Review Sub-Committee Meeting

DoubleTree Hotel - Arlington, VA

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Reg Modlin, Chrysler

Dave Raney, Honda

Ethanol – Crescendo of Headlines

- Clean Air Act Calls for Oxygenate in Gasoline – from MTBE to Ethanol to Moot Point.
- Ethanol Overcapacity – filling the MTBE void to ethanol oversupply.
- The Battle for Corn – Food or Fuel?

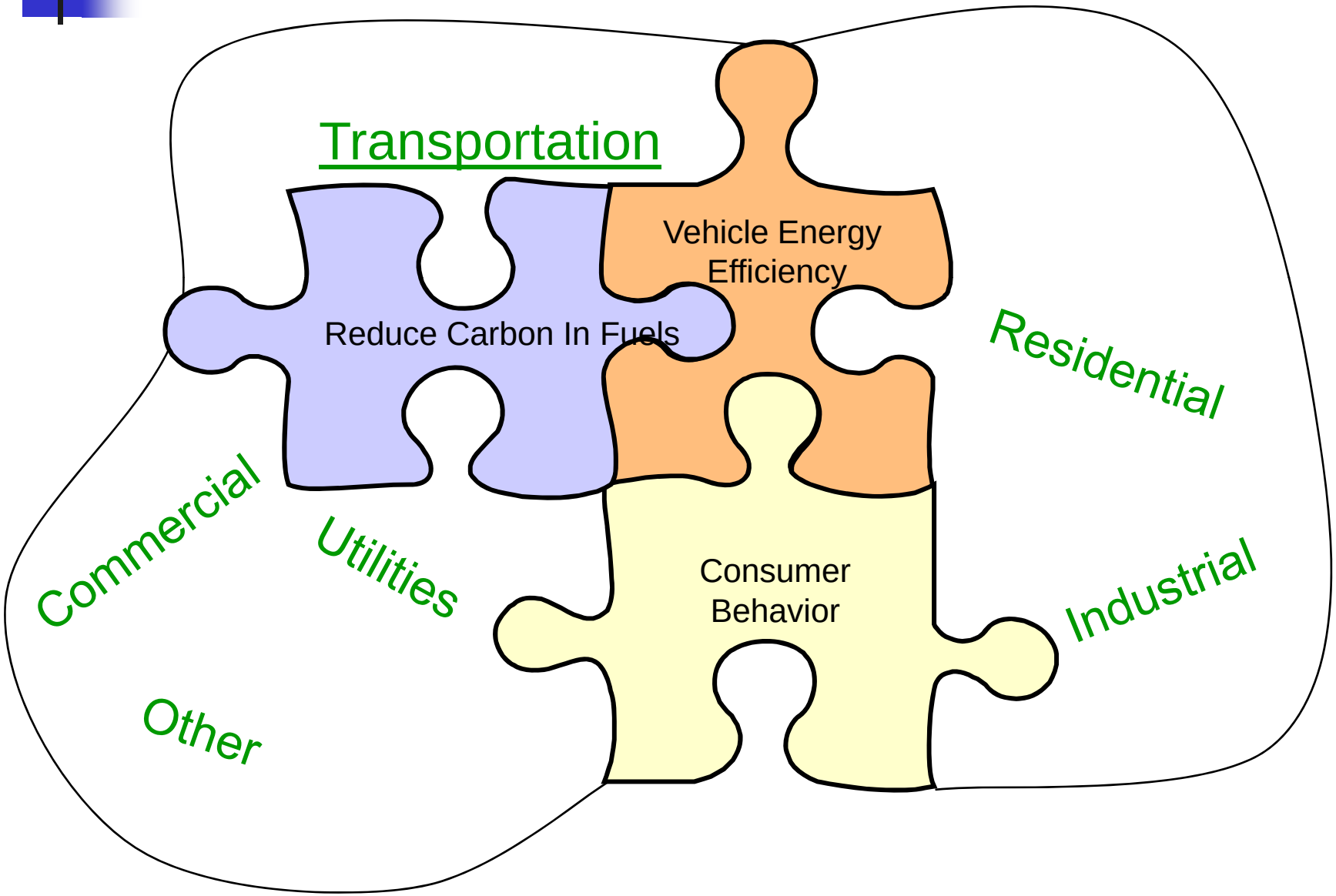
Crescendo of Headlines – Cont'd

- The Clean Energy Myth – Corn-based Ethanol – All they're doing is driving up food prices & making global warming worse. *Time Magazine*.
- What's the true life cycle effect of ethanol?
- Oil Companies sued for corroding boat tanks, engines.
- Call for Auto Manufacturers to make more vehicles to use the over-supply of ethanol.

Societal Drivers

- Assure America's energy security.
- Reduce carbon emissions from transportation.

Energy Consumption Reduction Puzzle

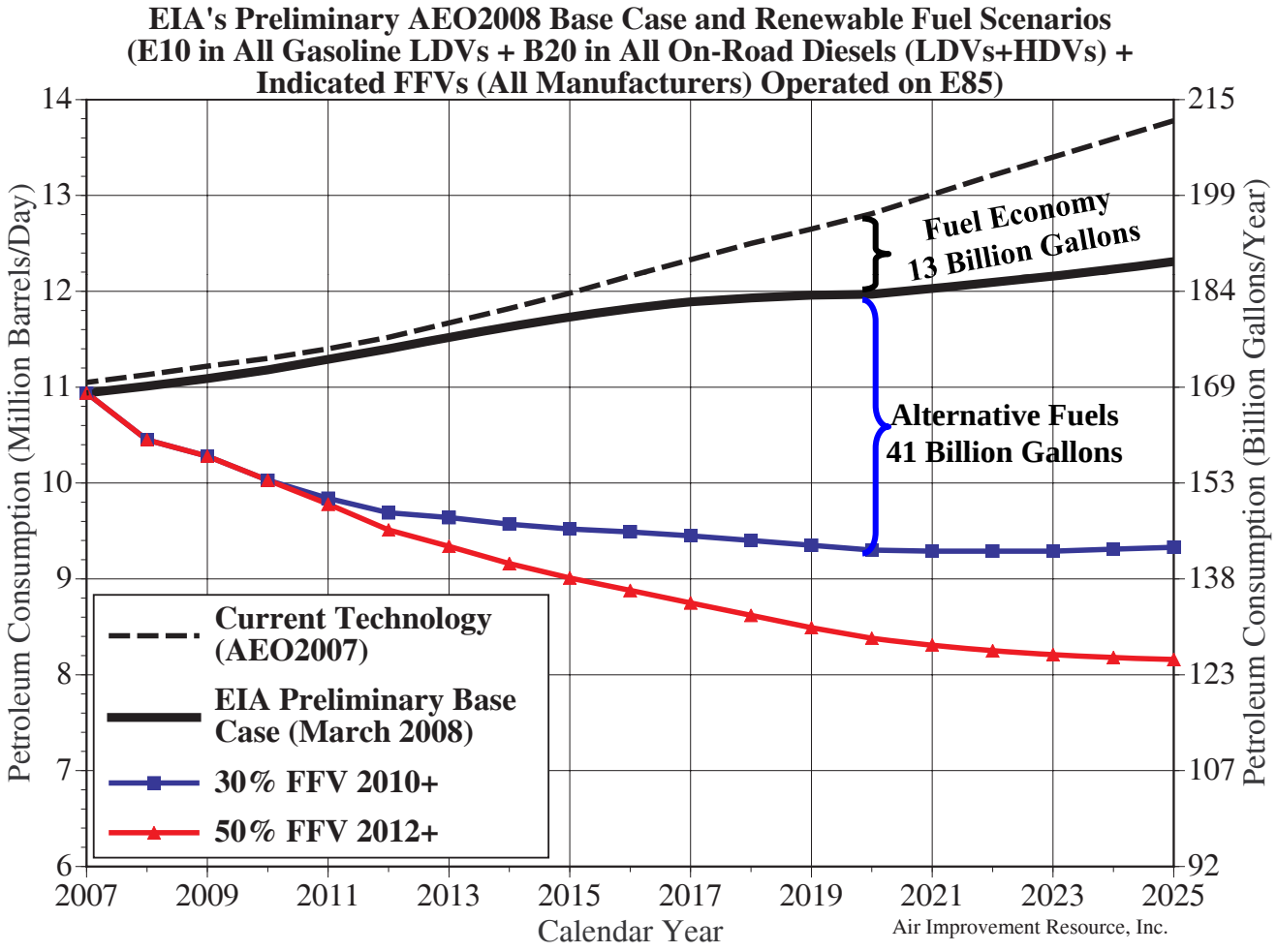


Challenge: Get the right fuels, right cars and right consumer behavior

- All automakers will build maximum energy efficient vehicles to meet fleet-wide 35 MPG fuel economy as directed by Congress.
- Chrysler, Ford and GM CEOs committed to Congress and President to expand production of alternative fuel vehicles to 50% by 2012. Putting alternative fuel into these vehicles will use all alternative fuels required under renewable fuels standard.
- Set a carbon cap on fuel that is equally stringent to the challenge imposed on automakers.
- Make consumers committed to reducing energy consumption in transportation.

How Much Petroleum Can Biofuels Displace?

- **Various bio-fuels scenarios demonstrate that petroleum consumption can be reduced**
- **Petroleum consumption can be reduced by over 30% compared to DOE's projections if:**
- **All Gasoline is E10**
- **All Diesel fuel is B20**
- **30% E85 FFV production in 2010 with 100% E85 use**
- **50% E85 FFV production in 2012 with 100% E85 use**



Recent Topic of Discussion: Ethanol Oversupply

- Alternative fuel vehicle capacity will be ramping up and in place to use the ethanol.

- Many products (furniture, builders, fiber optics, automobiles, etc.) have or are facing similar over production or over capacity concerns with no rush from others to offer remedies.

- An additional solution under consideration is mid-level ethanol …

Mid-level Ethanol

- Before a customer puts an alternative fuel nozzle in the tank, we want to know what will happen.

- Need to understand any potential unintended consequences of introducing mid-level ethanol blends.

Assess the Effect of Mid-Level Ethanol Blends

- Topics of Interest:
  - Durability
  - Tailpipe (health-based) emissions
  - Evaporative emissions
  - Drivability
  - Materials compatibility
  - Emissions inventory
  - On-Board Diagnostics (OBD) Integrity

Analysis Thresholds

- This program is not intended to be a test protocol for a waiver determination

- Evaluations proposed and in place are thought to be sufficient to initiate policy discussions
  - Some guidance was given to EPA regarding such analyses

Analysis Thresholds – Cont'd

- CAA Section 211(f)(4)
  - *"The Administrator…may wave the prohibitions {of the CAA}…if he determines that the applicant has established that such fuel...will not cause or contribute to a failure…to achieve compliance by the vehicle with the emission standards…"*
- EISA Provided Further Direction
  - *Section 251: Expanded scope of CAA Section 211(f)(4) to include a broader spectrum of products*
    - *"…over the useful life of the motor vehicle, motor vehicle engine, nonroad engine or nonroad vehicle…"*
  - *Gave EPA a firm task to answer waiver requests*
    - *"…The Administrator shall take final action to grant or deny an application…after public notice and comment…within 270 days of the receipt…"*

Spectrum of Products Using Gasoline

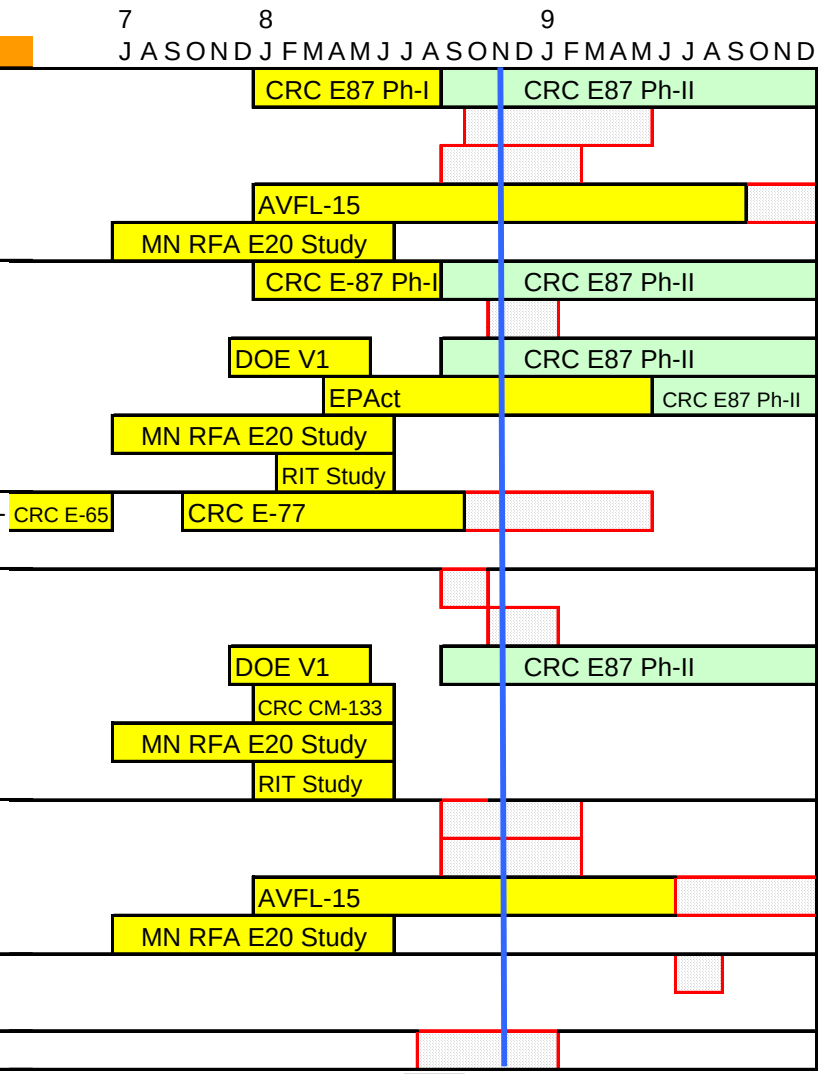
- On-Road Vehicles
  - Cars / Trucks ~ 250M units
  - Highway Motorcycles ~ 6.4M units
- Off-Road Engines/Equipment
  - Marine Products ~ 18M Recreational Boats
  - Off-Road Motorcycles & All Terrain Vehicles ~ 8M units
  - Lawn and Garden
    - Chainsaws, trimmers, edgers, lawn mowers, snow blowers
  - Industrial Equipment
    - Generators, forklifts, etc.
  - Snowmobiles, etc.

Effects of Mid-Level Blends

- Historical context of products for evaluation
  - Legacy Products
  - Future Products
    - Introduction of advanced combustion technologies
      - e.g. Gasoline Direct Injection
- Assess the effect of mid-level ethanol blends
  - Topics of interest and the collaborative test program

Car & Truck - Assess the Effect of Mid-Level Blends

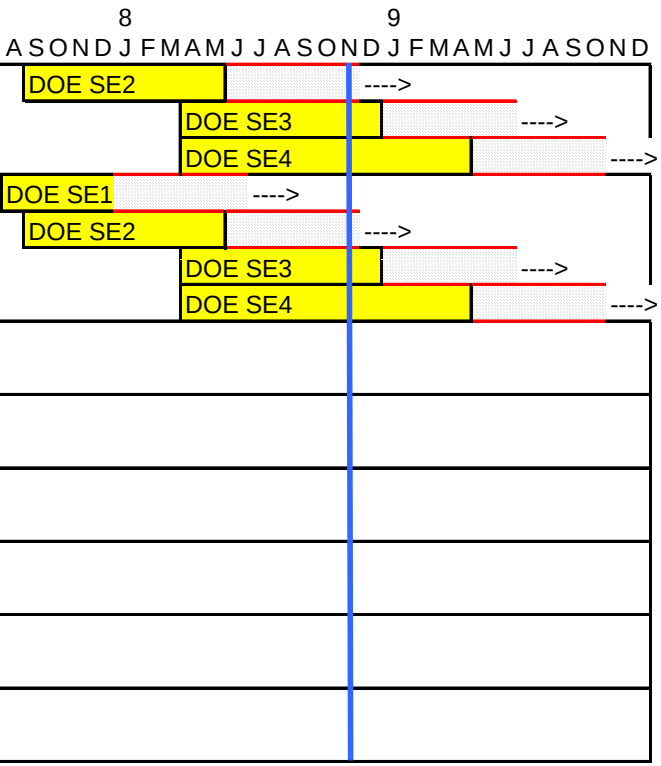
Topics of Interest		Auto Mfrs	DOE/EPA
Durability (DT)	Catalyst Durability Aging	DT1	DT1
	Evap Emissions Systems	DT2	
	Base Engine	DT5	
	Fuel system, Damper, Lvl sen, Mat'l Comp	DT3,4	DT6
	Fuel Pump Sending Unit - DOE will monitor		DT7
Tailpipe Emissions (TP)	Catalyst Durability Aging	TP1	TP1
	Powertrain Systems cold operation	TP2	
	Vehicle Emissions, Late Models	TP1	TP3
	Vehicle Emissions, Legacy Models	TP1	TP4
	Emissions - DOE will monitor		TP5
	Veh Perf & Emissions - DOT sponsored		TP6
Evap Emis (EV)	Evap Emissions, Permeation and Durability	EV1,2	EV3
Drivability (DR)	Fuel Damper	DR1	
	Powertrain Systems cold operation	DR2	
	Vehicle Emissions, Late Models		DR3
	Drivability of 20 FFVs 6 non-FFVs		DR4
	Drivability of 80 vehicles - DOE will monitor		DR5
	Veh Perf & Emissions - DOT sponsored		DR6
Materials Compatibility (M)	Base Engine	M1	
	Permeation of Fuel System	M2	
	Fuel system, Damper, Lvl sen, Mat'l Comp	M3,4	M5
	Elastomer, Plastic & Metals - DOE will monitor		M6
Emis Inventory (EI)	Emissions/Air Quality Monitoring	EI1	
OBD Integrity (OB)	On-Board Diagnostics	OB1	OB2



Note: 2003 Australian Orbital Study includes preliminary data for catalyst durability, emissions tests & materials compatibility.

Motorcycles & Off-Road Engine/Equipment – Assess the Effect of Mid-Level Blends

Topics of Interest		Mfrs	DOE
Durability (DT)	SNRE Full Useful Life Emissions & Durability		DT1
	SNRE Class II Full Useful Life Emissions & Durability		DT2
	SNRE Specialty Engines		DT3
Tailpipe Emissions (TP)	SNRE Emissions & Temperatures		TP1
	SNRE Full Useful Life Emissions & Durability		TP2
	SNRE Class II Full Useful Life Emissions & Durability		TP3
	SNRE Specialty Engines		TP4
Evap Emis (EV)	Additional programs to be determined		
Drivability (DR)	Additional programs to be determined		
Matl's Compat (M)	Additional programs to be determined		
Emis Inventory (EI)	Additional programs to be determined		
OBD Integrity (OB)			
Other Products			



SNRE = Selected Small, Non-Road Engine

Key:
- Comprehensive
- Preliminary, partial or screening
- Continued Testing

Next Steps

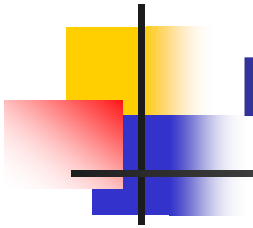
- Finish what's underway with the existing budget
- Assess and fund what's needed to move forward with effects analysis (estimated additional funds needed, $8-12M)
- Establish a funding plan
  - Search for additional funds
    - Supplement existing EPA/DOE budgets
    - Congressional action
    - State sources
    - Other interested stakeholders

Your Challenge

- Agree to participate
- Help in refinement of the Project
- Offer assistance in completion of the Project

Contributors to Development of Test Plan

Organization	Name	Title	Organization	Name	Title
Chrysler	Beard, Loren	Senior Manager Energy Planning & Policy	EPA	Kortum, Dave	Fuel Programs Support Group
Chrysler	Frusti, Jim	Senior Manager CAFE, Energy	EPA	Machiele, Paul	Director Fuels Center
DOE - EERE	Davis, Patrick	Team Leader Fuel Cell Team	EPA	Simon, Karl	Director Compliance & Innovative Strategies Division
DOE - EERE	Gougen, Steve	Supervisor Engines/Fuels/Deployment	Ford	DiCicco, Dominic	Fuels & Vehicle Energy Planning
DOE - EERE	Stork, Kevin	Team Leader Fuels Technologies & Technology Deployment	General Motors	Brinkman, Norm	Manager Laboratory
DOE - EERE	Wall, Ed	Program Manager FCVT	General Motors	Jones, Coleman	Manager Biofuels
DOE - NREL	Clark, Wendy	Group Manager & Principal Researcher Fuels Performance Group	General Motors	Schulz, Melisa	Senior Engineer Biofuels
DOE - NREL	Knoll, Keith	Senior Project Leader Fuels Performance Group	Honda	Raney, Dave	Senior Manager Environmental & Energy Affairs
DOE - ORNL	Graves, Ron	Center Director Fuels, Engines & Emissions	MIC & SBIA	Amette, Pamela	Vice President MIC
DOE - ORNL	West, Brian	Senior Research Staff Member Fuels, Engines & Emissions	NMMA	McKnight, John	Director Environmental & Safety Compliance
DOE - ORNL	Theiss, Tim	Acting Group Leader Fuels & Engines Research Group	OPEI	McNew, James	Vice President Technical & Marketing Services
EMA	Mandel, Jed	President EMA	Toyota	Valentine, Marie	Principal Engineer Vehicle Regulation & Certification Engineering
EPA	Fernandez, Tony	Assessment & Standards Division			



Backup Slides Follow

Deployment of Ethanol > E10

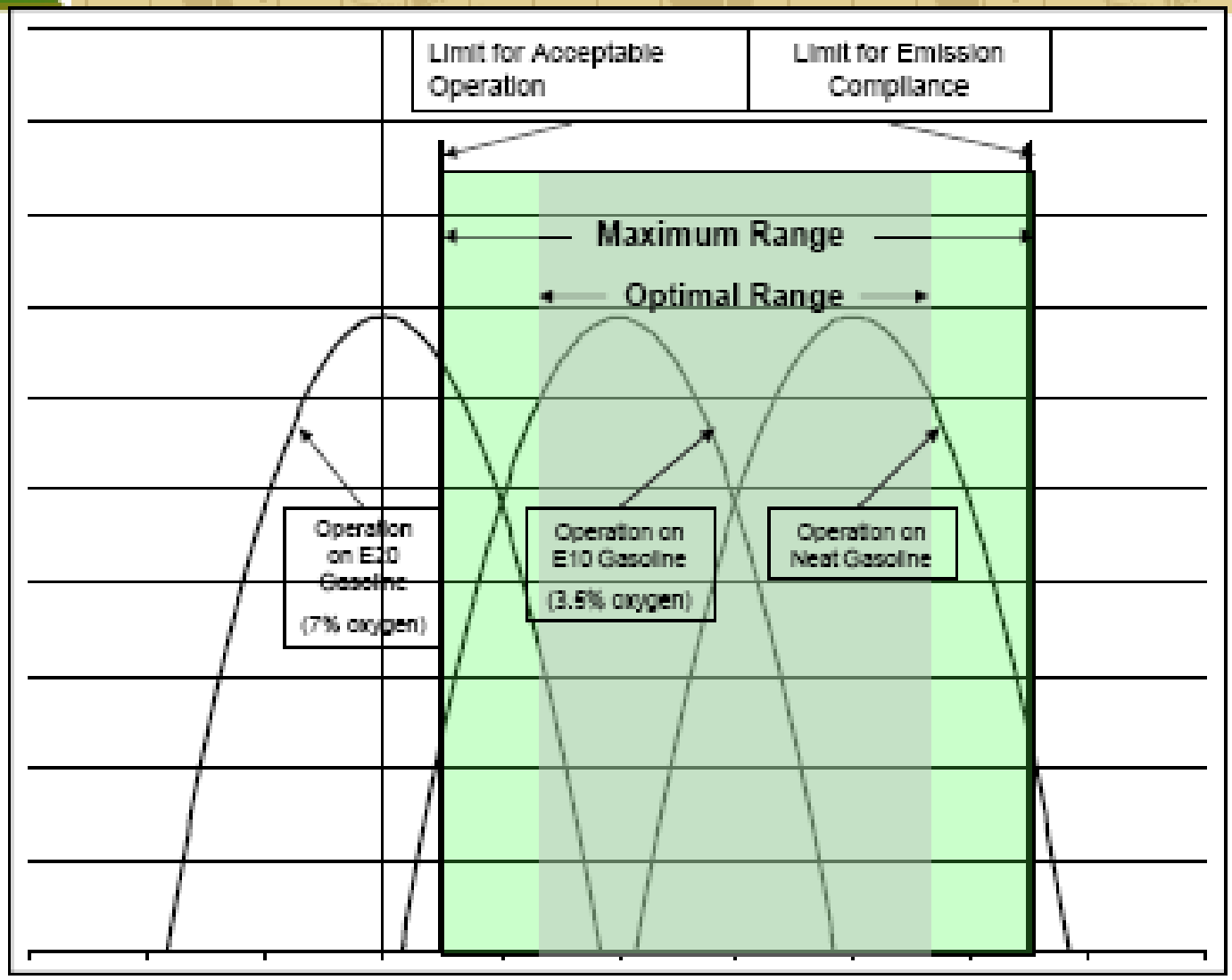
- Price it to sell
  - Price of ethanol blends at the pump must be less than gasoline on an energy basis
- Make and use it locally to minimize cost and maximize carbon reduction
- Continue research to define process necessary to make ethanol at a reasonable cost, sustainable at retail
- Deploy fruits of process research
- If policy makers cannot wait for process development,
  - Establish a fuel price incentive to assure a price advantage on an energy basis
  - Sunset the incentive (~5-10 years) to keep pressure on process development

Examples of Known Concerns

- Fuel dampers with flurosilicon are validated only up to E10. At E15, these dampers fail the component performance standard, leading to drivability issues and emissions failures.
- Unique Problems with Small Carbureted Engines with > E10 Fuels
  - Tight, fixed ranges for air:fuel ratios cannot adjust or compensate to different fuels.
  - Fixed carburetor settings on same engine cannot operate on both non-alcohol based fuels and E20.
  - Engines designed to run with E0 will run too lean on E20 resulting in “lean misfires” or “pre-ignition” from hot chamber surfaces causing “engine seizures.”
- Marine - Fiberglass fuel tank and ethanol fuel
  - See next two slides

Valve with carbon build-up from breakdown of the resin in fiberglass fuel tanks.

Post-mortem analysis of fiberglass fuel tank after exposure to ethanol fuel. Result of ethanol scouring inside of fuel tank.


Limit for Acceptable Operation
Limit for Emission Compliance
Maximum Range
Optimal Range
Operation on E20 Gasoline
(7% oxygen)
Operation on E10 Gasoline
(3.5% oxygen)
Operation on Neat Gasoline
Lean
Air:Fuel Ratio
Rich

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Concerns with Intermediate Ethanol Blends

- Any change in fuel will affect existing AND new equipment
- Roughly 500+ million pieces of existing equipment will be affected
- **Potential Failure Modes:**

Enleanment	Causes hotter temperatures and higher cylinder pressures	Blown head gaskets, burnt valves, burnt oil, loss of head bolt torque, damage to catalysts
Enleanment	Increased NOx emissions	
Water Separation	Fuel system materials degradation	Oligomers leach out of nylon, leaks develop in fiberglass fuel tanks, corrosion in steel tanks, corrosion in zinc components
Fuel and Material Incompatibility	Fuel system materials degradation; increased evaporative emissions or fuel leakage	Gasket and O-ring swelling causes loss of seal, fuel cap gaskets swell and block tank venting, fuel hose swelling can cause leakage

Other Potential Failure Modes

- Speed instability and audible speed hunting
- Poor load acceptance and sluggish acceleration
- Poor cold start
- Potential vapor lock
- Increased deposits in combustion chamber
- Long term storage
  - Increased water contamination
  - Fungus and algae formation in fuel

Concerns with Minnesota & RFA Evaluation

- None of the results reported apply directly to on-highway motorcycles, off-highway motorcycles, or all-terrain vehicles (ATVs)
- Statistical evaluation of the Drivability Project provides little useful information due to the test design and limited test fleet size. It is not possible to conclude statistical significance at the 95% confidence level in this test method.
- The test fleet selected was relatively new and included no high mileage vehicles. There were no representative fuel systems or technology included in the fleet that could be compared to that used on motorcycles or power equipment or marine products; e.g., no closed-loop control fuel systems are specified on the majority of these products.
- Elastomer testing involved only new materials which fails to consider the impacts of exposing in-use products to E20 that have potentially spent their life already exposed to E0-E10 blends.
- The E20 testing actually does indicates some damage to the materials but the Executive Summary tries to downplay these results. Broadening of the scope of the study is clearly needed to further evaluate these potential impacts as well as investigating impacts on different materials.
- Test fuel used not representative of real-world fuel.

Summary – Motorcycle/PE/Marine Perspective

- Current testing limited in scope and focus
  - Test protocols and fuel selection
  - Worst-case product selection
  - Product selection and age needs to be expanded
- Emissions evaluation needs more oversight from EPA
- Marine has unique issues; consideration of E0 availability
- Difficult (impossible?) to apply results from LDV/LDT testing to motorcycle/power equipment/marine
- Potential for customer dissatisfaction is significant; manufacturers should not be exposed to blame for a fuel they didn't know they had to design for.