

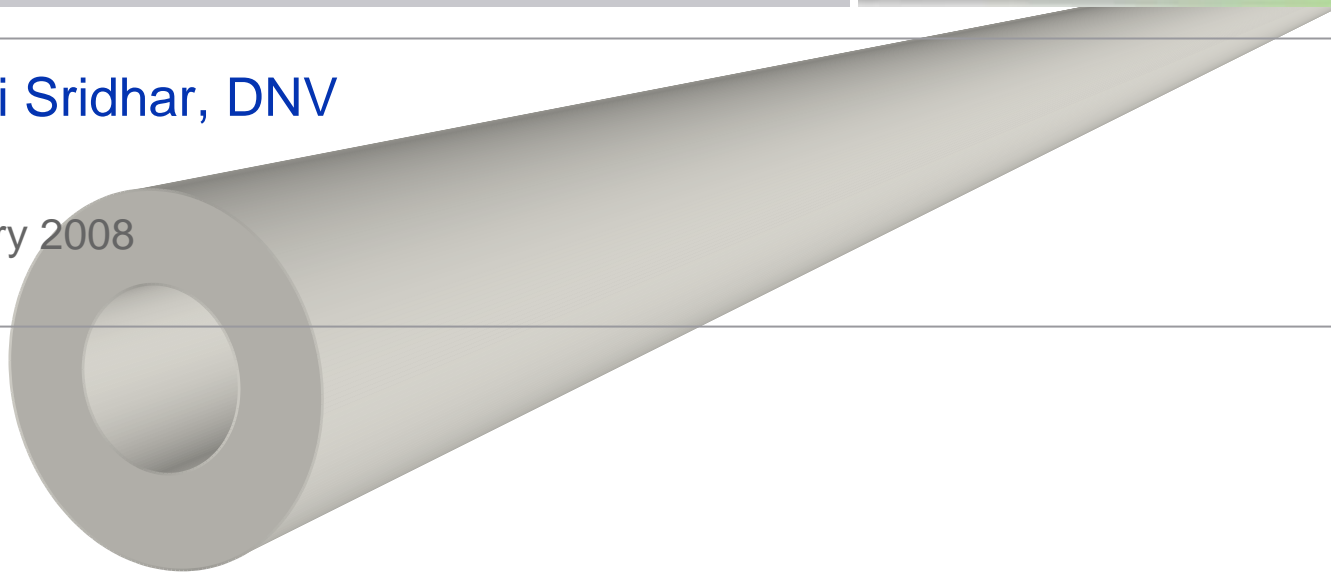


Transportation of Biofuel Through Pipelines



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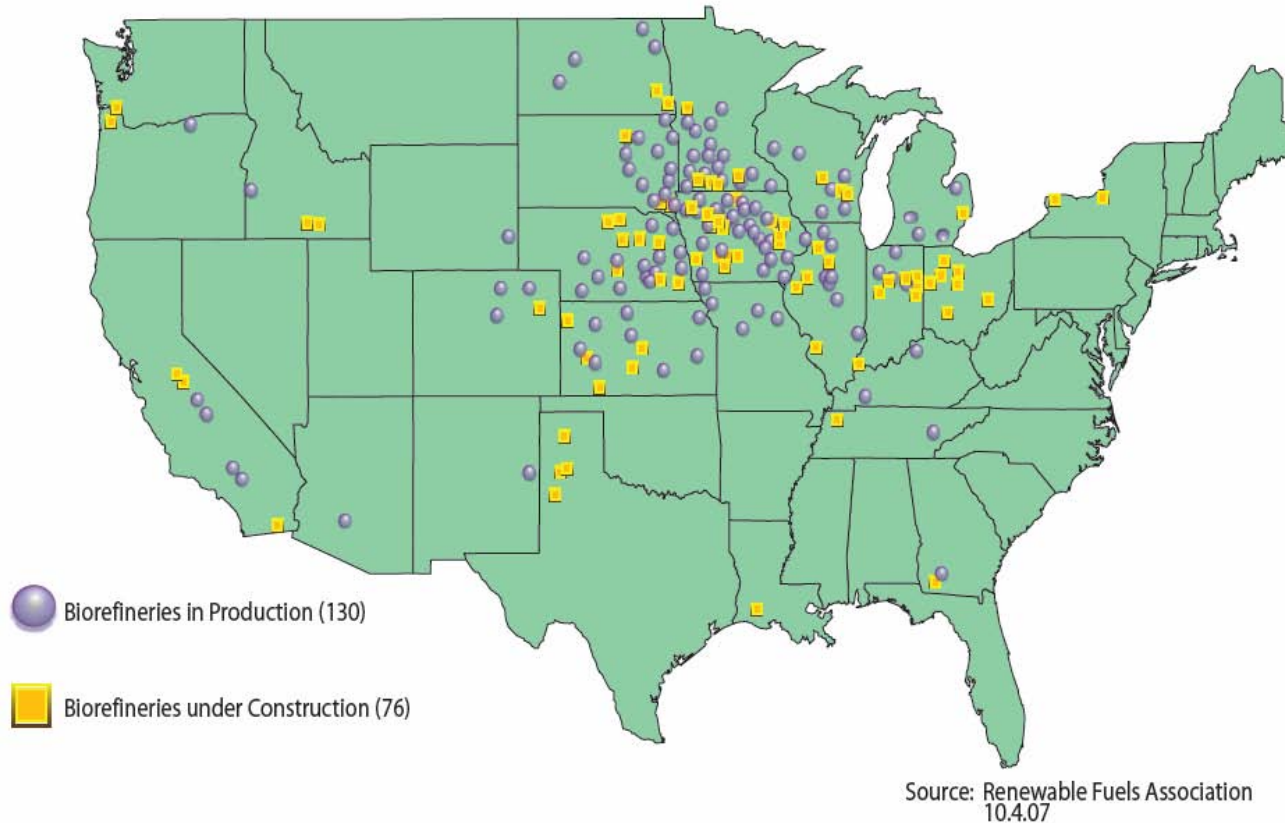
- Background
- Summary of ethanol roadmap workshop and action items
- Status of current research
- Future activities



Materials Compatibility Issues with Biofuel

- Alcohols (at present, mainly ethanol)
 - Stress corrosion cracking of steel
 - Compatibility of polymeric materials for piping/coatings
 - Compatibility of elastomeric materials (seals, gaskets)
- Other hydrocarbons (Biodiesel, Oils)
 - Mainly corrosion (Stress corrosion cracking is not important)
 - Compatibility of some polymeric materials

U.S. Ethanol Production Locations



Most of the ethanol is produced in the Nation's heartland, whereas 80 percent of population lives near its coastlines

- Meeting the alternate fuel goals requires reliable and cost-effective transportation
- Ethanol is now transported domestically by
 - Tanker trucks (67 %)
 - Rail cars (30%)
 - Barges (2%)
- These transportation modes (rail/barge/trucks) are nearing capacity with E10 supply and pose potentially more safety risks when moving higher volumes.
- Significant growth in ethanol will depend on pipelines for safe, reliable & cost-effective transportation solutions.

Why Pipelines?

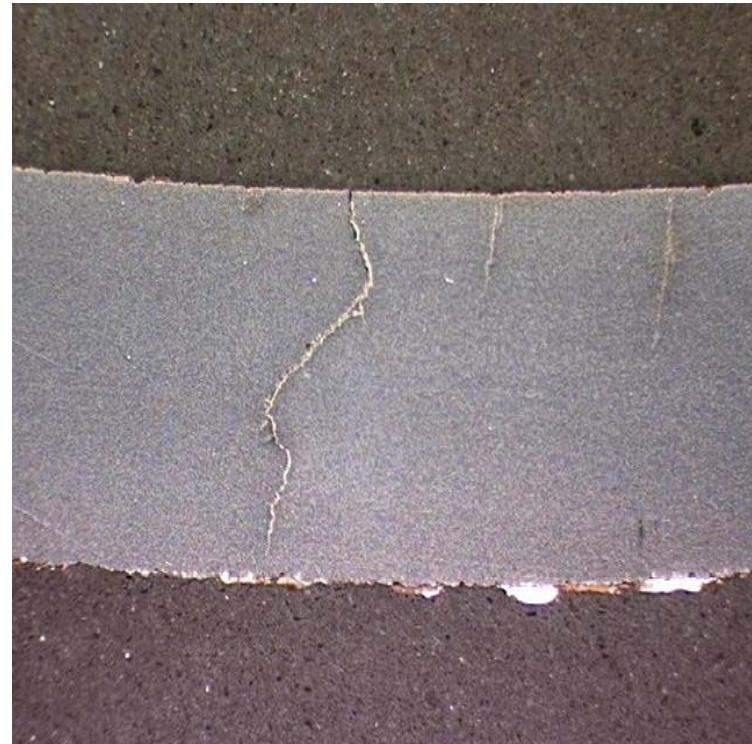
- Pipelines are a safer and more efficient way to transport large volumes of fuel and other hazardous liquids. For example:
 - 9375 large semi-trucks would be required to transport two million barrels of liquid product per day
 - It would take 24-100 car unit trains or 10-15 unit barge tows to transport two million barrels per day.
 - A representative 15-barge tow on a main-stem waterway moves the same volume of product as 870 trucks stretching 35 miles on the interstate highway system.
 - That same 15-barge tow would require two 100-car unit trains, extending nearly three miles long.

Major Technical Issues with Pipeline Transportation and Storage

- Stress corrosion cracking (SCC) of steel in ethanol
- Effect of ethanol on seals and gaskets
- Reaction of ethanol with other products or residues in pipelines
- Effect of ethanol on polymeric materials involved in distribution/gathering systems

- Prior to shipment, ethanol is denatured & inhibited
 - Natural gasoline is the most common denaturant
 - Octel DCI-11 is the most common inhibitor for general corrosion – designed for end-use
- At blending/distribution facilities, large tanks and piping facilities are used for blending operation and for storage
- SCC of tanks and piping documented back to early 1990s
 - User terminals
 - Storage tanks
 - Loading/unloading racks
- Recent failure in a short ethanol pipeline – details not published
- No failures reported at ethanol producer sites nor after ethanol was blended with gasoline
- No SCC reported by truck or railcar industries
- No failures reported by Brazil in several decades of ethanol transportation through pipelines

Piping Failures in Terminals

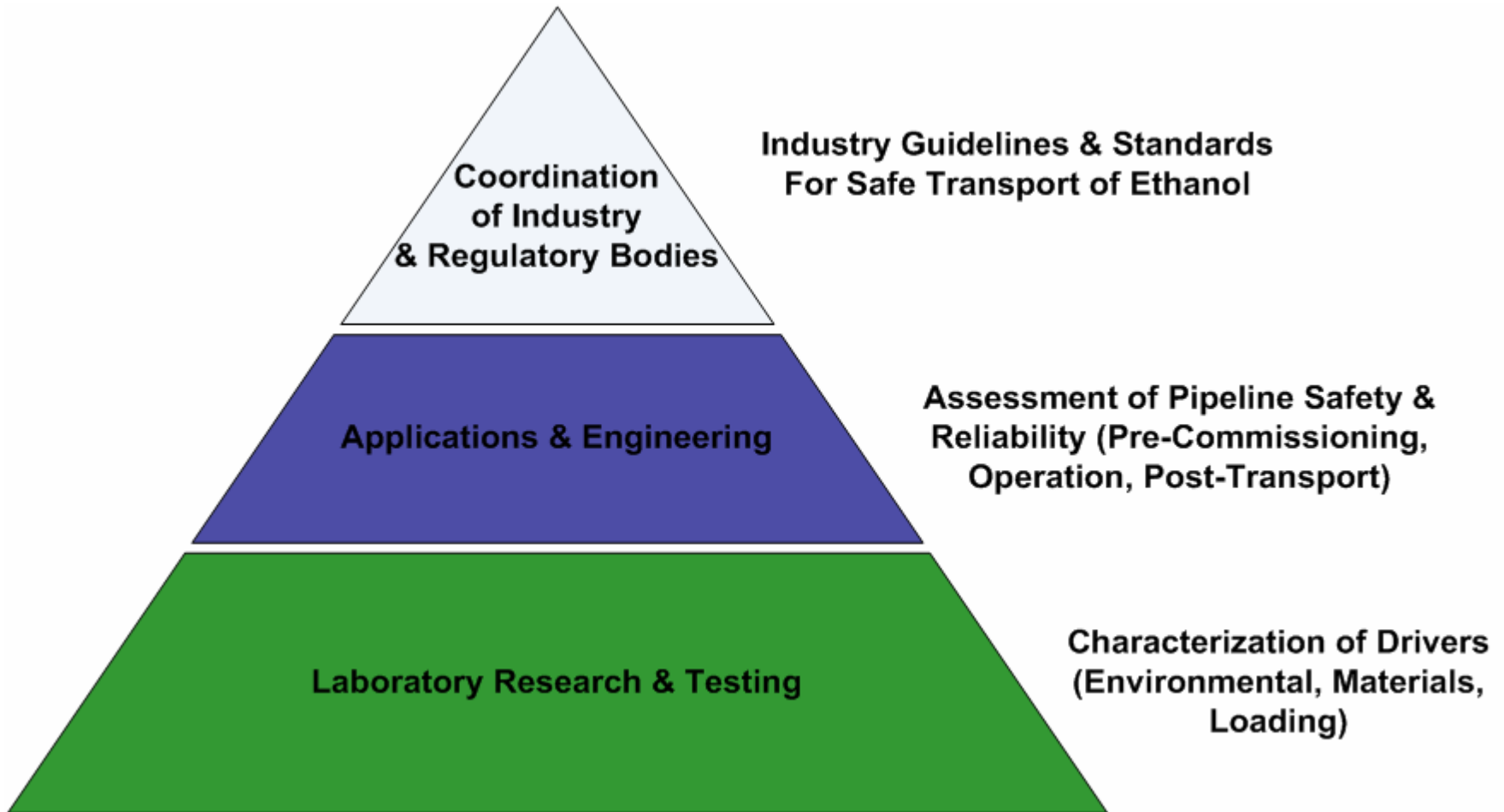


A Staged Approach to Address Challenges



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Key Challenges Facing Ethanol Transportation in Pipelines

From, Ethanol Roadmap Workshop, October 25-26, 2007

- Quantifying and managing risk
- Making the business case for new construction or dedicated lines
- Achieving operating efficiency with new product mixes
- Finding new materials solutions
- Learning from Brazilian experiences
- Investing under Changing regulations
- Understanding potential environmental threats
- Improving coordination and communication

Focus Areas of Recent Ethanol Roadmap Workshop

- Ethanol Sources and Quality Issues
- Pipeline Integrity Management Issues
- Pipeline Operations Issues
- Standards, Guidelines, & Training

From, Ethanol Roadmap Workshop, October 25-26, 2007

What are the gaps in current efforts?

Ethanol Sources and Quality Issues

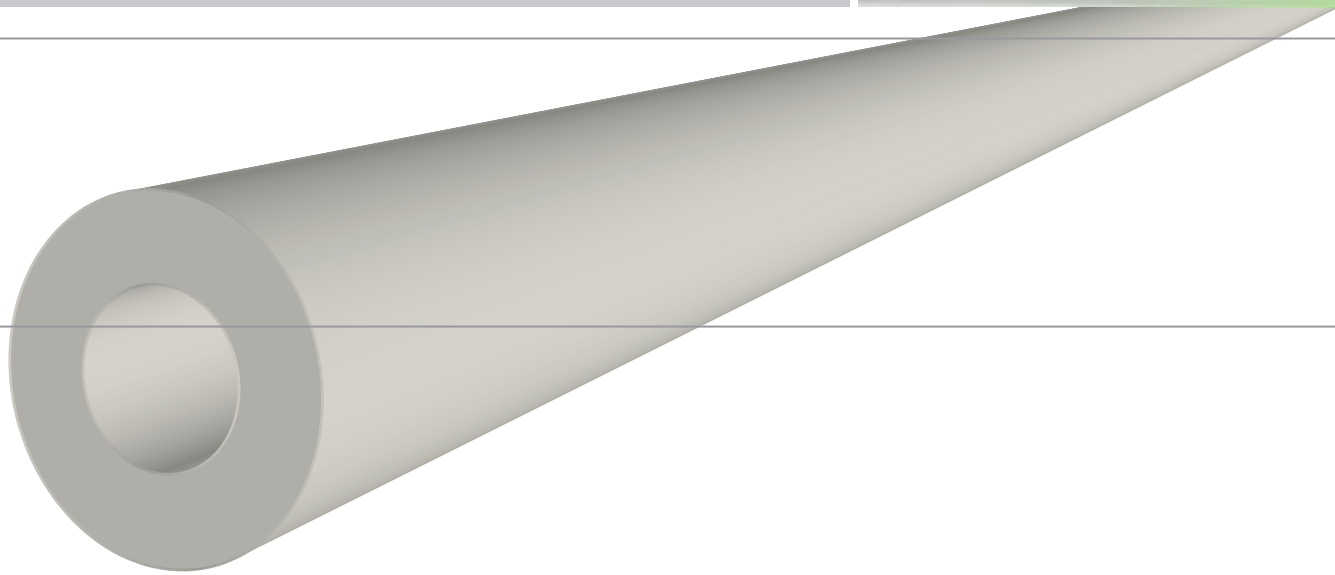


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- Lack of a practical method for ethanol testing
- Lack of “ASTM-like” specifications for FGE, but tailored for reliable transportation rather than just for end-use
- Challenges in ensuring product quality when products from different producers get commingled
- Lack of standardized ethanol source mixtures
- Incomplete knowledge of real oxygen concentrations in pipelines nor where stream is picking up oxygen
- Lack of understanding of how product composition changes during aging (time, head, length of travel, etc.)
- Gaps in knowledge of why different ethanol sources differ in their effect on materials of construction

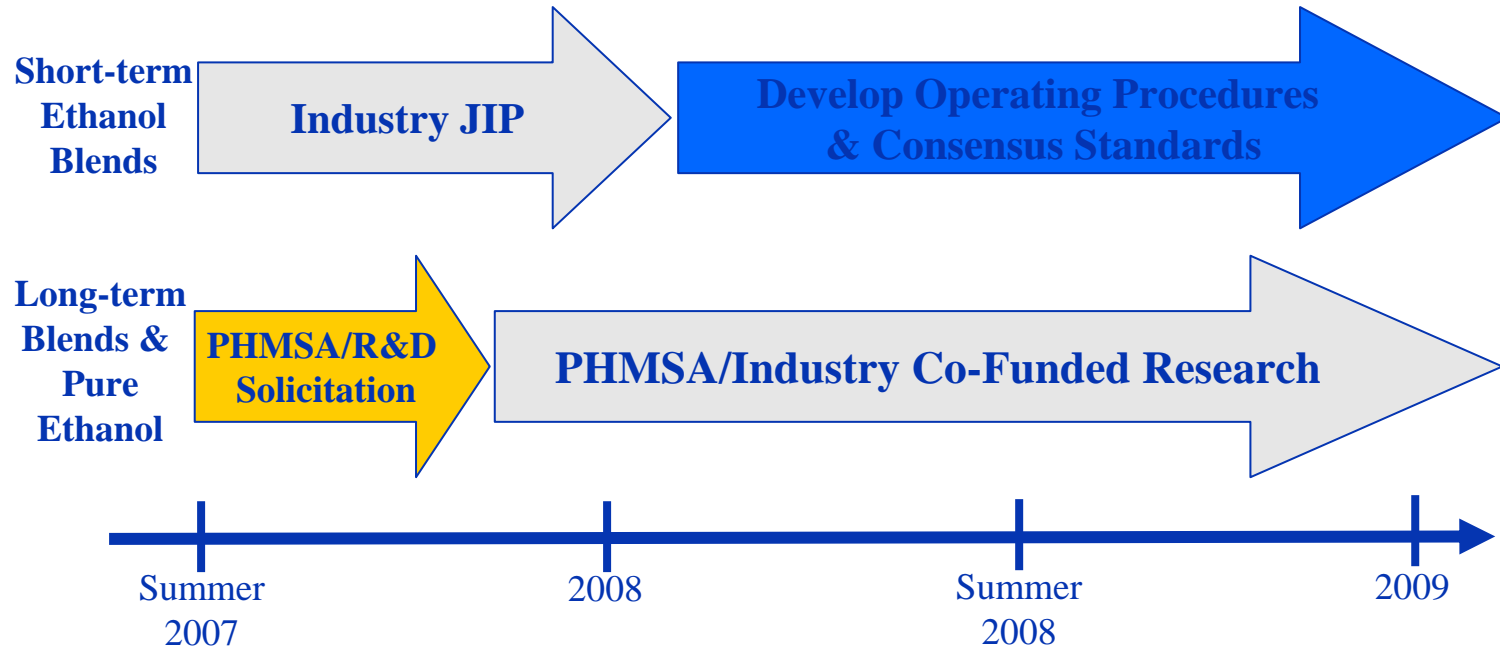


Current Research Activities



Ethanol Pipeline Research: "A Coordinated Strategy"

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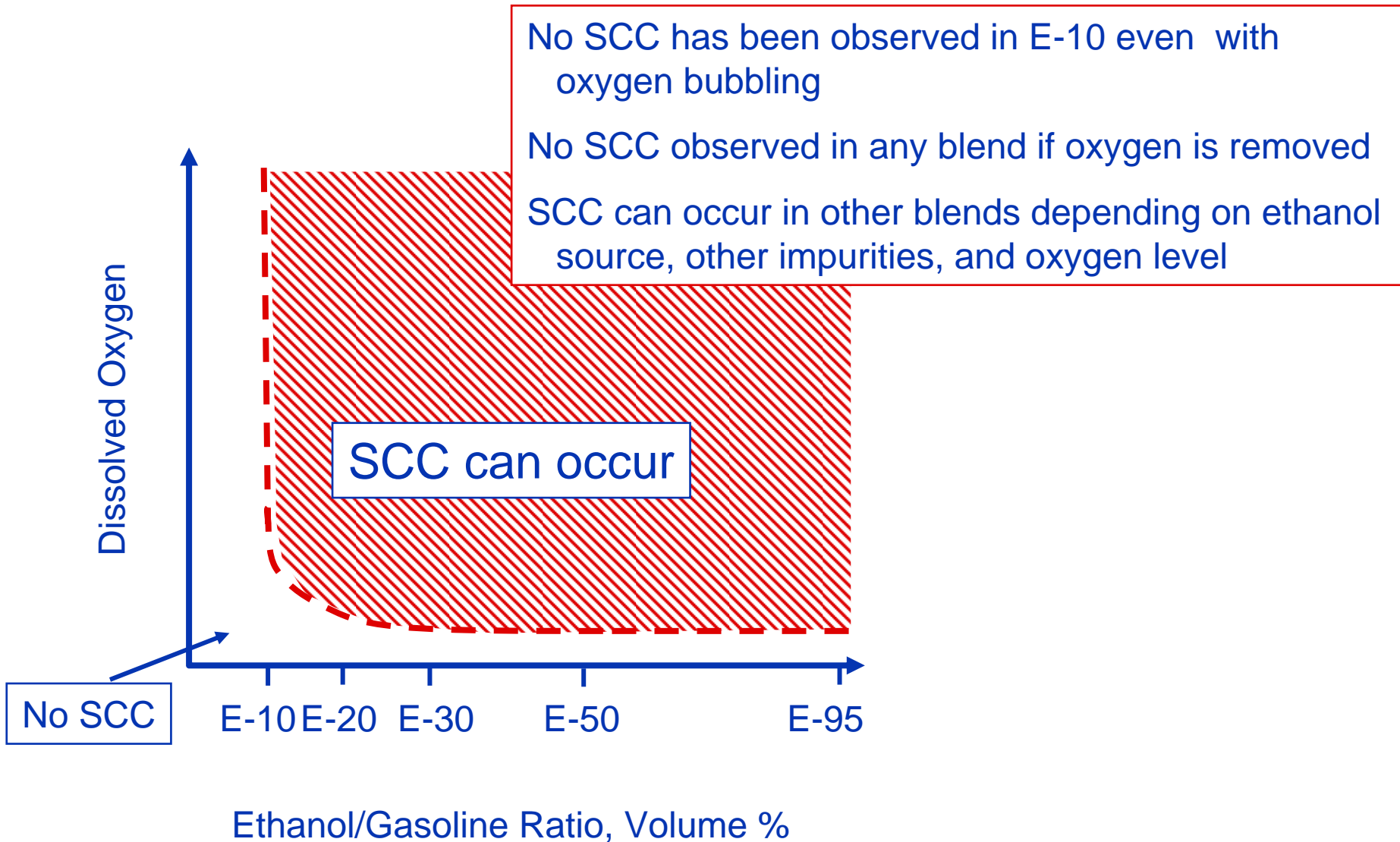


Ethanol Blends – Many technical questions answered by early 2008 with industry moving toward operating practices and consensus standard development

Pure Ethanol – Many unanswered technical questions needing 1-3 years of research and field testing before moving toward consensus standard development

- SCC potency of ethanol-gasoline blends decreases with increasing gasoline concentration
- SCC potency of FGE decreases with decreasing oxygen concentration
- Considerable variability in potency of actual FGE
- Evidence that FGE contains natural inhibitors that degrade with time
- Dissolved oxygen in ethanol can be monitored and a probe is being developed
- Corrosion potential can be reliably measured in ethanol

Salient Result from SCC4-4 Program



- There is a need to establish a Center for Biofuels and Alternate Fuels Transportation
 - Clearinghouse for information on technologies, issues, policies, and standards
 - Acts as an interface between different biofuels groups (production, end-use)
 - Has long-term focus (i.e. not just reactive but anticipatory studies)
 - Funded jointly by industry and government