Turner, Mason & Company
energy consulting & advisory

Economic Assessment of Ethanol Blending

Mexico
Indonesia
Nigeria

November 8, 2022

Dallas | Houston | London

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** Global Crude & Refined Products Outlook; Worldwide Refinery Construction Outlook*

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Introduction and Background

INTRODUCTION

- TM&C was engaged by the U.S. Grains Council to assess the economic benefits of blending ethanol into the gasoline supply in various countries.
  - Mexico
  - Indonesia
  - Nigeria
- Study focused on the financial benefits of adding ethanol into nonoxygenated gasoline (E0) and conversion from MTBE blends to ethanol blends. The ethanol blends are E5, E10, E15, and E20.
- The economic benefits are in several categories.
  - Pricing
  - Octane
  - Dilution
  - Other

PRICING BASES

- All ethanol, gasoline, and MTBE prices were obtained from Platts quotations.
- Ethanol prices for each country included delivery costs from the U.S. Gulf Coast. Platts ethanol quotes were assumed to include D6 RIN values. Export ethanol prices likely vary from the Platts domestic quotations.
- Gasoline prices are specific to each region:
  - Mexico prices are East coast Mexico.
  - Indonesia prices are Singapore spot.
  - Nigeria prices are Northwest Europe delivered to West Africa.

GLOBAL OCTANE REQUIREMENTS

Global gasoline octane consumption is increasing.

- Euro grades require higher Research Octane Numbers (RONs).

Euro Gasoline Specifications						
		Euro Grades				
Property	**Units**	**Euro II**	**Euro III**	**Euro IV**	**Euro V**	**Euro VI**
Implementation Year		1996	2000	2005	2009	2014
RON	Minimum	92	93	94	95	95
Sulfur	Max. PPM	500	150	50	10	10
Benzene	Max. Vol. %	5	1	1	1	1
Aromatics	Max. Vol. %	---	42	35	35	21/24

- Numerous countries have increased RON consumption in the last decade.
  - U.S. – 0.12 RON
  - Mexico – 0.42 RON
  - Indonesia – 2.0 RON

GLOBAL OCTANE PRODUCTION

But global octane production from refineries is decreasing without capital expenditures.

- Achieving stricter Euro grade specifications reduces refinery octanes.
- Declining aromatic and benzene levels reduce the supply of high-octane components.
- Reducing gasoline sulfur levels also reduces octanes by converting olefins into paraffins.

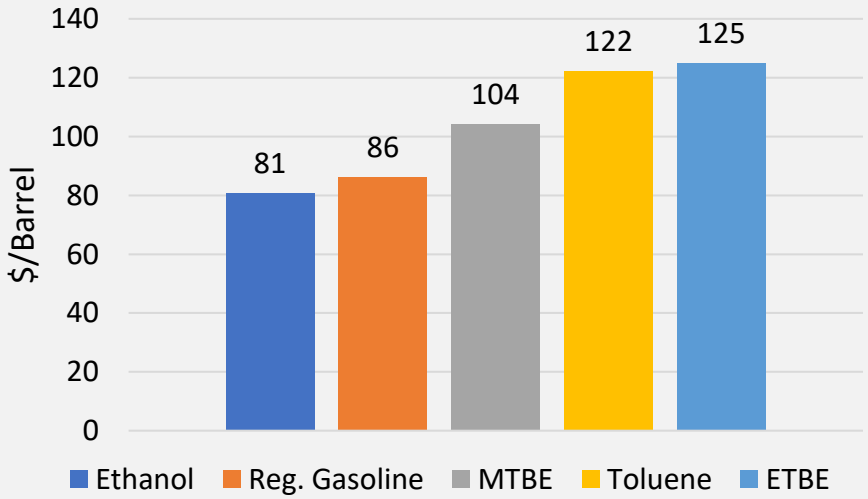
OXYGENATES AND OCTANE ENHANCERS

Ethanol has many advantages over other oxygenates and octane enhancers.

- Ethanol has a higher RON

Research Octane Numbers	
Product	RON
Ethanol	130
ETBE	120
MTBE	119
Toluene	121

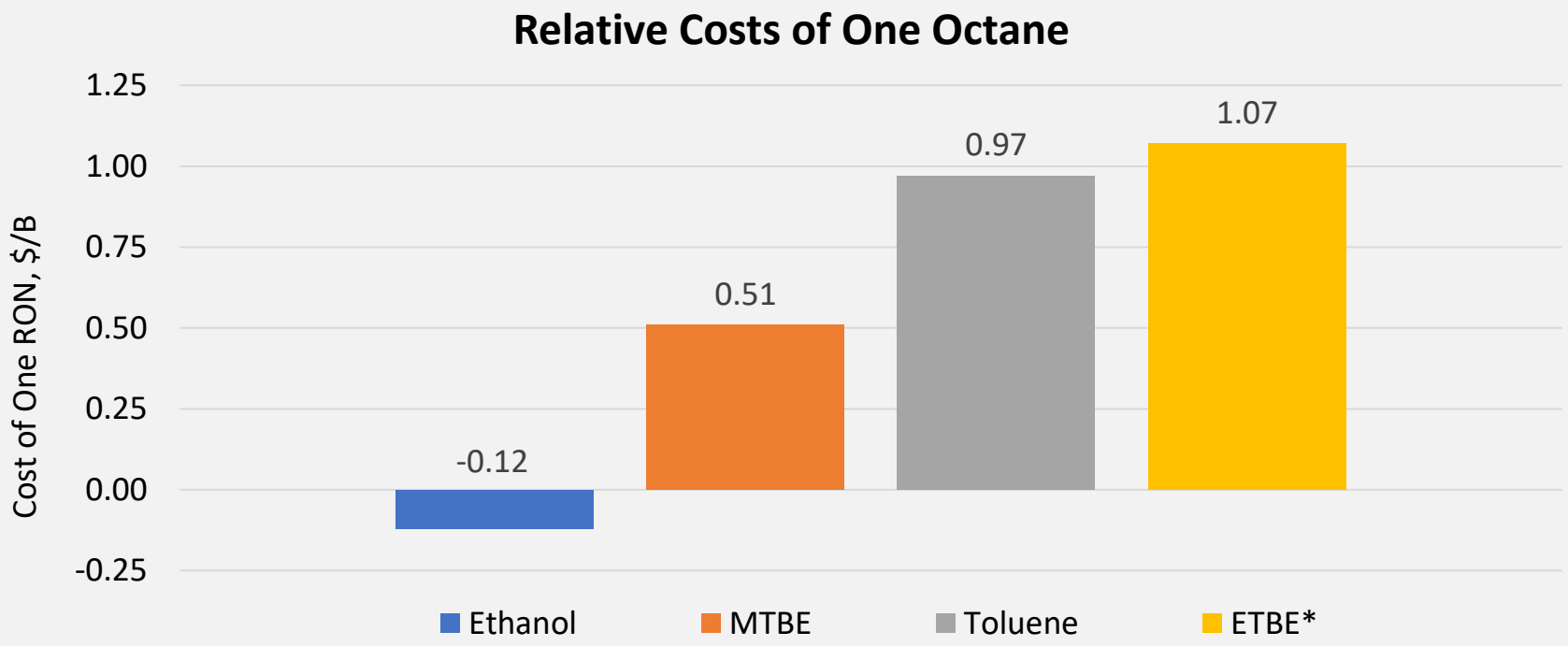
- Ethanol is less expensive*



* U.S. Gulf Coast prices from 2012 through 1H2022

ETHANOL VALUE

Ethanol lowers the cost of gasoline while MTBE, toluene and ETBE increase the cost.

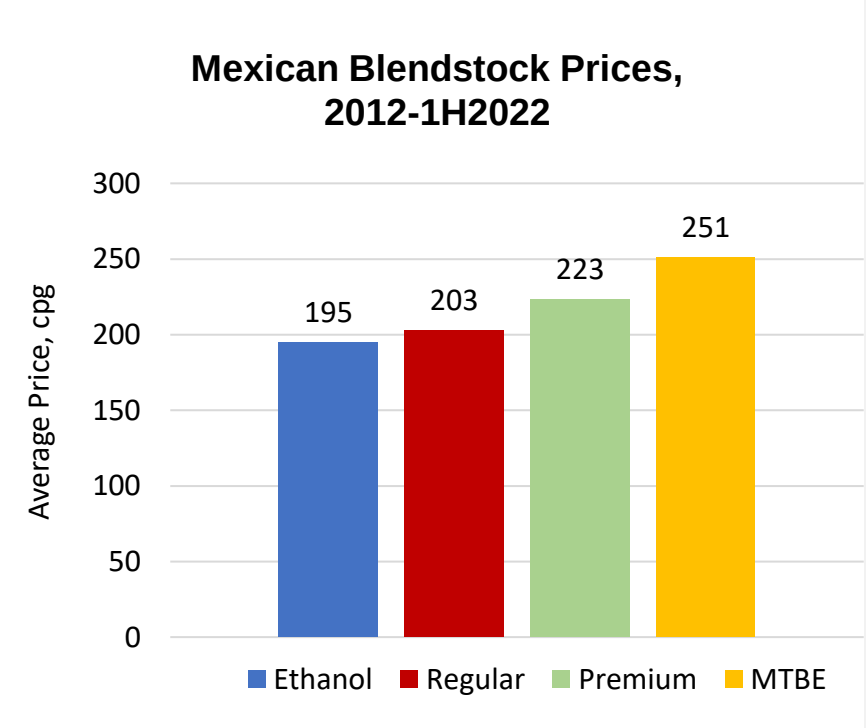


* Assuming ETBE price at 120% of MTBE price

TM&C Study Results

MEXICO - BACKGROUND

- Delivered ethanol prices are generally lower than base gasoline.
- Mexico currently blends MTBE in most regions, even when not required.
- MTBE blending is not optimized.
- No ethanol is currently blended.



MEXICO – BENEFITS TO CONVERT FROM E0

- Economic benefits improve as ethanol concentration increases.
- Octane benefits of ethanol are the largest component of cost reductions.
- Pricing benefits are likely understated.
- Pricing benefits are higher with premium gasoline while octane benefits are higher with regular gasoline.

Gasoline Cost Reductions (Outside MCMR), cpg		
	Regular	Premium
E5		
Pricing Benefits	0.4	1.4
Octane Benefits	5.2	4.4
Dilution Benefits	0.25	0.25
Total Reductions	**5.8**	**6.1**
E10		
Pricing Benefits	0.7	2.8
Octane Benefits	10.4	8.9
Dilution Benefits	0.5	0.5
Total Reductions	**11.6**	**12.1**
E15		
Pricing Benefits	1.1	4.1
Octane Benefits	15.5	13.3
Dilution Benefits	0.75	0.75
Total Reductions	**17.4**	**18.2**
E20		
Pricing Benefits	1.4	5.5
Octane Benefits	20.7	17.8
Dilution Benefits	1.0	1.0
Total Reductions	**23.2**	**24.3**

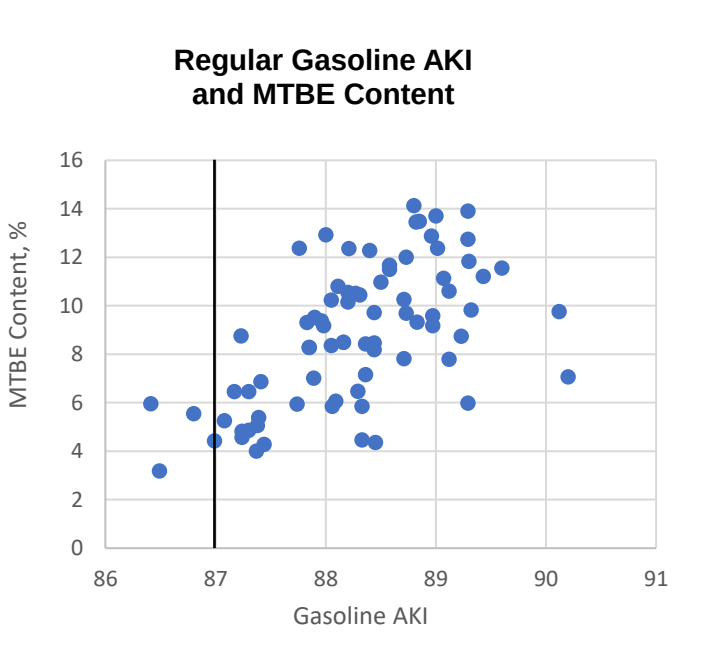
MEXICO – BENEFITS TO CONVERT FROM MTBE

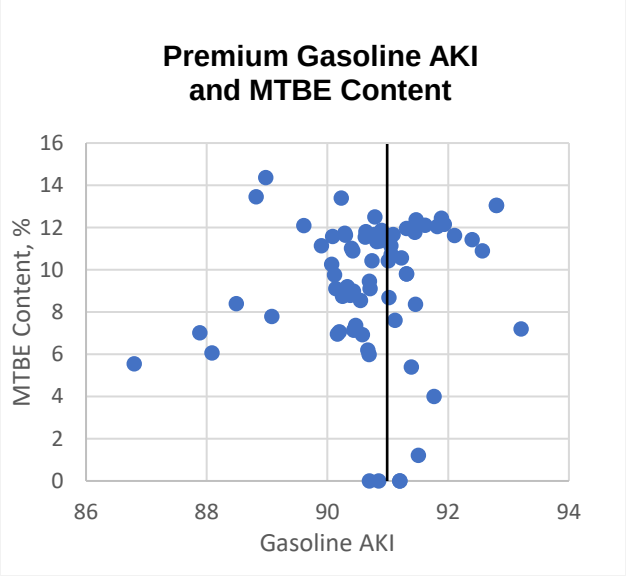
- 10.5% MTBE has been assumed as current blending level inside MCMR.
- Pricing benefits are greater when converting from MTBE versus E0.
- Octane and dilution benefits are negative when converting to E5 due to the reduced volume from 10.5% MTBE.
- The economic benefits with premium gasoline are greater than regular for E15 and E20 but less than regular for E0.

Gasoline Cost Reductions (Inside MCMR), cpg		
	Regular	Premium
E5		
Pricing Benefits	5.4	4.3
Octane Benefits	-4.3	-3.4
Dilution Benefits	-0.25	-0.25
Total Reductions	**0.9**	**0.7**
E10		
Pricing Benefits	5.8	5.7
Octane Benefits	1.4	1.5
Dilution Benefits	0.0	0.0
Total Reductions	**7.2**	**7.2**
E15		
Pricing Benefits	6.1	7.1
Octane Benefits	7.1	6.3
Dilution Benefits	0.25	0.25
Total Reductions	**13.5**	**13.7**
E20		
Pricing Benefits	6.5	8.4
Octane Benefits	12.7	11.2
Dilution Benefits	0.5	0.5
Total Reductions	**19.7**	**21.6**

MEXICO – MTBE MISBLENDING

- The gasoline testing data presented to TM&C indicates a high degree of MTBE misblending.
- 95% of the monthly regular averages were above the required octane levels indicating substantial octane give-away.

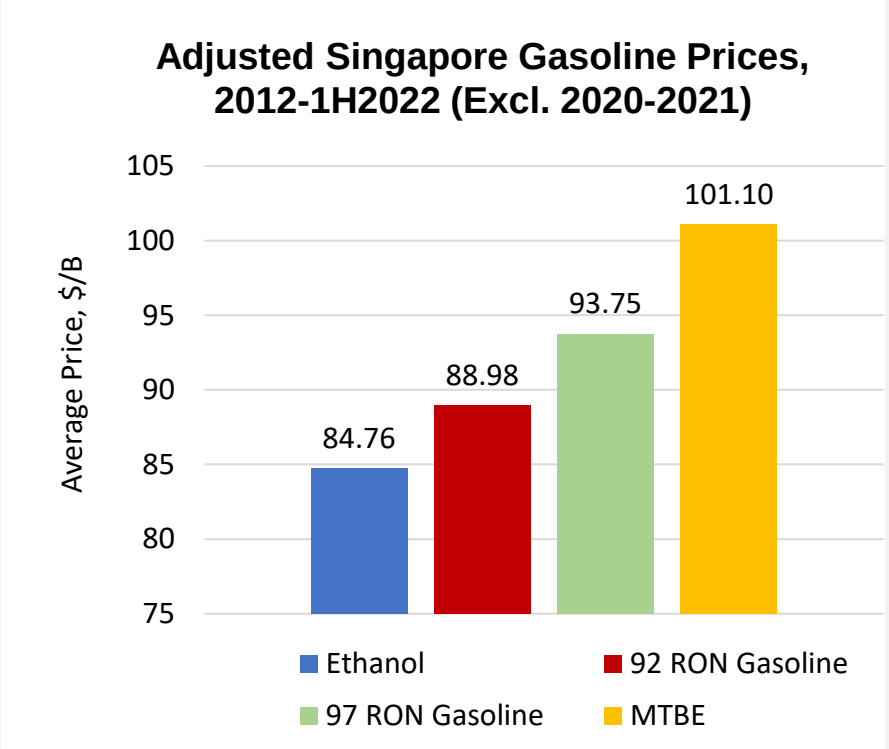




- 61% of the monthly premium averages were below the required octane levels indicating most premium sales are noncompliant.

INDONESIA - BACKGROUND

- COVID years of 2020 and 2021 were excluded.
- Delivered ethanol prices are generally lower than base gasoline.
- Indonesia currently blends MTBE, even when not required.
- No ethanol is currently blended.



INDONESIA – BENEFITS TO CONVERT FROM E0

- Economic benefits improve as ethanol concentration increases.
- Octane benefits of ethanol are primary component of cost reductions.
- Pricing benefits are likely understated.
- Pricing benefits are higher with premium gasoline while octane benefits are higher with regular gasoline.

Cost Reductions from Adding Ethanol, $/B		
	Regular	Premium
E5		
Pricing Benefits	0.21	0.45
Octane Benefits	1.81	1.57
Dilution Benefits	0.15	0.15
Total Reductions	**2.17**	**2.17**
E10		
Pricing Benefits	0.42	0.90
Octane Benefits	3.63	3.15
Dilution Benefits	0.30	0.30
Total Reductions	**4.35**	**4.35**
E15		
Pricing Benefits	0.63	1.35
Octane Benefits	5.44	4.72
Dilution Benefits	0.45	0.45
Total Reductions	**6.52**	**6.52**
E20		
Pricing Benefits	0.84	1.80
Octane Benefits	7.25	6.30
Dilution Benefits	0.60	0.60
Total Reductions	**8.70**	**8.70**

INDONESIA–BENEFITS TO CONVERT FROM MTBE

- 10% MTBE has been assumed.
- Pricing benefits are greater when converting from MTBE versus E0.
- Octane and dilution benefits are negative when converting to E5 due to the reduced volume from 10% MTBE.
- The economic benefits with premium gasoline were equivalent to regular as changes in pricing benefits offset changes in octane benefits.

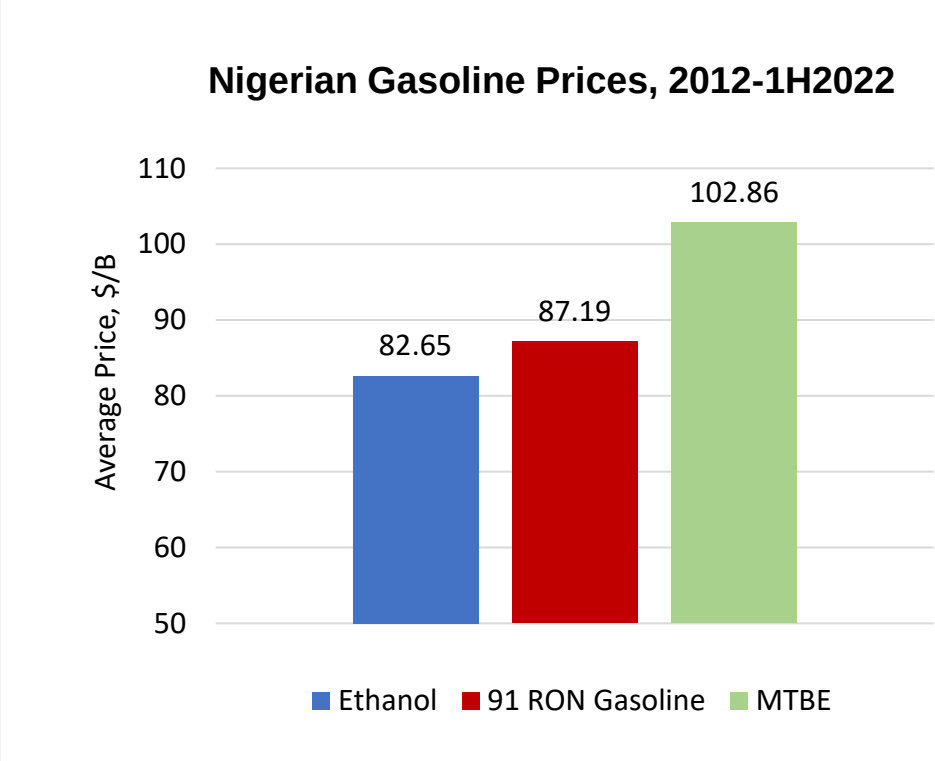
Cost Reductions of Ethanol versus MTBE, $/B		
	Regular	Premium
E5		
Pricing Benefits	1.42	1.18
Octane Benefits	-0.91	-0.64
Dilution Benefits	-0.15	-0.15
Total Reductions	**0.37**	**0.39**
E10		
Pricing Benefits	1.63	1.63
Octane Benefits	1.05	1.05
Dilution Benefits	0.00	0.00
Total Reductions	**2.68**	**2.68**
E15		
Pricing Benefits	1.84	2.08
Octane Benefits	3.01	2.74
Dilution Benefits	0.15	0.15
Total Reductions	**5.00**	**4.97**
E20		
Pricing Benefits	2.06	2.53
Octane Benefits	4.96	4.43
Dilution Benefits	0.30	0.30
Total Reductions	**7.32**	**7.27**

INDONESIA – SUMMARY

- The use of ethanol offers the opportunity for Indonesia to reduce its cost of gasoline production.
- The current use of MTBE results in modest octane give-away. The use of ethanol with inline blending systems would improve octane optimization.
- Imported gasoline appears to meet stricter environmental specifications compared to domestic production. Dilution effects of ethanol could become an important factor.

NIGERIA - BACKGROUND

- Only one grade of gasoline is sold in Nigeria, 91 RON regular.
- Delivered ethanol prices are generally lower than regular gasoline.
- MTBE is blended into some gasoline but is not mandated. No ethanol is currently blended.



- Recent gasoline outages have plagued the supply picture. Several cargoes have contained methanol.

NIGERIA – BENEFITS OF ETHANOL BLENDS

- Economic benefits improve as ethanol concentration increases.
- Octane benefits of ethanol are the largest component of cost reductions.
- Pricing benefits are likely understated.
- 10% MTBE has been assumed.
- Octane and dilution benefits are negative when converting to E5 due to the reduced volume from 10% MTBE.

Cost Reductions from Adding Ethanol, $/B		
	Vs. E0	Vs. MTBE
E5		
Pricing Benefits	0.23	1.79
Octane Benefits	4.29	-2.21
Dilution Benefits	0.15	-0.15
Total Reductions	**4.66**	**-0.57**
E10		
Pricing Benefits	0.45	2.02
Octane Benefits	8.57	2.42
Dilution Benefits	0.30	0.00
Total Reductions	**9.32**	**4.44**
E15		
Pricing Benefits	0.68	2.25
Octane Benefits	12.86	7.05
Dilution Benefits	0.45	0.15
Total Reductions	**13.99**	**9.44**
E20		
Pricing Benefits	0.91	2.47
Octane Benefits	17.14	11.67
Dilution Benefits	0.60	0.30
Total Reductions	**18.65**	**14.45**

NIGERIA – SUMMARY

- The use of ethanol offers the opportunity for Nigeria to reduce its cost of gasoline production.
- The country suffers from poor quality oversight and would benefit from an ethanol inline blending system to standardize gasoline quality. None of the gasoline test data presented to TM&C achieved the required octane or sulfur levels.
- MTBE was used in some of the samples but was not blended in the appropriate volume to achieve the desired octane.

Conclusions

CONCLUSIONS

- Ethanol can reduce gasoline production costs.
- Global gasoline octane requirements are expected to rise in the future.
- Ethanol is the least expensive path to increasing gasoline octanes.
- Ethanol inline blending systems can improve blending optimization and better achieve required product specifications.
- The use of ethanol diversifies the transportation fuel slate by moving away from volatile crude prices and to a safer supply source in the U.S.

NEXT STEPS

- Additional analysis and study is necessary to determine the optimum ethanol implementation strategy for each country.
- Future studies would ideally be conducted in cooperation with foreign governments or national oil companies.
- Studies should incorporate additional blending efficiencies, such as the practice of misblending MTBE, and the necessity of achieving required fuel specifications.