Biofuels: **Cleaner Air**, Fewer Carbon Emissions, & Ecosystem Solutions

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Life Cycle Modeling and Tailpipe Emissions Modeling

Tailpipe Emissions:

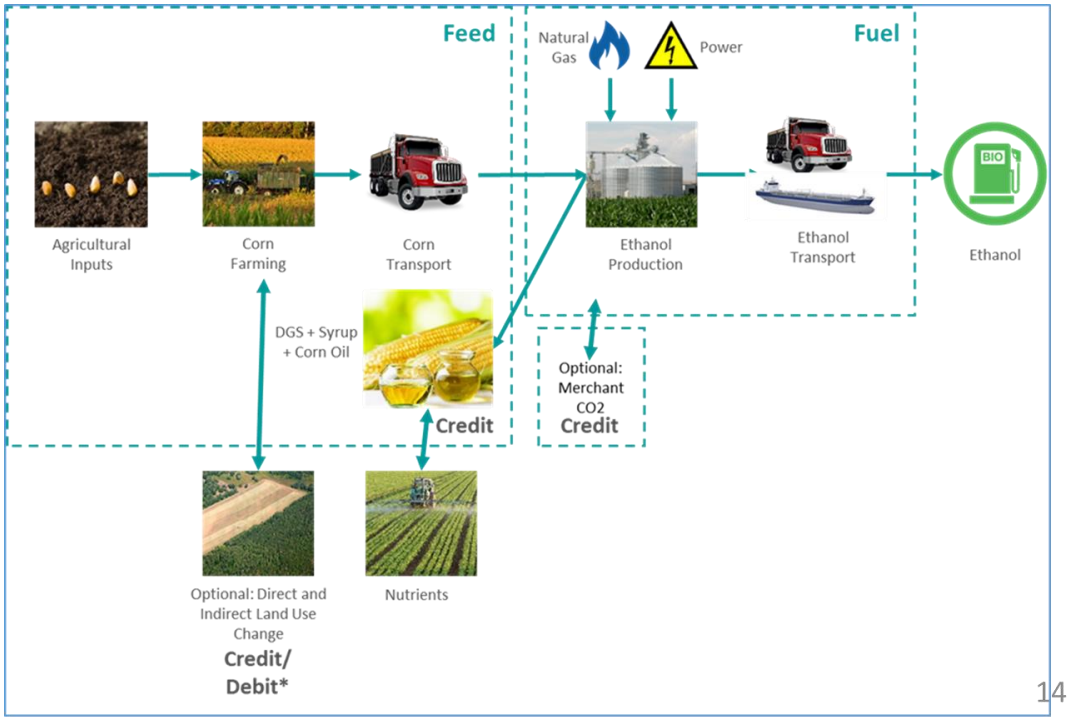
Assess **Local Air Emissions Impact** from Vehicle Traffic for key pollutants and air toxins:

- Particulate Matter,
- Carbon Monoxide,
- Nitrogen Oxides,
- Volatile Organics
- Air Toxins (Benzene; 1,3 Butadiene, Aldehydes)

Life Cycle Emissions:

Assess **Emissions Impact from Cradle to Grave (e.g. Well to Wheel WTW)**

- Useful for all emissions but particularly for emissions with global impact such as Greenhouse Gas Emissions (GHGs)



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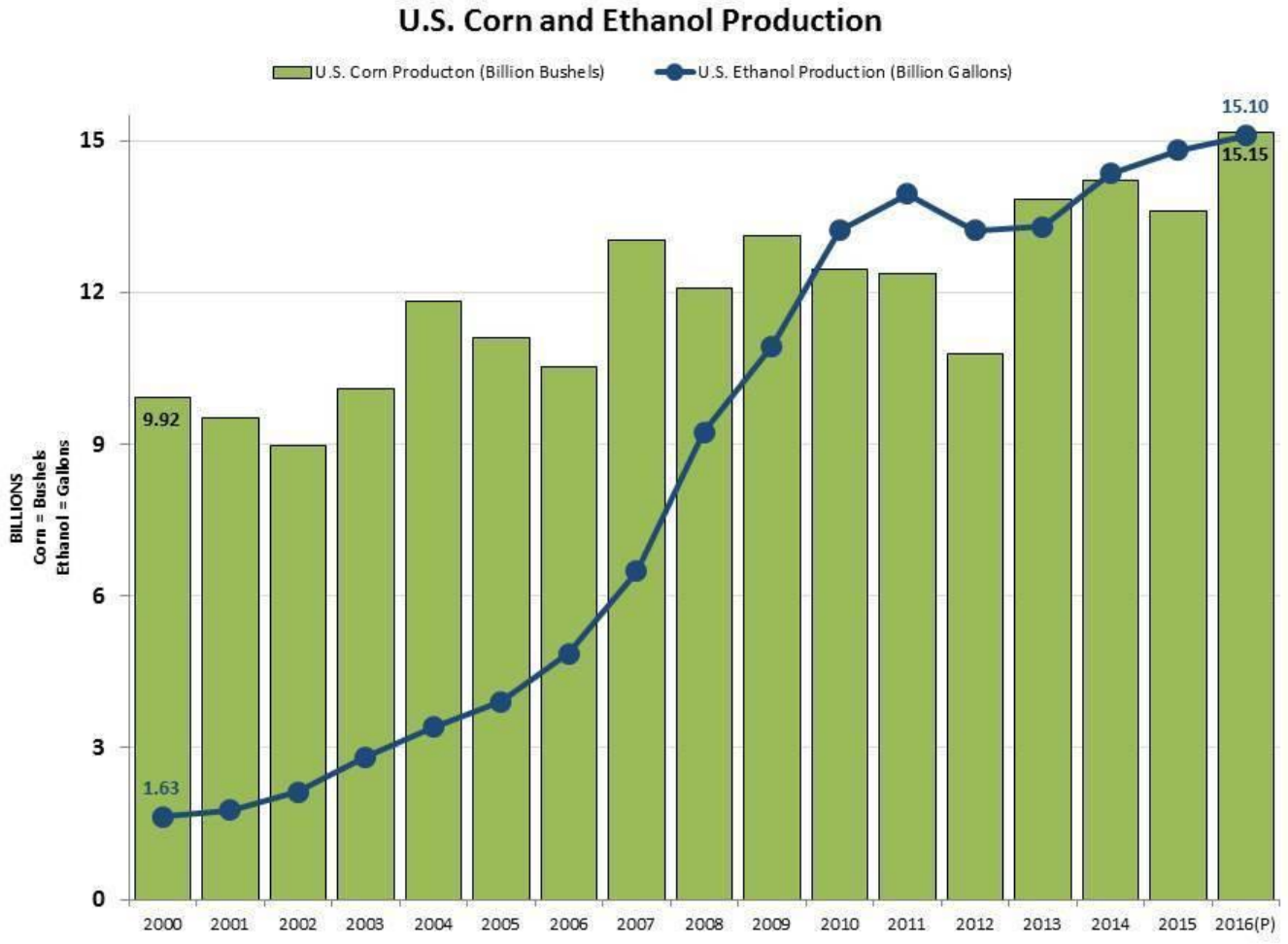
Increase in Corn Ethanol Use…



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....decrease in Air Toxins in California

Ambient and Emission Trends of Toxic Air Contaminants in California

Environmental Science & Technology Article

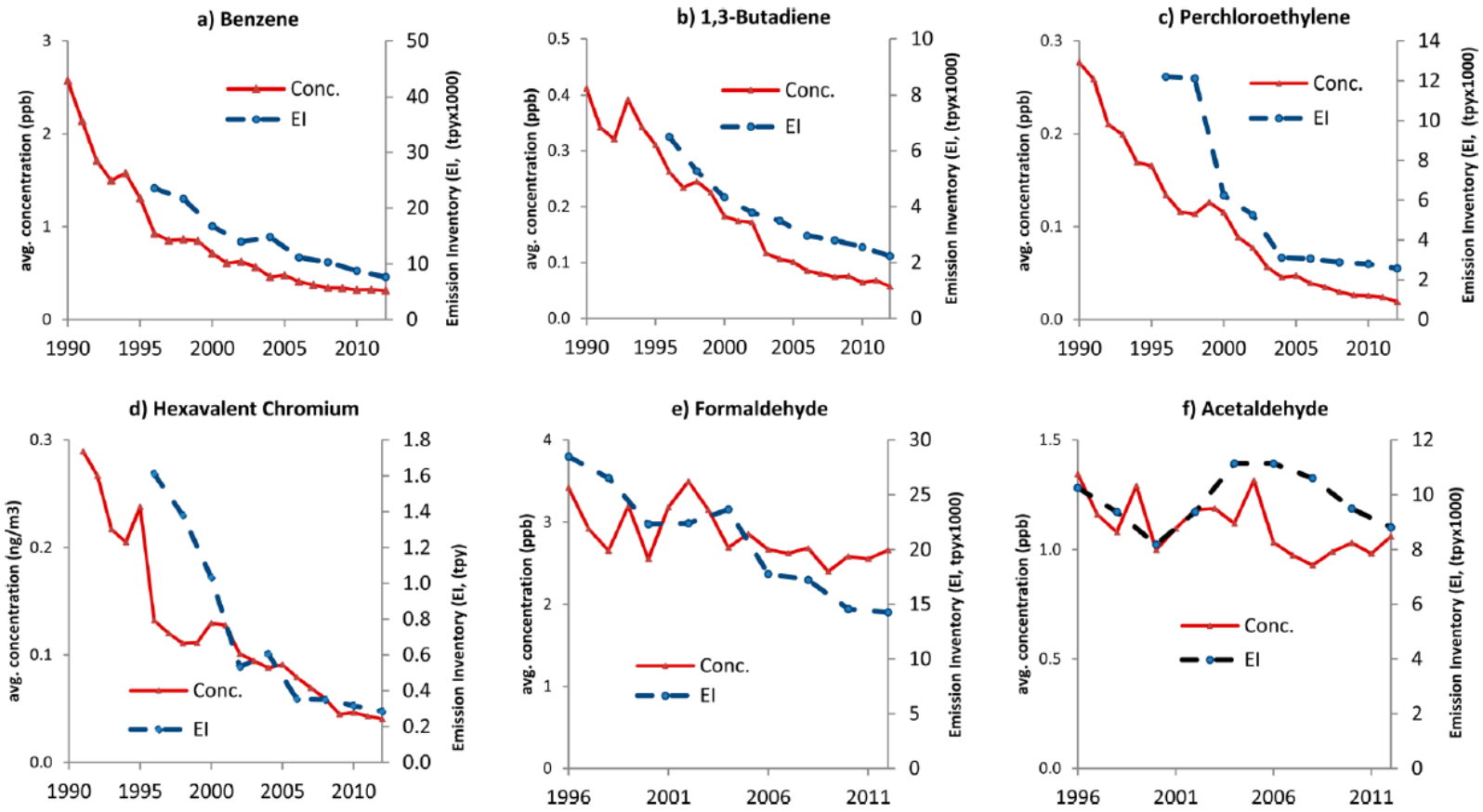

Figure 3. Statewide annual average concentrations and emissions inventory (EI) trends for six toxic air contaminants. EI data were available starting in 1996. (a) Benzene (1990–2012), (b) 1,3-Butadiene (1990–2012), (c) Perchloroethylene (1990–2012), (d) Hexavalent Chromium (1991–2012), (e) Formaldehyde (1996–2012), (f) Acetaldehyde (1996–2012).

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United States Environmental Protection Agency Fuel Trends Report (Released October 2017)

https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100T5J6.pdf

- Page 8: " Ethanol's high octane value has also allowed refiners to **significantly reduce the aromatic content of the gasoline**, a trend borne out in the data. Other direct effects of blending in ethanol are described below."

EPA United States Environmental Protection Agency

CG= Conventional Gasoline

	1990	2000		2016 RFG		2016 CG	
Property	Baseline	RFG Average	CG Average	Average	95%	Average	95%
Sulfur (ppm)	339	126	324	23.1	48.2	22.5	51.0
Benzene (vol%)	1.53	0.59	1.15	0.51	0.86	0.63	1.27
RVP (psi)	8.7	6.78	8.27	7.1	7.47	9.08	10.0
Aromatics (vol%)	32	19.3	28.5	17.12	27.3	21.76	32.1
E200 (vol%)	41	47.6	45.2	47.9	54.8	53.0	61.4
E300 (vol%)	83	84.7	80.7	85.6	92.0	84.8	91.1
Olefins (vol%)	13.1	10.6	11.8	10.5	18.7	8.38	16.4
Ethanol (vol%)	0.6	1.14	0.84	9.61	9.97	9.28	9.8

CG= Conventional Gasoline; RFG= Reformulated Gasoline

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International Activities:
UIC/US Grains Council 5 Cities Study

Tailpipe Emissions Modeling

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5 Cities Study

- This study examines the cumulative future **tailpipe** and **greenhouse gas emissions benefits** from adopting higher ethanol blends for the light duty vehicle market in light of current and predicted fuel demand in five major global cities.
- The study also assesses refinery profitability considerations associated with producing these fuels.
- The modeling spreadsheet is called the International Biofuels Emissions Analysis Model (iBEAM)
- The five cities of interest are:

Beijing, Mexico City, New Delhi, Tokyo, and **Seoul**

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5 Cities Study

Mexico City seeks solutions to improve air quality

First published in ITS International 2017December as Mexico City fights for clean air

David Crawford ponders prospects for one of the world's most congested and polluted cities.

In 1992, the United Nations named Mexico City as the world's most polluted urban centre. In the first half of 2016

Mexico City has some of the world's worst air pollution - much of it generated by road traffic.

New Delhi is the most polluted city on Earth right now

By James Griffiths, CNN
Updated 12:41 AM ET, Tue November 8, 2016

Tailpipe Emissions Modeling Results

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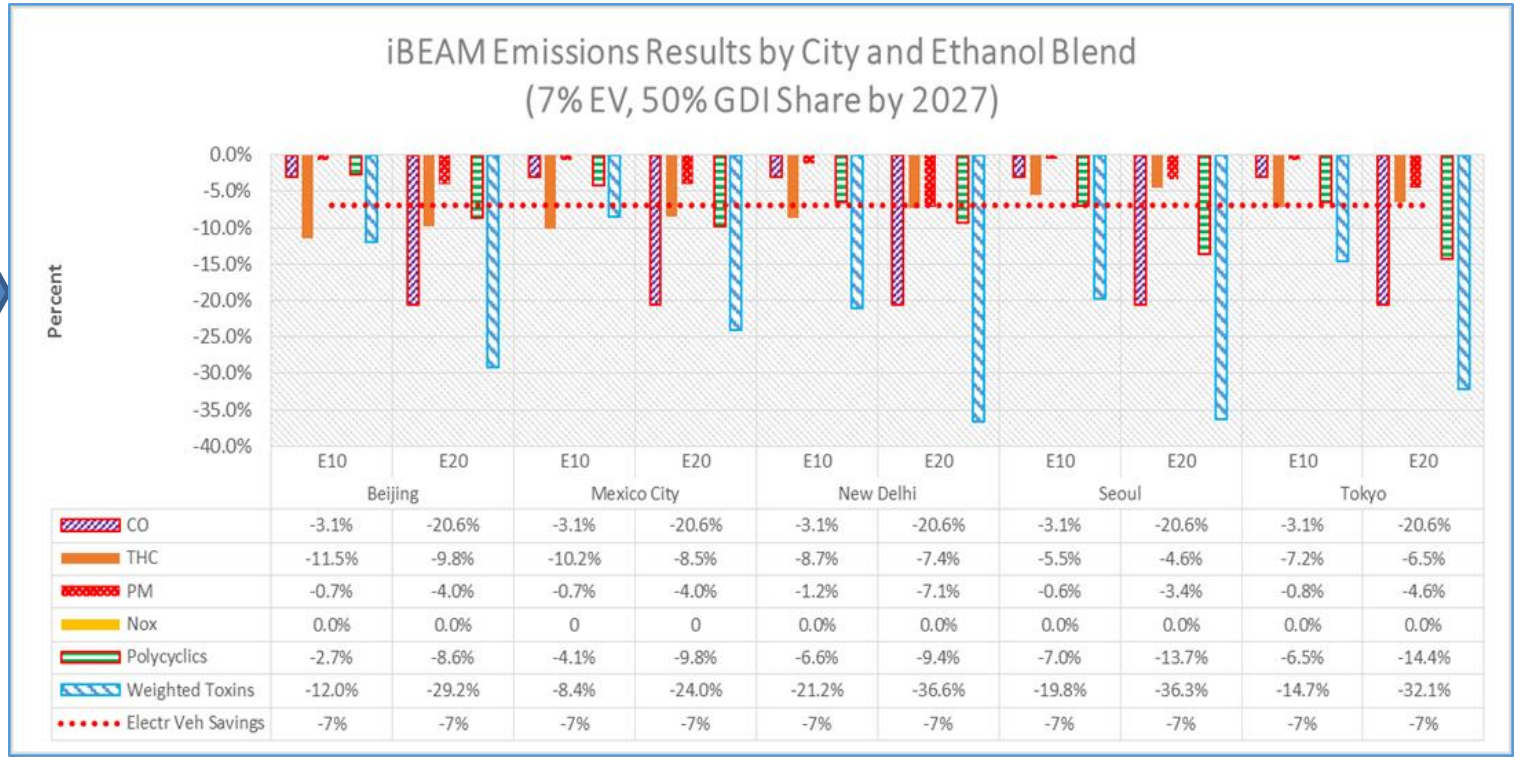
5 Cities Study Model Tailpipe Emissions Results

Significant Emissions Reductions with Ethanol



	E10 Beijing	E20 Beijing	E10 Mexico City	E20 Mexico City	E10 New Delhi	E20 New Delhi	E10 Seoul	E20 Seoul	E10 Tokyo	E20 Tokyo
CO	-3.1%	-20.6%	-3.1%	-20.6%	-3.1%	-20.6%	-3.1%	-20.6%	-3.1%	-20.6%
THC	-11.5%	-9.8%	-10.2%	-8.5%	-8.7%	-7.4%	-5.5%	-4.6%	-7.2%	-6.5%
PM	-0.7%	-4.0%	-0.7%	-4.0%	-1.2%	-7.1%	-0.6%	-3.4%	-0.8%	-4.6%
Nox	0.0%	0.0%	0	0	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Polycyclics	-2.7%	-8.6%	-4.1%	-9.8%	-6.6%	-9.4%	-7.0%	-13.7%	-6.5%	-14.4%
Weighted Toxins	-12.0%	-29.2%	-8.4%	-24.0%	-21.2%	-36.6%	-19.8%	-36.3%	-14.7%	-32.1%
Electr Veh Savings	-7%	-7%	-7%	-7%	-7%	-7%	-7%	-7%	-7%	-7%

- Significant Total Hydrocarbon Reductions (THC, VOC).
  Resulting in likely reduced risk of Ozone Formation for the Cities
- Significant Polycyclics and Weighted Toxins Reductions.
  Resulting in Lower Cancer Risk for the Cities
- No effect on NOx
- Reduced CO Emissions reduces heart disease and other health effects

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GHG Models Used

- The iBEAM model displays the energy inputs and emissions from corn ethanol over the life cycle from farming to end use. The carbon in the corn is treated as biogenic carbon neutral and the approach follows the methods for ANL's GREET model and the Biograce Model
  - The **GREET model developed by Argonne National Laboratory** is the gold standard for U.S. based life cycle analysis and contains **the most up to date information** on corn ethanol production and many other pathways.
    - A California version of the GREET model is used for the Low Carbon Fuel Standard.
    - An earlier version was used by the US Environmental Protection Agency for the Renewable Fuel Standard modeling.
  - **The Biograce Mode**l is a European life cycle model that evaluates European fuel pathways under the Renewable Energy Directive (RED). Current Japanese modeling efforts are also closely aligned with the EU RED methodology.

GHG Modeling Results

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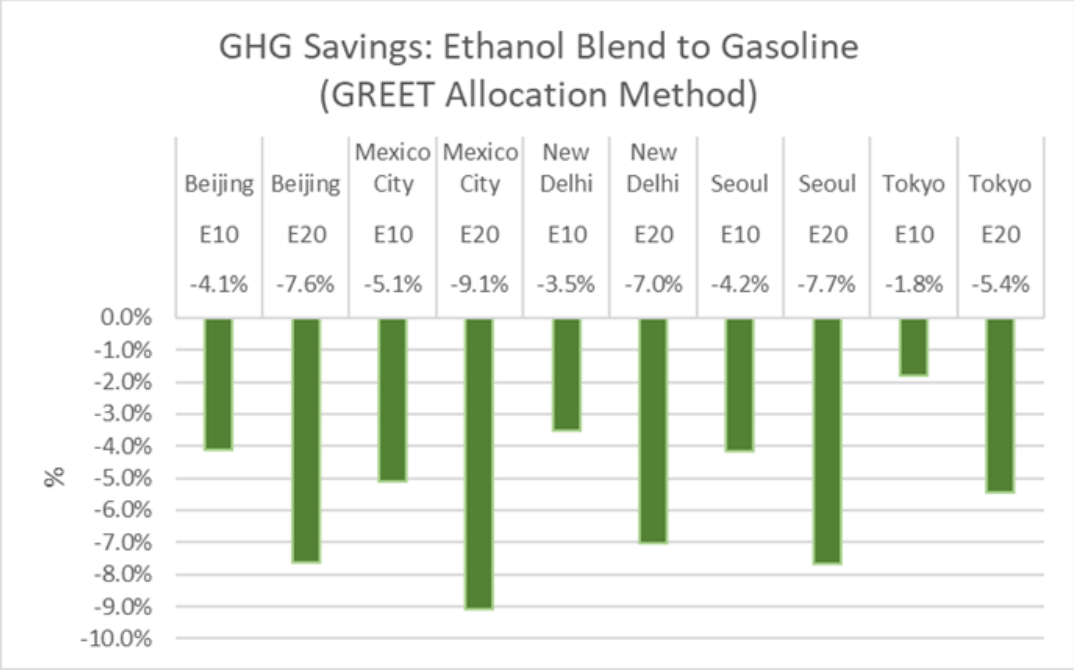
GHG Summary

- On a total tonnage and percentage basis the study shows sizable greenhouse gas reductions for all cities and ethanol blends.
  - Cities with high fuel demand and current MTBE use can realize large GHG savings due to the high GHG intensity of the MTBE production pathway.
  - Beijing and Mexico City, for example, can save 10 and 15 million metric tonnes of CO_2 emissions, respectively, from E10 blends through 2027.
- EV Adoption: We looked at projected global EV Vehicle Stock Turnover which projected to be about 6% by 2027.
  - Ethanol adoption into the existing fleet provides about the same benefits **but right now.**



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New Export Markets for Corn Ethanol based on GHG Benefits

- Many countries try to meet their GHG reduction goals also with low carbon transportation fuels. Potential opportunity for US to export ethanol or finished fuels.
  - Columbia (20% reduction over the next 5 years)
  - Japan (opened market for US ethanol based on latest life cycle data)
  - EU (new quotas with focus on “low land-use-change risk” biofuels)
  - Canada (new efforts for low carbon fuel standards)
  - Brazil (RenovaBio efforts)
  - China (10% ethanol blend use approved last September)
  - Mexico (approved E10 for metropolitan areas)

- Outdated life cycle modeling data has been repeatedly referenced by these countries when evaluating US produced corn ethanol.
  - Outdated life cycle modeling data such as 10 year old modeling runs performed by EPA for RFS2 need to be updated or removed from circulation.
  - GREET is **updated annually** and this data should referenced.

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