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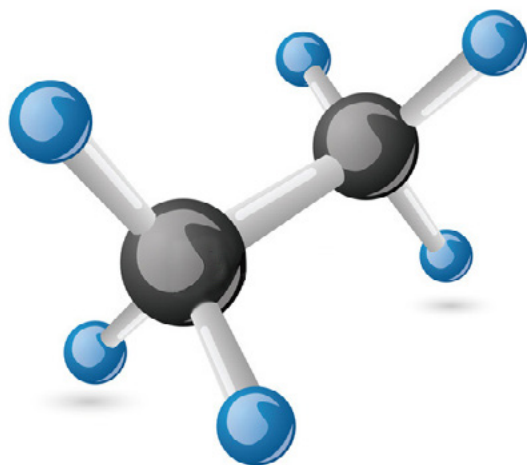
# OTTB & goEthane, inc.

## Ethane

*Low carbon, Low cost, High-performance Transportation Fuel*

3-5 July 2017

Prepared for PLEA 2017



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# OTTB & goEthane, inc.

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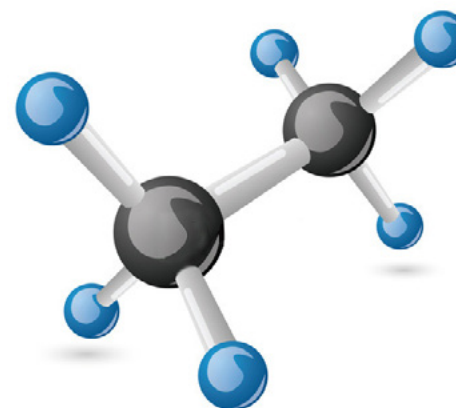
# what is ethane (C<sub>2</sub>H<sub>6</sub>)?

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## What is Ethane?

- Chemically stable hydrocarbon
- Liquifies when compressed
- Combustion products CO<sub>2</sub>(g), H<sub>2</sub>O(l)
- 1<sup>o</sup> use plastics manufacture (ethylene)
- Operates @ lower pressure than CNG

- Less CO<sub>2</sub>/mile than gasoline (**cleaner**)
- Residence time in the troposphere:
  - C<sub>2</sub>H<sub>6</sub> (78 days)<sup>(1)</sup> (**greener**)
  - CH<sub>4</sub> (~10 years)
  - CO<sub>2</sub> (100s of years)

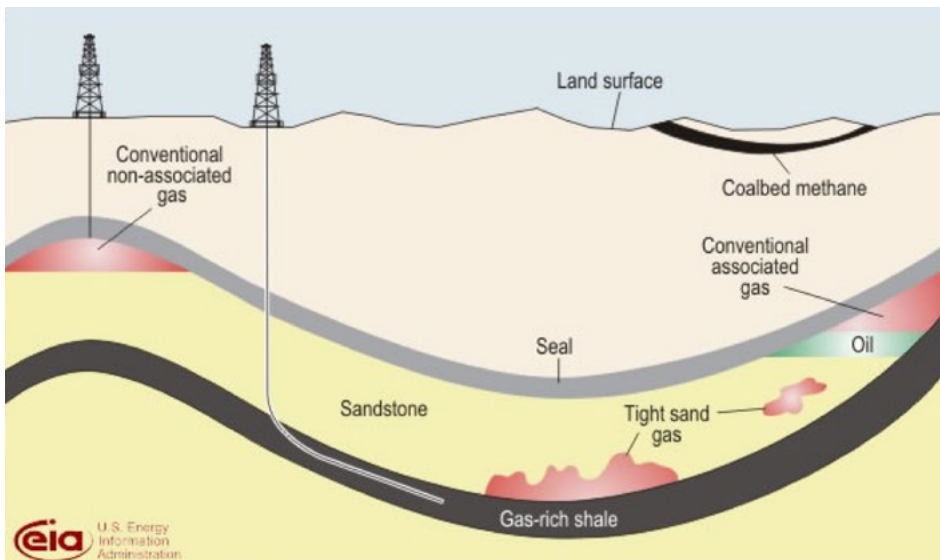


# where is ethane ( $C_2H_6$ )?

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## Where does Ethane come from?

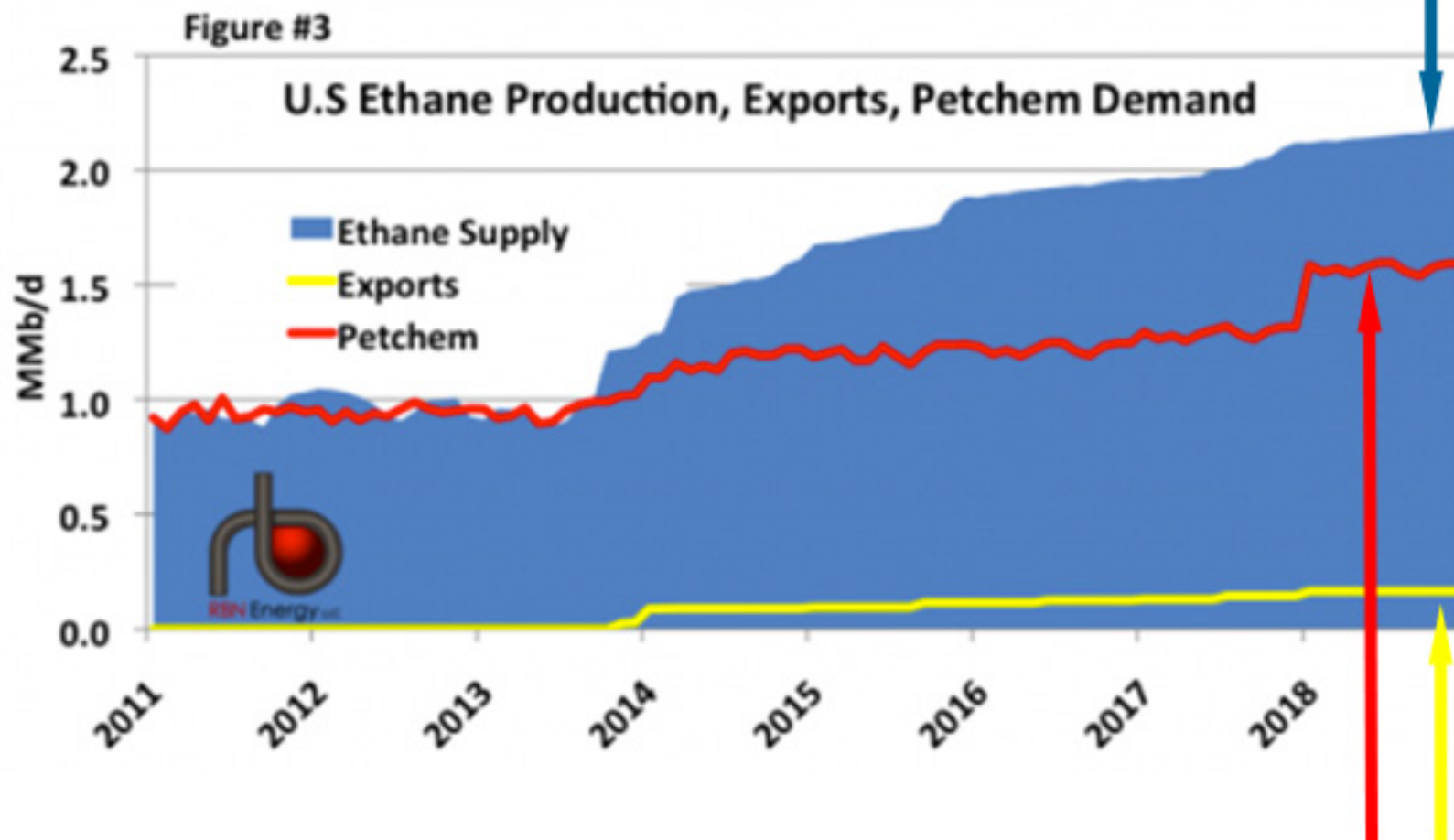
- Shale gas deposits in the USA (largest worldwide)
- Oil refineries (off-gas, re-injected, used in boilers)
- Natural Gas well heads (unprocessed)



# where is $C_2H_6$ ? (cont'd)

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## Ethane Supply Far Exceeds Demand



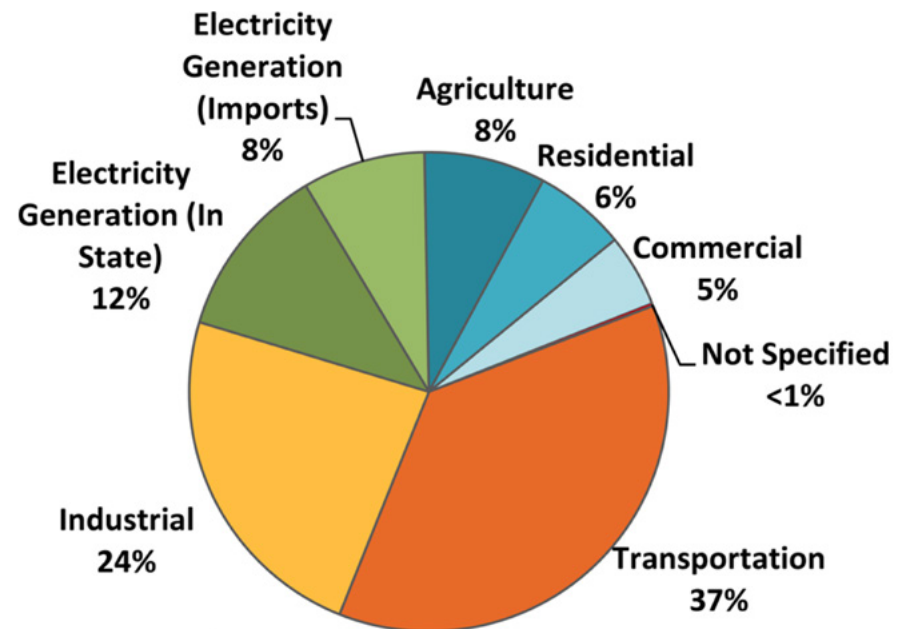
Sad To Waste Ethane To Make More Plastics

## Ethane's Future

- USA Ethane surplus ~500,000 bbl/day next 10+ yrs
- 1.6 bbl ethane == 1 bbl gasoline ~300,000 bbl/day GGE (Gasoline Gallon Equivalent) to market
- Petrochemical manufacturing:
  - Uses all the Ethane consumed today
  - Going forward - Cannot grow to consume all the Ethane to be produced
- Exports of Ethane may come about—will not bring demand into balance with supply

## CA SB 43 Community Self-Generation Initiative

- CPUC, PG&E green tariff, customer generated programs, shared REs
  - EVs
  - NG Vehicles
- PG&E's biggest customers
  - BART
  - Chevron



2014 Total CA Emissions: 441.5 MMTCO<sub>2</sub>e

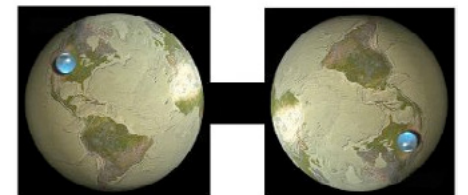
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# who is behind this idea?

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## Lindsay Leveen, The Green Machine

- Thermodynamics expert
  - Chemical Engineer
  - "Frighteningly Bright"
- Industry Consultant & Strategist
  - L'Air Liquide
  - Air Products
- Award Winning Journalist
  - Web site | [Greenexplored.com](http://Greenexplored.com)
  - Textbook | *Hydrogen—Hope or Hype: A Primer on Energy and Sustainability*



# public perception

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## Richmond, CA, USA

- Chevron refinery relationship with the city
  - Long standing history of accidents, spills, releases, etc.
  - Uses wealth to assert agenda
  - Situated in a marginalized, underrepresented community
- CA SB 43 presented an opportunity to:
  - **Green** image -> convert CNG fleet to ethane
  - Reduce CO<sub>2</sub> emissions
  - Avoid cost handouts via SB 43 offerings
  - Improve community relations





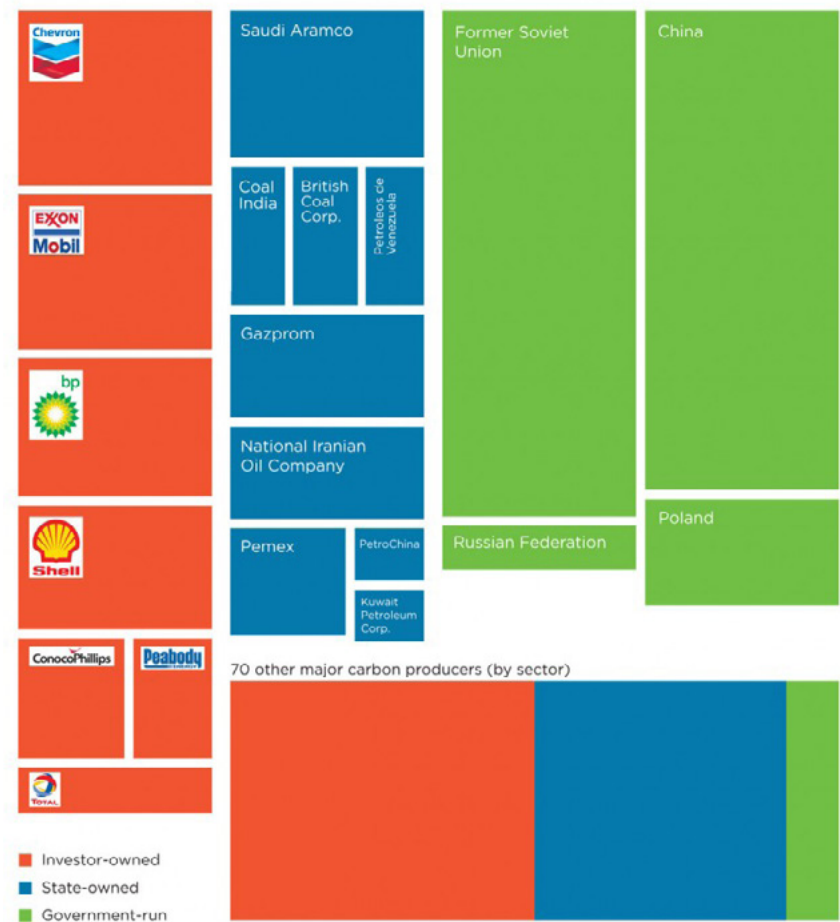
# chevron 'punted' (12/2013) 10

A recent report by the UCS cited nearly 2/3rds of all industrial carbon pollution in the last 150 years can be traced to 90 global actors.

*Citation: Who Is Responsible for Climate Change? New Study Identifies the Top 90 Producers of Industrial Carbon Emissions, <http://tinyurl.com/lys3orc>*

## Major Industrial Carbon Producers

Nearly two-thirds, 63 percent, of industrial carbon dioxide and methane released into the atmosphere from 1854–2010 can be traced to fossil fuel and cement production by just 90 entities. The top 20 entities, shown here, produced 48 percent of all industrial carbon pollution, with 15 percent produced by another 70 entities.





# enter nucor steel corp.

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KEEPING AMERICA BEAUTIFUL  
FOR OVER 45 YEARS

WE'RE NORTH AMERICA'S LARGEST RECYCLER.

[DIVISION SITES >](#)

[▲ NUCOR CORPORATION](#)

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[▲ SKYLINE STEEL](#)

# nucor pilot ethane truck

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**1st vehicle in the world to run on Ethane**

Collaborators: Nucor, IMEGA Int'l USA, & **GOETHANE**

NB: Imega Int'l USA is now Ensida Energy

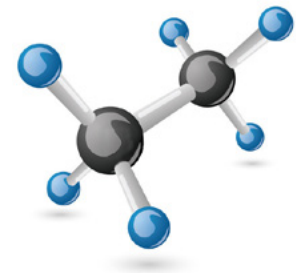


# why ethane?

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Ethane ( $\text{C}_2\text{H}_6$ ) is a great transportation fuel and works well in engines.

- **1st tests:** 9%-17% ↑ in miles/GGE vs Gasoline
- **Ethane:**
  - High powered fuel, high octane fuel
  - Burns completely in an engine
  - Superior to propane as a transportation fuel
- **CNG (Methane):**
  - High powered, high octane fuel
  - Does not burn completely in an engine
  - Not a great fuel in ICEs, requires higher activation energy

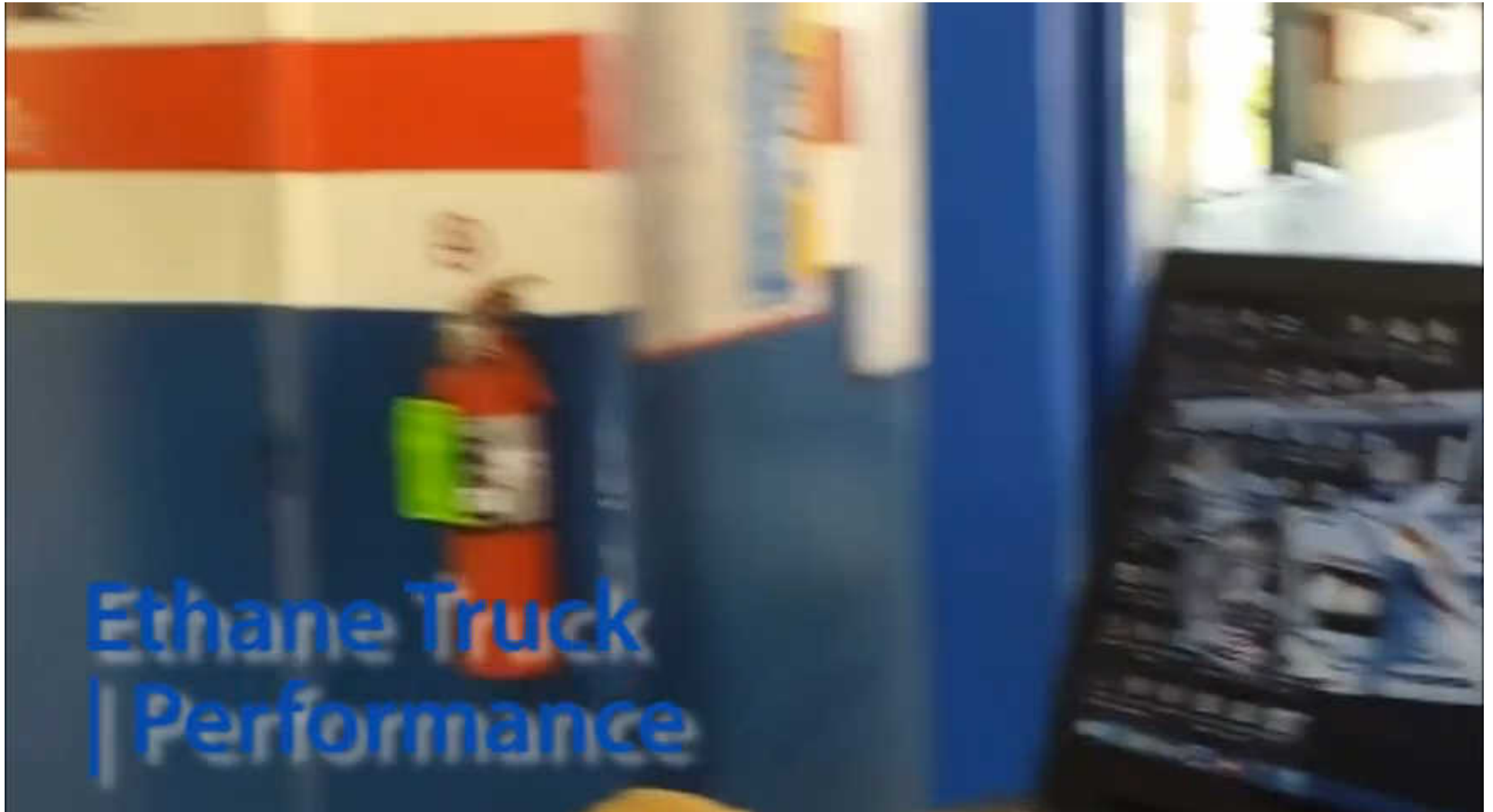




# [VIDEO] imega int'l usa

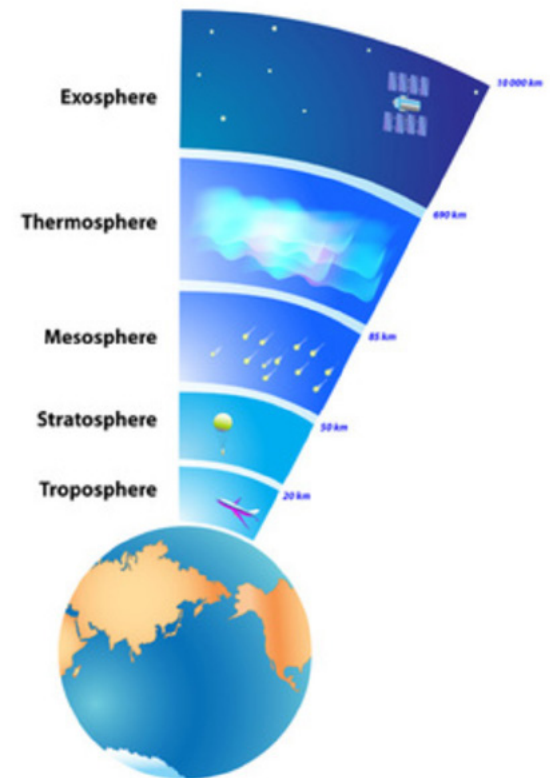
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## Performance



## Green(er), clean(er) transportation fuel

- Decomposes 'quickly' in the atmosphere compared to  $\text{CH}_4^{(1)}$
- 100-year indirect global warming potential (GWP)
  - Ethane 5.5
  - Methane 25



(1) Handbook of Atmospheric Science: Principles and Applications, pp.93-97, [Online] - [Cited: 12 October 2015] <http://www.scribd.com/doc/23585958/Handbook-of-Atmospheric-sciences>.

# ethane field trial results

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## Ethane ( $C_2H_6$ ) is the low $CO_2$ /mile fuel

- More  $H_2$  rich than Propane ( $C_3H_8$ ) and Gasoline
- Emits lowest  $CO_2$ /mile for the same vehicle, beating:
  - CNG (Compressed Natural Gas)
  - Propane
  - Gasoline
- Nucor Steel Ford F150 On-road Test, Jewett, TX:
  - Conducted in the Spring of 2015
  - ~30% lower than gasoline in  $CO_2$ /mile
  - 1.1 lbs/mile vs 1.6 lbs/mile in the same vehicle, same route, same traffic, same speed, same driver

# [VIDEO] imega int'l usa

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## Emissions



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# ethane w2w CO<sub>2</sub> is low

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## Not needed:

- Refining and chemical processing (unlike Gasoline)
- Massive energy input for storing (unlike CNG)
  - Ethane @ 600 psi
  - CNG (Compressed Natural Gas) @ 3,500 psi
- Massive energy to liquefy (unlike LNG)
  - Ethane is a liquid at room temperature and 600 psi
  - LNG (Liquified Natural Gas) is cryogenic

## Simply needs:

- Fractionation from Natural Gas (like Propane)



# why implement ethane?

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1/2 the price of propane, more hydrogen, less carbon/BTU

Table 2. Upstream Emissions Factors (grams per million Btu)\*

	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	TOTAL CO <sub>2</sub> EQUIVALENT
ETHANOL (E85)	-14,409	113	41.0	-387
NATURAL GAS	6,995	317	1.34	16,228
PROPANE	12,867	188	0.26	18,204
GASOLINE	16,010	118	3.95	20,368
COMPRESSED NATURAL GAS	10,985	324	1.40	20,429
DIESEL	18,727	118	0.31	22,104
FUEL OIL	18,727	118	0.31	22,104
ELECTRICITY	182,897	317	2.84	192,523

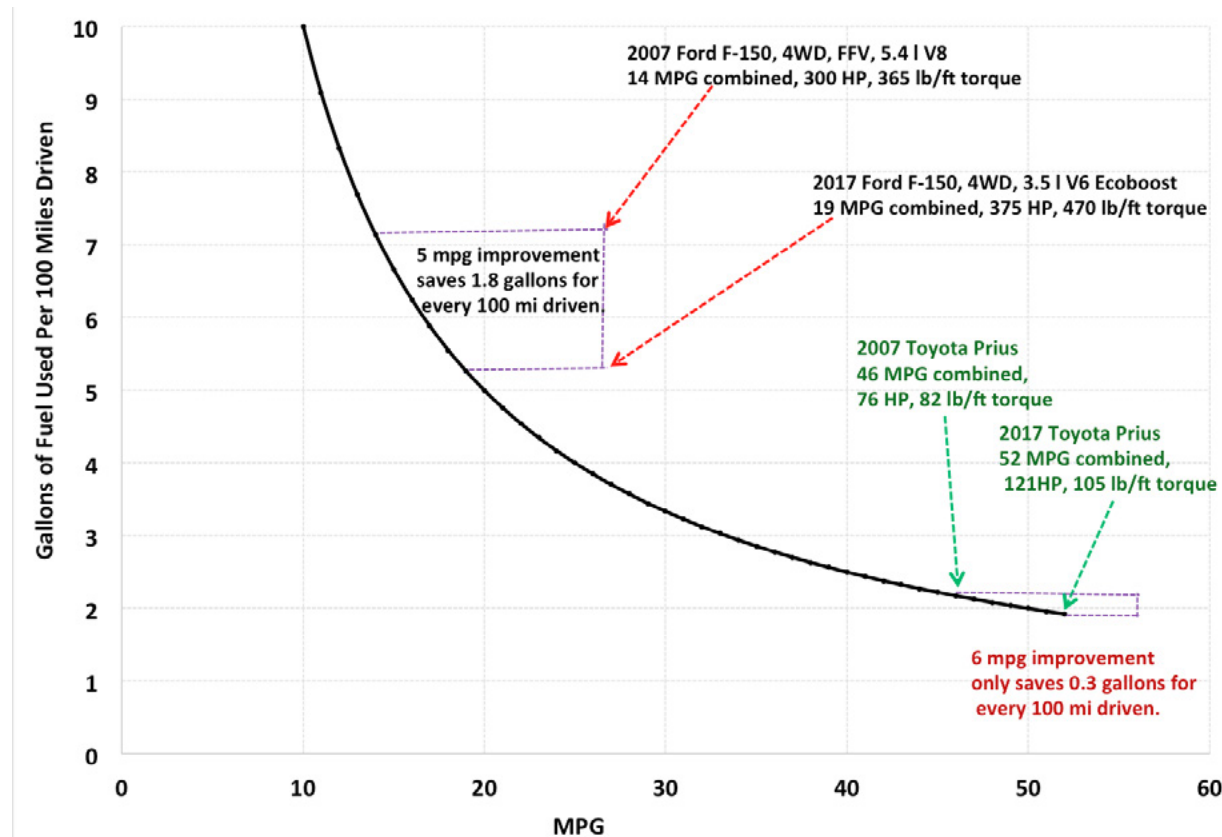
Ethane

\*End-use emissions are based on the lower heating value, density, and weight ratio of carbon atoms per unit volume of each fuel provided in the GREET model software. All carbon is assumed to be released as CO<sub>2</sub>.

# why implement ethane?

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Thirstier vehicles offer the highest return on fuel efficiency investment <sup>2</sup>



(2) G. Collins, Seeking Scalable, Cost-effective Reductions in Gasoline Demand and Tailpipe Emissions? Focus on Pickup Trucks, Not Priuses, Rice University's Baker Institute for Public Policy, Policy Brief, 14 June 2017

# how to implement ethane 21

## Challenges for implementing ethane as a transportation fuel

- Infrastructure and Logistics
  - Onboard storage cylinders [PRELIMINARY TEST - DONE]
  - Delivery infrastructure
  - Supply chain
  - Identify refueling stations locations



## Secure funding for on-road testing in California

- Prove viability of ethane vehicle requirements e.g.
  - Honda CNG Civics fueled with Ethane to prove improvement over CNG
  - Side-by-side test of UPS 'Bread Truck' on Ethane vs Gasoline
  - Dual-fuel with Diesel in:
    - Large trucks
    - Locomotives
    - Ferries
- Provide infrastructure to fuel vehicles



Compressed Ethane ( $C_2H_6$ ) has the largest value add w/the least capital intensity, and it:

- Is more than **twice as effective** as CNG.
- Is almost as energy dense as gasoline/petrol.
- Is a GHG emissions **game-changer**.
- Has an upstream carbon footprint similar to Propane, and lower than Gasoline, CNG, and LNG.
- Better use—**alternative transportation fuel** throughout the USA vs. sending offshore (plastics manufacturing)