go ethane!, itz a gaz, inc. & out think the box

Ethane—a green(er) clean(er) transportation fuel opportunity

SF Bay Area, CA, USA

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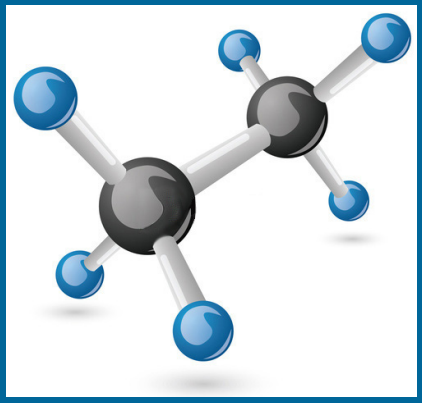

acknowledgements

Timing, diversification and luck deserve acknowledgement. In 2014, the price of natural gas recently surged to a four year high. Being agile and adaptable to usage of a veritable plethora of greener fossil fuels will further green house gas emissions reduction in industrial processes. And now that the USA federal leadership is finally willing to embrace the inclusion of trucks as part of the long overdue improved national fuel efficiency standard, this too presents a unique, historical opportunity. Ethane (C_2H_6) could be the lucky star.

NB: This document was originally prepared in 2014.

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the pitch

Since the world does not need more plastics, abundant ethane (C_2H_6), instead of methane (CH_4), can be the greener fuel transportation opportunity.

Recent historical record of USA ethane exports for the offshore plastics manufacturing industry:

- April 2018 - 390,000 gal/day
- May 2016 - 85,000 gal/day
- May 2013 - 0 gal/day

Source: EIA

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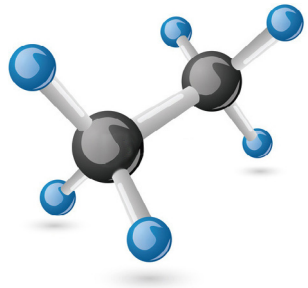
02

summary

ethane—THE green(er), clean(er) transportation fuel opportunity

Given their reliance on emissions-heavy air transport, package delivery companies are challenged to reduce their carbon footprints. One way to greening their ground fleets is to optimize their energy use in low-emission vehicles.

Hydraulic hybrid propulsion systems deployed in the newer UPS-type delivery trucks use energy efficiently and produce less pollution than conventional delivery trucks. UPS-type trucks are rarely used on the highway; stopping and starting is the key to saving fuel with a hydraulic hybrid. Using ethane can expand the these cleaner vehicle truck options, provide an oil saving solution, and reduce global warming emissions without drivers having to change their driving habits. This is the best use of ethane that adds the highest value using the simplest technology.



03

There are two main areas of focus in current market trends for messenger and delivery companies with urban located large truck fleets:

- ‘burn less’ by utilizing hybrid vehicles; aerodynamic optimized vehicles; maximum speed reduction or electronic modified engine control.
- ‘burn clean(er)’ by electric vehicles deployment and utilization of alternative fuels.

United Parcel Service (UPS) operates about 2,500 low-emission vehicles running on alternative fuels and technologies. FedEx has one of the largest hybrid-electric fleets in the industry; upwards of 2,000 alternative energy vehicles in service worldwide. Deutsche Post DHL has 3000+ vehicles.

UPS recently started using propane (C_3H_8) in a test. Ethane (C_2H_6) is far less expensive than C_3H_8, yet has similar range and is less carbon intensive.

The market is massive. The performance compared to the standard is improved—same driving range, less cost, less carbon emissions. Compressed Natural Gas (CNG) has range limitations. Compressed ethane does not. Ethane has more hydrogen content per BTU than gasoline $(CH_2)n$, hence less CO_2/mile. There is a real savings, both financially and environmentally by choosing ethane as a transportation fuel.

The market is MASSIVE. The performance compared to the standard is improved—same driving range, less cost, less carbon emissions.

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category of the action

Reducing emissions from transportation

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what are the actions proposed?

As long as the ethane is compressed to its critical pressure and below its critical temperature, it will be a liquid in the gas cylinder/tank.

Our aim is to recover ethane in the oil refinery process or natural gas capturing process. Instead of using ethane as fuel input to boilers at refineries or in the manufacture of plastics, we propose it be re-purposed as a transportation fuel for the use in package delivery trucks or for similar delivery applications in other, appropriate industries. This proposition uses ethane as a transportation fuel by optimizing the pressure rating for the ethane on the vehicle in the onboard storage tank and via fuel control system. As long as the ethane is compressed to its critical pressure and below its critical temperature, it will be a liquid in the gas cylinder/tank.

Ethane when compressed and cooled with cooling tower water is a liquid under pressure; it is non-cryogenic. Companies like Air LIquide sell ethane in cylinders that are almost full of liquid ethane. A 44 litre cylinder with ethane has 32 pounds of ethane. This has a lower heating value of 650,000 BTU or about 5.7 gals of gasoline. The same cylinder if filled with methane, compressed natural gas (CNG) would hold about 290 scf (standard cubic foot) of methane at 2,400 psi (pounds per square inch) and only have 267,000 BTU. The ethane has about 2.5 times as much energy for the same volume and mass of storage tank. Vehicle range depends on the BTUs stored—hence rather than CNG, compressed, liquid ethane for vehicles is proposed. This schema should be workable for a large (extremely large) truck fleet operator in collaboration with a company like Air Liquide to perform the compression and logistics.

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Compressed ethane will be as good as Liquified Natural Gas (LNG), and sans the additional energy input to cool to super low temperatures. Ethane will not require additional expense for cryogenic vessels/tanks required in the cryogenic process. Furthermore, Compressed Natural Gas (CNG) has a limited driving range and challenging to store. The ITZ A GAZ/It's A Gas process will yield a lower carbon fuel for a lower price than diesel or gasoline, and driving range will not be sacrificed much.

A company in Southern California is considering providing storage tanks for onboard ethane in delivery truck vehicles. The ITZ A GAZ/ It's A Gas vision has been acknowledged and this company agrees what ITZ A GAZ/ It's A Gas proposes is rich in merit and worthy of pursuit.

A guestimate of the available feedstock of surplus ethane is about 200,000 barrels/day from the USA refining process alone. If one considers the shale gas in Pennsylvania and Colorado, without including Texas, there are probably about 400,000 barrels/day in surplus.

...the largest value add with the least capital intensity is to simply compress ethane and have a fuel that is more than twice as good as CNG...

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An outline of our consultation services aims follow:

preparation

1. Research and consultation.

Investigate available federal and state incentives for on-site refueling to locate tax deduction for refueling site opportunities for businesses. In the past in the USA, these incentives have included:

- ► Incentives for companies purchasing converted fleets.
- ► A discounted motor fuel tax.
- ► Loans to companies to convert older vehicles to alternative fuels.
- ► Encourage local agencies to offer:
  - ▹ Exemption from fuel excise tax for fleets using compressed ethane
  - ▹ compressed natural gas (CNG), or liquefied petroleum gas (LPG).
  - ▹ Tax credit of 50% of the cost of converting a vehicle to compressed ethane or LPG.
  - ▹ Tax credit of 10% of the cost of conversion equipment or the cost of an alternative fuel vehicle (AFV).
  - ▹ Tax credit for 50% of the construction costs or improvements for filling stations providing compressed ethane, or LPG.

2. Contingency planning.

Plan ahead by procuring parts and supplies, budget for possible higher costs for replacement parts for alternative fuel engines.

3. Benchmarking performance.

Develop performance and maintenance measurement methods, fuel costs, and compare data to trucks using gasoline or diesel, to control operating costs from the get-go.

4. Provide stakeholder interaction.

Meet with managers/stakeholders to gain support. Describe plans and rationale for purchasing or retrofitting vehicles. Also inform employees, especially those who may be impacted by such activities.

on-going activities

1. Logistics.

Analyze required range and routes of current and future alternative fuel fleet. Identify locations of publicly available Compressed ethane or LPG stations for situations where fuel runs low or anticipated pickups cause vehicle to exceed range.

- ► assign the right vehicle to the right route.
- ► research outlying areas, arrange for access to public fueling stations.
- ► contract towing services in case vehicles exceed their range for towing to home base.

2. Provide training.

Integrate information into training programs. Address differences for drivers, technicians servicing and repairing vehicles e.g. range, fuel availability, power.

3. Coordinate installations.

Install on-site fueling facilities and/or share cost of installation by partnering w/a utility, municipality with similar needs.

4. Stay current on evolving technologies.

Compare notes with collaborators/partners e.g. UPS, FedEx and DHL.

5. Data analysis.

Collect and analyze data on emissions from the pilot package vehicles using ethane, compared to emissions from three similar vehicles using diesel fuel.

6. Evaluate the economic, technical, emissions, and safety factors.

Information is obtained by collecting and comparing data on the operational, maintenance, performance, emissions, and durability of the ethane-powered vehicles and similar CNG/diesel/gasoline-powered control vehicles.

7. A place holder in case another activity is required

Information is obtained by collecting and comparing data on the operational, maintenance, performance, emissions, and durability of the ethane-powered vehicles and similar CNG/diesel/gasoline-powered control vehicles.

long term strategies

1. Review the big picture.

Will economies in fuel costs be offset by increases in employee time and mechanical issues e.g. time to fuel, certifications, maintenance/service training, added expenses [engine, exhaust, fuel system], support components' longevity.

2. Obtain feedback.

Provide regular updates to drivers, re-fuelers, technicians, etc. Seek input often from drivers and mechanics.

3. Transparent communications.

Communicate regularly with other stakeholders about company commitment to cleaner air, planned use for alternative fuels, participation in test programs or demonstrations, and responses from personnel and customers.

who will take these actions?

This opportunity will be best suited for delivery truck companies located in dense urban locations e.g. UPS, FedEx, DHL, USPS, grocery store, municipal waste management, etc. Municipalities, local or city governments with a fleet of service vehicles may also benefit from this opportunity. In general, any industrial carbon producers with delivery truck fleets can benefit from taking these actions.

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where will these actions be taken?

Optimal locations will be a densely populated urban center with delivery truck services, or locations where there are opportunities for capturing ethane and converting it for use in a delivery truck fleet e.g. steel manufacturing plant.

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emissions reductions vs bau

How much will emissions be reduced or sequestered vs. business as usual (bau) levels?

The ethane aboard a vehicle has a lower CO_2 footprint than gasoline or diesel. Ethane has three hydrogen atoms for each carbon atom. Gasoline and diesel have two hydrogen atoms for each carbon atom. Ethane produces 6% less CO2/mile in automobiles. If ethane is not used in transport and is added to pipeline natural gas it actually worsens carbon emissions, as it displaces methane that is even richer in hydrogen. Hence, by using ethane in transportation rather than in pipeline natural gas we get a two fold carbon reduction—less carbon from the vehicle and less from traditional combustion of natural gas if laden with ethane. Therein is a green story, as well as compelling economics.

In summary, the excess ethane is best used as a transport fuel where it has improved range compared with CNG and lower carbon emissions. Using the ethane for plastics or combusting it instead of methane in boilers is simply wasteful of a fuel with wonderful potential in the transportation sector.

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other key benefits

Ethane can act as a greener bridge in the transportation sector.

What are the other key benefits?

Compressing ethane and using it as a transportation fuel is more valuable than cracking it to make ethylene which is used in the manufacture of plastics. Ethane can act as a greener bridge in the transportation sector. When combusted, ethane emits less CO_2/mile than gasoline, has many more BTUs stored in the same high pressure compressed natural gas (CNG) tank and liquifies at normal operating temperature.

Ethane as a liquifed natural gas (LNG) only requires 3%-4% of the energy input for compression. A cylinder filled 92% of H2O volume only requires compression at ~600 psi and can be stored in a cylinder designed to handle 1800 psi.

Liquified ethane can also be transported by tankers and filled in small, end use cylinders, essentially utilized in the existing delivery infrastructure. The compression ratio of ethane is closer to that of gasoline than CNG, thus enabling ethane to be applied as a more powerful duel fuel operation and increase driving range.

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proposal's cost

What are the proposal's costs?

Assumptions and results for realizing the viability of ethane (C_2H_6) for use as a transportation fuel follows:

assumptions

Calculations follow (2014 are in black, 2018 are in green):

- Pounds per day ethane | 200 lbs ethane/day/truck -> ~36 gal gasoline/day ~=300 mi/day of travel/truck
- Days per year operations | 24x7 w/holidays
- Unit sell price per mmbtu | $2.90/gallon ($2.06/gallon) of gasoline (Based on NYMEX - 6 Apr 2014, 2 Aug 2018)
- Unit sell price per pound | $2.90/gallon ($2.06/gallon) of gasoline (Based on NYMEX - 6 Apr 2014, 2 Aug 2018)
- Delivery cost per pound | 5¢ a pound, 20,000 lbs delivered by bulk tanker to on-site tank.
- $1,000/trip cost @ $4.00/mi traveling 250 miles round trip to make the bulk delivery
- Cost of ethane per mmbtu | $4.50
- Delivery of ethane | 5¢ a pound x pounds per year

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break even [occurs between year 2 and year 3]:

- Unit sell price per pound: $0.45 at a 50% discount to gasoline
- Revenues per year: $3,503,360
- Gross Margin: $1,404,504
- Profit before tax: $4,504

Net income: $2,702

year 5:

- Unit sell price per pound: $0.45
- Revenues per year: $243,712,000
- Gross Margin: $142,136,800
- Profit before tax: $121,136,800

Net income: $72,862,080

timeline

Compared to an ethane cracker, which takes upwards of four years to bring online, an ethane compression station only requires two months to commence operations.

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related proposals

Nucor Steel Corporation ethane transportation fuel pilot test project(s). [Completed Spring 2017]

Steel companies like Nucor Steel Corporation who have backward integrated into the energy supply chain will have as much as 10 million gallons a month of spare ethane in the future. Energy producers like Encana who are Nucor's partner in shale gas production will have even more. For example, for 20,000,000 gal/month, and $6/mmBTU as the value of ethane, Ethane is reinjected and simply has methane value in a location like Meeker, CO where the Nucor fractionator is located. This ethane is not intended for plastics and petrochemicals conversion. The transport value of the fuel is $25/mmbtu and there is a $19 value add with very low capital intensity and processing. In Meeker, CO alone, with Nucor's and Encana's ethane there could be a $40 million a month business in this transport fuel. The possibilities with Marcellus Shale Ethane are many fold beyond this example.

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references

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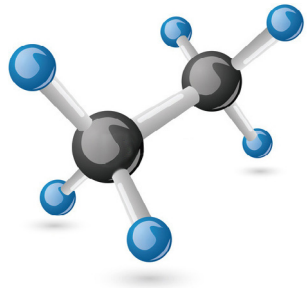
Business Ethics web site. [Cited: January 18, 2014] - http://business-ethics.com/2013/05/12/1020-fedex-up-delivery-fleets-get-gree/

DHL web site. [Cited: January 19, 2014] - http://www.dpdhl.com/content/dam/presse/pdfs_zu_pressemitteilungen/2011_01/factsheet-gogreen.pdf

Lindsay Leveen, The Green Machine, Vice President, Itz A Gaz, Inc., http://www.greenexplored.com

Road and Track web site. [Citied: January 18, 2014]- http://www.roadandtrack.com/special-reports/page-3---2006-dhl-sprinter-vs-2007-fed-ex-w700-hybrid-vs-2006-ups-sprinter-p57d

USA EPA web site. [Cited: January 19, 2014] - http://www.epa.gov/region9/air/hydraulic-hybrid/index.html



appendix

Info-graphic on following page.

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A Green(er) Story

Ethane as a transporation fuel opportunity

Natural Gas Distribution

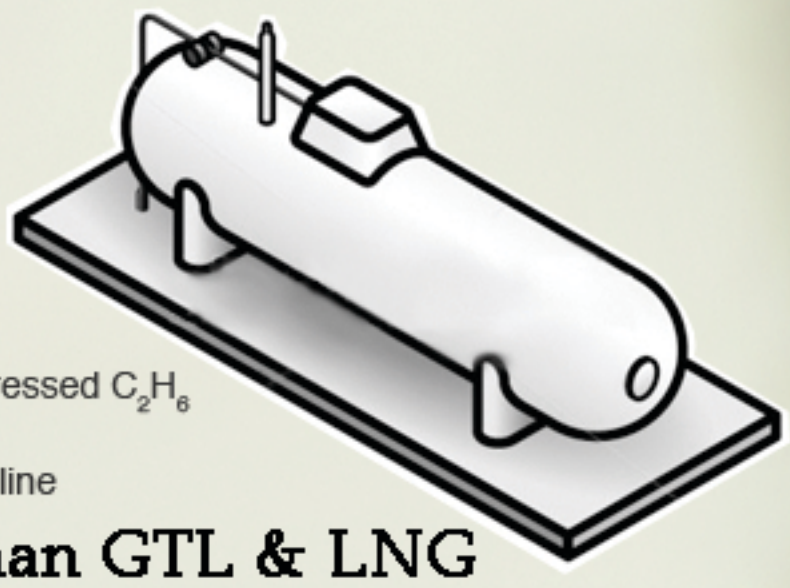
C_2H_6 liquifies when compressed

3%-4% energy required to compress
Critical pressure 48.72 bar (706.6 psi)
Critical temperature 32.17 °C (89.9 °F)
LNG is gaseous unless cooled below -82.6 °C

Driving range not limited

2.5x energy for same volume & mass of storage as CH_4

Gas Vehicle Comparison (BTU/tank)



- 17.5% CNG
- 48.6% Compressed C_2H_6
- 65.4% LNG
- 100.0% Gasoline

Green(er) than GTL & LNG

- 6% less CO_2/mile [cars]
- 7%-8% less CO_2 [boilers]

Less hassle, Less capital intensive to build

- Not cryogenic
- Compression station – 2 months
- Ethane cracker – 4 years

Natural Gas Wells

[Mixed CH_4, C_2H_6, C_3H_8, C_4H_{10}]

CH_4 - Methane
C_2H_6 - Ethane
C_3H_8 - Propane
C_4H_{10} - Butane

Separation & Processing

Compression Station

RECOVERY

[Two Pathways]

Pathway 1

Natural Gas to Pipeline

OR

Flaring

OR

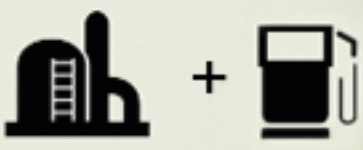
Reinjection

Pathway 2 .. C_2H_6 ..

Compress liquid in bulk tankers

NB: Current market is the petrochemical industry

Storage Tank



Delivery Truck Depot

200 trucks/depot x 40 depots = 8,000 trucks
10,000,000 gal/month
$140mil Gross Margin

OR

C_3H_8 C_4H_{10}

Market

Sources: Lindsay Leveen, The Green Machine