



***Clean Energy***<sup>®</sup>

*North America's leader in clean transportation*

# **Understanding LNG as an HD Transportation Fuel.**

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# About Clean Energy



Largest Natural Gas Fuel Provider in North America

## CNG

Compressed Natural Gas

## LNG

Liquefied Natural Gas

## 200 Million

Gallons Natural Gas



Clean Energy

Largest Alternative Transportation Fuel Provider

Retail Fueling

Station Builder

LNG Supplier



700+ FLEET CUSTOMERS



9000+ TRANSACTIONS PER DAY



30000+ NGVS FUELED DAILY



400+ NATURAL GAS FUELING STATIONS



# Why Natural Gas?

- **It's Cheaper**
- **It's Cleaner**
- **It's Abundant and Stable**
- **It's Proven**
- **It's Needed**



# Facts: Natural Gas

- **CNG (Compressed )Is Natural Gas**
- **LNG (Liquefied)is Natural Gas**
- **Natural Gas has been used for years in MD/LD vehicles Worldwide**
- **Natural Gas has been used a very short time for Heavy Duty Vehicles (Engines)**
- **CNG Pipeline Natural Gas can vary widely in Methane content (75%-95% Methane)**
- **LNG is a very pure form of Methane 95%+**
- **All Natural Gas Burns the same in the Engine**

# Facts: CNG and Clean Energy



CNG

Clean Energy Fuels



CNG



**Fact: 70% of Clean Energy Fuels business is CNG. 30% is LNG.**

**Fact: Clean Energy Owns and Operates over 317+ CNG stations in the US.**

**Fact: Clean Energy Has over 90%+ Market Share of CNG at National Airports**

**Fact: Clean Energy will ALWAYS have a big portion of their business as CNG**

**Fact: Clean Energy has found a new friendship in LNG as well.**

# Fuel: #1 Cost Factor / Driver Pay #2



HEAVY DUTY TRUCK  
MARKET POTENTIAL IS  
HUGE

25B



Gallons of Fuel Used Per Year

# The Fuels : Some Differences

## CNG

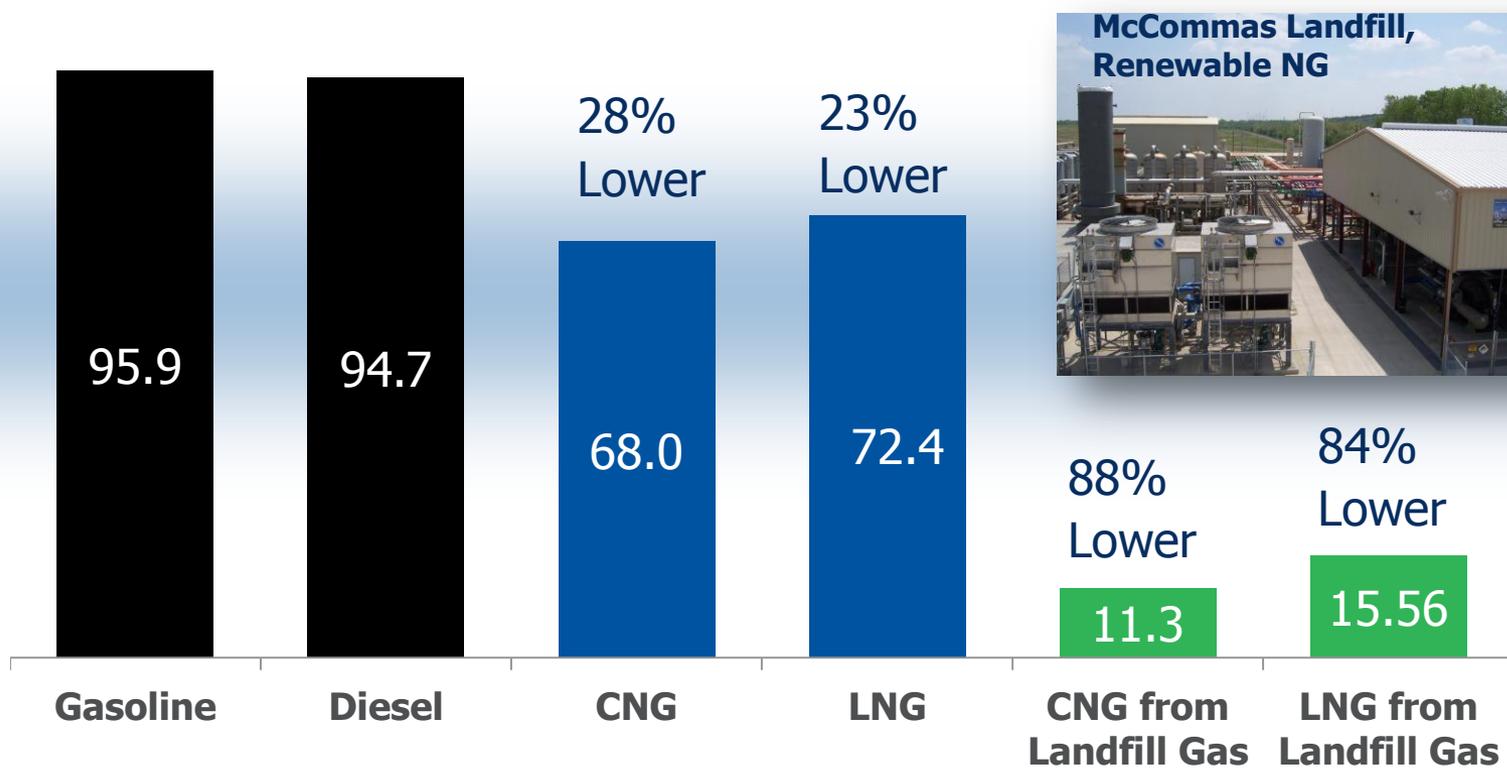
- Used in Transportation Vehicles and Manufacturing
- Need NG Pipeline infrastructure
- Delivered via pipeline into a Compressor Station
  
- Gaseous dispensed at 3600 psi
- 4x the space need of diesel for equal energy content
- Cooled down to -260, it becomes LNG
- Most CNG fills at 3-7 gal/min
- CNG Stations are primarily in metro and designed for LD/MD

## LNG

- Used in Transportation Vehicles and Manufacturing
- No Pipeline Infrastructure Needed
- Delivered via trucks like Diesel and off-loaded into tanks on station site
  
- Liquid: Cryogenic at -260 Degrees
- 2X the space need of diesel for equal energy content
- Heated up to -240 or above, it starts to becomes CNG
- Most LNG fills at 20-25 gal/min
- Most LNG stations are in key transportation corridors, outside of metro designed for HD Trucks.

# NGV's Have Lowest Possible Carbon Footprint

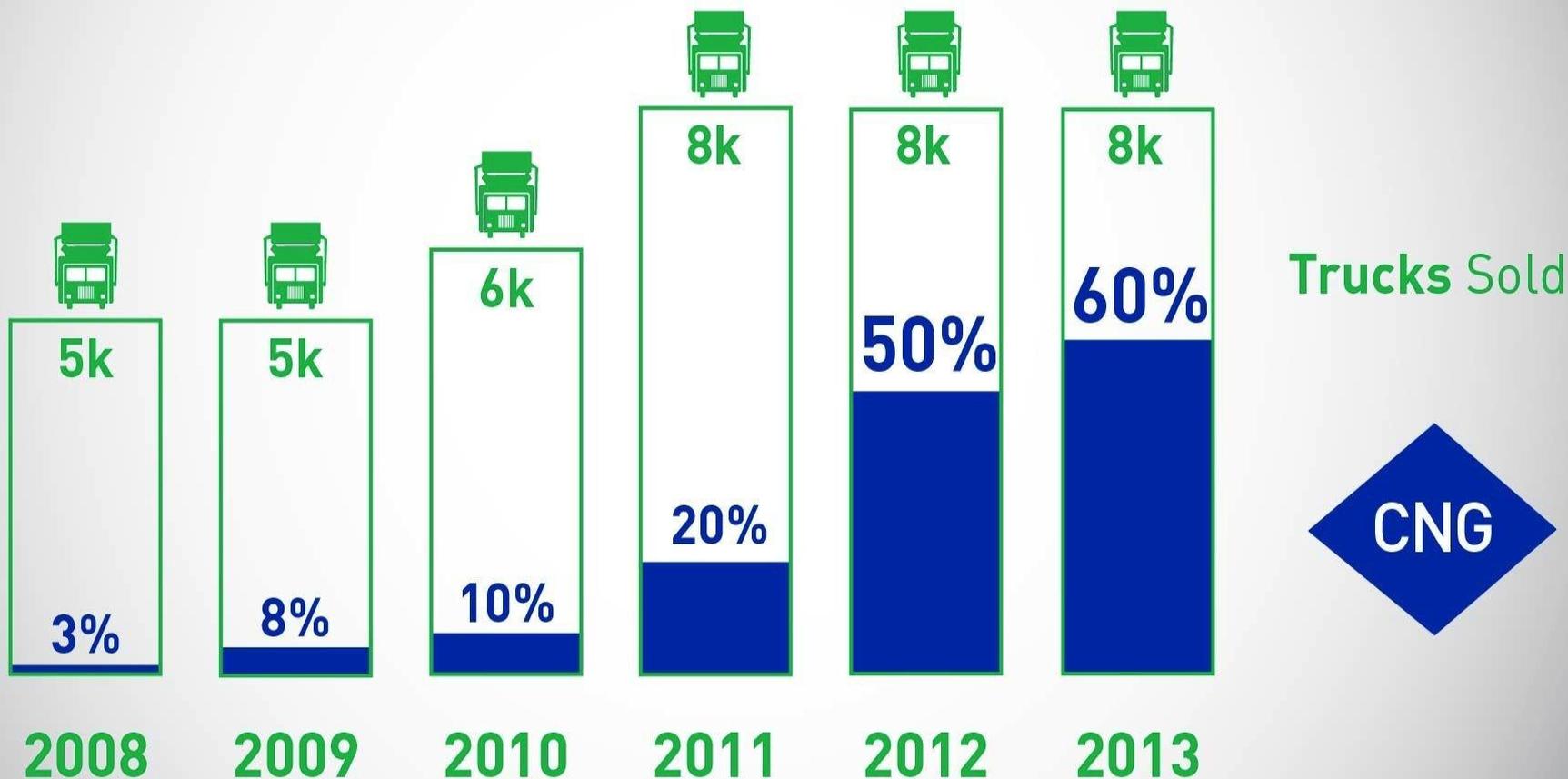
WTW Greenhouse Gas Emissions\*  
(in grams CO<sub>2</sub>eq/MJ)



\*CARB Low Carbon Fuel Standard "Well-to-Wheels" GHG Emissions

# Refuse Sector Adoption Curve

## Refuse Truck Adoption



\*9 Liter Introduced

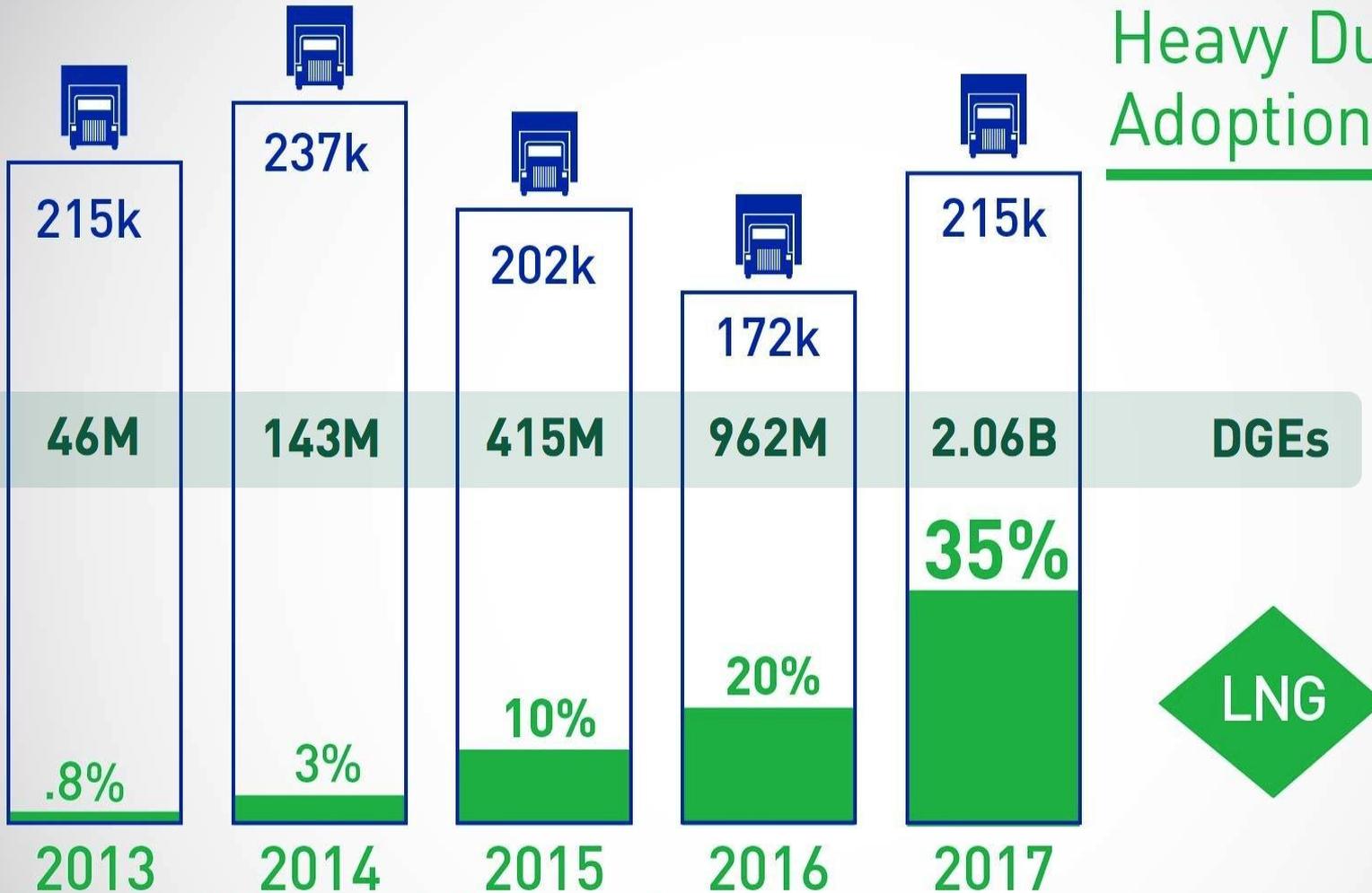
# Why A 60+% Refuse Sector CNG Adoption Rate?



- **Municipalities promoted public services to move on Natural Gas Vehicles**
- **Right Engine for 66K GVWR was released**
- **CNG Fuel Tank weights and range needs are not a big factor in refuse.**
- **Regional low mileage/high idle format worked excellent with NGV's**
- **Private station costs are low, compression needs are very minimal re fill speeds/energy use.**
- **Return to Base/High Fleet Daily down–time works excellent for slow fill times/fullness of tank capacity**
- **Miles driven annually are low, so ROI can be longer**
- **NGV users created so much operational savings, it mandated conversion to simply be competitive!**

# Heavy Duty Adoption Potential

## Heavy Duty Truck Adoption Potential



\*12 Liter Introduced \*13 Liter Introduced \*15 Liter Introduced

Annual truck rates based on Americas Commercial Transportation (ACT) Research. These figures are for illustrative purposes only and are not a prediction or estimate of results by Clean Energy.

# Facts: LNG For HD Trucking

- **FACT: Trucking is about maximizing time on the road**
- **FACT: HOS/CSA/Fueling Time all effect a driver's weekly pay**
- **FACT: You CAN upfit your HD Truck with CNG**
- **FACT: LNG is a great fuel form for HD Trucks for the following reasons:**
  - **2x the amount of energy on board truck vs CNG in same space.**
  - **Driver HOS not effected for Drivers filling at 20-25 gal/min---same as diesel**
  - **Stations cater to truck drivers ( space & amenities)**
  - **Fuel Tanks are lighter weight than CNG**
  - **Longer Range capability for less incremental cost vs.CNG**
  - **Good gauge: 300-350mpd or greater is a good LNG fit**

# Fuel Systems: CNG or LNG?

## Factors: Weight, Cost, and Time

### LNG



Range ~ 400 miles  
DGE's: 69  
Tank Configuration: Single HLNG150 Tank  
Weight penalty: 300 pounds less than diesel  
Cost : Diesel + ~\$20,000  
Fill Rate:   Maximum   23 GPM  
              Low           20 GPM  
              Average    20 GPM  
0 Additional Fuel Hours Per 100,000 Miles

### CNG



Range ~ 400 miles  
DGE's: 72 (at 80% fill rate)  
Tank Configuration: Dual 45 DGE tanks  
Weight penalty: 700 pounds more than LNG  
Cost: Diesel + ~\$40,000  
Fill Rate:   Maximum   10 GPM  
              Low           1 GPM  
              Average    5 GPM  
42 Additional Fuel Hours per 100,000 Miles

# HD Natural Gas Engines and OEM's



GVW	≤ 66,000 LBS	≤ 80,000 LBS		
ENGINE	9L - ISL G	12L - ISX12 G		
AVAILABILITY	NOW	NOW		
     	<p>320, 382, 384</p> <p>T440, T470, W900S</p> <p>M2-112, SD-114</p> <p>TranStar</p> <p>VNM</p> <p>TerraPro</p>	<p>320, 382, 384, 365</p> <p>W900S, T660, T800SH</p> <p>Cascadia</p> <p>VNL</p> <p>Pinnacle, Granite</p>		

# Expanding Choices for HD Natural Gas Engines



- **Currently Available**

- 8.9 liter Cummins-Westport SI (CWI)
- CWI 12 liter SI engine
  - Offered by most all OEMs
  - Commercial release in February 2013

- **Planned and Announced**

- Volvo 13 HPDI liter engine
  - Field testing underway with OEMs
  - Planned introduction in mid 2014
- CWI 6.7 liter SI engine
  - Planned introduction in late 2015



320HP/1000Ft.lbs.Trq  
66,000 GVWR Max.

**ISL G**



400HP/1450Ft.lbs.Trq  
80,000 GVWR Max.

**ISX12 G**

# Hours of Service- -Fuel Time Consideration

Fueling Time Per Year in Hours

	6	7	8	10	11	13	16	17	20	22	24	27
25	6	7	9	10	12	14	16	17	21	23	25	28
24	6	7	9	11	12	14	17	18	22	24	27	29
23	6	7	9	11	13	15	18	19	23	25	28	30
22	6	8	10	12	13	16	19	20	24	26	29	32
21	7	8	10	13	14	17	19	21	25	28	31	33
20	7	8	10	13	15	18	20	22	26	29	32	35
19	7	9	11	13	15	19	22	23	28	31	34	37
18	8	9	12	14	15	19	22	23	28	31	34	37
17	8	10	12	15	16	20	22	23	28	31	34	39
16	8	10	13	16	17	21	22	23	28	31	34	42
15	9	10	13	16	17	21	22	23	28	31	34	44
14	10	12	15	18	20	24	25	26	31	34	37	48
13	11	13	16	19	21	26	30	32	36	40	44	51
12	12	14	17	21	23	28	32	35	42	46	51	56
11	13	15	19	23	25	30	35	38	45	51	56	61
10	14	17	21	25	28	33	39	42	50	56	61	67
9	15	19	23	28	31	37	43	46	56	62	68	74
8	17	21	26	31	35	42	49	52	63	69	76	83
7	20	24	30	36	40	48	56	60	71	79	87	95
6	23	28	35	42	46	56	65	69	83	93	102	111
5	28	33	42	50	56	67	78	83	100	111	122	133
4	35	42	52	63	69	83	97	104	125	139	153	167
3	46	56	69	83	93	111	130	139	167	185	204	222
2	69	83	104	125	139	167	194	208	250	278	306	333
1	139	167	208	250	278	333	389	417	500	556	611	667
Gallons/Year	8,333	10,000	12,500	15,000	16,667	20,000	23,333	25,000	30,000	33,333	36,667	40,000
Miles/Year	50,000	60,000	75,000	90,000	100,000	120,000	140,000	150,000	180,000	200,000	220,000	240,000

LNG Ave.

CNG Ave.

A 42 hour difference per year per truck

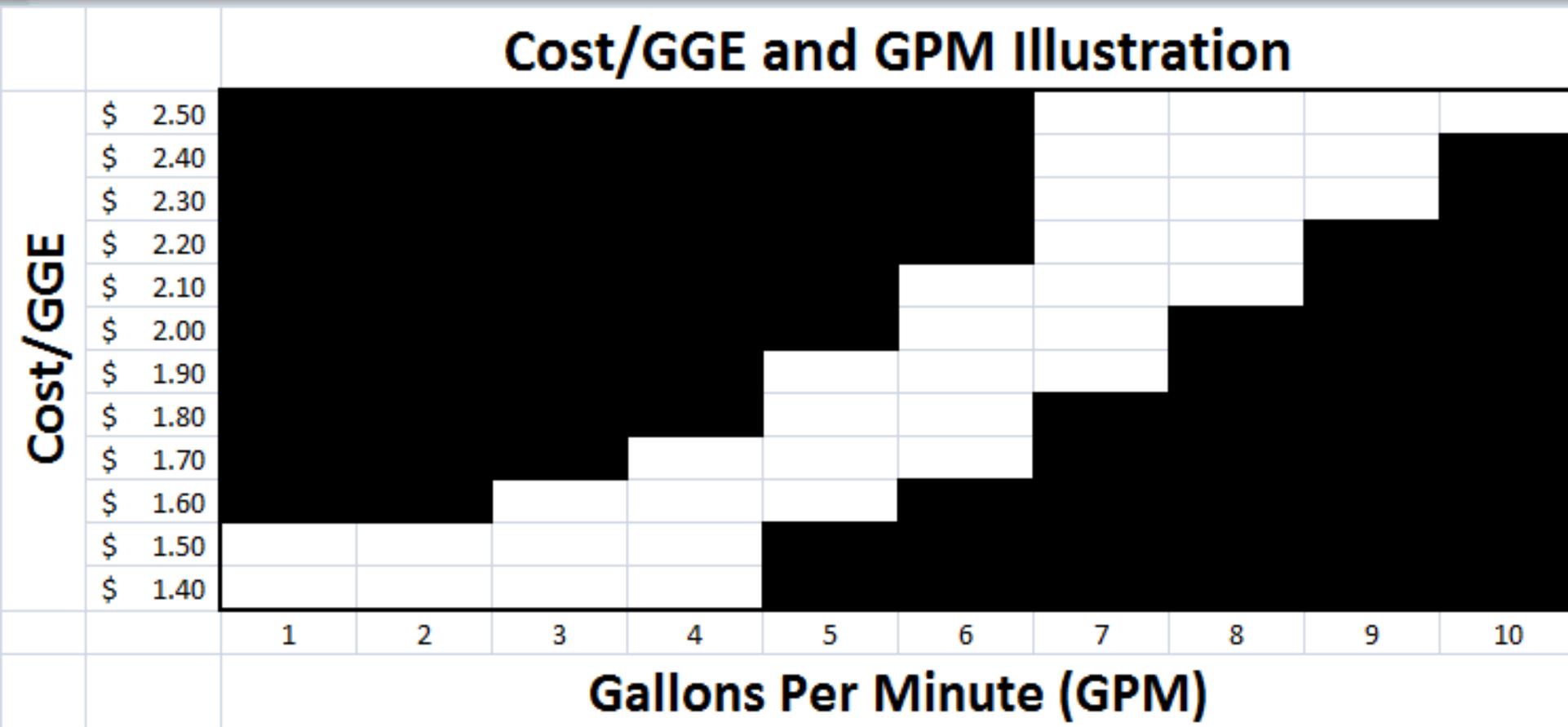
Hours of Service 2011  
THE NEW PROPOSED RULES

TIME IS MONEY

# CNG Cost and GPM Illustration



## Cost/GGE and GPM Illustration



The key points are:

- The lower the price the slower the fill. On small tanks, or with Time Fill, time is not as big a factor. Speed of fill increases station costs ( compressors) and electricity costs ( horsepower).
- If you are in a Fast Fill duty cycle, and/or time is an issue, the price will be higher and the heat of compression will impact capacity and range.

# We Can Be Friends With The Right Application!



# Thank You and Questions ?



***Cheaper***



***Cleaner &  
Low Carbon***



***Domestic &  
Abundant***

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# Filling Up! America's Natural Gas Highway – LNG Infrastructure Vision



Current ANGH Station Design

# America's Natural Gas Highway Caters to the HD Trucking Population



**Hope Hull, AL**



**Latta, SC**



**Oklahoma City, OK**



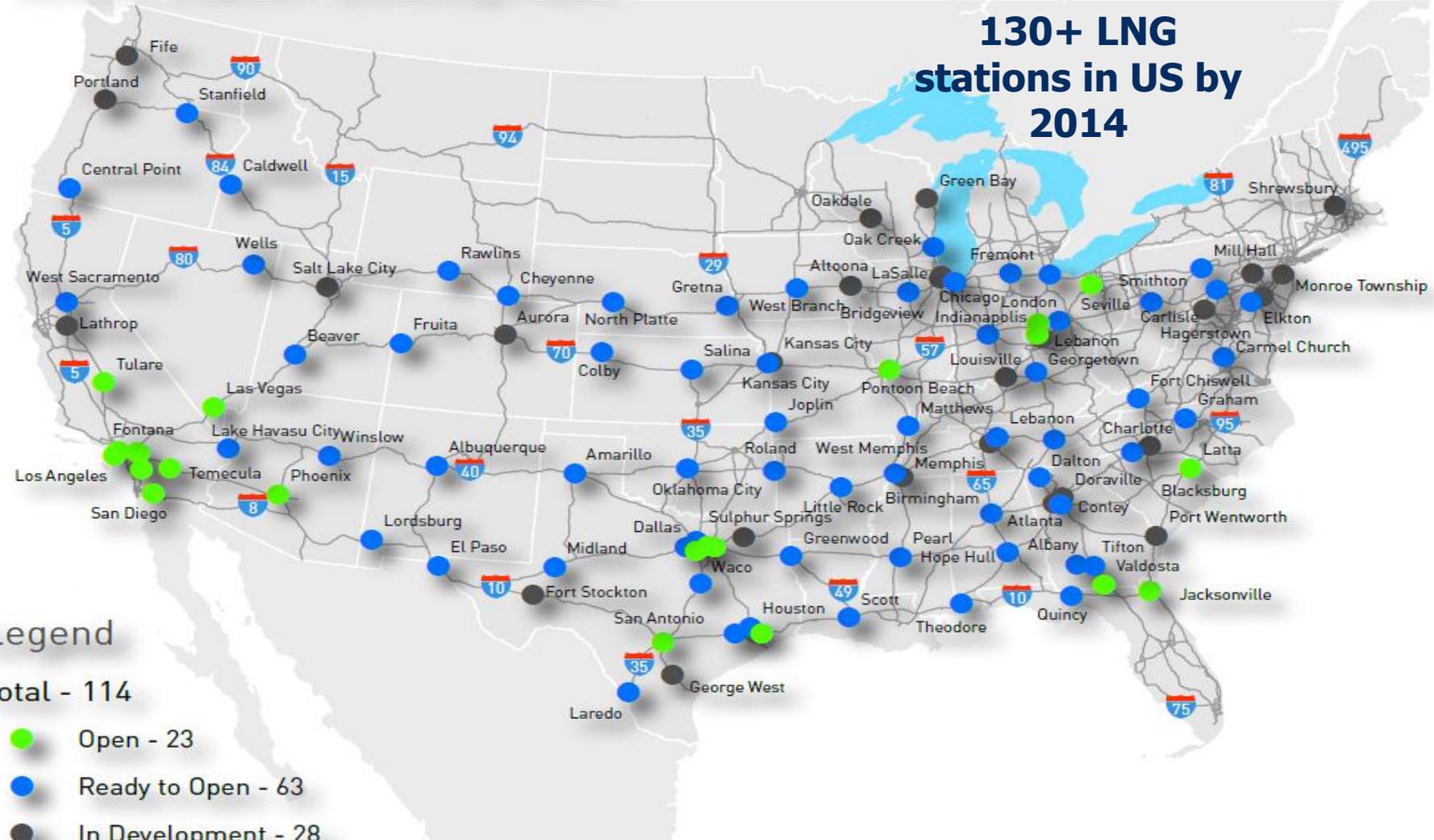
**Pearl, MS**

# America's Natural Gas Highway

## The Infrastructure Reality- LNG Fuel



### ANGH Station Development



# CNG Station Reality

...the majority of current CNG stations are not “Truck Friendly”



# CNG Station Reality

...the majority of current CNG stations are not “Truck Friendly”



# America's Natural Gas Highway

## Las Vegas LNG Station



# America's Natural Gas Highway

## Mesquite, TX "LCNG" Station

