

HDR



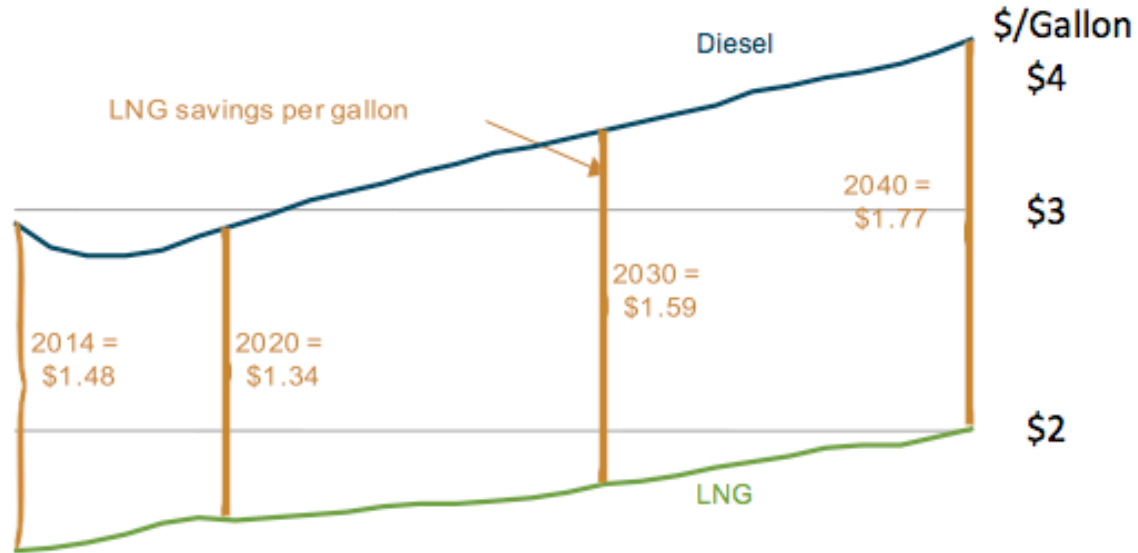
Liquefied Natural Gas for Railroad Locomotive Fuel

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Projected Price Spread of LNG and Diesel Locomotive Fuel



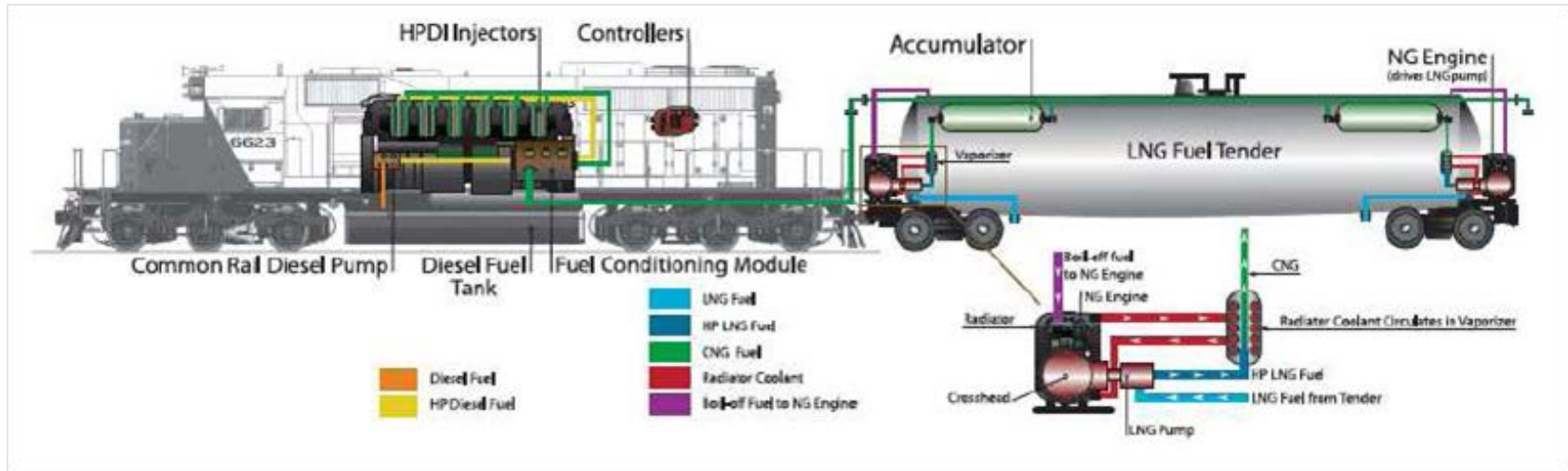
Source: EIA 2014

All-In Costs are \$1-2 per gallon lower than diesel

Diesel Fuel is Very Simple

- Broad demand base = spread cost for infrastructure
- Higher energy content per gallon than LNG (1.7 to 1)
- Non-perishable
- Widely available
- No tenders required
- Highly reliable





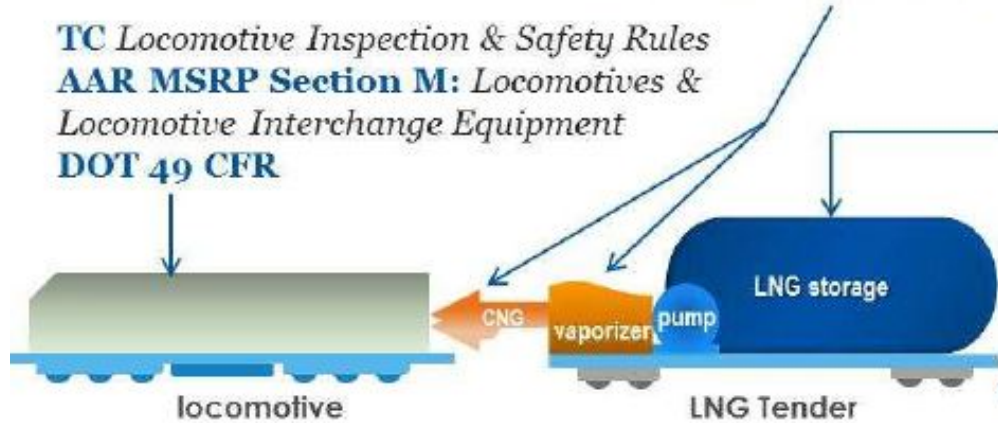
Technical considerations

NFPA 52: *Vehicular Gaseous Fuel Systems Code*
AAR MSRP Section K: *Railway Electronics*
AAR MSRP Section B: *CoNSlers*

TC Locomotive Inspection & Safety Rules
AAR MSRP Section M: *Locomotives & Locomotive Interchange Equipment*
DOT 49 CFR

ASME Section VIII: *Pressure Vessel Code*
CSA B625-08: *Portable Tanks for the Transport of Dangerous Goods*
CAN/CGSB 43.147: *Means of Containment... Transporting of Dangerous Goods by Rail*
AAR MSRP Section CIII: *Tank Car Specs*
DOT 49 CFR

AAR MSRP CII: *Design, Fabrication, Construction of Freight Cars*



The regulatory environment

Liquefaction – Cost and Scale

- 10,000 gallons/day = \$50 million = fuels 1/6 trains/day
- 200,000 gallons/day = \$120 million = fuels 3-4 trains/day
- 1,200,000 gallons/day = \$500 million = fuels 20 trains/day
- A single railroad might need 6 to 12 \$500/million plants
- Each plant ~ 120 acres
- Total cost \$25 billion+



LNG Locomotive and Tender Fleet – Cost and Scale

Locomotives:

- 40,000 locomotives in line-haul fleet
- \$2 million each new
- \$500,000 each to convert to LNG
- \$20 billion to convert

Tenders:

- 1 for every 2 locomotives
- \$500,000 each
- \$10 billion to acquire



LNG Network Effects

Train Length:

- 3 LNG tenders = 4 typical cars
- Either trains get longer, or productivity declines
- Infrastructure and train length are closely matched

Fueling Stops:

- Highly centralized fueling
- Causes fixed business plan
- Causes loss of flexibility
- Causes loss of market share



Prognosis

LNG is highly attractive for captive operations

- Fixed operating plan and infrastructure
- Narrowly defined public interactions

LNG has promise for network operations

- Lower emissions
- Immense fuel cost savings
- Potential market share gain

