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PGDC 2

THE NEW 'MARKET SWEET SPOT' : LNG IN TRANSPORT

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The ‘New Market Sweet Spot’

- The main driver for future global gas demand growth will be in the power generation sector

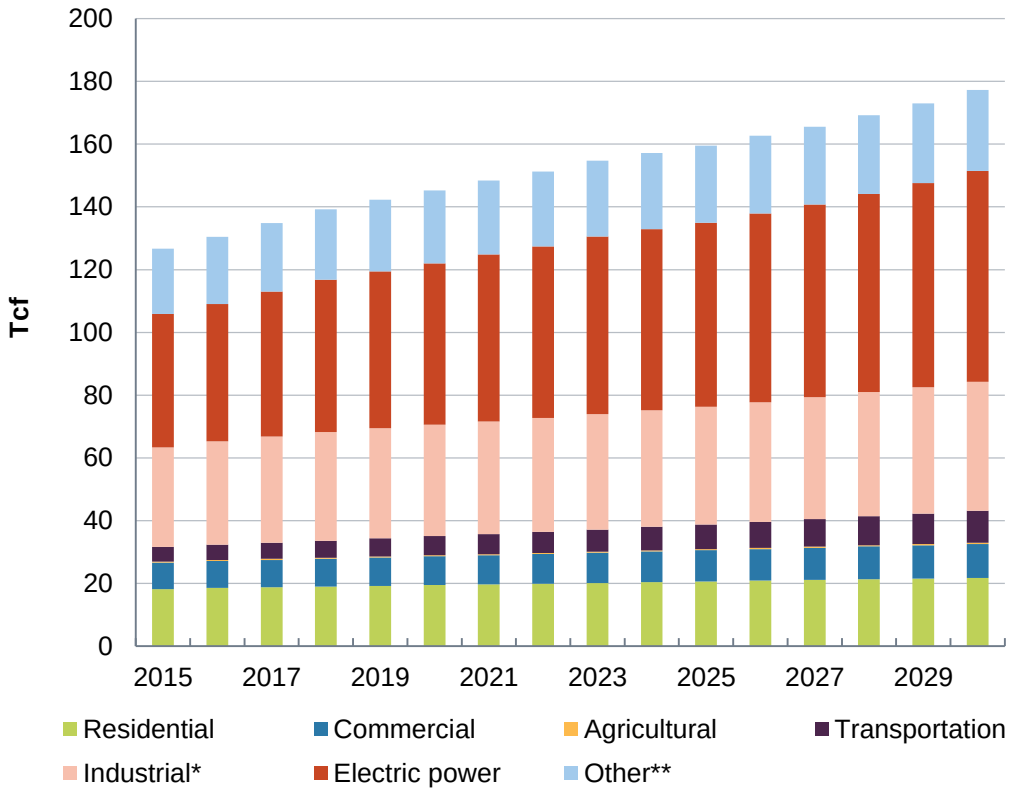
- However the transport sector may provide a greater source of value if/when oil prices rebound

Thesis

- Most global outlooks for natural gas demand project big increases in the power market, and only a niche role in the transport sector. But...
- Power generation is an intensely competitive sector and the value of gas in power is declining as--
    - Coal remains cost competitive and trades at a strong discount to LNG
    - The costs of some renewable generation technologies come down
    - Capacity factors for thermal generation decline as ‘zero marginal cost’ renewable generation (solar and wind) expands
- By contrast the value of gas in transport may be increasing
    - If/as the oil price recovers
    - Natural Gas Vehicle (NGV) truck costs come down and retail infrastructure expands
- While the transport market for gas will not be as big as the power market, it can be an important sizable market for LNG
- The fall in oil prices since late 2014 will slow the uptake of gas in transport, but the medium and long-term drivers remain in force
- IHS estimates
    - gas demand in HGV and marine transport will be 98 Bcm by 2030
    - LNG demand in HGV and marine sector will be 48 mt by 2030
- Gas developers need to focus more on the transport market, and especially the truck market, not as an alternative to power but as a high value add-on

Natural Gas Demand to grow strongly, driven primarily by the power sector

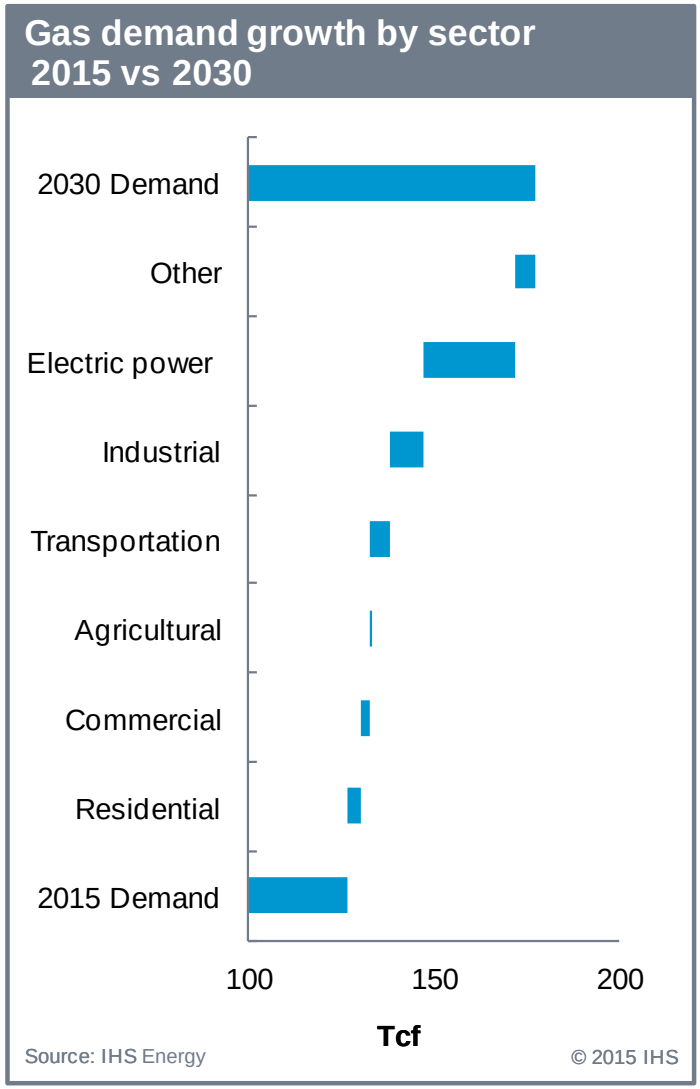
Gas demand growth by sector: 2015 to 2030



Notes: * Includes feedstocks. **Includes energy sector uses, distribution losses and statistical differences.
Negative numbers may indicate use of synthetic fuels.
Source: IHS Energy

- Global gas is projected to grow from 120 Tcf in 2013 to 177 Tcf in 2030
  - Gas use in power increases from 40 to 67 Tcf
  - Industrial gas use increases from 29 Tcf to 41 Tcf
- The percentage share of electricity rises from 34% in 2013 to 38% in 2030

Power is the main growth market; transportation is niche



- Gas demand will grow 50 Tcf between 2015 and 2030
- The biggest sector of growth is power—accounting for 48% of growth
- The second biggest sector of growth is industrial use, both energy and feedstock combined
- Transport is forecast to grow by only 5.6 Tcf

Aim

- To examine the potential for natural gas, and specifically LNG, as a fuel in the transportation sector, with a special focus on the heavy-goods vehicle (HGV) truck market globally

- To compare the *size and drivers* of the transportation sector opportunity for natural gas relative to the size and drivers of the traditional market sectors, notably power generation.

- To calculate the theoretical value of natural gas—and specifically LNG—in transportation applications relative to its alternative fuel

Model methodology for HDV tractor outlook

Start with Historical Fleet
Size of HDV Tractor Fleet
Categorize by PADD, Long Haul vs Regional, and vehicle miles travelled
Sources: IHS Polk, EIA, and 2002 Vehicle Inventory and Use Survey

Forecast HDV Tractor Sales
Sales based on:
- IHS Automotive Class 8 HDV Sales Growth Rate through 2026
- GDP post-2026, industry efficiency gains

Source: IHS Automotive

Truck Cost Differential
Diesel vs. CNG/LNG truck price
Fuel economy
Fuel and vehicle tax credits
Source: IHS

Fuel Price Differentials
Natural gas (domestic and imported)
Liquefaction, retail and tax
Ultra-low-sulfur diesel
Source: IHS Energy

Calculated By PADD & VMT Category

Calculated at the Fleet Level

Result

Forecast Fleet Profile
Fleet Size = sales minus retirements

CNG/LNG Attractiveness
CNG/LNG Penetration a function of:
- Payback period / VMT
- Previous Year's Fleet Penetration
- New Technology Acceptance

Source: IHS

HDV Tractor Fleet By VMT & Fuel Type:
Split HDV Sales by Fuel Type
- Diesel
- CNG Spark-Ignited
- LNG Spark-Ignited

Retirements by fuel type based on VMT
Total Fleet by fuel type

HDV Tractor Fuel Consumption by Fuel Type:
- Diesel
- CNG
- LNG

Total HDV Tractor Fuel Demand
- Diesel
- CNG
- LNG

Natural gas faces increasing competitive pressures in power generation

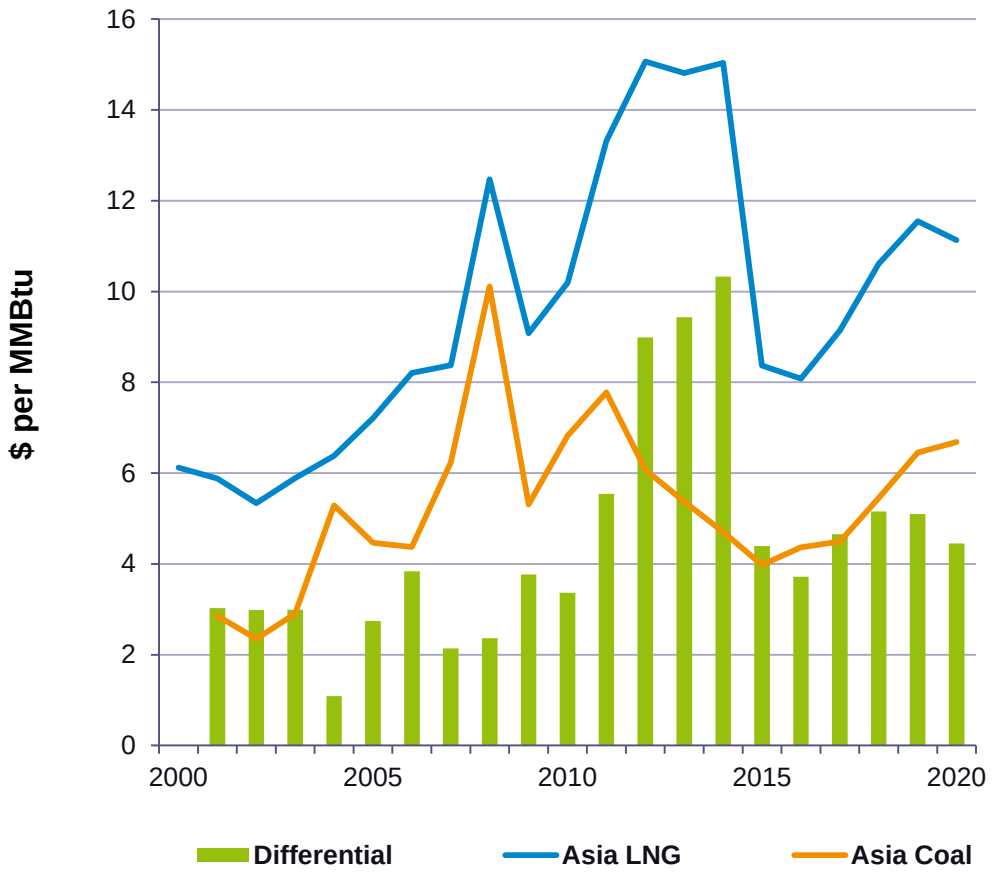
1. Coal will continue to be a highly cost competitive fuel for power generation
    - Unless it is explicitly mandated away or subject to high carbon penalties
    - Coal will be fuel of choice across most of Asia

2. The costs of renewable energy sources are coming down
    - Onshore wind already cost competitive if back-up costs not internalised
    - solar PV costs sharply down
    - Offshore wind the next frontier in Europe

3. As renewables deployment squeezes the ‘space’ for dispatch generation, the cost of gas-fired power increases
    - In Europe, where solar and wind technologies have been most deployed, the dispatch of CCGTs has been significantly reduced

1. The coal—LNG price differential will be higher than in the past, making coal a cost competitive option versus LNG

Coal (gas equivalent) Vs. Gas Prices

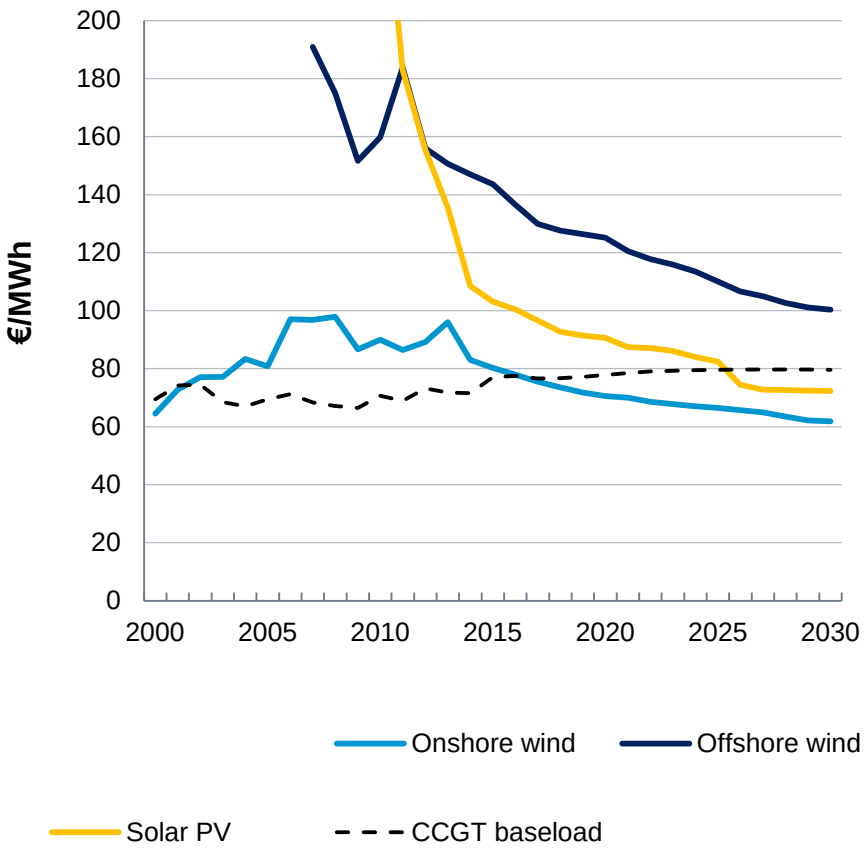


Source: IHS

- Between 2009 and 2014 the spread between coal and oil-linked LNG prices widened significiantly.
- This gap narrowed as oil prices fell even more than coal prices in early 2015
- However IHS expects coal prices to continue at approximately a $4 - $5/MMBtu discount to Asian LNG

2. The cost of renewable power generation is increasingly competitive, or rather, 'less uncompetitive': European example

LCOE - European Union



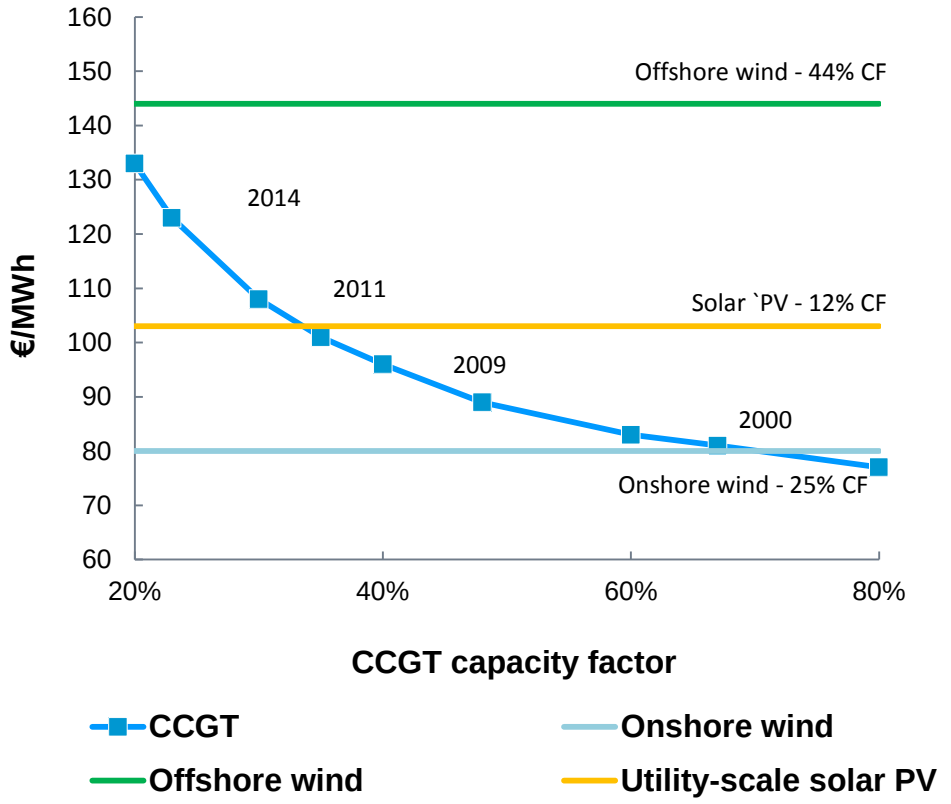
Notes: An LCOE cost comparison *overstates the economic competitiveness* of renewables because it does not take into account intermittency and back-up costs

Source: IHS

- The levelised cost of electrcity (LCOE) for onshore wind is comparable to the LCOE of CCGTs in Europe
- The LCOE of solar has declined significantly during this decade. Costs are projected to fall further, although at a lower rate
- Offshore wind is high cost although costs should decline with wider deployment
- Note: An LCOE cost comparison *overstates the economic competitiveness* of renewables because it does not take into account intermittency and back-up costs. But it does demonstrate recent *reductions in some renewable costs relative* to thermal power costs

3. As renewable deployment increases, the capacity factors for thermal generation decrease and the costs rise

LCOE - CCGT



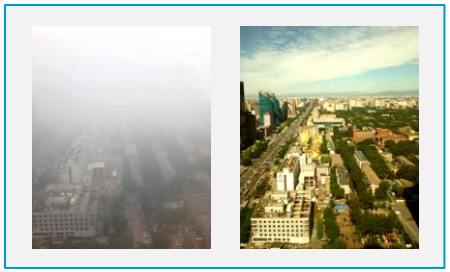
Notes: LCOEs are claculated as a function of capacity factor for CCGTs and represent 2015 values. LCOEs for onshore wind, offshore wind and solar PV are calculated as 2015 values with fixed capacty factors.
Source: IHS

- With an 80% capacity factor, CCGT has a lower LCOE than either wind or solar power
- However in Europe, the average capacity factor for CCGTs has declined in recent years as ‘must-run’ renewables have grown.
- Once capacity factors fall below 50% the LCOE of CCGTs rises rapidly.
- The commercial attractiveness of CCGTs will depend on capacity remuneration mechanisms

Three key enablers are coming together to push the case for natural gas in transport

Economic

- Natural gas expected to be priced at a large discount to oil in the long term
- Differentials in fuel prices create strong commercial incentive for switch to natural gas



Environmental

- Natural gas offers much lower harmful emissions in transport, even with increasingly strict fuel standards for oil
- Policies to improve air quality make a stronger case to move to natural gas

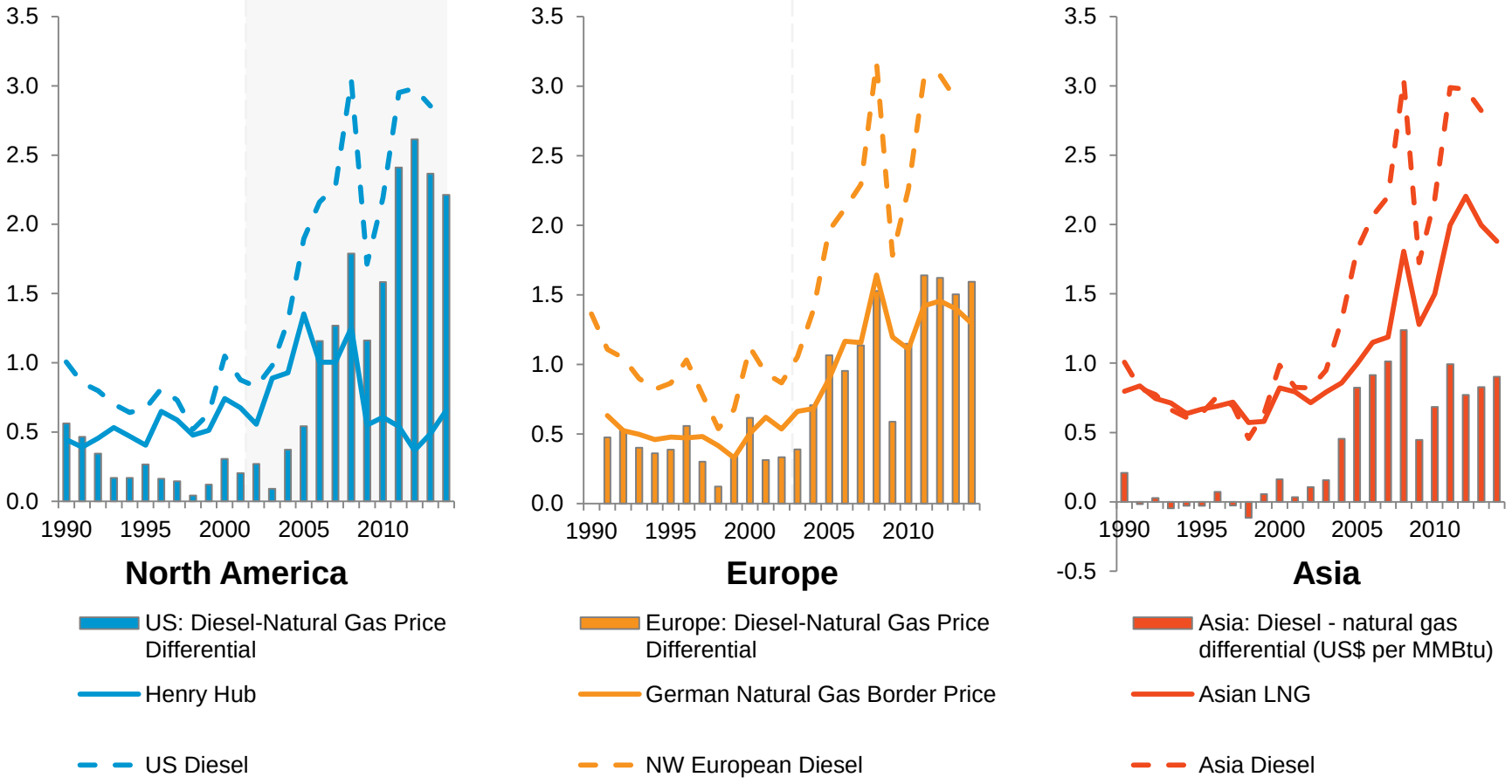
Technical

- Technology for natural gas engines has continued to develop, closing the performance gap to diesel
- New generation of vehicles are becoming more attractive for operators

Historical fuel price trends suggest a growing divergence between diesel and natural gas prices

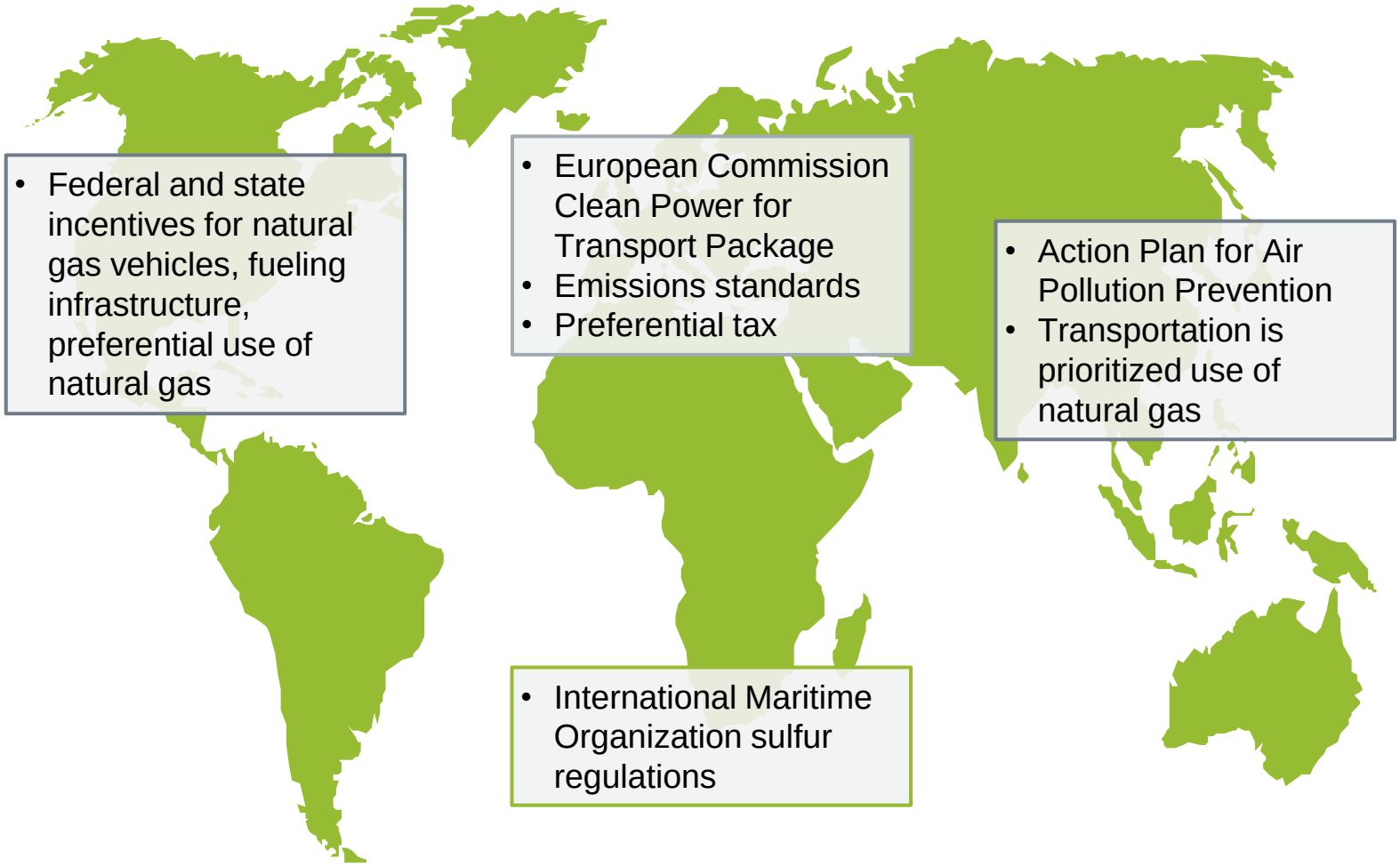
However 2014/15 oil price collapse makes investors cautious

Diesel and natural gas price outlooks—key regions (Real 2013 US$ per diesel gallon equivalent)



ULSD = Ultra-low sulfur diesel, ppm = parts per million. $1 per MMBtu = $0.13 per diesel gallon
Source: IHS Energy.

Why now?
The environmental case: A mixture of policy support and mandates

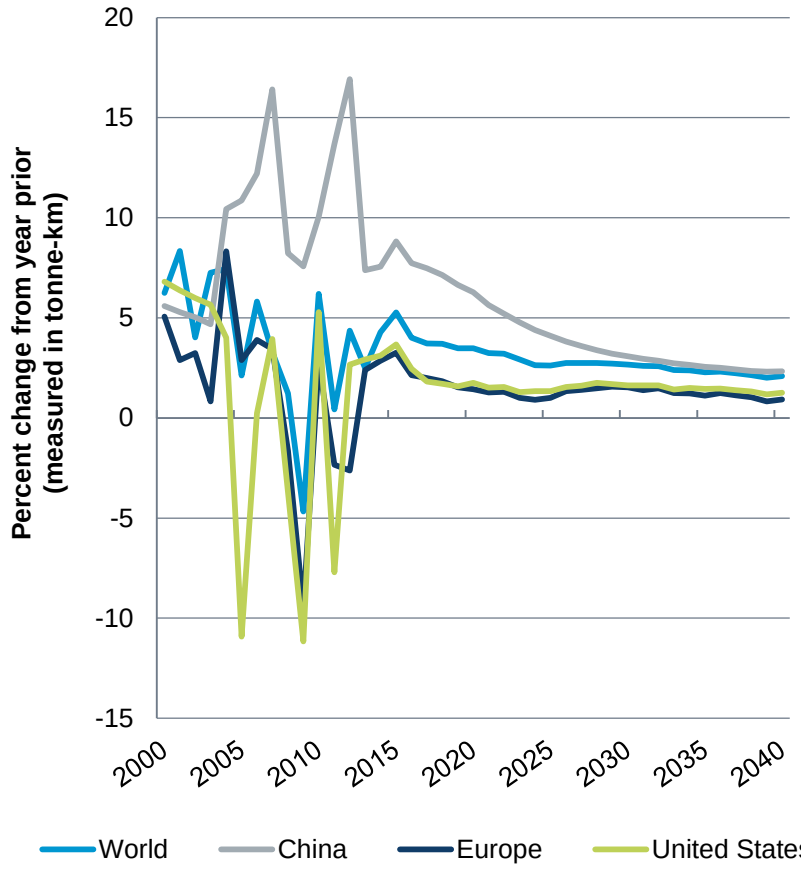


Overall economic health will continue to drive demand for road transport of goods

Real GDP Growth

Source: IHS Economics, July 2014

Growth in demand for heavy goods transport

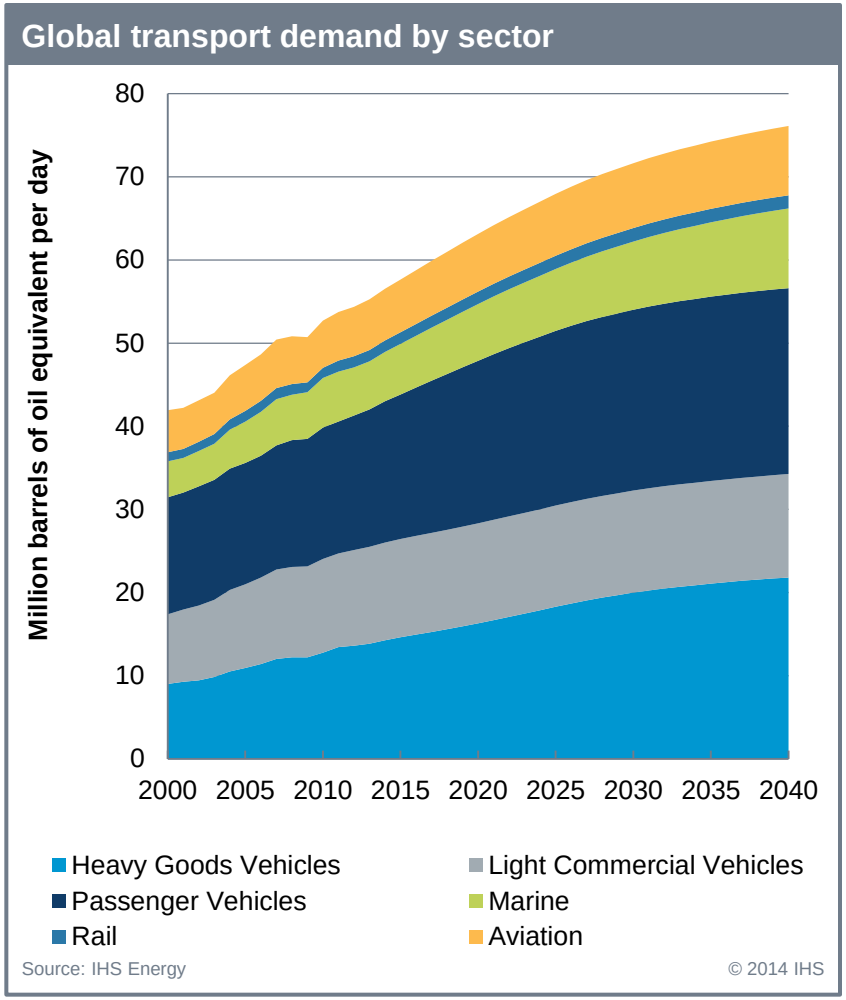


Source: IHS Energy

Global transport demand

- HGVs, marine bunkers and rail today account for
  - more than 20% of total oil demand
  - Almost 40% of transport demand
  - over $730 billion* in fuel consumption
- HGVs and bunkers—which would likely use LNG more than CNG--are expected to grow faster than other sectors, representing over half of incremental transport demand growth

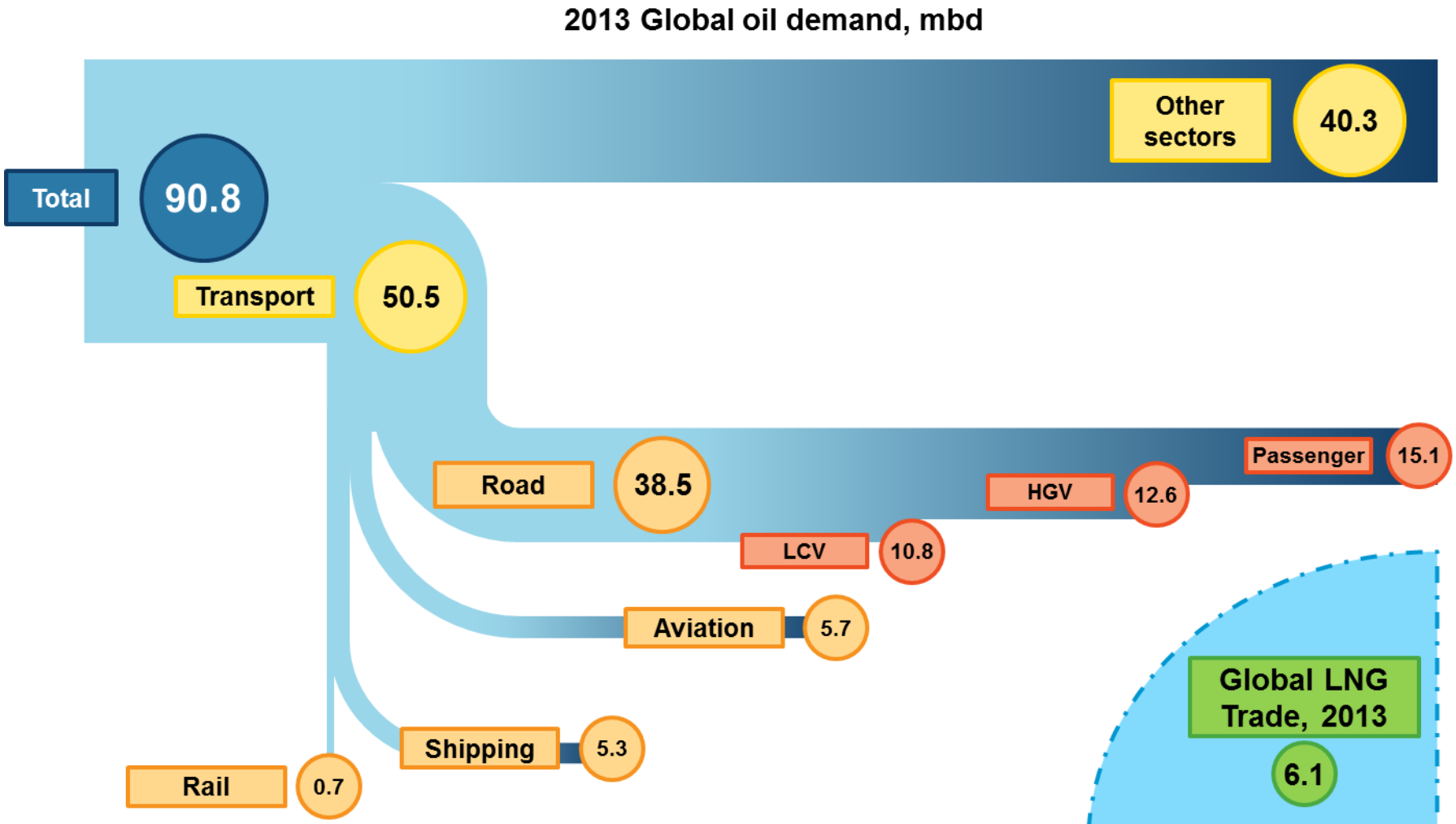
*Rough estimate based on Brent price of $108.66 per barrel of oil equivalent. Does not consider liquid fuel price differences.



Global transportation demand to reach 76 MMboe/day in 2040, an increase of 37% (21 MMboe/d) from 2013 levels.

Why transportation?

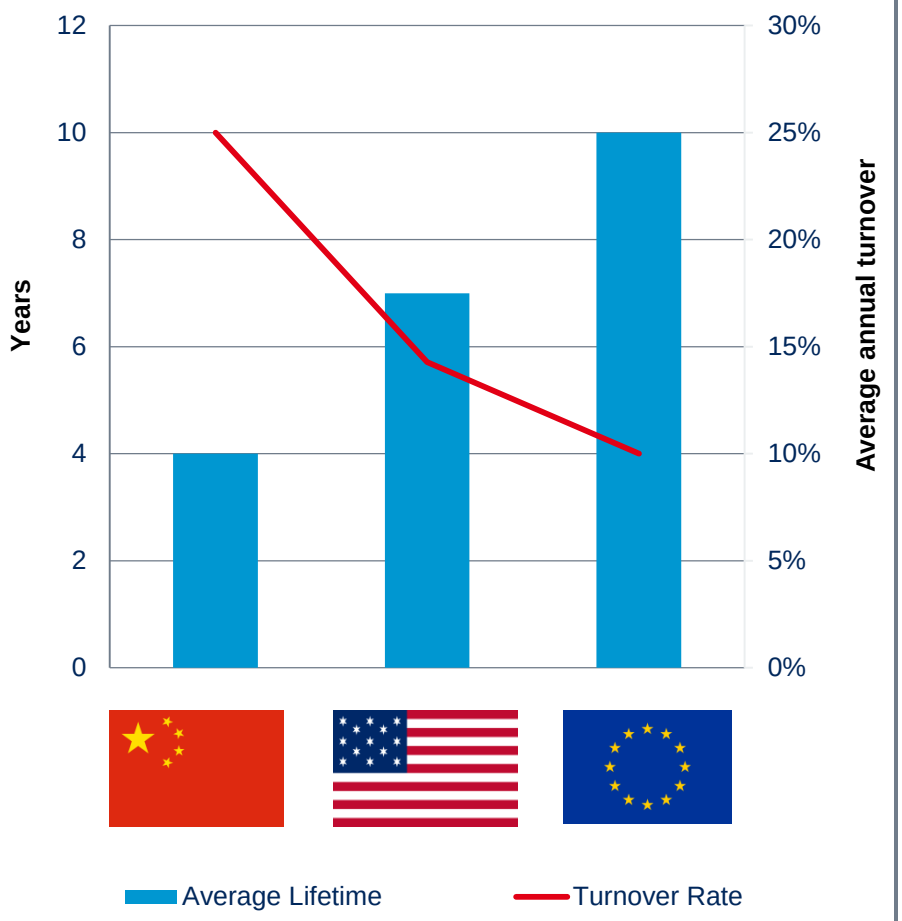
HGVs, marine bunkers and rail account for more than 20% of total oil demand



Source: IHS Energy. HGV = Heavy Goods Vehicles, LCV = Light Commercial Vehicles. Other transport demand of 0.1 mbd not shown.

Truck fleet has a rapid turnover outlook: How fast will LNG trucks penetrate the heavy-duty vehicle fleet?

Fleet turnover regionally varied

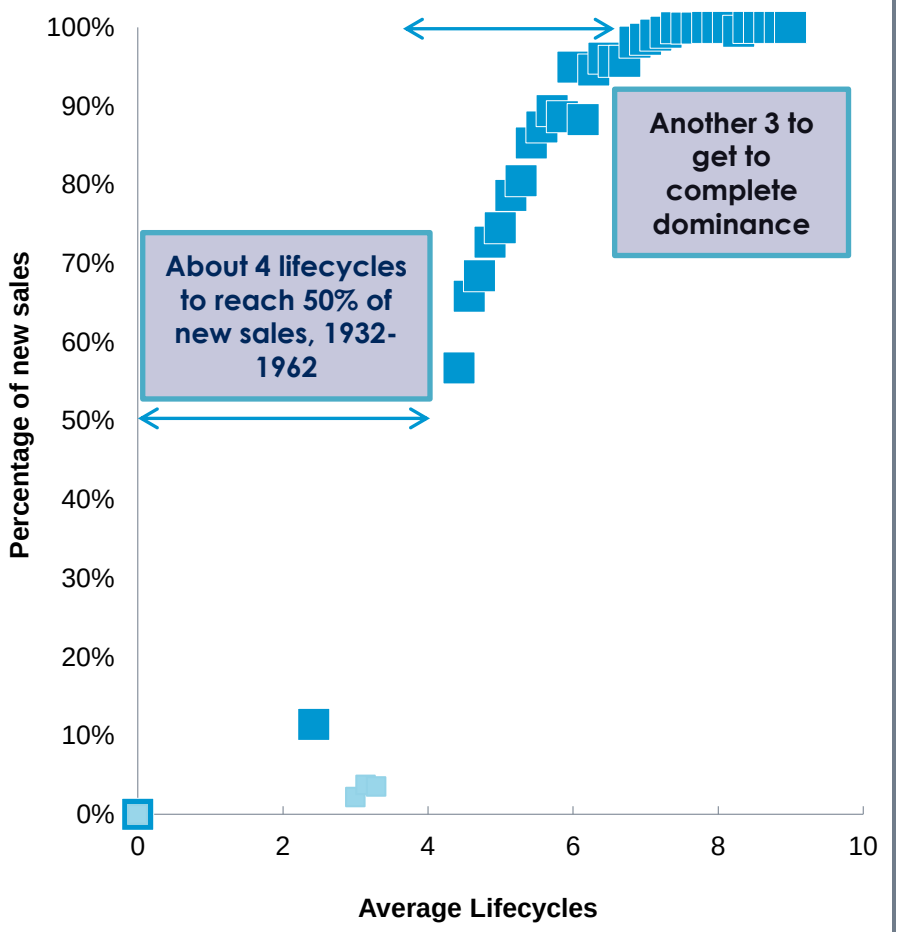


Source: IHS

- The relatively quick turnover of the truck fleet makes possible a rapid uptake of gas-fuelled solutions
- Most of the world's trucks for use post-2025 have not yet been built or ordered
- Trucks in China have an average life of approximately 4 years
- Trucks in the US have an average life of approximately 7 years
- Trucks in Europe have an average life of approximately 10 years

Historical examples of the shift to new fuels

Share of new diesel Class 8 truck sales in the United States

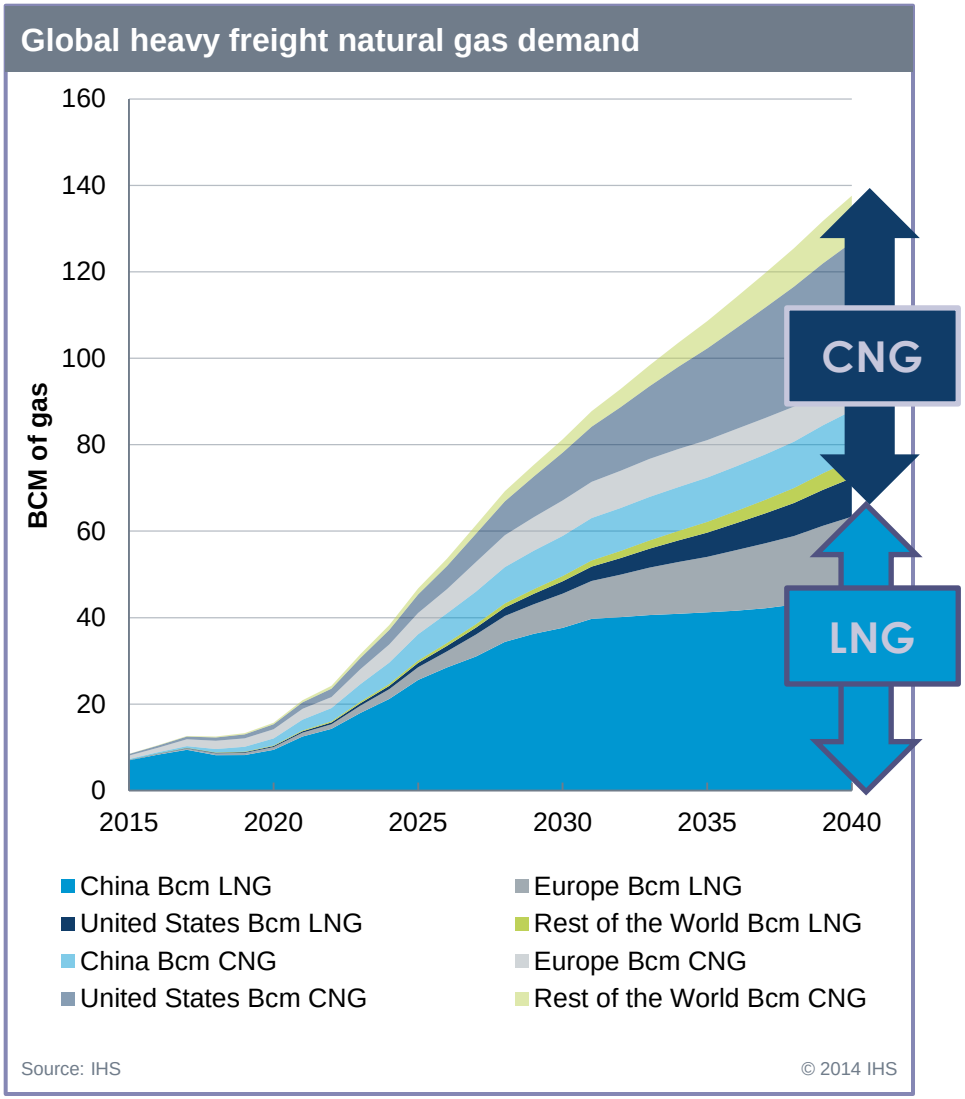


Source: IHS Energy

- The transition to NGVs will not happen overnight, but growth could be rapid
- Other transportation transitions (boats, trains) have completed in 4-5 lifecycles
- The switch to diesel in the US saw diesel take over 50% of the market after four turnovers of the fleet

Oil loses considerable market share to natural gas, but maintains its dominance (I)

Global outlook for natural gas in heavy freight

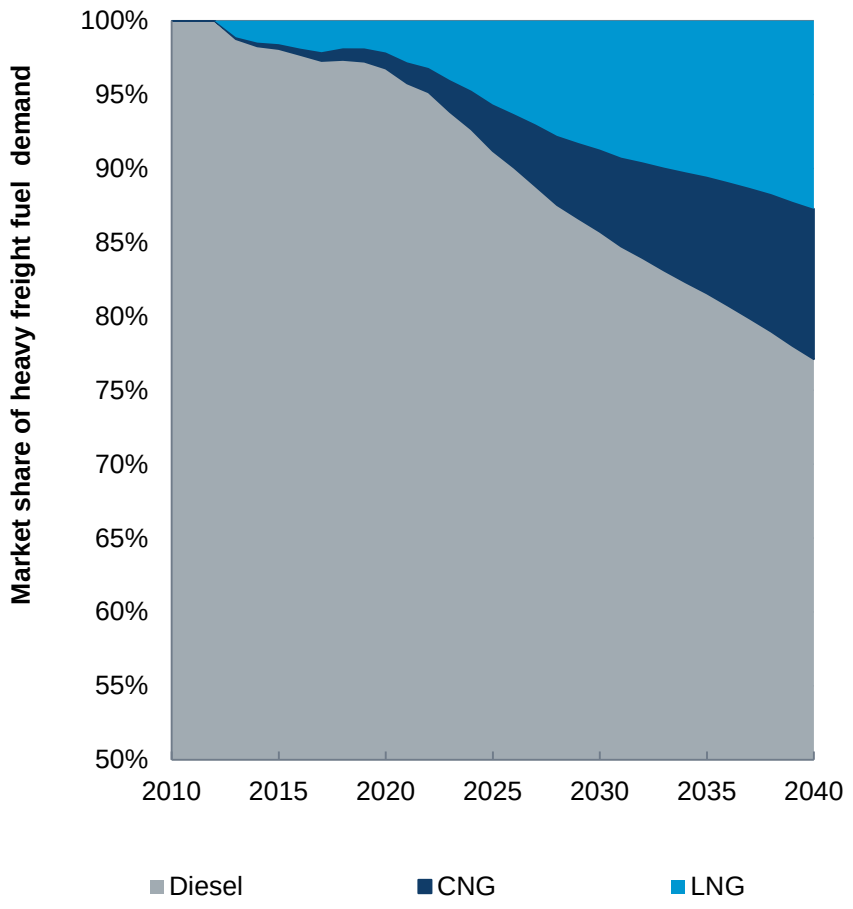


- By 2040 the total demand for natural gas in the HGV sector is projected to reach 138 Bcm
- China is expected to lead the way for deployment of LNG in trucks
- The United States is expected to opt more for CNG
- Europe will grow strongly after a slower start, subject to government decisions on excise tax levels

Oil loses considerable market share to natural gas, but maintains its dominance (II)

Global outlook for natural gas in heavy freight

Global heavy freight natural gas market shares



Source: IHS

- Diesel is projected to lose its monopoly position within the HGV sector.
- Diesel's share of this sector is forecast to drop to around 75% by 2040
- LNG is forecast to account for 13 percent by 2040
- CNG is expected to account for 10 percent

Two Case Studies

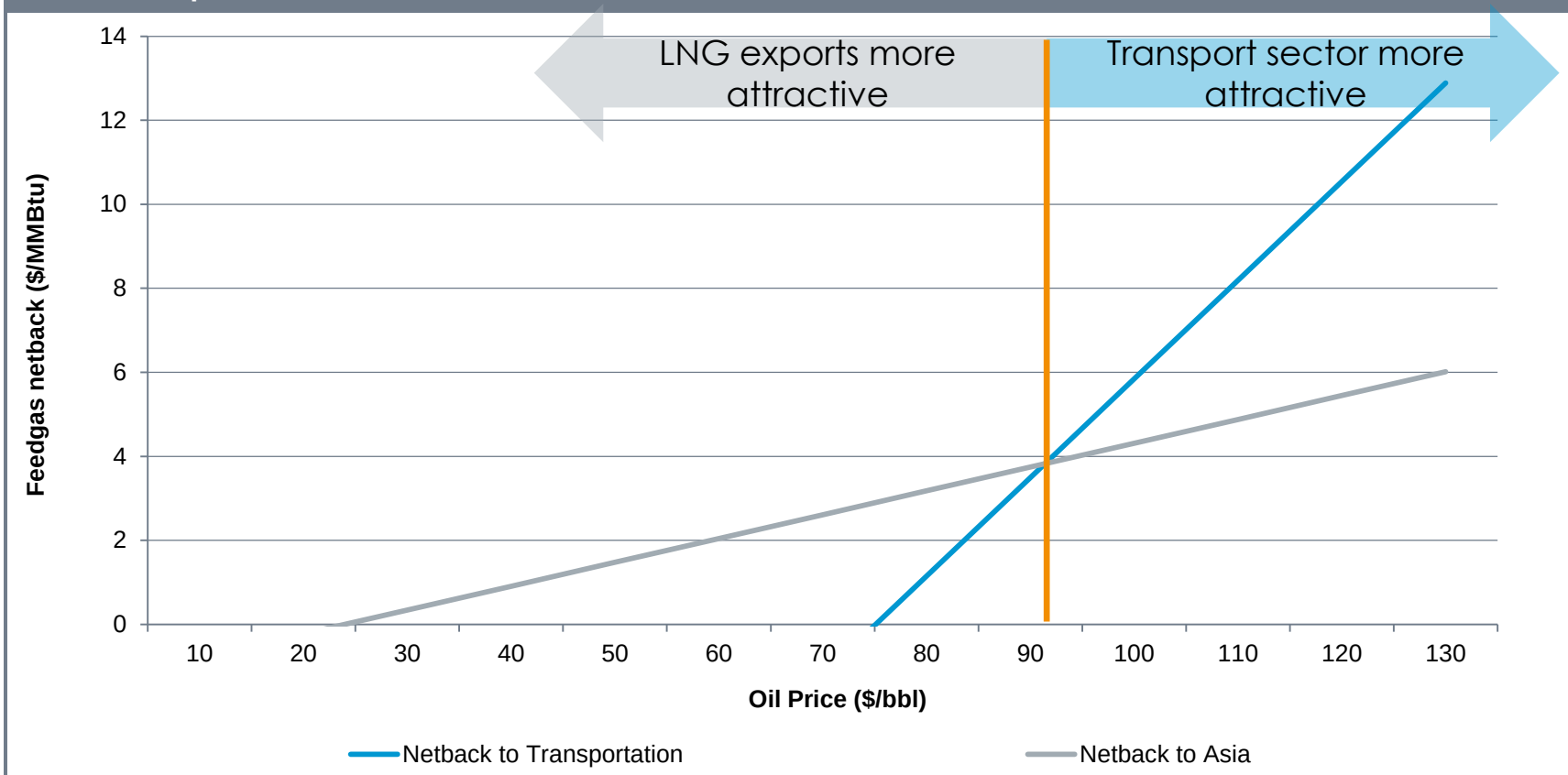
1. What is the netback value of gas if exported as LNG from the US versus if the LNG is sold domestically in the truck fleet?

2. What is the netback value of natural gas if used in trucks?

- The netback value of gas is shown relative to oil prices. LNG is competing with diesel, and a link between the diesel retail prices and the equivalent crude oil price is assumed
- Netbacks are shown for the US, for Europe (case of France), and for China

Case Study 1: US LNG exports vs US LNG Truck Sales

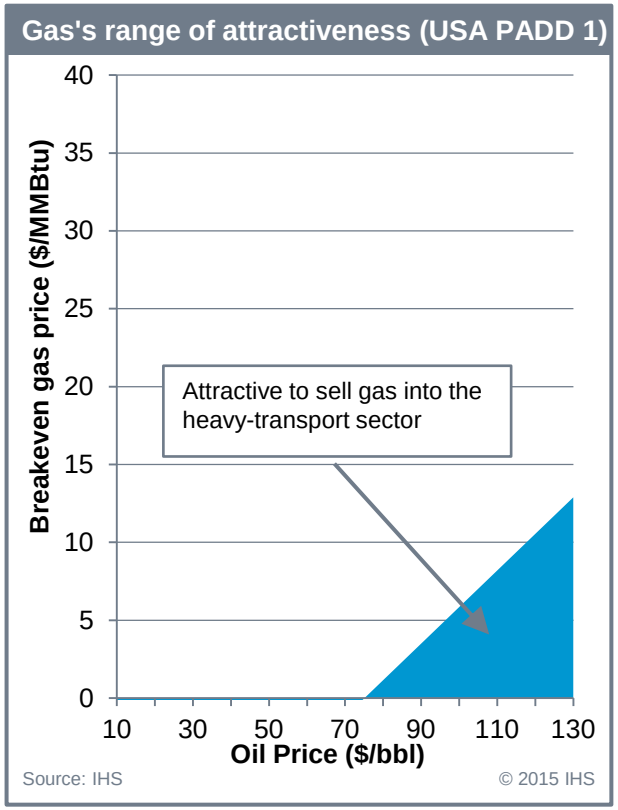
US LNG - export or domestic?

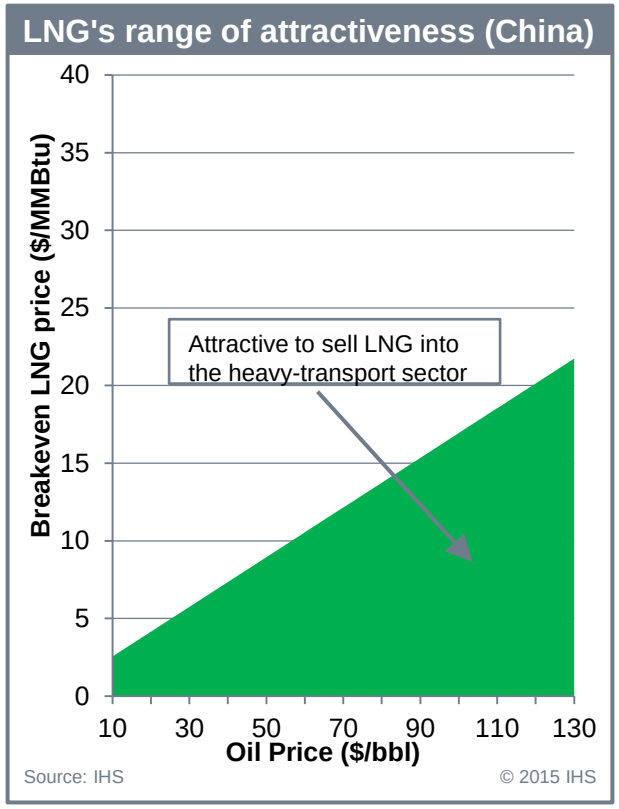


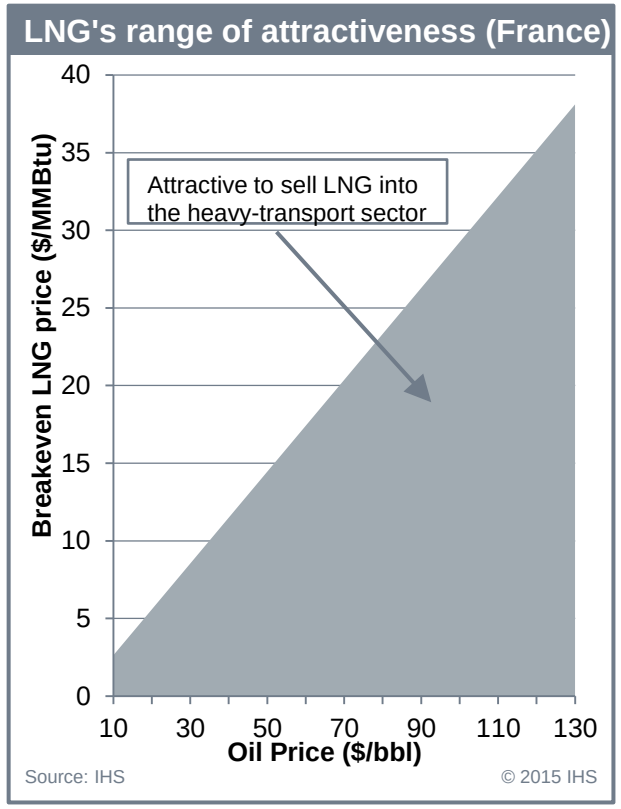
Notes: 3 year payback for a truck running 100,000 miles per year in the US . Diesl prices based on historical relationships with WTI (US). Incremental truck cost of $32,000. Fuel economy of 6.5 mpg (diesel) and 5.4 mp dge (LNG). Asian spot prices based on foreward looking relationship between spot prices and Brent. LNG shipping a function of oil prices. $3 liquefaction, 15% own use and fees.

Source: IHS

Case Study 2: The netback value of gas used in trucks







Notes: Three year payback for a "typical" truck (100,000 miles per year in the US, 90,000 in France and 40000 in China). Paybacks of 3 years in the US and France, 2 in China. Diesel prices based on historical relationships with WTI (US) and Brent (France, China). Incremental truck costs of $9,800 (China), $32,000 (US) and $40,000 (France). Fuel economy (diesel, LNG) of 6.5 and 5.7 in USA, 7.8 and 6.8 in France, and 5.9 and 4.9 in China. Negative feedgas price indicates 3-year payback not achievable at the specified annual mileage and incremental costs.

Market Conclusions

- The main growth market segment for natural gas globally will be power
- However, natural gas faces strong and diverse competition in the power sector, with significant downside risks to growth and value drivers
- The demand for gas in the transport sector will be relatively small. However it has significant upside growth potential and in certain cases it can offer more attractive netback values
- The case for gas in transportation is supported by environmental, economic and technology drivers
- While the volumes of gas in transport are only a small percentage of total gas demand, the volumes of LNG in the HGV and shipping market could be a significant percentage of incremental LNG growth.
- IHS estimates
    - gas demand in HGV and marine transport will be 98 Bcm by 2030
    - LNG demand in HGV and marine sector will be 48 mt by 2030
- With a large overhang of potential LNG projects relative to conventional demand outlets, producers need to catalyze development of the HGV and marine markets