

# Development of CNG Market Using Flared Gas

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## Why consider CNG?

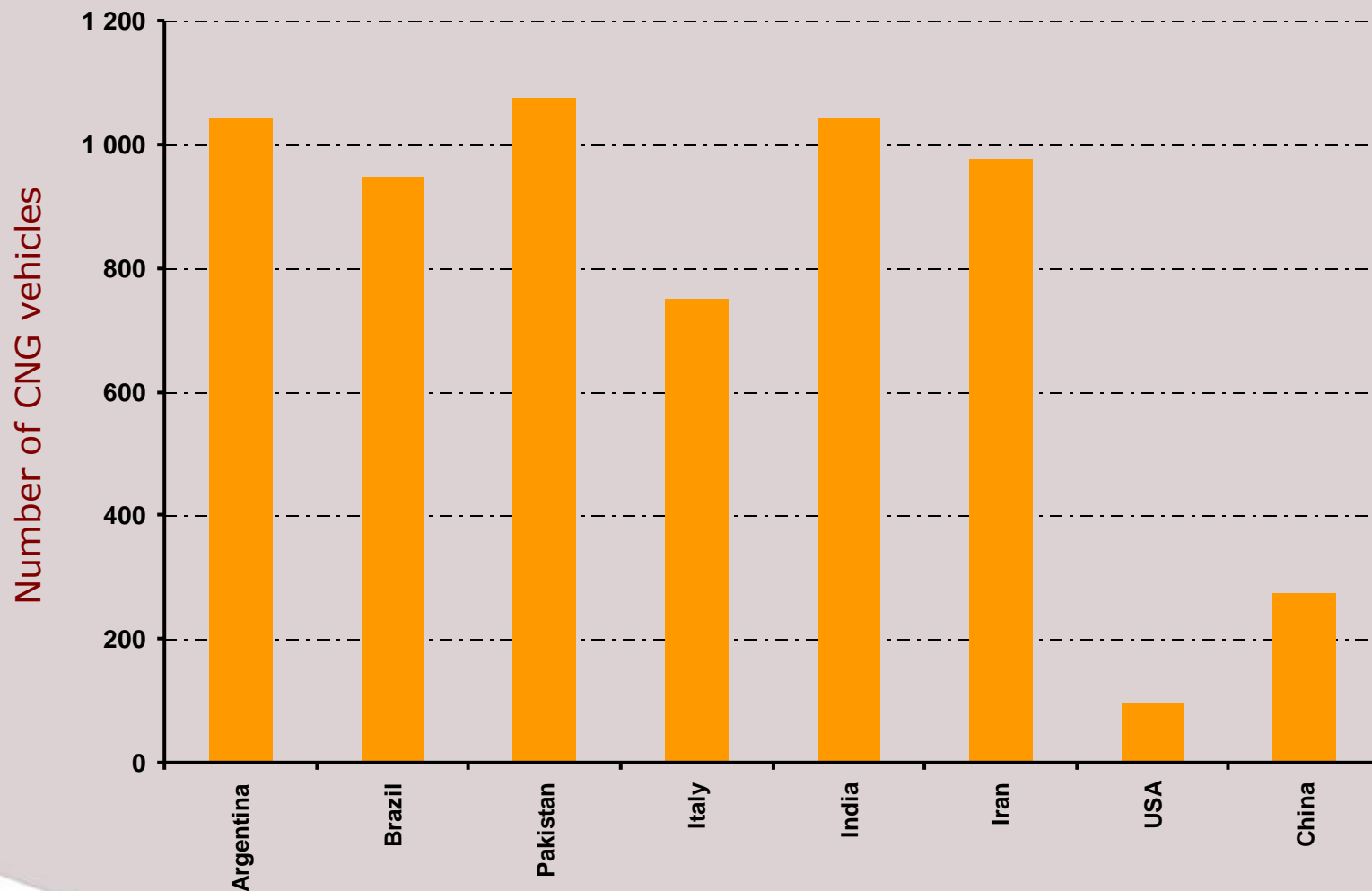
- Fuel diversification
  - Historical reason for switching to CNG (Argentina)
- Reducing emissions of harmful pollutants
  - Much lower emissions of small PM, and non-methane HC compared to conventional diesel, two-stroke engine gasoline, or old-technology gasoline vehicles
- Potentially cheap alternative fuel if flared gas is used
  - Fuel cost can be small or even negative

# Eight largest CNG markets



Source: IANGV

# Eight largest CNG markets: # of vehicles per filling station



Source: IANGV

## Technical benefits of CNG vehicles

- Very low particulate emissions
- Very low emissions of airborne toxins
- Negligible sulfur-containing emissions
- Quieter operation than diesel
- Less vibrations than diesel
- Less odor than diesel

## Disadvantages of CNG

- Much more expensive fuel distribution and storage
  - Suited for fleet vehicles that all “come home”
- Higher vehicle cost, primarily due to higher cost of fuel cylinders
- Shorter driving range
  - Problematic for public transport vehicles or if there are few fueling stations
- Heavier fuel tank, reducing fuel economy and leading to greater braking distances
- Potential performance and operational problems compared to liquid fuels

## Economics of CNG

- Baseline is gasoline or diesel
- Incremental cost of procuring CNG vehicles must be recovered by lower operating costs
- Maintenance costs can be higher
  - Lower fuel cost (*fuel price + cost recovery for refueling stations*) critical to making CNG economic
- Suited especially for regions importing gasoline and diesel, or where natural gas is very cheap

# Barriers to CNG uptake

- Fuel pricing policy
  - Highest taxes are generally levied on gasoline
  - Taxes on diesel often much lower in developing countries: economy-wide effects of high diesel prices
  - Low CNG prices are achieved through tax differentiation
- Switching from diesel to CNG, aside from price considerations, is technically challenging

## Switching from gasoline to CNG

- Same spark ignition technology
- Conversion of existing gasoline vehicles by far the most prevalent form of CNG use in transport
- Conversion from two-stroke gasoline to four-stroke CNG provides large environmental benefits
- Little or even negative environmental benefits of conversion when compared to modern technology gasoline  $\Rightarrow$  OEM

## Switching from diesel to CNG

- Conversion not recommended: going from compression ignition to spark ignition
- Low diesel fuel taxes make it difficult to make the switch financially viable
- Consistent reports that CNG buses from the early 1990s did not perform as well as their diesel equivalents
- Experience with current technology is mixed:
  - Not positive in NY City
  - More positive in Washington DC

# Use of flared gas for CNG

- Advantages

- Price of gas less correlated with world oil prices than traded gas
- Higher world oil prices increase attractiveness of CNG

- Disadvantages

- Has all other disadvantages of CNG
- Economics are adversely affected by the absence of a gas distribution system

## Large quantities of flared gas

- Examples: Iraq, Nigeria
- First call on natural gas will be power and other large applications
- But with enough surplus natural gas, potential for development of large-scale CNG market
- Compare economics of exporting gasoline/diesel/crude oil and developing CNG market vs. exporting natural gas and exporting less gasoline/diesel/crude oil

## Small quantities of flared gas

- Very low economic opportunity cost for gas
- Localized use only? If long-distance pipeline construction can be justified, other uses of natural gas are likely to be more economic
- Economics could become favorable if liquid fuels have to be trucked long distance and natural gas is close by
- Fleet operators
- Bi-fuel vehicles an alternative, although vehicle not optimized for either fuel
- Start off with gasoline to CNG?

## Environmental benefits of CNG

- Main driver for CNG mandates in India
- Particulate emissions (*to which diesel and two-stroke engine gasoline vehicles contribute*) the greatest threat to public health from urban air pollution in developing countries
- CNG substantially reduces particulate emissions compared to conventional diesel and old gasoline technology

Fuel	CO	NOx	PM
Diesel	2.4 g/km	21 g/km	0.38 g/km
CNG	0.4 g/km	9 g/km	0.01 g/km
<b>% Reduction</b>	<b>84</b>	<b>58</b>	<b>97</b>

# Experience of NY City Transit

- 5-year experience reported in 2000
  - Only 50-75% as reliable as comparable diesel buses
  - 41% less energy efficient in urban service
  - Significantly more expensive to operate
    - Maintenance \$0.13/km more
    - Fuel cost \$0.10/km more
    - \$5 million/depot for refueling (30 buses/hour)
    - \$10-40 million/depot for safety modifications

## Experience of Washington DC Transit

- Evaluation published in 2006 for buses delivered in 2000 and 2001
  - Fuel economy 17% lower
  - Maintenance costs 12% (CWI) and 2% (Deere) lower
  - CWI more reliable than diesel, Deere less reliable
- Total operating cost (\$/mile)

Bus	Fuel	Maintenance	Total
Diesel	0.47	0.59	1.06
CWI	0.57	0.52	1.09
Deere	0.56	0.58	1.14

## Making diesel-to-CNG switch a success



- Champion in the early days
- Dedicated OEM
- Awareness raising
- “Training, training, and more training”
- Commitment of management
- High-usage vehicle fleet operators exploiting economies of scale in all aspects (refueling stations, maintenance staff training, etc.)
- Adequate safety and performance standards that are monitored and enforced
- Fuel pricing policy that makes CNG financially viable

# Conclusions

- Rising world oil prices should make use of flared gas for CNG more attractive
- Economics depend on each specific situation:
  - Is it costly to bring gasoline or diesel to the location?
  - Are the fuels that CNG is displacing taxed reasonably or heavily?
  - Are there captive fleets that do not travel outside the town? Or would bi-fuel make sense?
  - What is the cost of vehicle conversion or purchasing new dedicated CNG vehicles?
  - Are there mechanics who can maintain CNG vehicles, or who are capable of being trained?
  - What is the cost of constructing a refueling station?
- Do a quick analysis, and, if promising, follow up with a feasibility study