Using Natural Gas To Improve Air Quality

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Natural Gas & Air Quality Improvement Opportunities

> Natural gas can provide significant air quality improvements in all end use sectors
  - Homes and commercial businesses
  - Industrial manufacturing
  - Power generation
  - Transportation

> Tighter emissions standards, regional air quality programs, and incentives are options to bring about ambient air quality improvements
U.S. Urban Air Quality Challenges
Los Angeles, CA

- Nearly 40% reduction in ozone concentration
- Over 45% less particulate matter emissions

Achieved through:

- Tighter emission standards and controls
- Incentive programs
- Using of natural gas & renewables in place of coal and diesel/fuel oil
China Environmental Challenges Driven By High Coal Use

> China’s remarkable growth has relied heavily on coal

> Coal has multiple societal impacts:
  
  ─ Local air quality:
    > Nitrogen oxides (NOx)/ozone
    > Particulate matter
    > Sulfur dioxide
    > Other pollutants (e.g., mercury)
  
  ─ Mine safety
  
  ─ Rail and road transportation impacts
<table>
<thead>
<tr>
<th>Efficient Use of Natural Gas in Homes and Businesses</th>
<th>Natural Gas for Manufacturing Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Space Heating</td>
<td>• Chemical/Petrochemicals</td>
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<tr>
<td>• Water Heating</td>
<td>• Iron &amp; Steel</td>
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<tr>
<td>• Cooking</td>
<td>• Glass, Cement</td>
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<td>• Drying</td>
<td>• Pulp &amp; Paper</td>
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**Less emissions & primary energy loss compared to electric resistance equipment**

<table>
<thead>
<tr>
<th>Efficient, Clean Natural Gas Power Generation</th>
<th>Clean Natural Gas Vehicles</th>
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</thead>
<tbody>
<tr>
<td>• Combined-Cycle Gas Turbine Plants</td>
<td>• On-road (buses, trucks)</td>
</tr>
<tr>
<td>• Combined Heat and Power (CHP) Systems</td>
<td>• Off-road (rail, mining)</td>
</tr>
</tbody>
</table>

**Reduce coal use to improve air quality**

<table>
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<tr>
<th>Clean Natural Gas Vehicles</th>
<th>Avoid emissions from diesel and fuel oil to improve air quality</th>
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Direct Natural Gas Use In Homes & Businesses

Large energy losses and air quality impacts in producing electricity. Direct gas use much more efficient than electric resistance heating.

Source: GTI (source to site efficiency, natural gas: 91.9%, electric: 32%)
Natural Gas Is Dominant Energy Choice For U.S. Manufacturing

Major uses: chemicals, petrochemicals, iron & steel, food, pulp & paper, and glass manufacturing

EIA Manufacturing Energy Consumption Survey (MECS), 2010
Natural Gas for Chemical and Petrochemical Industries

- Natural gas can play a greater role in China’s chemical and petrochemical industries – replace coal or naphtha-based processes
  - Methane as a chemical feedstock
  - Process heating
  - Steam generation
Ultra-Low NOx Industrial Burners

> Low-NOx (<30 ppm) natural gas burners
  — Ultra-low NOx burners <9 ppm for Southern California and other high ozone regions

> For boilers, steel reheat and heat treating furnaces, refinery process heaters, glass furnaces, etc

ALZETA CSB Ultra Low NOx Burner (Boilers)

Power Flame Ultra Low NOx Premix Burner (Process Heating, Boilers)

Eclipse PrimeFire 400 Low NOx, High Luminosity Burner (e.g., glass manufacturing)
Glass Manufacturing and Oxy-Gas Combustion

> High-Temperature Furnaces
  - Oxygen-Enriched Air Staging
  - High Luminosity Burner (PrimeFire 400 from Eclipse)
  - Used in glass manufacturing, other high-temperature processes
  - Includes ultra low-NOx combustion techniques to minimize emissions
Blast Furnace Gas Injection

> Natural gas can be used as a supplemental energy and chemical reducing agent for ironmaking blast furnaces.
MIDREX Direct Reduced Iron (DRI) Process

The Midrex process

Flue Gas

Natural Gas

Process Gas System

Top Gas Scrubber

Shaft Furnace

Iron Oxide

Flue Gas Compressors

Reducing Gas

Fuel Gas

Natural Gas + O₂

Reformer

Main Air Blower

Reducing Gas

Feed Gas

Combustion Air

Natural Gas

Ejector Stack

Heat Recovery

Midrex Direct-reduced Iron

Cooling Gas Compressor

Cooling Gas Scrubber

Natural Gas
Natural Gas Central Power Generation

> High-efficiency natural gas turbine combined-cycle power plants can achieve 50-60% efficiency (LHV)
  — 38-45% in simple-cycle mode

> With advanced combustion and emission controls, can achieve exceptionally low NOx emissions

> Newer flexible, fast-response gas turbines allow for load following

Flexible, fast-ramp-rate gas turbines
Photos courtesy of GE
Major Emission Benefits When Shifting From Coal To Natural Gas

1. Power Generation Technical Performance Advantage

<table>
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<tr>
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<th>Efficiency</th>
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<tr>
<td>Coal</td>
<td>~35-40%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>~50-60%</td>
</tr>
<tr>
<td>Combined Cycle</td>
<td>~50-60%</td>
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% Improvement: ~40-50%

2. Fuel Attribute Advantage*

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<tr>
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<th>kg CO2/KJ</th>
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<tr>
<td>Coal</td>
<td>88.1</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>50.3</td>
</tr>
<tr>
<td>% Lower</td>
<td>43%</td>
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* Can vary depending on coal properties.

Together, technical & fuel factors result in a 55-63% reduction in carbon dioxide emissions per kWh produced.

Using natural gas also significantly improves local air quality – lowering ozone, particulate matter, and SO₂ levels.
Natural Gas Co-Firing and Reburn Technology

> Natural gas as an add-on supplemental fuel with coal boilers to reduce emissions
  - Lower NO\textsubscript{x}, SO\textsubscript{x}, particulate matter, CO\textsubscript{2} emissions
  - Reburn can drop NOx emissions by 50-60% while displacing 10-20% of coal firing
  - Can be used on a seasonal or temporary basis

> U.S.-based Breen Energy Solutions is one supplier

www.breenes.com
Natural Gas Combined Heat and Power Systems

> Onsite CHP systems can provide high overall efficiency (60-80%)

> Provide thermal energy for industrial operations (e.g., hot water, steam, process heating)

> More efficient and less polluting than coal power generation
Natural Gas for Transportation

On-Road

- Buses
- Refuse
- On-Road Trucks
- Light-Duty Trucks/Trades
- Police/Taxi
- Light-duty Cars

Dedicated NGVs or dual-fuel (diesel/natural gas) systems
NGVs For Off-Road Uses

Marine
- Tug/Towboats
- Ferries
- Cargo & Tankers

Locomotive Rail
- Freight
- Passenger
- Switcher units

E&P/Mining
- Gas/Oil Drill Rig & Material Movement (water, sand, pipe, etc)
- Other mining operations

Material Handling
Air Quality Improvement Programs
Shanghai Natural Gas Clean Energy Study

> GTI worked with Shanghai Gas Engineering Design & Research Co. to assess potential emission reductions through coal and fuel oil displacement with natural gas

> Included comprehensive assessment of current and future technology, emissions characteristics, and environmental cost-effectiveness

> Findings point to major opportunities for lowering NOx, particulate matter, and SOx emissions
  — Primarily resulting from coal displacement in power and industrial sectors
Shanghai Natural Gas Clean Energy Study: NOx Emissions

Avoided NOx Emission

- Power generation
- Industrial Heating and CHP
- Coal Displacement
- Direct Combustion
- Taxi
- City Bus
- Inland River Shipping
- Industrial Heating
- Heating Oil

[Graph showing avoided NOx emissions for different sectors and sources, with data points for low, medium, and high scenarios.]
Shanghai Natural Gas Clean Energy Study: PM Emissions

Avoided PM2.5 Emission

- Power generation
- Industrial District Heating and CHP
- Direct Combustion
- Coal Displacement
- Taxi
- City Bus
- Inland River Shipping
- Industrial Heating
- Diesel
- Heating Oil
Summary

> Improve air quality by displacing coal, fuel oil, & diesel

> Natural gas low-emission benefits in all market sectors
  
  – **Homes and businesses**: direct use in place of inefficient electric resistance heating devices
  
  – **Industrial manufacturing**: for process heating, steam generation, chemical feedstock
  
  – **Power generation**: natural gas combined cycle, natural gas reburn with coal, onsite CHP systems
  
  – **Transportation**: displace diesel and fuel oil

> New systems as well as add-on solutions using natural gas to supplement existing coal or oil equipment

> Shanghai Natural Gas Clean Energy study points to significant emission reduction potential
Thank You!

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