Towards Recovery and Shared Prosperity;

Natural Gas Opportunities for a Sustainable World

IEF-BCG Background Materials Session 1
Panel Session 1:
Opportunities in Growing Gas Markets:
Producer Consumer Perspectives on New Realities
Towards Recovery and Shared Prosperity
Disclaimer

The observations presented herein are meant as background for the dialogue at the 7th IEF-IGU Ministerial Gas Forum hosted by the government of Malaysia. They have been prepared in collaboration with Boston Consulting Group and should not be interpreted as the opinion of the International Energy Forum or Boston Consulting Group on any given subject.
Market Context

- The Global LNG market is heavily affected by the COVID-19 pandemic, with mixed mid-term outlooks, but strong long-term market fundamentals for gas growth.
- Gas is expected to play a key role in energy transition but requires collaboration and support.

Session Objectives

Exchange perspectives on COVID-19 impacts on projected gas demand and supply and global trade with focus on Asian growth markets.

Key Questions

COVID-19 Impact and Market Outlook
- How does COVID-19 impact gas markets across world regions?
- How do natural gas prospects differ in Asia (China, India, ASEAN), the Middle East, and Africa?

Role and Importance of Gas in Energy Transition
- Will the downturn in global economic growth limit gas demand/options for coal to gas switching?
- How can ministers best leverage abundant and more flexible gas supplies in clean recovery strategies?
- Will better economics of coal and renewables or the quest for hydrogen limit or add opportunities?

Enablers for governments to unleash gas potential
- What should governments focus on, to reduce hurdles and advance global natural gas trade?
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   Pages 6 - 18

2. Role and Importance of Gas in Energy Transition
   Pages 19 - 32

3. Enablers for Governments to Unleash Gas Potential
   Pages 33 - 44
COVID-19 Impact and Market Outlook
COVID-19 pandemic impacted the gas demand differently in each key gas market

H1 2020 vs. H1 2019 gas consumption growth/decline in key gas consuming markets

- Spain: -13.0%
- Malaysia: -13.0%
- Italy: -10.8%
- Thailand: -10.0%
- Indonesia: -9.7%
- Japan: -5.7%
- US: -2.2%
- India: -1.8%
- China: 4.0%
- S Korea: 5.9%
- Taiwan: 13.7%

Malaysia, Indonesia and Thailand numbers based on Press search and projections

Source: Press search, BCG LNG market model
Global LNG demand for 2020 is expected to stay flat at the best, compared to 2019

Perspectives on global LNG demand in 2020

Source: BCG LNG market model
In the longer term some fundamental demand drivers at play as before COVID-19

**Looming upstream oil and gas investment crisis**
- Global gas markets expected to become more volatile and limit exports from US
- More stringent ESG and environmental policy requirements can widen the demand gap and deepen gas market deficits

**Primary energy demand growth**
- Economic development in Asia a critical enabler of market growth
- In developed markets stagnating energy demand will slow gas demand growth

**Fuel switching, driven by policy and technology developments**
- Regulatory ambitions to decommission coal-fired power generation and nuclear generation remaining unchanged (particularly in Europe), growing gas relevance within the power and industry mix and possible pressure
- Open question on strong renewable capacity installation vs. gas growth potential (to replace share of coal in energy mix)

**New investments on gas and downstream infrastructure**
- Capacity and willingness of governments and investors to develop new capacity for gas access and consumption

**Investments incurred in new regas capacity in niche markets, to add new destination market**
- 20+ Mtpa in regas capacity in new markets under construction or with FID take

**Small Scale LNG businesses and LNG for mobility to continue to contribute**
- SSLNG in remote areas (e.g. Brazil), LNG bunkering, LNG long-haul trucking, etc.

Source: BCG analysis
Non-OECD Asia will remain the greatest but more uncertain driver of demand growth

Global LNG demand low case

Global LNG demand base case

Global LNG demand high case

Incremental gas demand growth in Emerging Asia 2019-2025

Note: European countries defined as EU 28, Norway, Switzerland, Turkey, and Central Europe; non-OECD Asia covers China, India, selected ASEAN countries
Source: IMF, IEA, GIE, Eurostat, Cedigaz, BNEF, BCG analysis
## Impacts of COVID-19 on long term outlook are mixed so far (1/3)

### Signposts to watch

<table>
<thead>
<tr>
<th>Country</th>
<th>Issues</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>State of coal switching policy, Pace of infrastructure build out, Success of midstream market liberalization</td>
</tr>
<tr>
<td>India</td>
<td>Scale of CGD investment, Level of fuel switching in power sector, Gail spinoff of transmission assets</td>
</tr>
<tr>
<td>Japan</td>
<td>Scale of coal plant retirements, Nuclear power policy, Local gas distribution liberalization</td>
</tr>
<tr>
<td>South Korea</td>
<td>Pace of coal shutdowns, Nuclear power policy</td>
</tr>
<tr>
<td>Myanmar</td>
<td>Pace of regasification infrastructure investment, Market deregulation and reform</td>
</tr>
</tbody>
</table>

### Evidence to date is mixed

- **Fuel switching slowdown**: China slowed its coal switching program during 2019 trade war; Unclear how govt. will respond in COVID-19 aftermath
- **Regas delays**: Five new LNG regasification terminals and two terminal expansion projects have been delayed to 2021
- **Increased fuel switching**: Low LNG prices have stimulated coal-to-gas switching in the power sector; Sustainability unclear
- **CGD investment viability**: Uncertainty around the ability of investors to mobilize capital and around the regulated rates set by Government
- **Nuclear delays**: Several nuclear restarts faced safety upgrade work delays
- **Coal fleet turnover**: In July Japan announced that it will accelerate the closure of 100 coal units, but replace them with new more efficient coal plants
- **Proposed carbon price**: Proposed Korean Green New Deal would create carbon tax, making gas more competitive against coal
- **Myanmar gas-to-power project**: Developing 4,000 MW of LNG-to-power projects as natural gas imports rise in response to reduced hydroelectric supply and declining domestic gas production
- **Fallout of COVID**: Unclear how COVID will affect gas infrastructure development

### Source

Press reports, BCG analysis
### Impacts of COVID-19 on long term outlook are mixed so far (2/3)

<table>
<thead>
<tr>
<th>Country</th>
<th>Signposts to watch</th>
<th>Evidence to date is mixed</th>
</tr>
</thead>
</table>
| **Malaysia** | • Upcoming New Energy Policy  
            • Upcoming Gas Roadmap | **Gas-based growth**: Expected to embrace and develop thermal (gas) power capacity growth for the next decade, focus on renewables, increased gas consumption for industrial and petrochemicals sector  
**Commitment from energy sector to building sustainable business, delivering clean energy and low carbon solution** |
| **Singapore** | • Pace of renewables adoption | **Stable but uncertain**: LNG sector continues to see developments as COVID recovery begins, power sector recovers driving bulk of gas demand, however, mid-term focus could shift towards renewables |
| **Indonesia** | • Clean energy policy improvement implementation challenges | **Transition from coal difficult**: Difficult road for gas, coal receives substantial government support: coal price cap, tax exemptions, loan guarantees |
| **Thailand** | • Domestic Upstream CAPEX cuts  
             • Carbon pricing | **Increased reliance on LNG**: Gas-heavy nature of the Thai power mix will see the country become ever more reliant on LNG imports going forward as domestic production declines  
**Putting a price on carbon**: Currently considering a national emission trading system (already has Voluntary Emission Reduction programme and Carbon Offsetting Program) |
| **Taiwan** | • Denuclearization and coal retirement | **COVID Immune**: Taiwan LNG demand expected to increase as Gas-fired power to grow to 50% of mix by 2025 versus 35% at present  
**Signal of higher future LNG demand growth**  
**Signal of lower future LNG demand growth** |

Source: Press reports, BCG analysis
Impacts of COVID-19 on long term outlook are mixed so far (3/3)

<table>
<thead>
<tr>
<th>Brazil</th>
<th>Argentina</th>
<th>Colombia</th>
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<tbody>
<tr>
<td>• Strategic initiatives driven by ANP (COVID recovery strategy)</td>
<td>• Shale gas monetization approach</td>
<td>• Coal to gas switch (power gen)</td>
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<tr>
<td></td>
<td>• Market regulation</td>
<td>• Upstream commercial attractiveness</td>
</tr>
<tr>
<td><strong>Signposts to watch</strong></td>
<td><strong>Evidence to date is mixed</strong></td>
<td><strong>Signal of higher future LNG demand growth</strong></td>
</tr>
</tbody>
</table>
| | **Infrastructure investment to pick-up:** Expected to expand natural gas infrastructure to comply with new climate commitments; companies exploring LNG tankers to tackle lack of pipeline capacity | ?
| | **New Gas Market:** Development of Open, Competitive and Dynamic natural Gas market | ? **Gas production stimulus:** Plans to subsidize Shale Gas production by granting subsidies worth $5.1 billion for its drillers (reduces LNG imports and bolsters investments and tax collections by $2.5 billion) |
| | - Monetize natural gas produced at pre-salt and other new discoveries | ? **Tariff freeze:** Imposed maintaining low gas prices for end-users to support local economy |
| | - Increase share of gas in energy matrix (power gen and industrial) | ?
| | - Improve tax regime, foster alignment (federal, state, local) | **Gas as a strong driver in energy transition:** Natural gas expected to become the transitional fuel of choice as the country focuses on meeting its Paris Agreement emission targets |
| | | ? **Energy security critical:** Growing optimism to boost reserves and production (requires appropriate incentives), but declining production and reserves, and increasing reliance on LNG imports |

Source: Press reports, BCG analysis
LNG supply growth slowing, but not materially

Comparison of Pre-COVID liquefaction capacity base scenario and revised base case

- Pre-COVID liq. Scenario - Base case
- Revised liq. Scenario - Base case

Source: BCG LNG market model
Substantial incremental capacity available for FID, but delays expected

Reasons to delay FID decision to 2021-2022 mainly depending on facility owner typology
- Projects owned by infrastructure developers are having great difficulties to secure financing in current market environment
- Projects owned by E&P players have been forced to reduce CAPEX due to low oil prices

Delaying FID decision will imply for some of these projects to start production after 2025
- Projects with relatively higher development costs could struggle to reach FID, especially after COVID pandemic
- Moreover, additional competition driven by large expiration of LT contracts linked to existing assets, if LNG demand does not catch up
Moderate LNG oversupply expected in 2020 in all demand scenarios

LNG S/D balance in 2020 (Mtpa)

Key potential impacts on LNG market

1. Lower for longer LNG prices
   - Oversupply to lead to high availability of uncommitted volumes (high liquidity) and downward pressure on prices
   - Sustained very low oil price environment to flow into oil-indexed LT volumes

2. Rebound expected, but impact on medium-term growth
   - Impact of 2020 crisis will have repercussions on medium-term growth potential (lost growth for 2020-2030)
   - China and Asian emerging markets expected to drive growth in 2021 – benefitting from attractive gas prices

3. Lower liq. utilization rates due to lack of profitable alternatives
   - US exports down 50%+ through the summer due to cargo cancellations
Market likely to still be oversupplied in 2025

<table>
<thead>
<tr>
<th>Supply scenario</th>
<th>Demand scenario</th>
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</thead>
<tbody>
<tr>
<td>Low</td>
<td>Base</td>
</tr>
<tr>
<td>Low</td>
<td>-2</td>
</tr>
<tr>
<td>2025</td>
<td>2025</td>
</tr>
<tr>
<td>Base</td>
<td>18</td>
</tr>
<tr>
<td>2025</td>
<td>2025</td>
</tr>
<tr>
<td>High</td>
<td>63</td>
</tr>
<tr>
<td>2025</td>
<td>2025</td>
</tr>
</tbody>
</table>

(Mtpa)

- **Oversupply**
- **Undersupply**
Under base case supply and demand the global LNG market may not rebalance until late 2029

2019-30 Base case supply with no additional FIDs vs. demand scenarios

Maximum gap of 65 MTPA in 2030 under high demand & base case supply

Note: Supply assumes global liquefaction capacity operates at 85% utilization annually.
Source: IMF, IEA, GIE, Eurostat, Cedigaz, BCG analysis
Role and Importance of Gas in Energy Transition
**Transition to cleaner fuels more rapid than prior energy transitions observed in history**

Total global primary energy supply by source (%)

- **Oil crises and US natural gas growth**
- **Diversification, rise of gas**

**In 2040, Oil and Gas expected to constitute ~53% and Renewables to constitute ~15% of primary energy supply**

<table>
<thead>
<tr>
<th>Change in Share (%)</th>
<th>'10 – '20</th>
<th>'20 – '40</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>-2</td>
<td>-5</td>
</tr>
<tr>
<td>Gas</td>
<td>+1</td>
<td>+2</td>
</tr>
<tr>
<td>Coal</td>
<td>-3</td>
<td>-6</td>
</tr>
<tr>
<td>Renewables</td>
<td>+4</td>
<td>+10</td>
</tr>
<tr>
<td>Hydro</td>
<td>+1</td>
<td>+0</td>
</tr>
<tr>
<td>Nuclear</td>
<td>-1</td>
<td>-1</td>
</tr>
</tbody>
</table>

Note: Projections are based on the Energy Transition scenario of the BP Energy Outlook; The nature of the energy transition pathway will differ for various countries.

Source: BP Energy Outlook, BCG
Primary energy demand expected to shift away from coal and oil towards cleaner sources of fuel

% of global primary energy mix

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</thead>
<tbody>
<tr>
<td>27% Natural gas</td>
<td>11% Coal</td>
<td>17% Coal</td>
<td>20% Coal</td>
<td>20% Coal</td>
</tr>
<tr>
<td>31% Oil</td>
<td>25% Coal</td>
<td>24% Coal</td>
<td>20% Coal</td>
<td>20% Coal</td>
</tr>
<tr>
<td>14% Renewables (incl. Hydro)</td>
<td>33% Nuclear</td>
<td>30% Nuclear</td>
<td>22% Nuclear</td>
<td>26% Nuclear</td>
</tr>
</tbody>
</table>

Increased response to energy transition and climate change action

Source: IEA, Shell Energy Outlook, BP Energy Outlook
Accelerated pace of energy transition creating many new growth opportunities

Energy transition trends and growth opportunities ...

**Future of Mobility**
- Electric Vehicles and V2G
- Autonomous Vehicles
- Sharing Economy

**New Energy**
- Solar, Wind, Bioenergy
- Green and Blue Hydrogen
- Energy Storage Solutions

**Energy Efficiency Tech**
- Smart Homes & Devices
- Smart Grid Technologies
- Demand Mgmt. Solutions

**Circular Economy**
- Eco & Energy Efficient Design
- Industrial Symbiosis
- Recycling & Energy Recovery

**Green Economy**
- Carbon Capture & Storage
- Carbon Tax & Credit Trading
- E-S-G Investing

... and governments, investors, corporations already responding

- Research from Bloomberg New Energy Finance indicates that falling battery costs will mean electric vehicles will be cheaper to buy in the U.S. and Europe as soon as 2025.
- Hyundai will start making electric cars in Singapore from 2022
- Thailand to have 1.2 million electric vehicles running in streets by 2030
- Renewable Electricity Levelized Cost Of Energy Already Cheaper Than Fossil Fuels, And Prices Keep Plunging
- BP warns of oil demand peak by early 2020s
- Coronavirus pandemic ushers in an earlier than anticipated decline for the fossil fuel era
- Smart Home Market to Rise at 18.4%; Rising Inclination toward Energy Saving Boosts Market
- Smart-grid plan aims to make Thailand the electricity hub of ASEAN
- Norway uses waste as eco-friendly fuel
- UK Government announces new waste strategy for a circular economy
- EU considers tax, emissions trading for carbon border plan
- Sustainable investing is set to surge in the wake of the coronavirus pandemic

1. V2G = Vehicle-to-Grid  2. ESG = Environmental, Sustainability, Governance

Source: Press Searches, BCG analysis
Countries are recognizing the importance of green COVID-19 recovery, and a deeper focus on environmental sustainability

China aims to hit peak emissions before 2030 and for carbon neutrality by 2060

- President Xi Jinping announcement at the 2020 UN General Assembly

- China constitutes 28% of global emissions and consumes half of the world's coal consumption

- Xi said that the COVID-19 pandemic has shown that “humankind can no longer afford to ignore the repeated warnings of nature.”

- He called on countries to pursue “scientific and technological revolution and industrial transformation” to achieve a “green recovery of the world economy” in the post-COVID era and to pursue innovative, coordinated, green and open development for all.”

Source: Press Search
Gas growth expected to continue

Key global gas consumption growth forecasts

World Gas Demand (Bcm)

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<tbody>
<tr>
<td>2020</td>
<td>3,500 Bcm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2025</td>
<td>4,000 Bcm</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>2030</td>
<td>4,500 Bcm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2035</td>
<td>5,000 Bcm</td>
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</table>

Immediate reduction in GHG emissions and air pollutants

Accelerator for Energy Access and Clean Cooking

Enabling distributed energy systems & increasing efficiency and economics of energy consumption

Cleanest fossil fuel to support energy transition agenda

Projections and growth CAGRs

1. 2008-2035 period. 2. 2014-2035 period. 3. Includes forecasts of EIA, IEA, BP. Note: NPS: New Policies Scenario, which is the base scenario used in annual World Energy Outlook Reports

Source: IEA Reports, EIA 2016 Report, BP Statistical Review 2016; BCG analysis
Gas technologies can abate up to 30% of global energy sector GHG emissions

### GHG reduction potential by 2040¹ (GT CO₂)

<table>
<thead>
<tr>
<th>Technology</th>
<th>Base case²</th>
<th>Potential³</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power switching</td>
<td>0.6</td>
<td>3.3</td>
</tr>
<tr>
<td>Industry switching</td>
<td>0.6</td>
<td>2.0</td>
</tr>
<tr>
<td>Industrial efficiency</td>
<td>0</td>
<td>0.1</td>
</tr>
<tr>
<td>Enabling renewable power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Road transport</td>
<td>0.1</td>
<td>0.4</td>
</tr>
<tr>
<td>LNG bunkering</td>
<td>&lt;0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>Renewable gas</td>
<td>0</td>
<td>0.9</td>
</tr>
<tr>
<td>Hydrogen</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CCUS</td>
<td>0.1</td>
<td>4</td>
</tr>
<tr>
<td>Buildings adoption</td>
<td>0.2</td>
<td>0.5</td>
</tr>
<tr>
<td>Distributed generation</td>
<td>0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>SSLNG</td>
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</tr>
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</table>

### Global GHG emissions reduction potential³ from gas technologies by 2040

- **GT CO₂e**
  - 2019 energy emissions⁵
  - 2040 increase in energy emissions²
  - 2040 energy emissions²
  - Climate action and sustainable cities
  - Low carbon gas
  - Energy access
  - Total

#### Notes
1. Estimated on the basis of gas demand growth multiplied by the average emissions benefit of switching from coal and or oil to natural gas or low carbon gas; 2. Base case is aligned with IEA 2019 Stated Policies Scenario; 3. Potential is based on the economic potential as defined in Chapter 1; 4. Emissions benefit achieved from the adoption of renewable power were not evaluated, as part of this analysis; 5. Emissions benefit accounted for in other categories; 6. Based on IEA data
Natural gas adoption would significantly reduce global emissions of key air quality pollutants

Potential 2040 annual local emissions reduction from gas adoption

Particulate matter

Global emissions PM 2.5 (MT)

- 2015: 30.8
- 2040 BAU: 25.9
- Fuel switching: -0.7 to -3.6
- Change: Up to 12%

Sulphur dioxide

Global emissions SO₂ (MT)

- 2015: 79.5
- 2040 BAU: 37.8
- Fuel switching: -5.0 to -26.6
- Change: Up to 34%

Nitrogen oxide

Global emissions MT NOₓ (MT)

- 2015: 108.0
- 2040 BAU: 71.4
- Fuel switching: -5.5 to -27.6
- Change: Up to 26%

1. Calculated as potential emissions benefit relative to business-as-usual 2040 emissions using Current Policies Scenarios from IEA 2016 WEO report; 2. Base case is aligned with IEA New Policies Scenario in prior WEO reports; 3. Potential is based on the economic potential as defined in Chapter 1

Source: IEA, WHO, BCG analysis
Gas adoption is a key enabler of improved urban air quality

Average urban PM 2.5 concentration (µg/m³)²

Gas share of energy consumption (%)¹

1. Includes weighted average of power generation, buildings, and industry sectors; based on 2015 data; 2. Based on cities in the WHO survey database
Source: IEA, World Health Organization, BCG analysis
**Gas can provide access to clean cooking fuel for up to 1 billion additional people by 2040**

**Population without access to clean cooking fuels relative to gas access**

2017 global population without clean cooking fuel access (billion)

- Developing Asia: 1.3
- Africa: 0.9
- China: 0.4
- Latin America: 0.1
- Middle East: 0.0

**Gas share of buildings sector energy demand (%)**

**Access to clean cooking fuels by 2040 with gas contribution for up to 1 billion people**

Population without clean cooking access in developing countries (billions)

- 2017 population without access: 2.7
- Est. increase in population without access: 1.0
- 2040 base case: 0.5
- 2040 Potential: 0.9

1. Other clean fuels consist of clean biomass, LPG, and solar; 2. Potential is based on the economic potential as defined in Chapter 1

Source: IEA, BCG analysis
Economic potential for natural gas defined based on competitiveness in different segments of use

<table>
<thead>
<tr>
<th>Sector</th>
<th>Drivers of gas deployment</th>
<th>Economic potential¹</th>
</tr>
</thead>
</table>
| **Power**   | • Competitiveness of gas at a national level  
              • **Gas replacing coal and oil generation only at the end of average plant lifecycles** | Demand growth by 2040 (BCM)                       |
|             |                                                                                         | GHG reduction by 2040² (GT CO₂)                   |
|             |                                                                                         | 2,400                                            |
|             |                                                                                         | 3.3                                              |
| **Industry**| • Declining cost of gas technologies based on recent innovation trends                  | 1,600                                            |
|             | • Average competitiveness of gas vs. coal in different industrial sub-segments          | GHG reduction by 2040² (GT CO₂)                   |
|             |                                                                                         | 2.0                                              |
| **Buildings**| • Gas replacing all remaining coal and oil products used to fuel commercial and residential buildings | Demand growth by 2040 (BCM)                       |
|             |                                                                                         | GHG reduction by 2040² (GT CO₂)                   |
|             |                                                                                         | 500                                              |
|             |                                                                                         | 0.5                                              |
| **Transportation**| • Road transport: Impact of technology trends, applied by segment (e.g. heavy duty best suited for LNG)  
              • Marine bunkering: Segment of marine consumption most exposed to action on air pollution | Demand growth by 2040 (BCM)                       |
|             |                                                                                         | GHG reduction by 2040² (GT CO₂)                   |
|             |                                                                                         | 900                                              |
|             |                                                                                         | 0.5                                              |

Note: In all cases, increasing cost of carbon assumed in line with requirements to limit warming to 2 degrees as included in the IEA SDS from the 2019 WEO; technology cost trends identified in the report are applied, otherwise economic assumption are generally aligned with IEA SPS from the 2019 WEO.

¹. Potential is based on the economic potential as defined in Chapter 1; ². Calculated as gas demand growth multiplied the emissions benefit of switching from coal and or oil to natural gas.

Coal-to-gas switching is NPV positive, even under rapidly rising carbon prices aligned with a 2-degree pathway

Example project cash flow in the US, EU, and China for an average CCGT plant

Pre-tax cash flow of a standard US, European and Chinese CCGT\(^1\) ($M)

Cumulative NPV of gas capacity additions aligned with economic potential for gas

Estimated cumulative NPV of new CCGT investments 2020-2040 ($B)

1. Revenue calculated assuming realized prices consist of power plant capital recovery and O&M, fuel costs, and CO2 price recovery as defined by the IEA 2019 WEO; Standard is defined as the averages used for Lazard’s LCOE 13.0 study with a 25% discount for Chinese O&M costs; Carbon tax escalates to $140 per metric ton of CO2e by 2040 in US and to $125 per metric ton of CO2e by 2040 in China

Source: Lazard, US EIA, IEA, BCG analysis
Power sector fuel switching provides the greatest opportunity for GHG emission reduction

Maximum potential annual emissions reduction from gas fuel switching by 2040

Power sector

Industry sector

Buildings sector

1. Calculated as the emissions reductions identified from the economic potential in this study relative to the IEA 2020 WEO Stated Policies Scenario

Source: IEA, EIA, BP Energy Outlook, NGVA Europe, IPCC, BCG analysis
Varying challenges across regions to deliver gas ambitions

Competitiveness vs. coal and supply infra remain as key issues for Asia

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<thead>
<tr>
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<tbody>
<tr>
<td>Africa</td>
<td>Improving competitiveness vs. coal in some countries</td>
<td>Supply infrastructure critical for expanding gas access</td>
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<tr>
<td>Asia</td>
<td>Improving competitiveness vs. coal across the region</td>
<td>Supply infrastructure critical for expanding gas access</td>
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<tr>
<td>CIS</td>
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<tr>
<td>Europe</td>
<td>Ensuring sustained competitiveness vs. coal and renewables</td>
<td>Diversified supply key for managing geopolitical concerns</td>
<td>Low carbon applications needed for long term carbon targets</td>
</tr>
<tr>
<td>Latin America</td>
<td>Improving competitiveness vs. coal in some countries</td>
<td>Supply infrastructure critical for expanding gas access</td>
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<td>Middle East</td>
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<tr>
<td>North America</td>
<td>Expanding infrastructure to access gas for transport</td>
<td>Low carbon applications needed for long term carbon targets</td>
<td></td>
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</tbody>
</table>

- Critical for achieving growth
- Moderate priority for gas growth
- Achieved/not a high priority
Enablers for Governments to Unleash Gas Potential
Three key enablers to deliver full gas potential

Government policy

Carbon pricing as a market incentive is growing; yet only covers ~20% global GHG emissions

Infrastructure investment

Investment in gas infra is well below the level needed to achieve the full potential of gas

Industry innovation

Recent advancement in new business model, as well as new technology (e.g. small-scale LNG)
Policy plays a critical role for shaping gas market development

Examples of successful policies

- Production targets
- Priority upstream licensing
- Market-based pricing

- Competitive tariff structures
- Foreign gas trade agreements
- Anchor agreements by public utilities

- Capacity development targets
- Expedited permitting
- Capex support/lending programs

- Pricing of environmental externalities
- Fuel switching requirements/incentives
- Priority sector-based incentives

Example: Divergence between China and India

- Incentives for CNG/LNG for transport; Target conversation of 200k coal boiler units to natural gas; new residential connection
Wide range of policy options available to enable gas technology development

<table>
<thead>
<tr>
<th>Technology</th>
<th>Mandate-based</th>
<th>Spectrum of options</th>
<th>Market-based</th>
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</thead>
<tbody>
<tr>
<td><strong>All</strong></td>
<td>R&amp;D early-stage support</td>
<td>Boiler purchase incentives</td>
<td>Actions to Remove Deployment Barriers</td>
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<tr>
<td>Cross-sector</td>
<td>Fuel mix targets</td>
<td>Natural gas adoption incentives</td>
<td>Carbon tax</td>
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<td></td>
<td>Infra. investment incentives</td>
<td>Gas T&amp;D² infra.</td>
<td>Cap and trade</td>
</tr>
<tr>
<td><strong>Climate action and sustainable cities</strong></td>
<td>Mandated coal phase outs</td>
<td>Boiler purchase incentives</td>
<td>Local pollution standards</td>
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<tr>
<td>Power switching</td>
<td>Natural gas adoption incentives</td>
<td>Capacity mandates</td>
<td>EE² standards</td>
</tr>
<tr>
<td>Industry switching</td>
<td></td>
<td></td>
<td>Capacity markets</td>
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<tr>
<td>Industrial efficiency</td>
<td></td>
<td></td>
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<tr>
<td>Enabling renewable power</td>
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<tr>
<td>Road transport</td>
<td>Natural gas adoption incentives</td>
<td>Vehicle/ vessel incentives</td>
<td>Local pollution standards</td>
</tr>
<tr>
<td>LNG bunkering</td>
<td></td>
<td>Refueling infra. support</td>
<td></td>
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<tr>
<td><strong>Low carbon gas</strong></td>
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<tr>
<td>Renewable gas</td>
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<tr>
<td>Hydrogen</td>
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<tr>
<td>CCUS</td>
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</tr>
<tr>
<td><strong>Access to affordable clean energy</strong></td>
<td>Government innovation and technology programs</td>
<td>R&amp;D incentives</td>
<td>Local carbon fuel standard</td>
</tr>
<tr>
<td>Buildings adoption</td>
<td>R&amp;D grants and loans</td>
<td>Feed in tariffs</td>
<td>Regulatory reform (for tech. adoption)</td>
</tr>
<tr>
<td>Distributed generation</td>
<td>Adoption incentives</td>
<td>Tax credits</td>
<td></td>
</tr>
<tr>
<td>SSLNG</td>
<td>R&amp;D grants and loans</td>
<td>Boiler purchase incentives</td>
<td></td>
</tr>
</tbody>
</table>

Legend: Penalize emissions, Technology incentives

1. Transmission and distribution, 2. Energy efficiency
Source: BCG analysis
Significant impact seen from advancement of industry innovation

- 20%+ efficiency in gas consumption for combustion apps.
- 10%+ efficiency in gas equipment CAPEX
- 50%+ reduction in upfront CAPEX through distributed & small-scale LNG
- 40%+ improvement in plant ramp times

Non exhaustive
Range of innovative gas applications – from traditional to emerging

Traditional
- Power Generation
- Industry
- Transport: CNG - light vehicles, LNG - heavy vehicles & marine bunkering
- Commercial: Heating & cooling
- Residential: Cooking gas, Heating & cooling

Petrochemical feedstock + Fuel use

Emerging
- Hydrogen Conversion\(^1\)
- Micro-grids
- SSLNG/ Micro LNG
- Solid-oxide Fuel cells

1. Grey and blue hydrogen
Flexible and low capital business models are critical - Example of FSRUs

FSRUs provide more flexible, lower capital gas supply ...

FSRUs require less up-front capital due to charter structure—$250mn vs. $750m

... FSRU capacity is growing ...

Global FSRU capacity (MTPA)

Argentina: FSRUs quickly added nine bcm of capacity to offset domestic production decline

Jordan: FSRU capacity restored gas supplies after Egyptian imports dropped given domestic supply shortages

Bangladesh: Plans currently in place to develop FSRU import aligned with new CCGT plants

... And is helping countries to diversify supply

Source: IGU, BCG analysis
Regional trends indicate Asian suppliers increasing transporting LNG through containerized cargo

- **China** has developed a network of 200 LNG producing and loading stations across the country that delivers the fuel to industries without a grid connection.

- **LNG terminal in East India** to help supply gas to Bangladesh, Myanmar, capable of reloading LNG to service proximate markets via the marine route and will also have truck-loading gantries to help grow the nascent LNG by truck market.

- **Growth in containerized LNG in India**: Truck loading facility at liquefied natural gas (LNG) terminal on India’s west coast to meet demand from industrial users.

- **LNG sales by ISO tanks** in Japan, signed contracts with buyers. Binding agreement with China to deliver liquefied natural gas (LNG) from its Shimizu terminal in western Japan.

- **Thailand Regional LNG trading plan**: Ready in terms of gas infrastructure and transport via marine vessels and heavy-duty trucks, as well as manpower for LNG trade.

- **LNG trucking** in order to supply LNG to off-grid customers in Peninsular Malaysia started in the second half of 2020.

- **Virtual Pipeline Network in Sabah** delivering LNG to customers in Sipitang, Tenom, Nabawan, Tawau, Kunak, Lahad Datu and Sandakan.

- **Sarawak is considering developing Virtual Pipeline network** covering LNG supply to Miri, Bintulu and Kuching.

Source: Desktop research, BCG analysis
SSLNG: Distribution by truck now a material segment of the Chinese market

Impact: LNG trucks provide off grid access—now supply 10% of Chinese gas market

Trucked LNG market expands access and fosters market competition

LNG trucks bring natural gas to off grid industrial customers, allowing them to comply with Chinese fuel switching policies

Both pipeline natural gas and off grid customers can check market prices and trading volumes on WeChat groups, improving competition and liquidity

Over 10% of Chinese natural gas consumption distributed by truck

Drivers & lessons: Attractive margin and ability to quickly expand drove market growth

Unit margins on trucked LNG distribution can be attractive

Organic market developed to meet policy-driven demand growth

Pipeline expansion could not keep up with rapid policy-driven demand growth

The speed with which truck loading infrastructure can be built helped LNG trucking grow quickly and meet excess demand

An organic trucking market quickly developed in an otherwise heavily regulated market

Sources: IEA, Wood Mackenzie, National Bureau of Statistics of China, OIES, BCG analysis
Extending gas infrastructure to cities

Gas provides specific advantages for cities

- **Air pollution**: nearly zero sulphur dioxide, nitrogen oxide, and no particulate matter emissions
- **GHG emissions**: 40% less than coal and 20% less than oil
- **Heat intensity**: Most heat intensive (and thus highest efficiency) fuel source
- **Scalability**: Ease of adding customers to existing networks once infrastructure is developed

Source: Business Insider

Journey from deploying gas first to industry and power applications, then extending infra to cities over time

- **1990s**: Consortium (Government and Private sector) developing pipeline gas connection to homes
- **1995**: Gujarat was center of domestic natural gas industry–fertilizer plants, petchem. plants, and gas fired power plant
- **2014**: Putting in place policy, providing lowest cost source of gas to CGD customers
- **NOW**: Connections established to >1M households (39% pipeline gas connection rates in Mumbai)
## Energy mix: Three strategies

<table>
<thead>
<tr>
<th>Objective</th>
<th>Access to industry, switch from diesel to gas</th>
<th>Coal to gas (200K boilers, 44 GW, 120M conn.) in power &amp; RCA</th>
<th>100% EV/Hydrogen vehicles by 2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Competitive advantage</td>
<td>Private sector interest to invest and high capability to operate</td>
<td>G2G deals and SOEs to negotiate gas imports and implement</td>
<td>Government has high willingness and capacity to invest</td>
</tr>
<tr>
<td>Liberalization</td>
<td>Deregulated diesel prices (Gas 20% cheaper)</td>
<td>Invest heavily in extending pipeline, new regas terminals</td>
<td>High gov. investment in recharging stations</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>Private sector bids for concessions on gas sales in city</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Taxes and subsidies</td>
<td></td>
<td>Targeted subsidies in 28 cities (Despite wider liberalization)</td>
<td>25% sales tax removed, import duties and road tolls waived</td>
</tr>
<tr>
<td>Regulations</td>
<td>Rule to ensure residential connections</td>
<td></td>
<td>Free use of road ferries and bus lanes</td>
</tr>
<tr>
<td>Gov. directive</td>
<td></td>
<td>Import contracts G2G and B2B (e.g., US, Russia, Australia)</td>
<td></td>
</tr>
<tr>
<td>Cost Impact</td>
<td>Industry Low increase</td>
<td>Government &gt; $100B</td>
<td>Government $1B p.a.</td>
</tr>
<tr>
<td>Success metric</td>
<td>CGD 16% of total gas demand within 9 years</td>
<td>130Mt CO2 reduction versus 2011</td>
<td>&gt;60% EV market share</td>
</tr>
</tbody>
</table>
# Maximizing value: Three strategies

<table>
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<th>Competitive advantage</th>
<th>Cost Impact</th>
<th>Success metric</th>
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<tbody>
<tr>
<td>Boost domestic gas production</td>
<td>Long-term production decline, assume already 'peaked'</td>
<td>Government &gt;$3B in next 20 years</td>
<td>Largest producer of natural gas, competitive gas prices</td>
</tr>
<tr>
<td>Maintain competitive advantage of port and develop gas trading hub</td>
<td>Ability to absorb upfront costs to “lock in” port customers</td>
<td></td>
<td>Expected to be largest LNG bunkering hub</td>
</tr>
<tr>
<td>Maintain gas production to meet power demand</td>
<td>Belief that consumers able to bear higher price of gas</td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>

### Competitive advantage
- **Objective:**
  - Boost domestic gas production
  - Maintain competitive advantage of port and develop gas trading hub
  - Maintain gas production to meet power demand

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<th>Liberalization</th>
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<th>Gov. directive</th>
<th>Cost Impact</th>
<th>Success metric</th>
</tr>
</thead>
<tbody>
<tr>
<td>Private sector allowed to do new drilling</td>
<td>Retrofit LNG Vessels ($2M) $2B mega-port expansion</td>
<td>Port dues discounted, craft dues waived</td>
<td>Law enabling private individuals to own O&amp;G under their land</td>
<td>International cooperation (e.g., Japan, Norway)</td>
<td>Government &gt;$3B in next 20 years</td>
<td>Largest producer of natural gas, competitive gas prices</td>
</tr>
</tbody>
</table>

### International cooperation
- (e.g., Japan, Norway)
- Pipeline and power plants in South Vietnam
- Expected to be largest LNG bunkering hub
- Maintained gas production to meet power demand
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