



Gas to Power: Natural Gas and LNG Alternatives

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1



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Fisoye Delano is President & CEO, at Delphi Ventura Group. He is Adjunct Professor at the Centre for Petroleum, Energy, Economics and Law at the University of Ibadan, Nigeria. He holds a B.Sc. and M.Sc. in Petroleum Engineering and an MBA. Mr. Delano has about 40 years' experience in the petroleum industry. He started his career as a Wellsite Petroleum Engineer at Shell and then worked for Texaco for 20 years in the US, Trinidad and Tobago and Nigeria and later joined Nigerian National Petroleum Corporation (NNPC). At NNPC, he led the commercial negotiations for the LNG projects. He has authored several publications on Natural Gas and LNG. He frequently makes presentations on aspects of natural gas and LNG at industry conferences.



Fisoye Delano
President & CEO
Delphi Ventura Group



Poll Question


What is your job title?



Poll Question

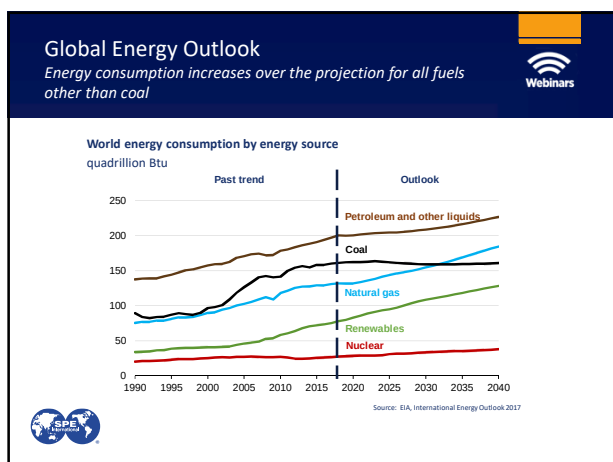

What geographic region are located in?

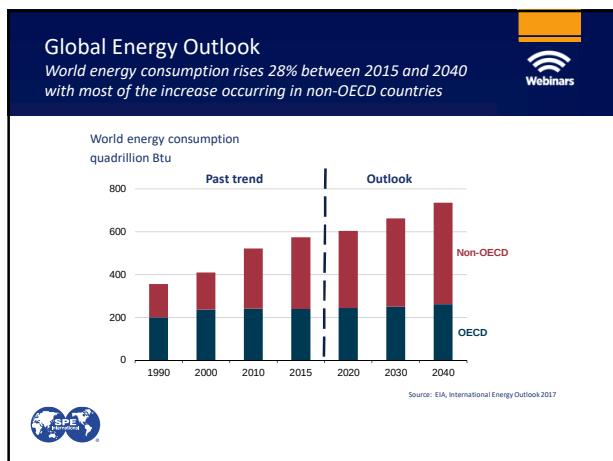


Gas to Power: Natural Gas and LNG Alternatives
Outline


- Global Energy Outlook
- Growing Global Gas to Power Demand
- Natural Gas Delivery
- Natural Gas and LNG Pricing
- Asian Gas market
- Sub-Saharan Africa Gas market
- LNG to Power - Integrated LNG based power solutions
- Summary
- Conclusion

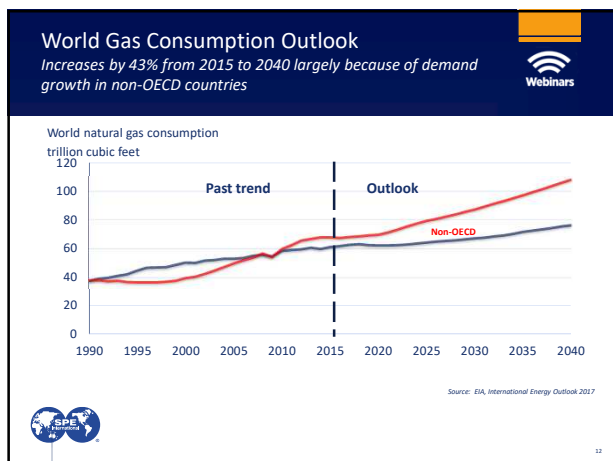
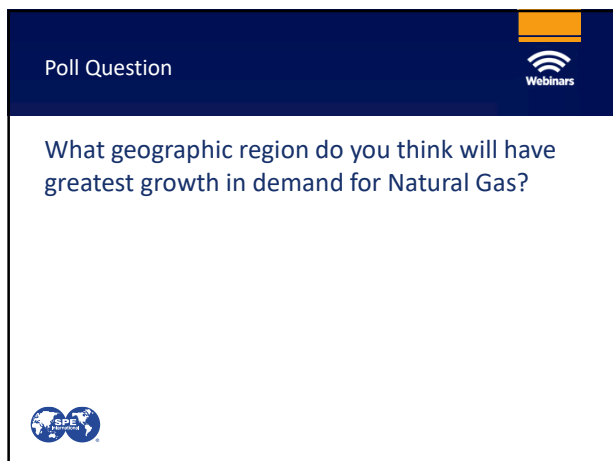
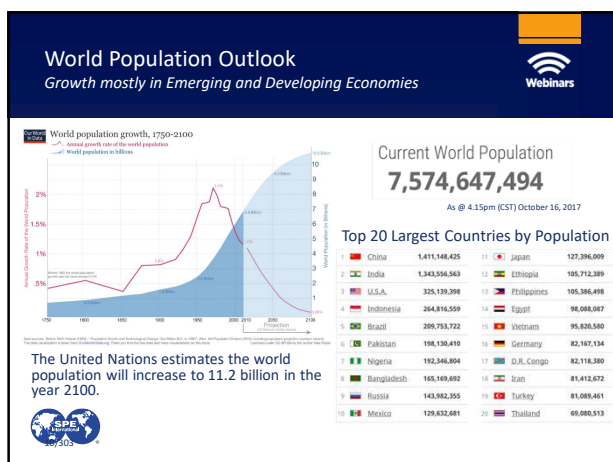






Poll Question

The world population is projected to increase from about 7.5 to 11 billion in 2100. What geographic region do you think will have greatest population increase?



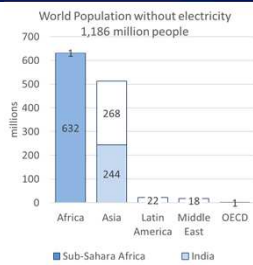
Growing Global Gas to Power Demand

Over 15% of the world population are without electricity



Unmet electricity demand

- In many countries today, electricity supply is erratic and sometimes low quality.
- Daily outages are rampant.
- About 1.2 billion people are without access to electricity worldwide (IEA WEO 2016 estimates)



13

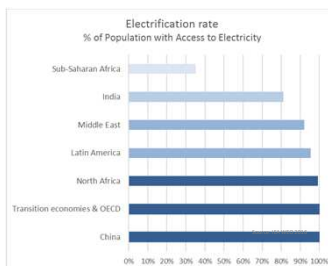
Growing Global Gas to Power Demand

About 65% of the population in Sub-Saharan Africa have no access to electricity



Unmet electricity demand

- Enormous deficit in electricity supply mainly in Sub-Saharan Africa and India.
- US Power Africa report outlined a goal to increase power generation in sub-Saharan Africa by more than 30GW by 2030.



14

Growing Global Gas to Power Demand

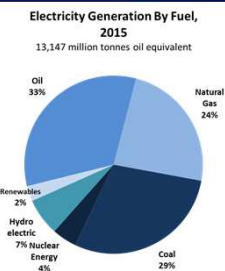
Natural Gas is the preferred fuel for electricity generation



Global Energy Mix

Power generation is the primary use of natural gas in most emerging markets.

Natural gas is the fuel of choice for power generation because of its lower carbon intensity compared with coal and oil.



15

Poll Question



What do you think is the percentage of natural gas in the fuel mix for electricity generation for the country where you are located?



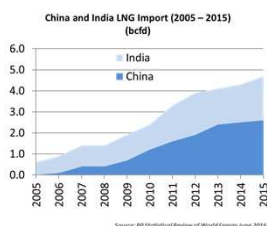
Growing Global Gas to Power Demand

Enormous amount of Natural Gas will be consumed in sub-Saharan Africa



Natural Gas Demand

To achieve the additional 30GW target estimated by USDOE for sub-Saharan, the amount of natural gas and LNG that would be required over the next 13 years would be comparable to the growth in LNG imports to China and India combined over a similar period if the fuel of choice is natural gas.



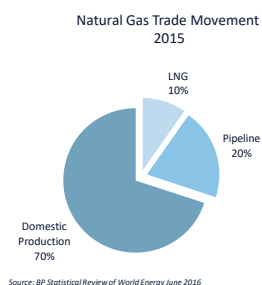
17

Natural Gas Delivery

Most of the gas produced worldwide is consumed in-country



- About 70% of the 123 tcf of natural gas consumed in 2015 was from domestic gas production
- Natural gas is transported between countries because of regional supply and demand disparities.



18

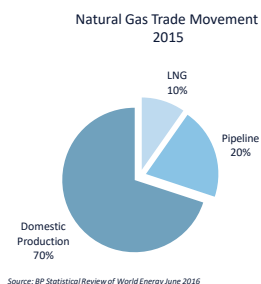
Natural Gas Delivery

LNG technology makes natural gas available throughout the world



The share of natural gas transported internationally as LNG grew from 26% in 2002 to the 32% in 2015.

LNG trade has grown at a faster rate than pipeline trade in recent years but pipeline transportation of natural gas remains an integral part of world natural gas trade.



Source: BP Statistical Review of World Energy June 2016

19

Natural Gas Delivery

Volume reduction makes gas economical to transport as LNG

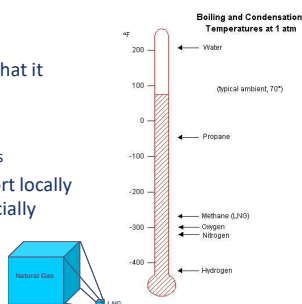


What Is LNG?

LNG is natural gas cooled such that it condenses to a liquid

- Temperature -256°F (-161°C)
- Atmospheric pressure.
- Volume is reduced 600 times

Thus it is economical to transport locally and between continents in specially designed vessels



20

Gas to Power: Natural Gas and LNG Alternatives

Natural Gas Delivery

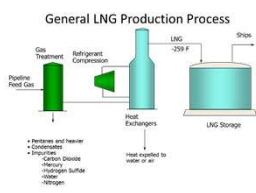


LNG Characteristics

LNG is odorless, colorless, non-corrosive, and non-toxic.

LNG has been safely handled for many years.

LNG constitutes essentially the sole source of natural gas for many economies in Asia and is also widely used in Europe.



21

Natural Gas and LNG Pricing

Priced at a discount to displace alternative fuel



General Gas Pricing Formula

The natural gas price in many parts of the world is indexed on available alternative fuel with transportation cost added. The general equation for natural gas price can be expressed as:

$$P_{Gas} = A \times P_{Alt} + C_T$$

P_{Gas} = Natural gas price

P_{Alt} = Alternative fuel price

A is made up of the relevant conversion factor for P_{Alt} given the heat content and applying a discount to make P_{Gas} competitive with P_{Alt}

C_T includes the total cost of processing and transporting the natural gas between two transaction points



23

Natural Gas and LNG Pricing

The US is different



US Gas on Gas Market

$$P_{Gas} = P_{HH} + C_T$$

where

P_{Gas} = Natural gas price, \$/mmbtu

P_{HH} = Henry Hub Gas Price, \$/mmbtu

A = 1 pipeline spec gas

C_T = Basis differential



24

Natural Gas and LNG Pricing

Priced to displace LPFO



Domestic Gas Price Indexed to Low pour fuel oil (LPFO)

$$P_{Gas} = A \times P_{LPFO}$$

P_{Gas} = Natural gas price, \$/mmbtu

P_{LPFO} = LPFO Pump Price, \$/liter

A = relevant conversion factor for P_{LPFO} given the heat content and applying a discount factor to make P_{Gas} competitive with P_{LPFO}

Gas Price - Applicable % of LPFO Price	
	% of LPFO Pump Price
Year 1	60
Year 2	65
Year 3	70
Year 4	75
Year 5 and beyond	80



30

Natural Gas and LNG Pricing

Includes LNG value chain cost



LNG Pricing in Asia

$$P_{LNG} = A \times P_{Crude\ oil} + C_T$$

- P_{LNG} = LNG, \$/mmbtu
- $P_{Crude\ oil}$ = price of crude oil in \$/Bbl
- A and B are constants negotiated by the buyer and seller. A is usually referred to as the 'slope' and ranges from 0.05 to 0.183. B usually reflects the transportation cost commonly ranges between 0.6 - 0.9.
- C_T includes the total cost of processing and transporting the natural gas between the two transaction points.



30

Natural Gas and LNG Pricing

Crude Indexation



If the LNG was priced on a crude oil parity basis, i.e. a Btu of LNG was the same price as a Btu of crude oil, the price profile and the formula would be:

$$P_{LNG} = \frac{1}{5.8} \times P_{CRUDEOIL} + B$$

Where:

Average crude oil Heat Rate = 5.8mmbtu per boe.

$$= 0.172 \times P_{CRUDEOIL} + B$$



30

Natural Gas and LNG Pricing

FOB



For free on board (FOB) sales the constant B may be zero, then

$$P_{LNG} = 0.172 \times P_{CRUDEOIL}$$

For most LNG SPA in Asia the LNG price is indexed on Japanese Custom Cleared crude (JCC) with a slope of 0.1485. It follows that for a LNG free on board (FOB) sales to Japan (B=0), the formula becomes

$$P_{LNG} = 0.1485 \times P_{JCC}$$



30

Natural Gas and LNG Pricing

DES



And if we assume a delivered ex-ship (DES) sales with $B=0.6452$ to cover the freight cost from say Indonesia to Japan. The LNG price formula becomes:

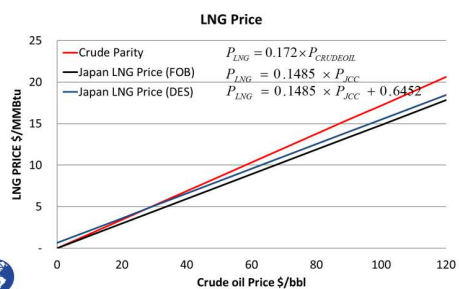
$$P_{LNG} = 0.1485 \times P_{JCC} + 0.6452$$



30

Natural Gas and LNG Pricing

in summary



30

Natural Gas and LNG Pricing

LNG Netback pricing



Netback pricing is particularly important for producing countries because netbacks allow the countries to understand the varying value of LNG in different destination markets.

Netbacks are calculated taking the net revenues from downstream sales of LNG/natural gas in the destination market, less all costs associated with bringing the commodity to market, including pipeline transportation at the destination, regasification, marine transport and, possibly liquefaction, and production depending on the starting point of the netback.



30

Natural Gas and LNG Pricing

Starting point and delivery point can vary



LNG Netback pricing

The starting point for calculating a netback price can be at the wellhead, or at the inlet to a liquefaction plant, or at the exit of the liquefaction plant.

The delivery point of the LNG sales contract can be at the liquefaction facility, a **free on board (FOB) sale**, or a **costs, insurance and freight (CIF sale)**, or at the destination market (a **delivered at terminal (DAT) sale**, or a **delivered at place (DAP) sale**).

The terms DAT and DAP are replacing the term **delivered-ex-ship (DES)**, although some parties continue to use the DES reference term



31

Natural Gas and LNG Pricing

LNG Netback formula



LNG Netback pricing

The general equation for LNG Netback price can be expressed as:

$$P_{Gas/LNG} = A \times P_{GRP} - B_T$$

$P_{Gas/LNG}$ = Natural gas or LNG price

P_{GRP} = Natural Gas Reference Market Price which can be based on gas market supply and demand or indexed on the alternative fuels such as crude oil, petroleum products and coal.

A takes into consideration fuel use and boil-off gas during shipping and regasification and utilization factors for regasification, pipeline and shipping

B_T includes the total cost associated with bringing the commodity to market.



34

Natural Gas and LNG Pricing

North America LNG market



LNG Netback pricing

For a FOB sale of LNG targeting North America market, the buyer takes title and risk of the LNG at the liquefaction facility and the buyer pays for LNG transportation from the liquefaction facility to the destination market.

$$P_{LNG} = A \times P_{GRP} - B_T$$

$$P_{LNG} = 93.55\% \times P_{HH} - 1.046$$

P_{LNG} = LNG price, \$/mmbtu

$P_{GRP} = P_{HH}$ = Henry Hub price (\$/mmbtu) is used to set natural gas reference market prices for virtually all gas sold in the US.

B_T - Transportation Costs

Basis Differential	\$0.035
Pipeline cost	\$0.034
Regasification cost	\$0.199
LNG Shipping cost	\$0.778
	\$1.046



34

Poll Question



What is the average domestic price of natural gas for power in the country where you are located?



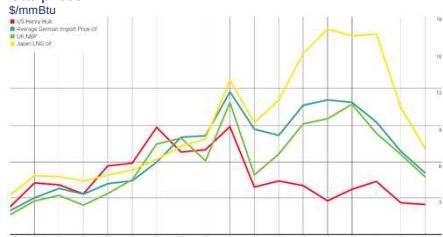
Natural Gas and LNG Pricing

Natural Gas Prices Highest in Markets where the Alternative is Oil



Gas prices
\$/mmBtu

■ US Henry Hub
 ■ European Gas Index (GRI)
 ■ UK NBP
 ■ Japan LNG



Asian Gas market

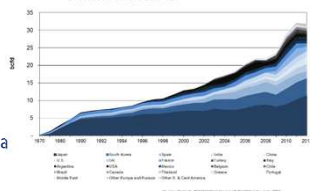
JKT still dominates the market, though less



Until recently, Asia Pacific LNG demand comprised of three markets: Japan, Korea and Taiwan (JKT).

In 2012, JKT still accounted for about 57% of global trade and 82% of Asia Pacific trade, this is a drop from about 90% in 2007.

Growth in LNG Demand



36

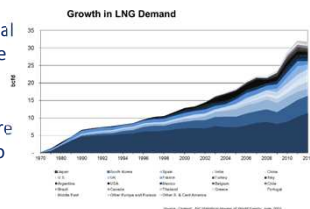
Asian Gas market

Stronger growth rate in China and India



In 2007, China and India consumed barely 6% of the global trade and 10% of the Asian trade however in 2012 China and India's share of the global LNG market rose to 12% and the share of the Asia Pacific market rose to 18%.

China and India's LNG demand growth is expected to continue.



37

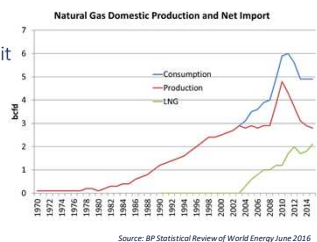
Asian Gas market

Growing LNG demand in India



India

- India was self-sufficient in natural gas until 2004, when it began to import LNG from Qatar.
- Gas consumption grew at an annual rate of about 10% between 2002 and 2012,



38

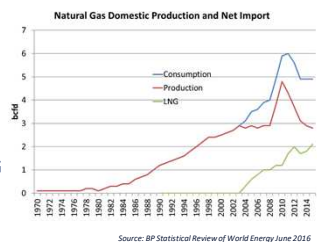
Asian Gas market

Increase LNG terminals



India

- In 2012, India consumed 1.9 tcf, and LNG imports accounted for about 38% of total gas demand.
- Petronet owns the country's two currently operational LNG terminals at Dahej and Hazira, and plans to increase the capacity at both LNG plants.



39

Asian Gas market

Need more Pipeline transmission and distribution



India

- Natural gas serves as a substitute for coal for electricity generation in India.
- Insufficient gas pipeline infrastructure constrains natural gas demand in India.
- The India has considered importing natural gas via pipeline through several proposed projects such as a transnational pipeline from Bangladesh, Iran-Pakistan-India (IPI) pipeline project, the Turkmenistan-Afghanistan-Pakistan-India (TAPI) project, also known as the Trans-Afghanistan Pipeline.



40

Sub-Saharan Africa Gas market

Gas is moved by pipeline to neighboring countries without gas



Within sub-Saharan Africa, there are neighboring countries without gas resources next to countries with gas production or large potential gas resources.

As a result, some cross-border gas supply has begun to be established and there is much potential for future trade as additional development occurs.

Examples of regional and trans-border pipeline projects.

- West Africa Pipeline System
- Mozambique to South Africa Pipeline
- Tanzania Pipeline Systems



41

Sub-Saharan Africa Gas market

Limited gas pipeline systems



Sources: Underline, Natural Gas and LNG Options, US DOE/Pwarr Africa

42

Sub-Saharan Africa Gas market

Excess gas is exported through LNG



Gas Supply in West Africa

- West Africa produces much more natural gas than is required for domestic consumption.
- The natural gas is exported within the region by pipeline and globally as LNG. Angola, Equatorial Guinea, Ghana and Nigeria are the main natural gas producers today.
- The largest natural gas reserves in the region are in Nigeria. Nigeria exports 22MTPA of LNG.



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43

Sub-Saharan Africa Gas market

Expansion of pipeline systems



Gas Supply in West Africa

- The West Africa Gas Pipeline (WAGP) transports natural gas from Nigeria to consumers in the Benin Republic, Togo, and Ghana.
- The WAGP receives gas from the Escravos-to-Lagos Pipeline System (ELPS) which gathers gas from Shell and Chevron fields in the Niger Delta.
- The capacity of ELPS is being expanded from 1.1 bcf/d to 2.2 bcf/d.



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44

Sub-Saharan Africa Gas market

High gas prices provides opportunity to receive more gas



Natural Gas prices in West Africa

- Domestic natural gas prices in many West African countries are quite high since the gas price is usually indexed on available alternative fuels such as crude oil or petroleum products, as in the case in Ghana and Nigeria.
- The natural gas prices for power generation range from about \$8 – 9.8/MMBtu in Ghana to about \$3.30 – 7.00/MMBtu in Nigeria.



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45

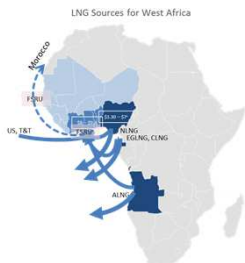
Sub-Saharan Africa Gas market

LNG makes gas available throughout the region



High Gas prices make LNG Import Feasible

- Great opportunity for LNG imports to fuel the projected growth of West African economies
- All the West African countries except Burkina Faso, Mali and Niger Republic have coastal access to the Atlantic Ocean.
- Over 30MTPA of LNG is exported from Nigeria, Equatorial Guinea and Angola.



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46

LNG to Power - Integrated LNG based Power solutions

Quicker and faster delivery of power



Floating Regasification and Storage Unit (FSRU)

- Many of the planned LNG import terminals are expected to be Floating Regasification and Storage Unit (FSRU).
- FSRUs are quicker to deploy to market, especially if they are converted from LNG carriers as opposed to being newly built.
- They are also cheaper than land based terminals.
- FSRUs have substantially lower capex than land based terminals.



47

LNG to Power - Integrated LNG based Power solutions

Porto de Sergipe power project in Brazil



Integrated LNG based power solutions

Example

- In Oct. 2016, Golar Power took FID for the Porto de Sergipe 1,516 MW power station project in Brazil.
 - Golar Power JV will own and operate the FSRU and associated terminal and power generation infrastructure.
 - The project cost is estimated at US\$1.3 billion and is scheduled to deliver power to 26 committed off-takers for 25 years from 2020.
- Similar strategy can be deployed from country to country in Sub-Saharan Africa.



48

Gas to Power: Natural Gas and LNG Alternatives Summary



- There is a significant unmet electricity demand worldwide. Natural gas continues to be the fuel of choice for the power and industrial sectors in many parts of the world, in part because of its lower carbon intensity compared with coal and oil.
- The natural gas and LNG prices in many parts of the world are indexed to the available alternative fuel with transportation cost added. The Netback Pricing structure is used also for many LNG transaction and also other pricing frameworks.
- The liquefaction technology makes natural gas available throughout the world.



49

Gas to Power: Natural Gas and LNG Alternatives Summary



- Three patterns can be seen:
 - Importing LNG to offset limited domestic gas production and maintain fuel supply. This is the case in India and China.
 - Gas exporting countries using LNG to transport gas to market whilst meeting domestic and regional power demand via pipeline systems – West Africa
 - Replacement of other fossil fuel to meet peak power demand or as a back-up power solution. Most of the countries fall in this category.
- Domestic demand for natural gas specifically to meet the electricity demand is growing.



50

Gas to Power: Natural Gas and LNG Alternatives



Q & A



51

Gas to Power: Natural Gas and LNG Alternatives



Thank You For Attending!



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52
