# Global LNG Outlook

## Medium and Long Term

**Quarter 1 2017**

www.nexantthinking.com

# Global LNG Outlook - Agenda

1. Introduction
2. Key Assumptions
   - A. Oil and Coal Prices
   - B. Demand and Supply
   - C. Infrastructure
3. Medium Term Outlook to 2020
   - A. Demand Trends
   - B. Key LNG Importers
   - C. LNG Export Capacity
   - D. LNG Trade
   - E. Spot and Contract Prices
4. Long Term Outlook – 2020 to 2040
   - A. Demand
   - B. LNG Export Capacity
   - C. Asia Pacific Trade Flows
   - D. Spot and Contract Prices
5. Wrap Up
   - A. Q & A
   - B. Detailed Model Output

# Introduction

# Introduction

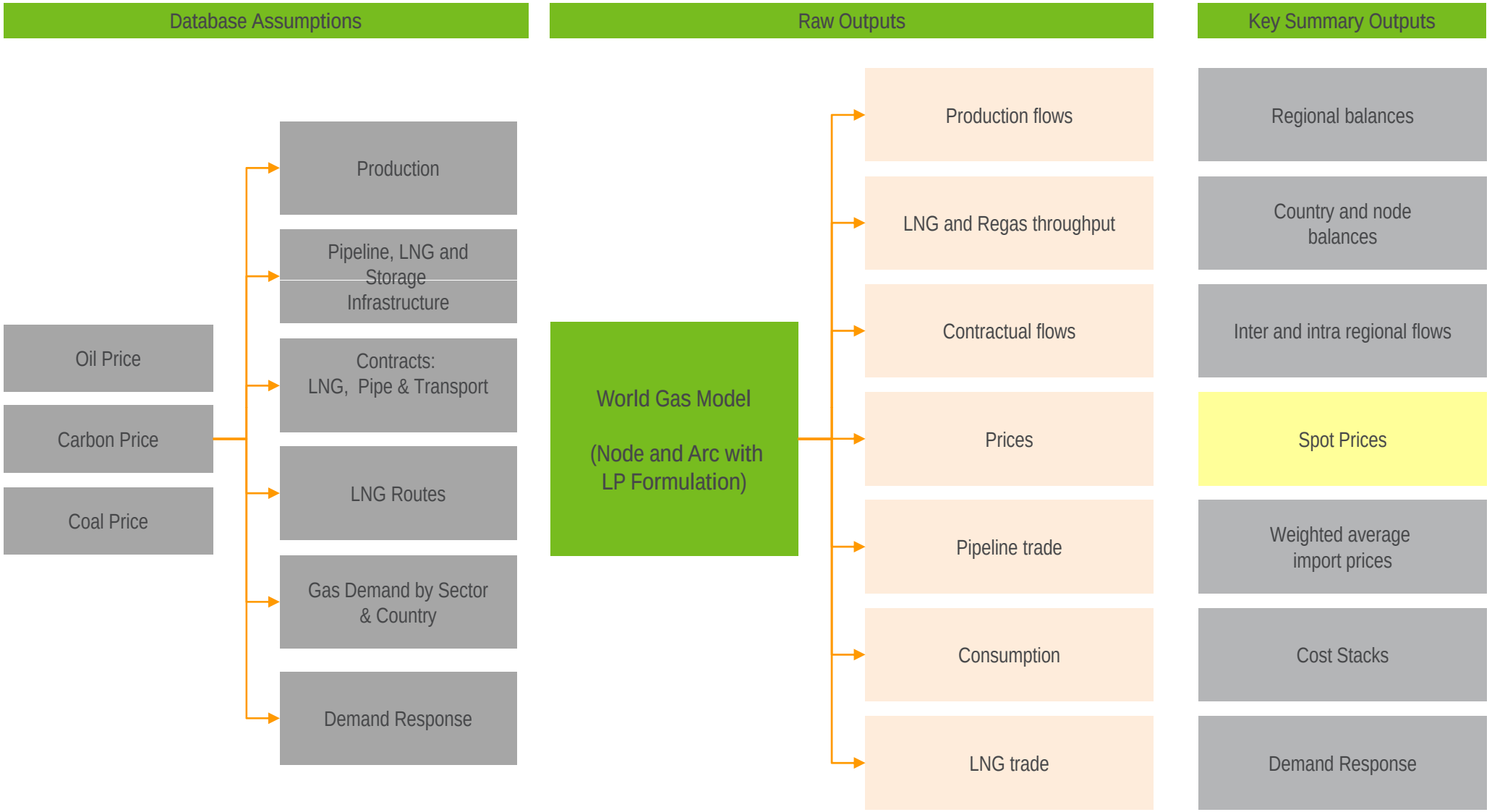
**Global LNG Outlook comes from the Nexant Base Case sent out to licensees of Nexant's World Gas Model (WGM). Licensees receive updates each quarter.**

**Decisions to invest in new supply and infrastructure are not solely based on economics but political and regulatory issues play an important part – the WGM user decides on supply and infrastructure start up dates – the model does not build capacity.**

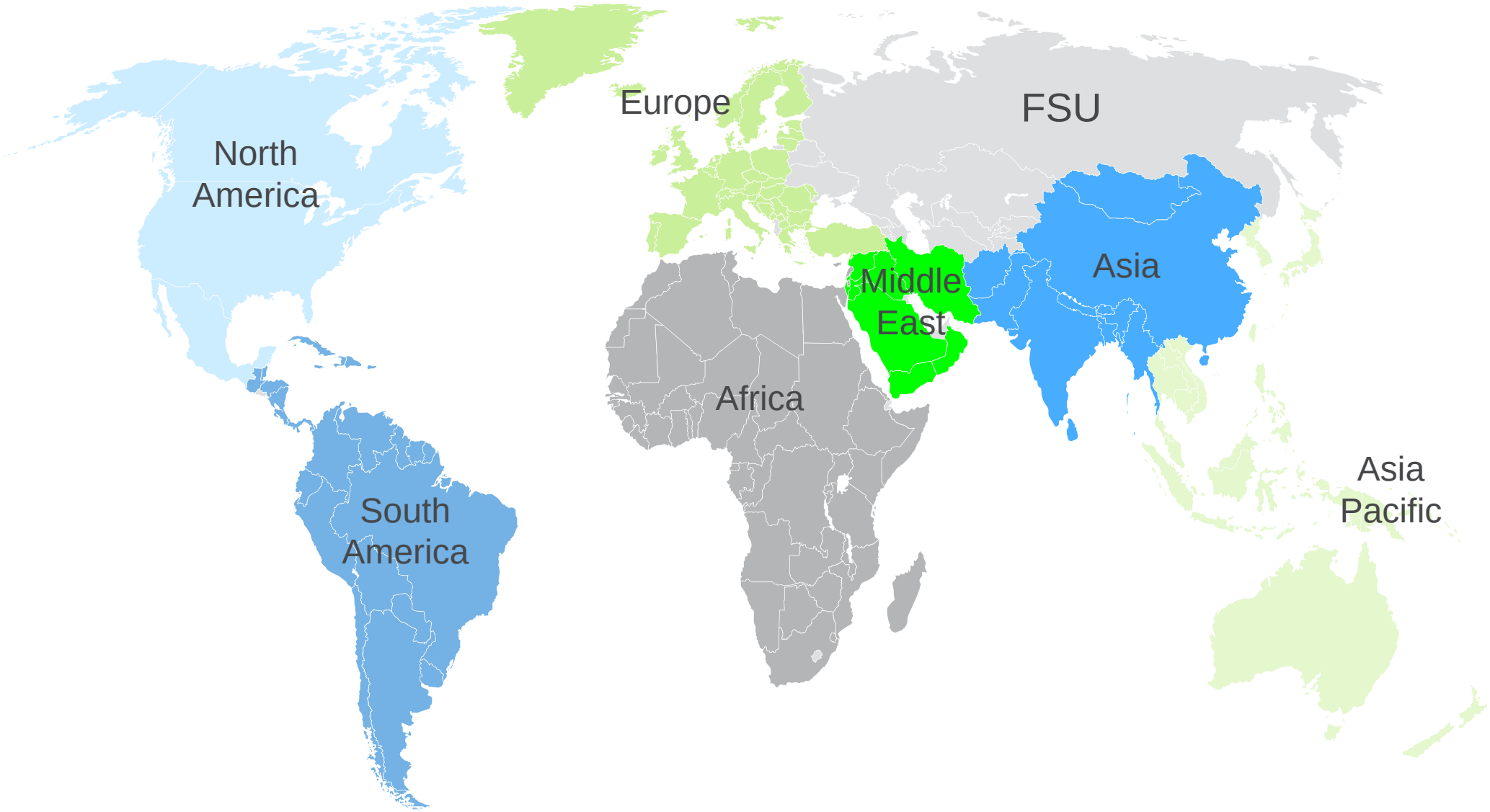
**Pipeline and LNG contracted flows take priority up to TOP levels. Most contracts expire at end of contractual term but some key ones assumed to be extended under the same terms and conditions e.g. Russia to Germany, Qatar to Japan**

**WGM solves for spot prices – they are not an assumption or input – based on the marginal cost of supply, competing prices and market tightness**

# World Gas Model - Overview



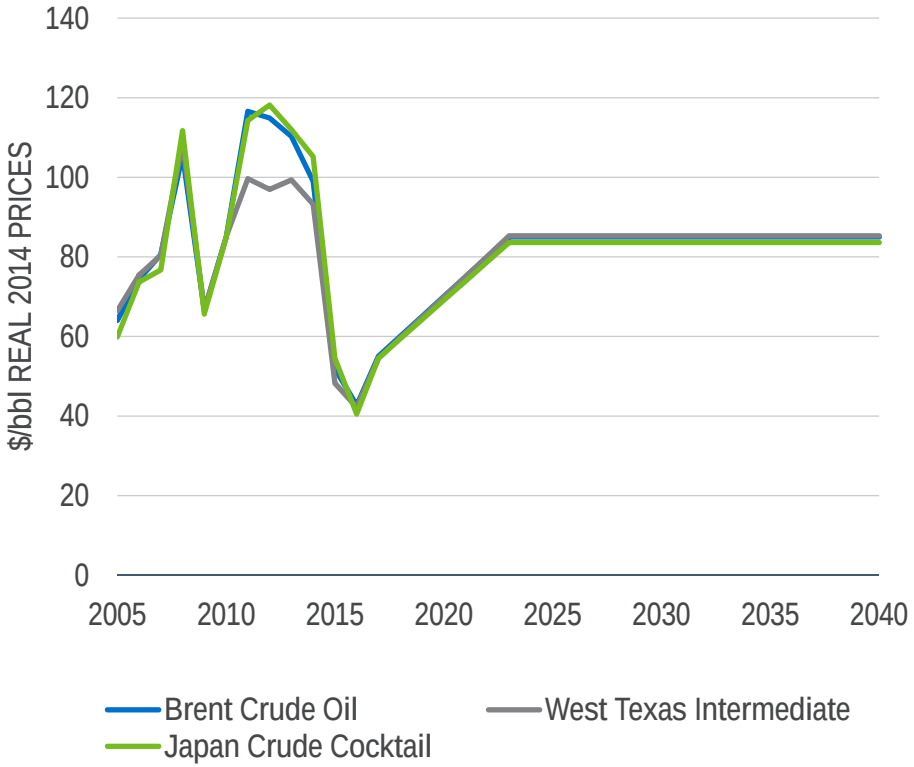
# Regional Definitions – IGU



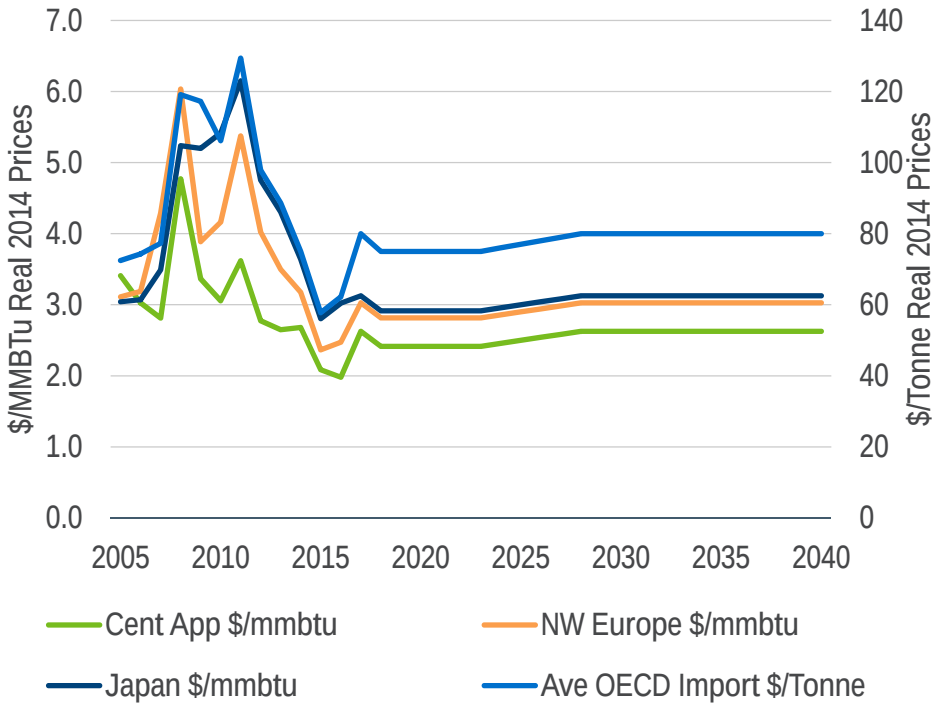
# Key Assumptions

# Oil and Coal Prices

## Oil Prices




## Coal Prices




**Oil prices are not assumed to rise above $100 a barrel in real terms – the levels seen in 2008 and in the 2011 to 2014 period, in excess of $100 a barrel, are seen as an aberration. Assumed to rise gradually to $85 a barrel by 2023**

**Coal prices average out at $80 a tonne in longer term**

# Demand and Supply

## Demand

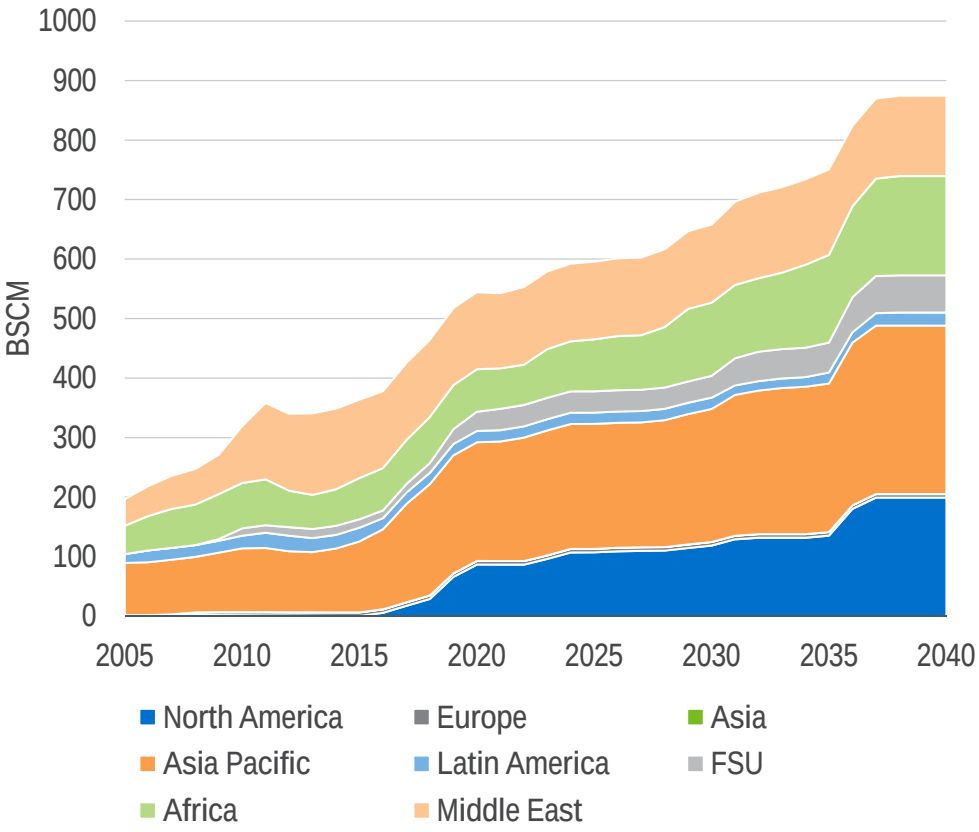
- Global demand through 2040 reflects a broad consensus view – close to the IEA's New Policies Scenario and also the recent BP, GECF and ExxonMobil base scenarios. These all suggest around 1.6% per annum growth in global gas demand between 2015 and 2040.
- World natural gas consumption growth rises from over 3.5 tscm in 2014 to almost 5.2 tscm in 2040.
- Projected growth is strongest in developing countries where gas still has a relatively low share of Total Primary Energy Supply. This is particularly true of China where growth in gas consumption will be determined by economic growth as well as by switching from other fuels to gas in the energy mix; Average annual growth is fastest in Asia followed by Africa and the Middle East.
- Demand is weakest in Europe and the FSU where gas already has a large share of the total primary energy share (TPES) and growth is limited by economic difficulties, improvements in energy efficiency, and a commitment to renewables.

## Supply

- Potential capacity is based largely on proven and probable reserves, although possible reserves are included for North America, together with assumptions about production profiles and costs. On this basis, there is more than adequate production capacity available in every year of the outlook period without any recourse to speculative reserves.
- The World Gas Model schedules production based on lowest cost, taking into account the cost of transport to market, by pipeline or LNG, as well as the cost of production, subject to contractual obligations
- US production continues to be increasing driven mainly by development of shale gas. Unconventional gas, which includes coal bed methane as well as shale gas, is also produced in this scenario in Europe, China and other locations. Nevertheless, conventional gas (which includes tight gas) continues to provide the majority of world gas supply

# Global Liquefaction Capacity

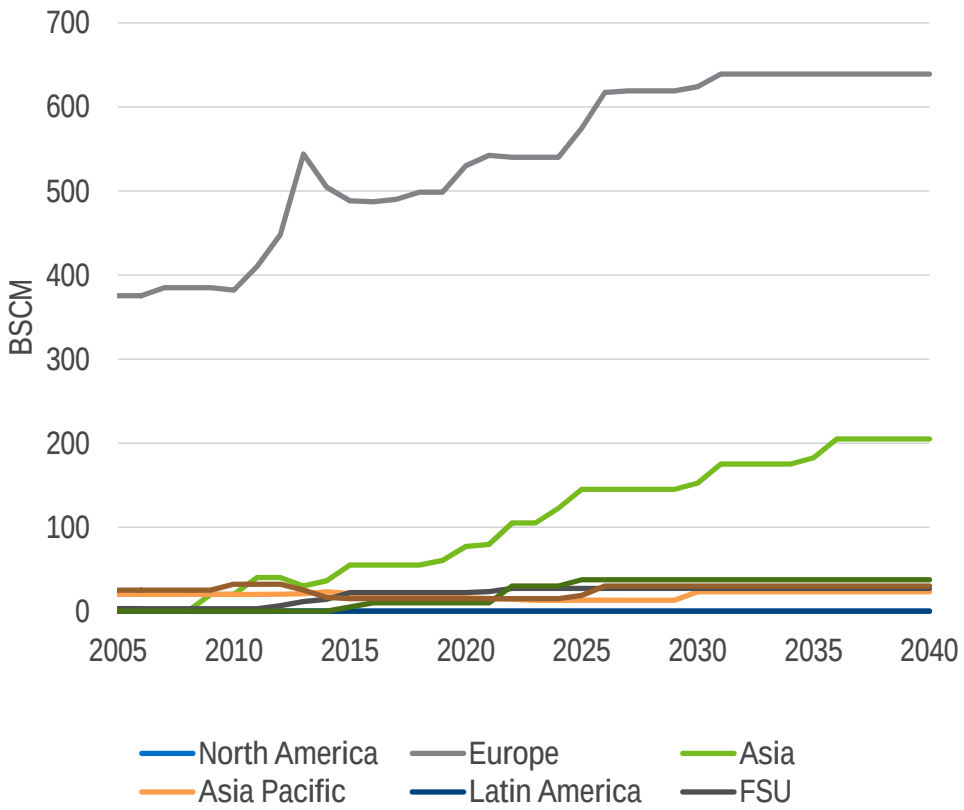
## Liquefaction Capacity Assumptions



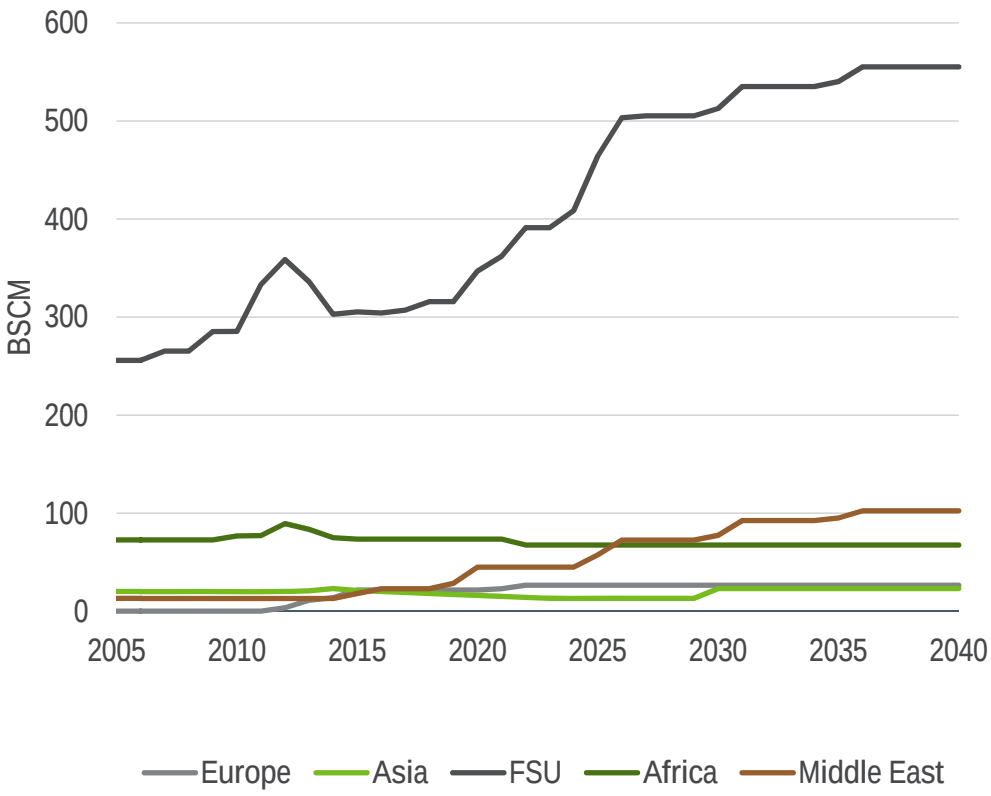

- Global capacity rises by 50% between 2015 and 2020, as multiple new projects currently under construction enter service. Final investment decisions for these projects were taken between 2009 and 2015, when global energy price outlooks and gas demand projects were generally stronger.
- There is a second wave of projects between 2024 and 2030 and a third wave from 2035
- The U.S. is expected to host six projects up to 2020, with expansions of these projects later in the forecast period, plus two new Gulf Coast based projects. Canada will launch three projects, all on the Pacific coast, in the second and third wave.
- Most Asia Pacific capacity additions are located in Australia, although Indonesia, Malaysia, and Papua New Guinea also contribute.
- The FSU has multiple new sources of LNG, all in Russia. In the medium-term, the Yamal LNG venture currently under construction and an expansion of the existing Sakhalin II venture provide incremental sources of regional supply
- In Africa, new liquefaction capacity is assumed in Angola, Cameroon, Equatorial Guinea, Mozambique and Tanzania, mainly 2025 on. Offline liquefaction capacity in Egypt is expected to re-enter full service in 2023.

# Pipeline Capacity

## Inter-Regional Pipeline Import Capacity




## Inter-Regional Pipeline Export Capacity



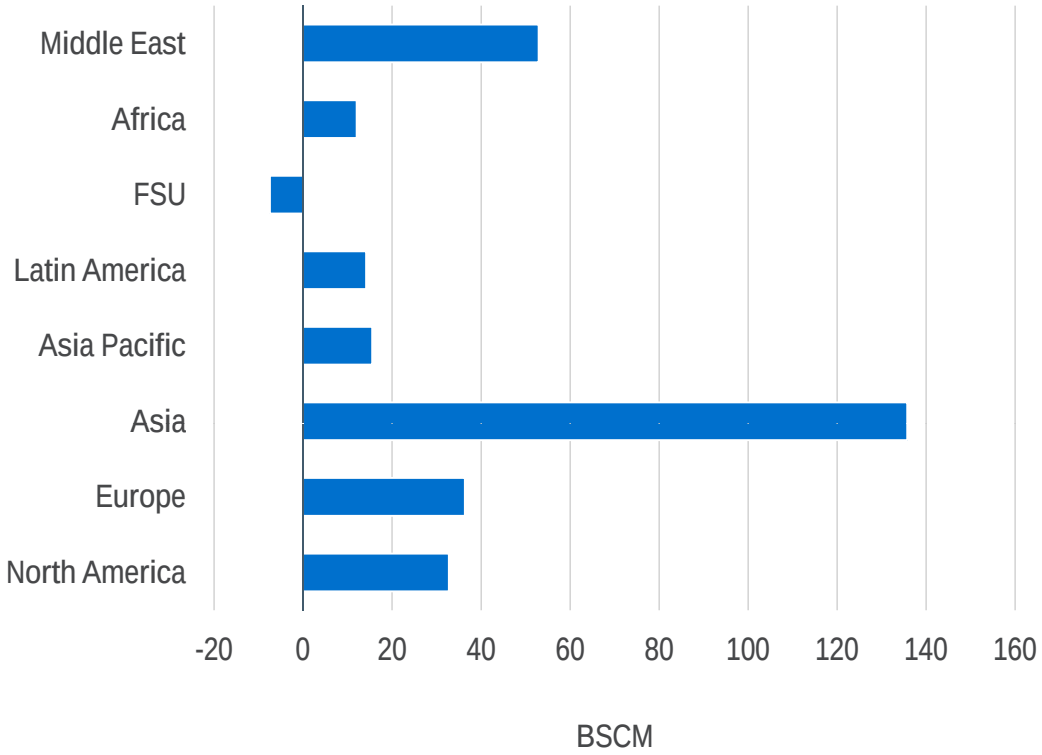

**Main growth in pipeline capacity is out of FSU – Russia, Azerbaijan, Turkmenistan – to Europe and Asia (China)**

**Middle East also expands out of Iraq and Iran to Europe and Asia (Pakistan)**

# Medium Term Outlook to 2020

# Demand Trends to 2020

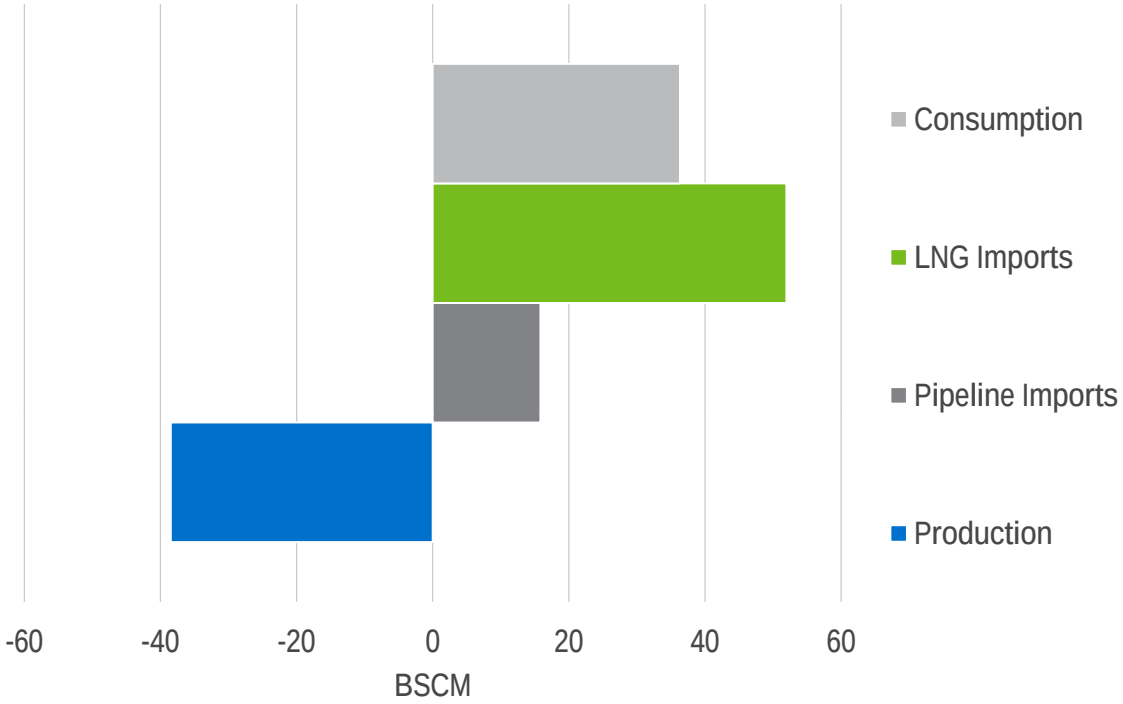
## Demand Growth by Region – 2015 to 2020




- Global demand grows by some 300 bscm or just over 8% to 3,806 bscm
- 100 bscm in China and 20 bscm in India
- Middle East evenly spread
- Asia Pacific driven mainly by Indonesia, decline in Japan
- UK and Turkey contribute most to Europe

# Europe Supply Gap

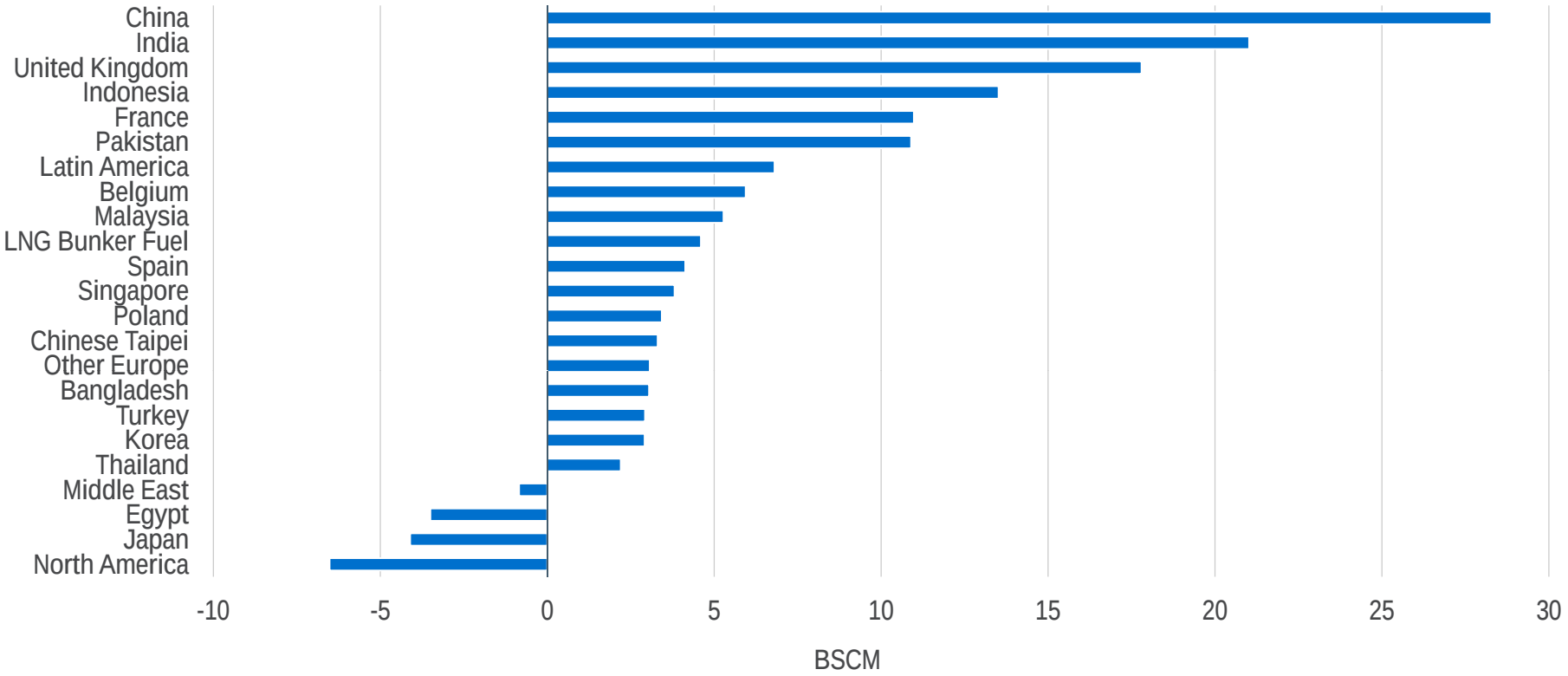
## Change in Europe Supply Demand – 2015 to 2020




- Europe supply gap widens by some 75 bscm – 20 bscm already happened in 2016
- Pipeline imports up 15 bscm – already 10 bscm higher in 2016
- LNG imports up by 50 bscm – doubling by 2020 compared to 2015 – small rise in 2016

# LNG Imports

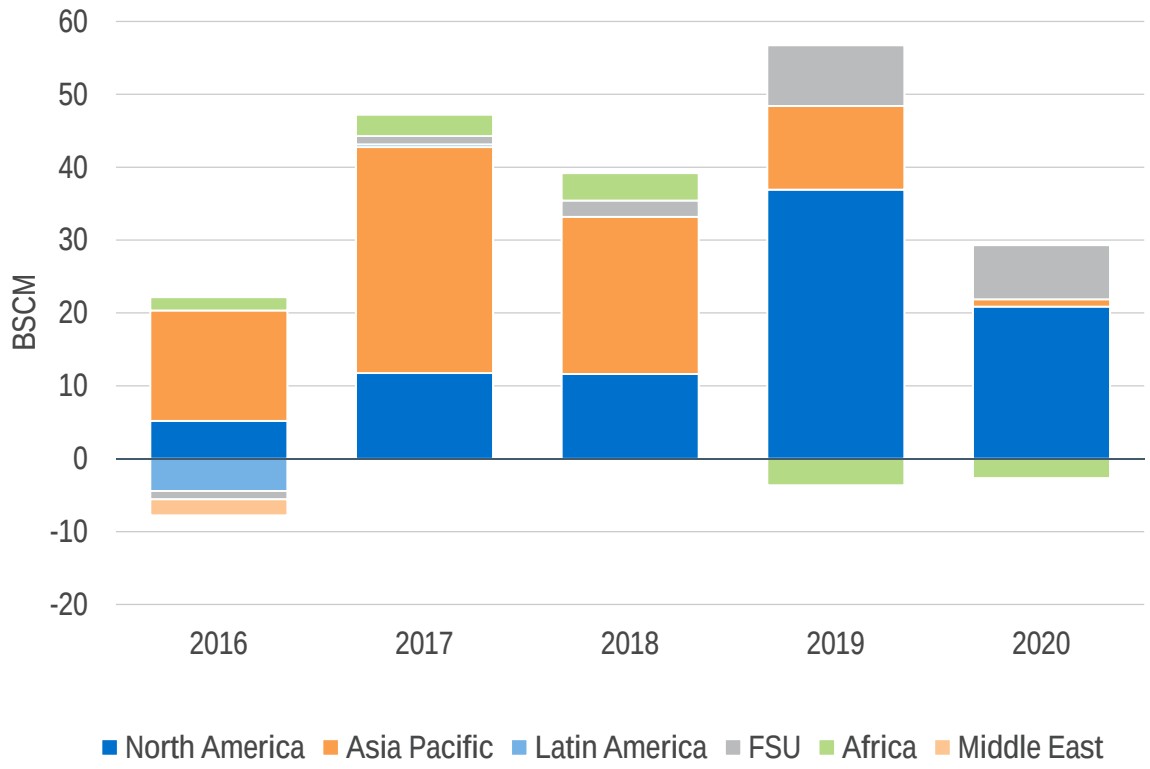
## Change in LNG Imports – 2015 to 2020




**China and India growth is key to increase in LNG imports. UK imports partly "re-exported" to continental Europe. Indonesia imports are mainly from "East" to "West". Start of use of LNG as bunker fuel. Japan imports decline**

# LNG Export Capacity

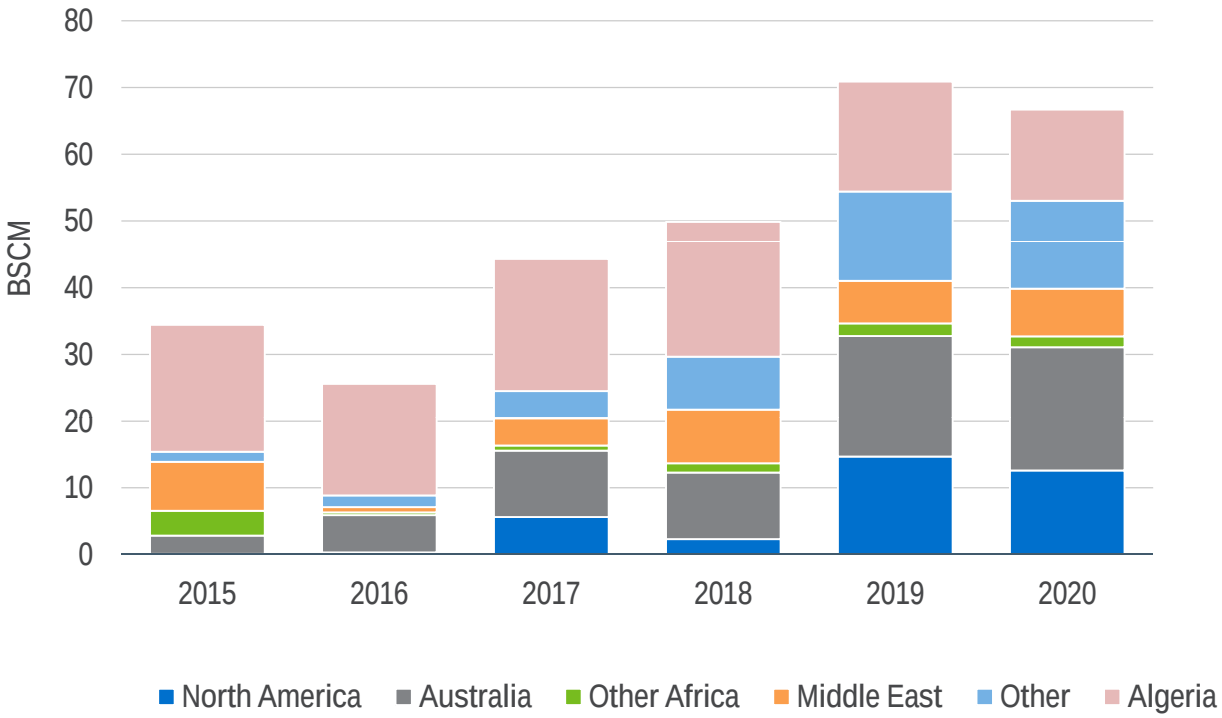
## Change in LNG Export Capacity – 2015 to 2020




| Terminal | Start Up | |
|---|---|---|
| Australia Pacific LNG CBM Train 1 | 2016 | 1 |
| Sabine Pass 1 | 2016 | 1 |
| Gladstone LNG (CSG) T2 | 2016 | 2 |
| Gorgon 1 | 2016 | 2 |
| Sabine Pass 2 | 2016 | 3 |
| Australia Pacific LNG CBM Train 2 | 2016 | 4 |
| Gorgon 2 | 2016 | 4 |
| PFLNG Satu | 2016 | 4 |
| Petronas LNG 9 Sdn Bhd (PL9SB) | 2016 | 4 |
| Gorgon 3 | 2017 | 2 |
| Sabine Pass 3 & 4 | 2017 | 2 |
| Wheatstone LNG 1 | 2017 | 3 |
| Sengkang LNG, Sulawesi | 2017 | 4 |
| Ichthys | 2018 | 1 |
| Prelude FLNG | 2018 | 1 |
| Wheatstone LNG 2 | 2018 | 1 |
| Yamal LNG T1 | 2018 | 2 |
| Cove Point | 2018 | 2 |
| Elba Island | 2018 | 2 |
| Cameron Trains 1&2 | 2018 | 3 |
| Freeport Phase 1 | 2018 | 4 |
| Yamal LNG T2 T3 | 2019 | 1 |
| Corpus Christi Train 1 | 2019 | 1 |
| Corpus Christi Train 2 | 2019 | 2 |
| Cameron Train 3 | 2019 | 3 |
| Sabine Pass 5 | 2019 | 3 |
| Cameroon FLNG | 2019 | 4 |
| PFLNG 2 (Rotan FLNG) | 2020 | 1 |

# Unutilised LNG Export Capacity

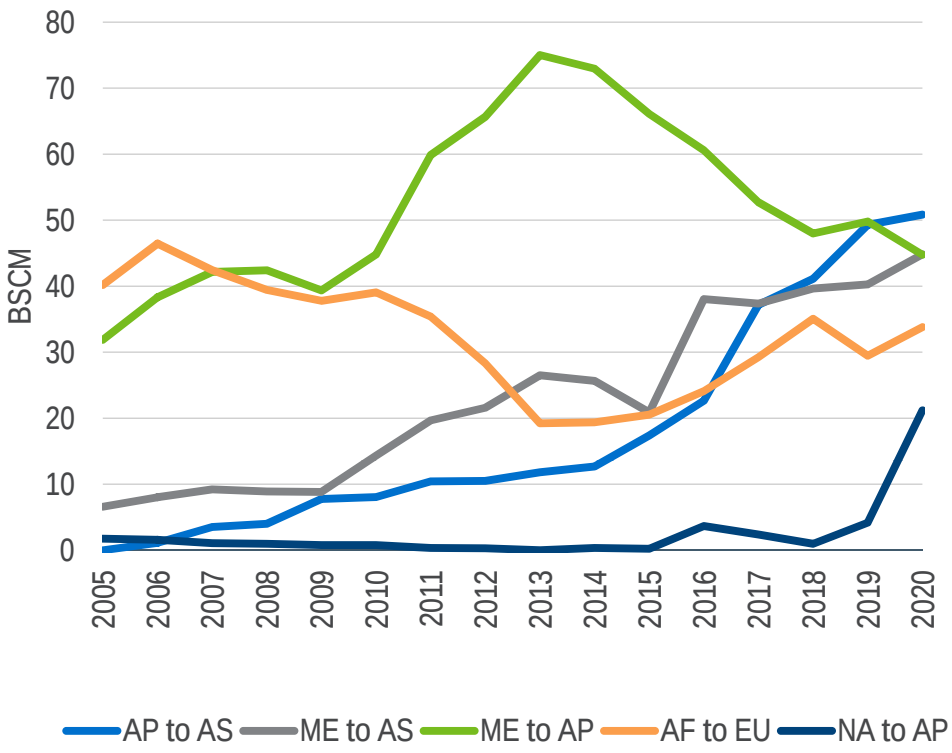
## Unutilised LNG Export Capacity – 2015 to 2020

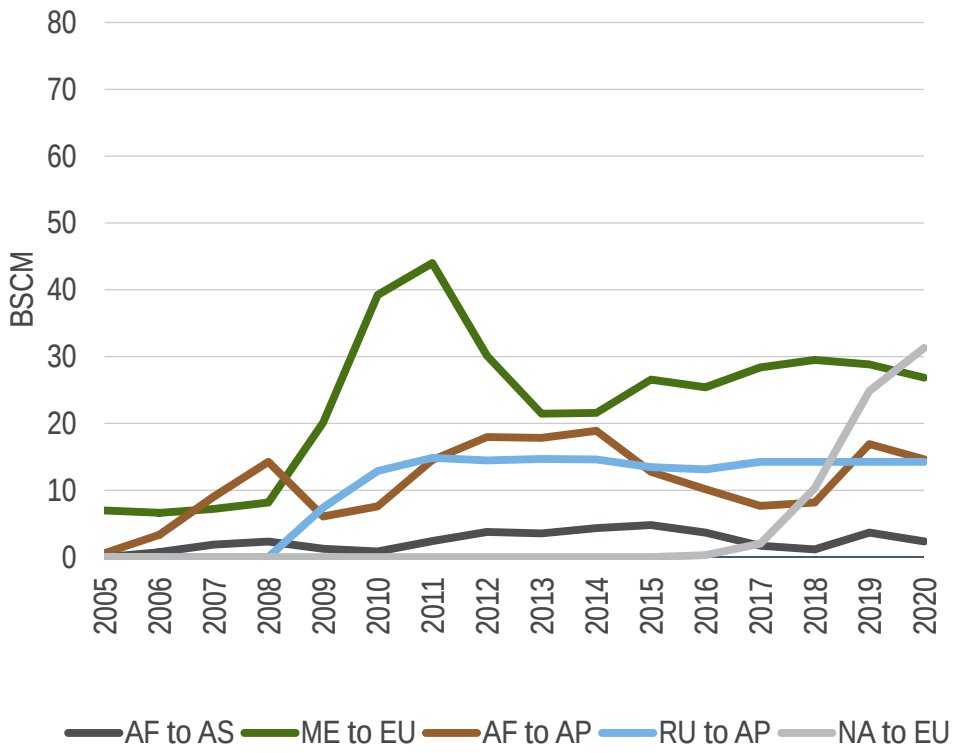



- Unutilised capacity largely contractually determined
- Spot LNG will be shut in if there is not enough demand
- Algeria has the option to export by LNG or pipeline – is it really unutilised?
- US reflects uncontracted capacity
- Middle East mostly Oman
- Other in 2019 and 2020 is the slow build up of Yamal

# Inter Regional LNG Flows

## Key Inter Regional LNG Flows – 2005 to 2020

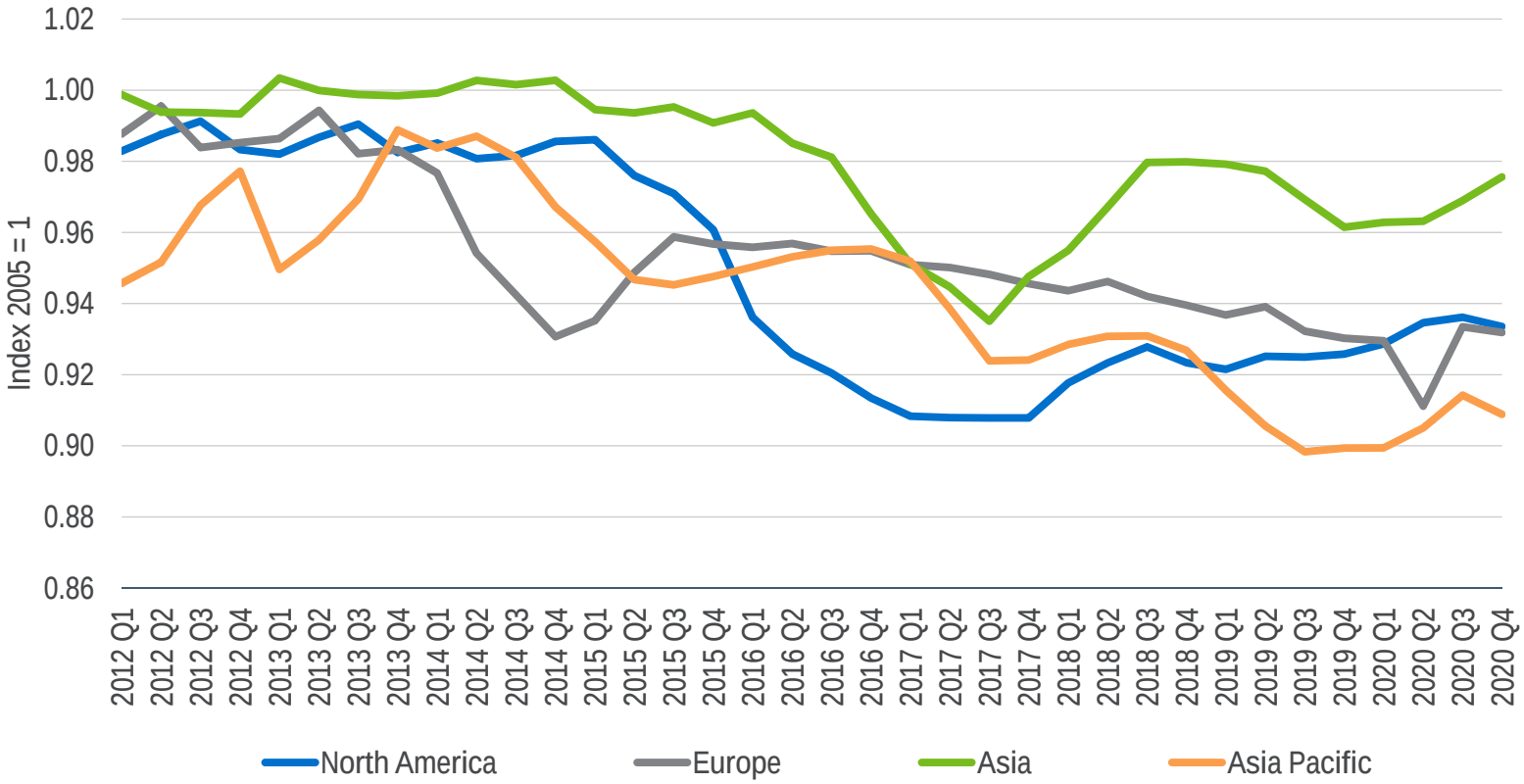



**Middle East exports more to China, India and Pakistan as volumes diverted away from Asia Pacific. Asia Pacific volumes also feed Asia. US volumes head to Europe and Asia Pacific**

# Market Tightness

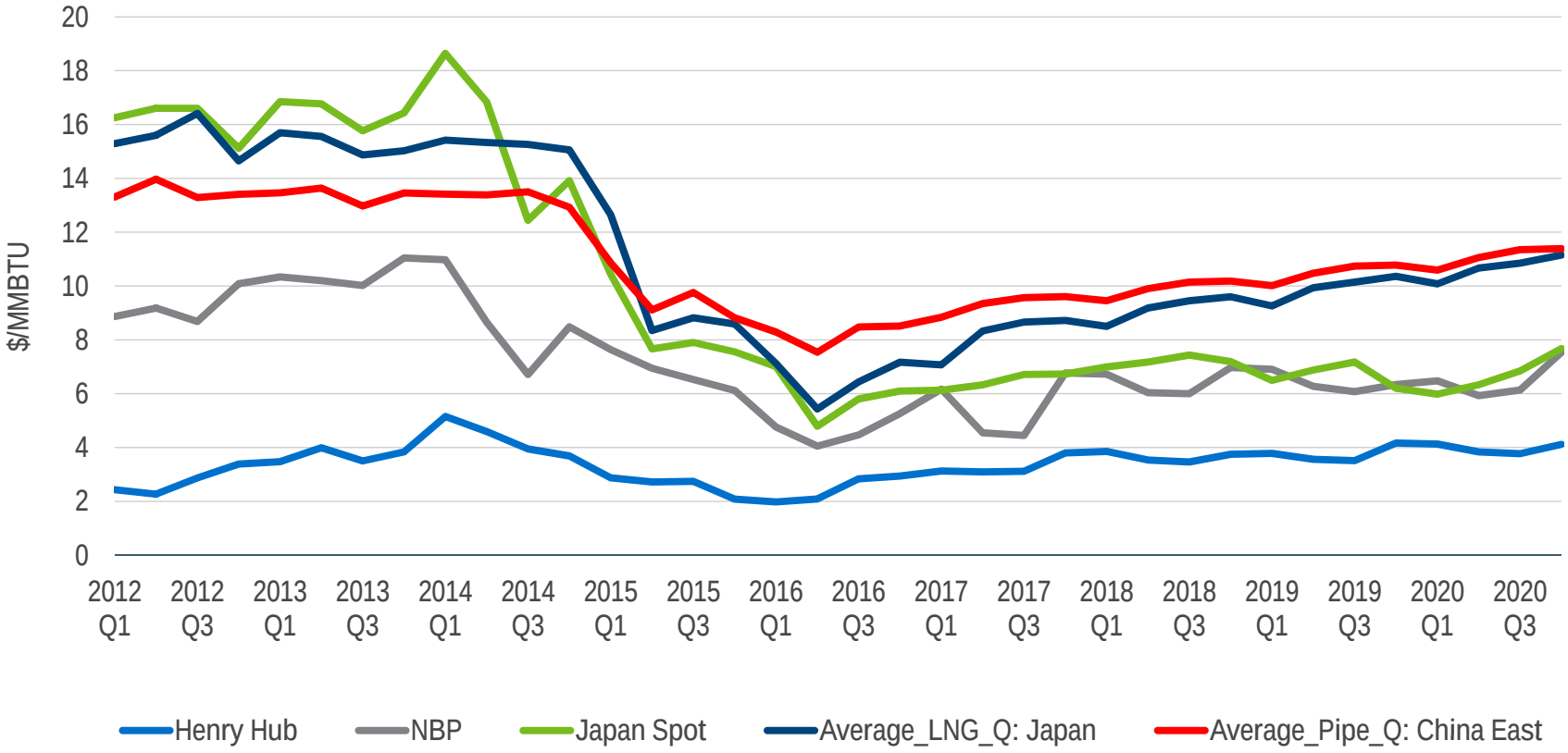
## Market Tightness Indices – 2012 to 2020




**Asia markets tighten as demand rises sharply. Europe tightened in 2015 as production declined but market eases as import supply increases. North America tightens as LNG exports rise. Asia Pacific eases again in 2017 as more LNG export capacity comes on**

# Spot and Contract Prices

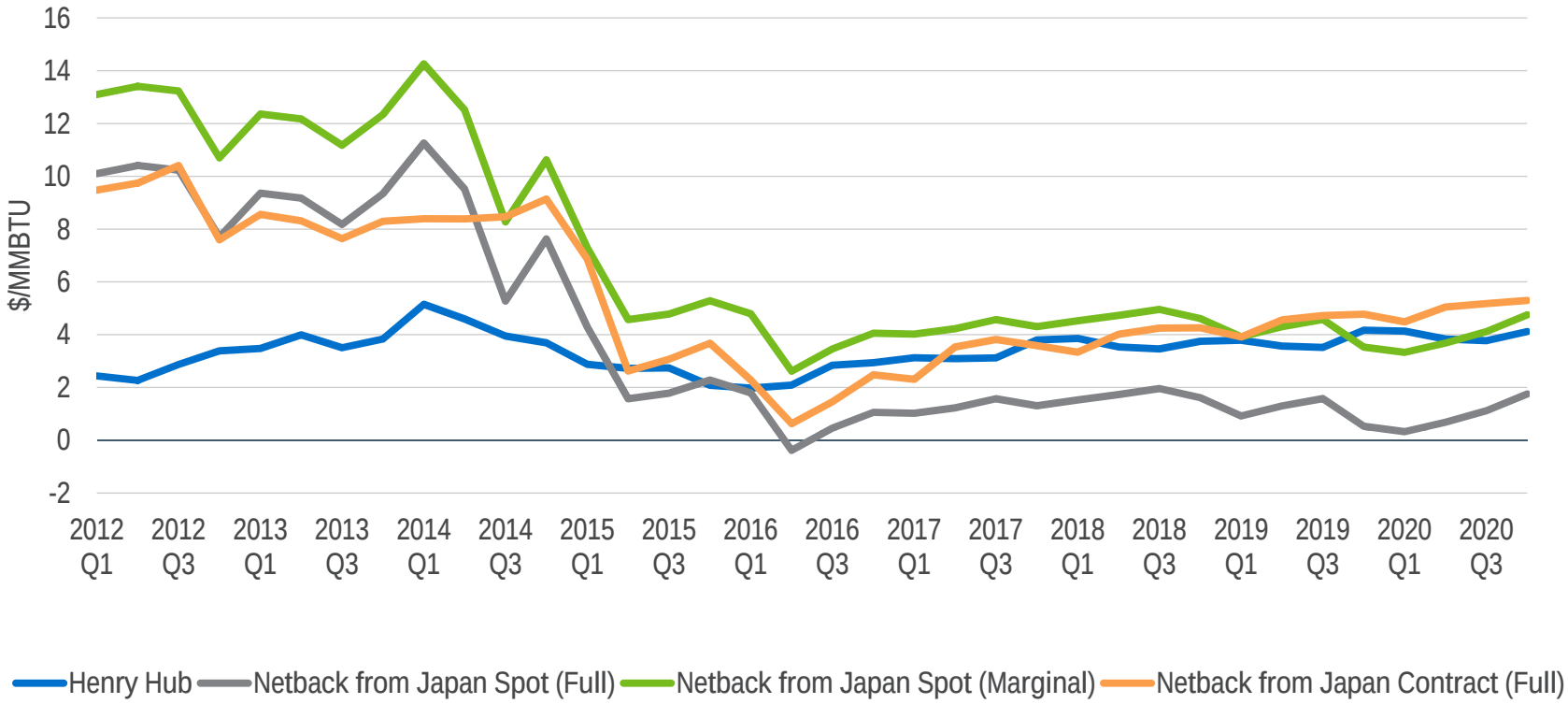
## Spot and Contract Prices – 2012 to 2020




**Even though Europe and Asia Pacific markets are becoming more supply long, spot prices remain flat – rising cost of supply and rising competing prices offset les tight market. Gap opens up between spot and contract prices in Japan as oil prices rise**

# Netback Prices to Henry Hub

## Netback Prices – 2012 to 2020



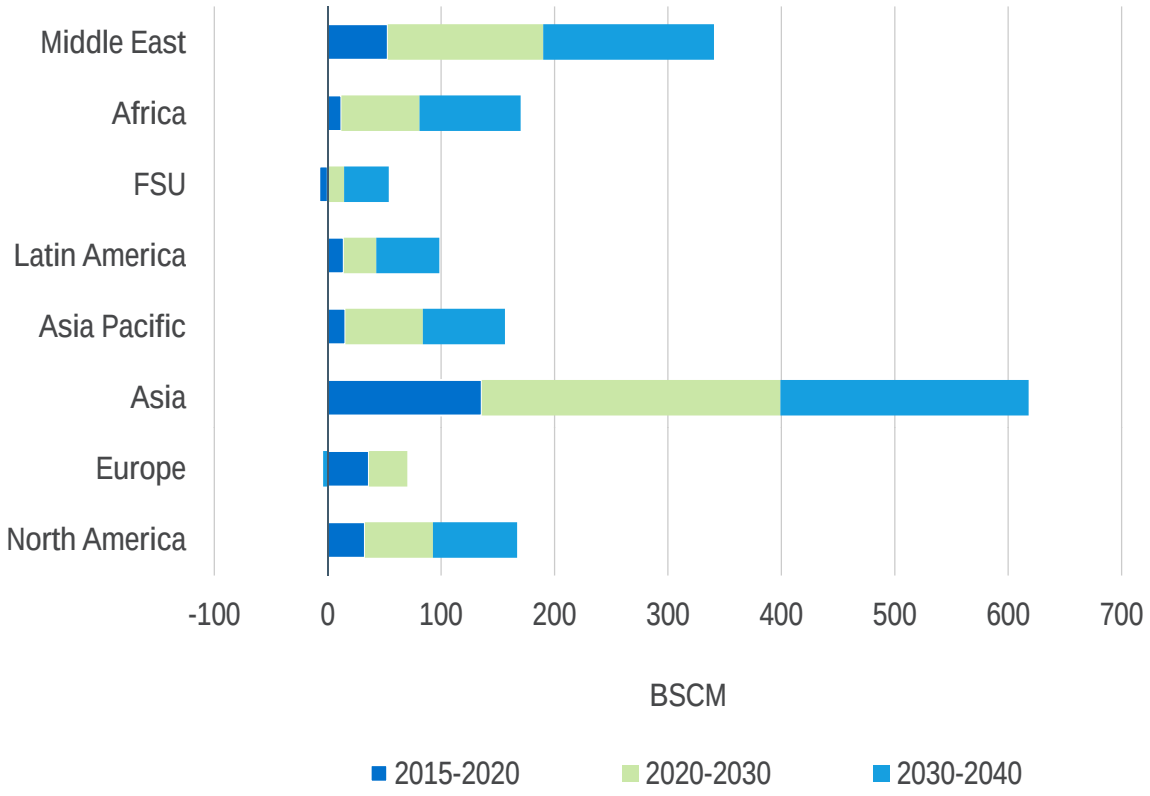

**Netback from Japan is higher than Henry Hub on a marginal basis. From end 2018 the netback from average Japan LNG contracts is higher than Henry Hub as oil prices rise**

# Long Term Outlook

2020 to 2040

# Demand Trends to 2040

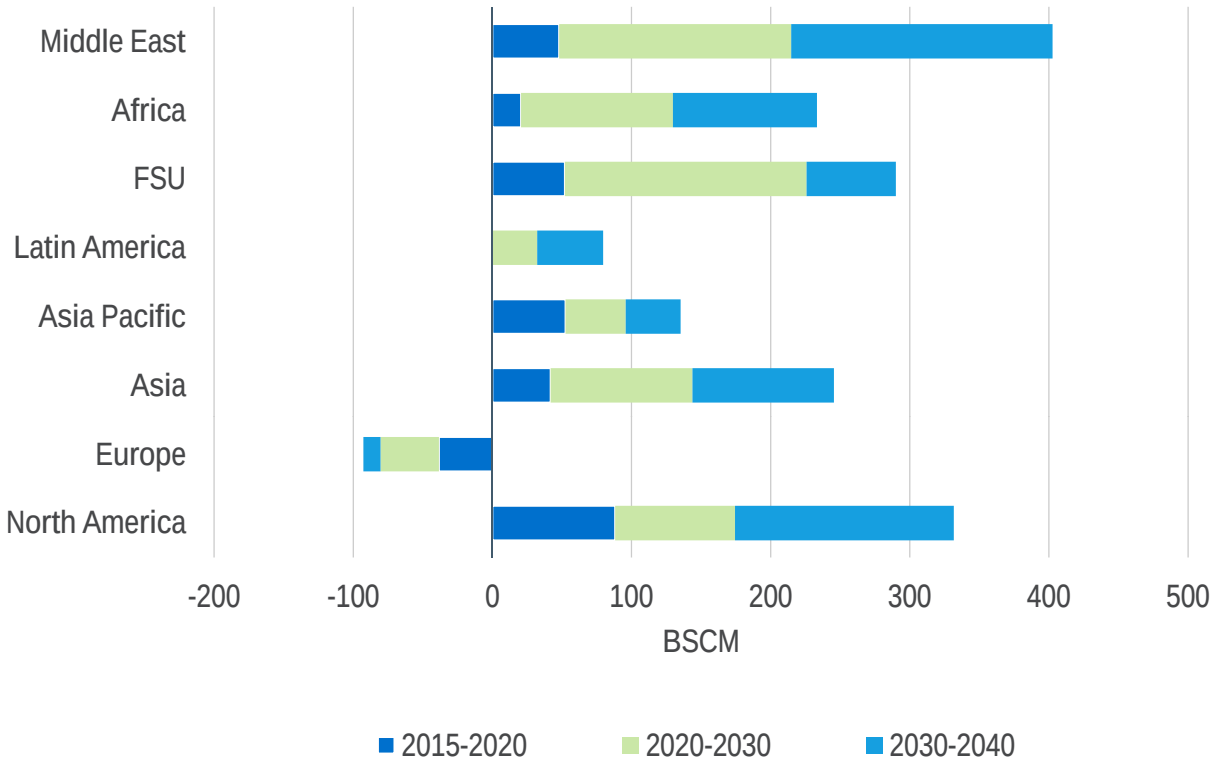
## Demand Growth by Region – 2015 to 2040




- Asia demonstrates high growth supported by population increases, greater wealth, rural electrification schemes, and gas' rising share of national primary energy mixes.
- Middle East demand also rises as oil producers seek alternate fuel sources to increase the volumes of petroleum available for export.
- Rising North American gas consumption is supported by growing and competitively-priced indigenous gas availability.
- European demand shows some recovery, but not to the extent of historic highs. Policies aimed at improving energy efficiency and boosting the share of renewable energy sources will help contain growth. Recovery is partly attributable to the fact that demand was so poor between 2011 and 2014; recovery is the only way forward.

# Supply Trends to 2040

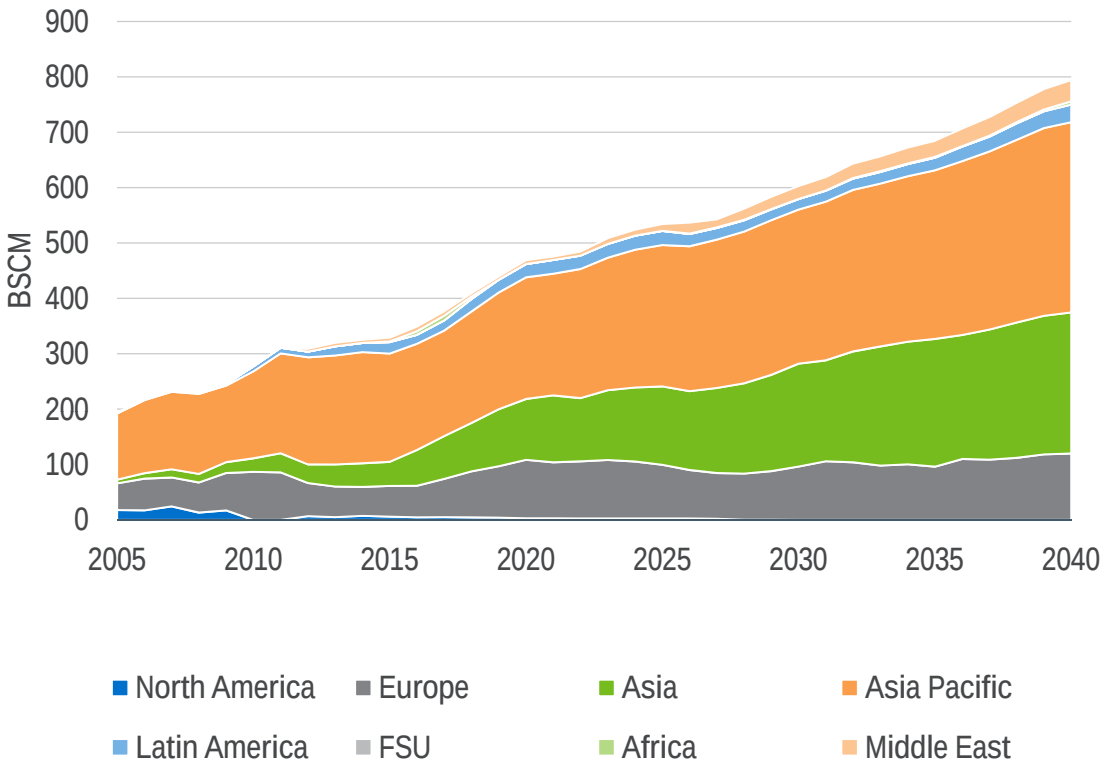
## Supply Growth by Region – 2015 to 2040




- With the exception of Europe, all regions show production increases under the Base Case. Global gas production growth is dominated by unconventional gas output gains.
- The Middle East records the largest gains in absolute terms, buoyed by robust Iranian and Qatari output
- Substantial North American gains support its broadening pipeline gas and LNG export base.
- Projected growth in regions like Africa, the FSU, and Asia Pacific is largely export-driven.
- Production growth in Asia, Latin America, and the Middle East is almost exclusively for domestic use.
- Against the backdrop of recovering European gas consumption, the region's declining output renders Europe increasingly dependent on natural gas imports.

# LNG Imports to 2040

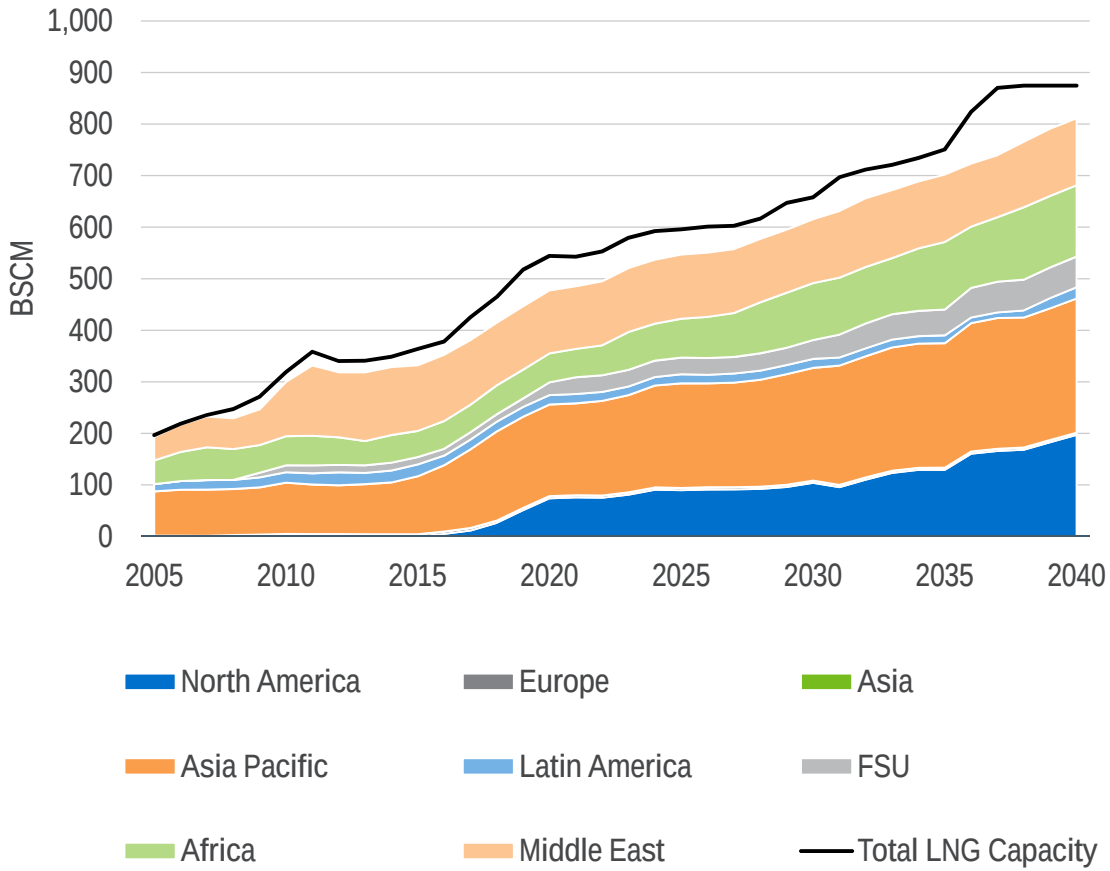
## LNG Imports by Region – 2005 to 2040




- Asia's increasing importance as an LNG importer reinforces the region's significance as an LNG demand centre. The start-up of new regasification capacity, and the increasing utilization of existing facilities, drives gains in Asian countries like Bangladesh, China, India, and Pakistan.
- Europe's LNG imports rise as sources of supply are diversified and compensates for declining domestic production, but its long-standing position as the world's second-largest LNG demand centre is superseded by Asia.
- Middle Eastern throughput increases as new terminals are commissioned in the Persian Gulf, and some existing importers continue to ramp up deliveries.
- As a region, Latin America's throughput level remains fairly consistent for most of the forecast period after 2018, although the line-up of countries importing LNG changes.
- The rise of several smaller regional LNG importers (e.g., Jamaica, Panama, and Uruguay) helps compensate for Brazil's reduced requirements in the 2020s.

# LNG Exports to 2040

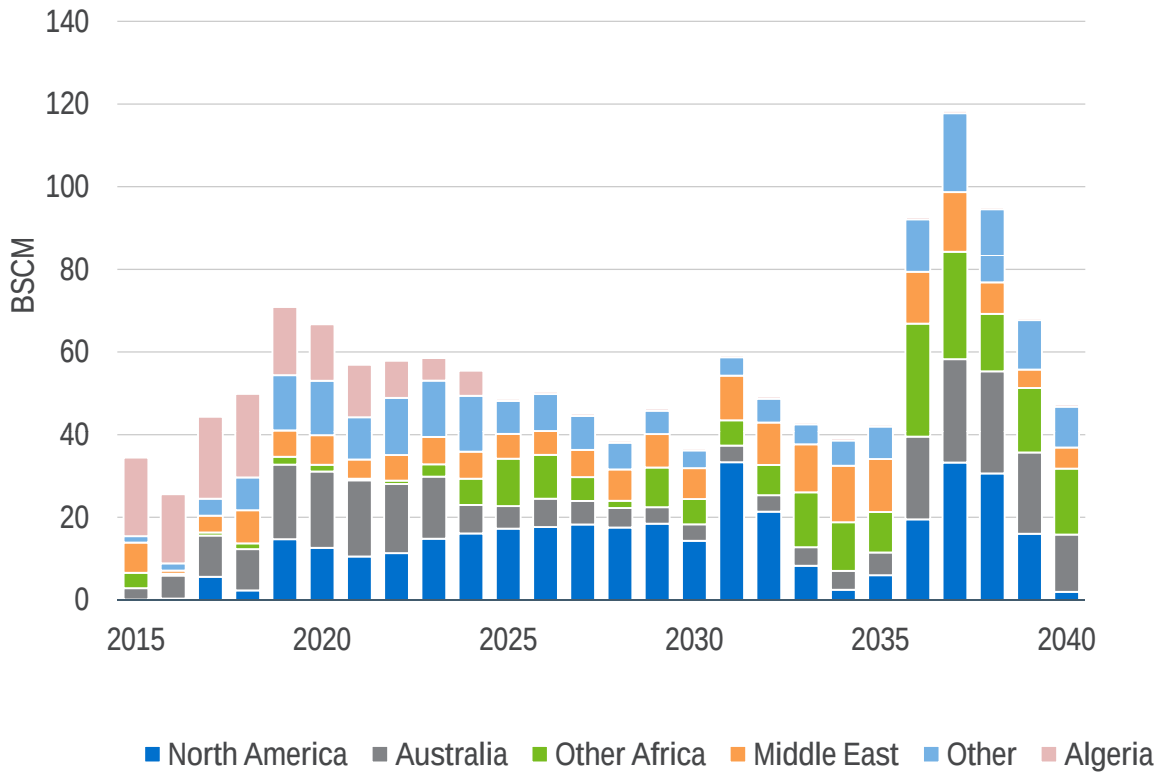
## LNG Exports by Region – 2005 to 2040




- Post 2020 capacity and throughput rise in line until 2030, when the market stars to tighten.
- North American throughput rises from virtually zero in 2015 to over 90 bscm by 2030 and continues to rise.
- This suggests that U.S. buyers will exercise their rights to take cargoes even if Henry Hub-NBP-Asian spot price differentials do not fully cover lifting costs.
- There is a rapid increase in Asia Pacific throughput due primarily to the ramp-up of new Australian liquefaction facilities. New capacity in Indonesia, Malaysia, and Papua New Guinea also contribute.
- African throughput rises rapidly to reflect the addition of new capacity, especially in East Africa, and the restoration of offline Egyptian capacity.
- There is also a rise in FSU throughput to reflect the Yamal LNG start-up, the Sakhalin II expansion, and the addition of greenfield Far East liquefaction capacity.

# Unutilised LNG Export Capacity

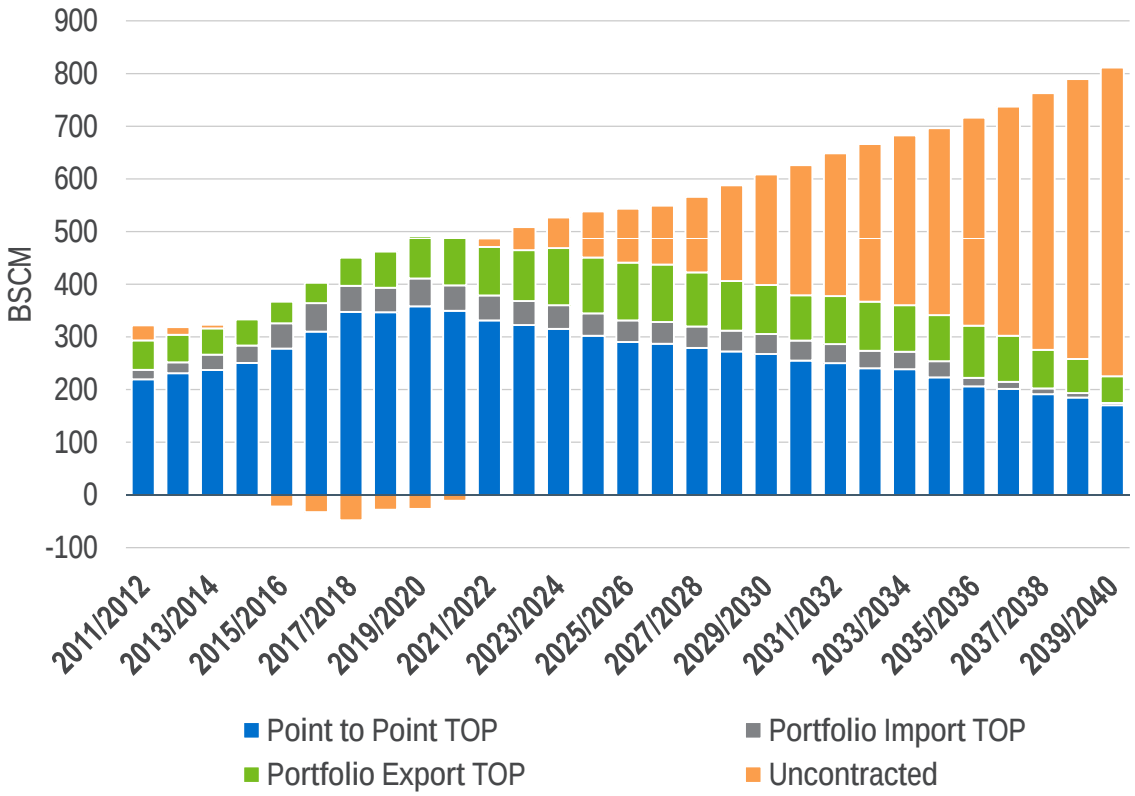
## Unutilised LNG Export Capacity – 2015 to 2040




- After 2020 unutilised capacity declines, although there is greater “slack” in North America plants and less in Australia – driven by contracts but also by the less competitive US gas as Henry Hub prices rise
- As more plants come online in 2030 “slack” rises again principally in North America but rising demand quickly reduces this prior to the third wave of capacity growth.
- Post 2035 as there are fewer contracts, the “slack” is primarily determined on competitiveness grounds

# LNG Contracts to 2040

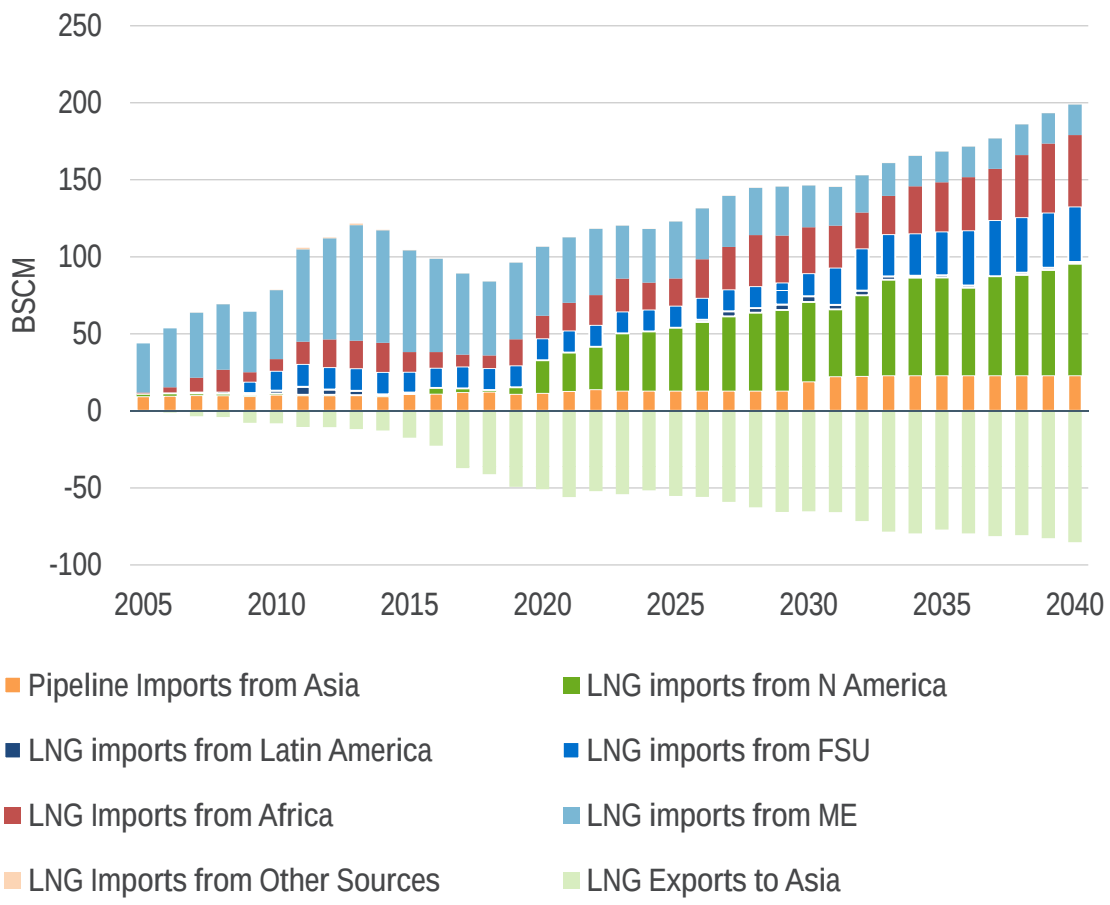
## LNG TOP Levels – 2011/12 to 2040/41




- Point to Point – contracts with destination clauses
- Portfolio import – import terminal has receipt obligation but supplied from anywhere
- Portfolio export – export terminal has deliver y obligation but can be delivered anywhere. The level of portfolio export in chart is total portfolio export TOP less portfolio import TOP
- Market appears over contracted through 2020 – some contracts will therefore undertake
- However, contracts may have more flexibility and lower TOP as part of renegotiations than thought

# Asia Pacific Trade Flows to 2040

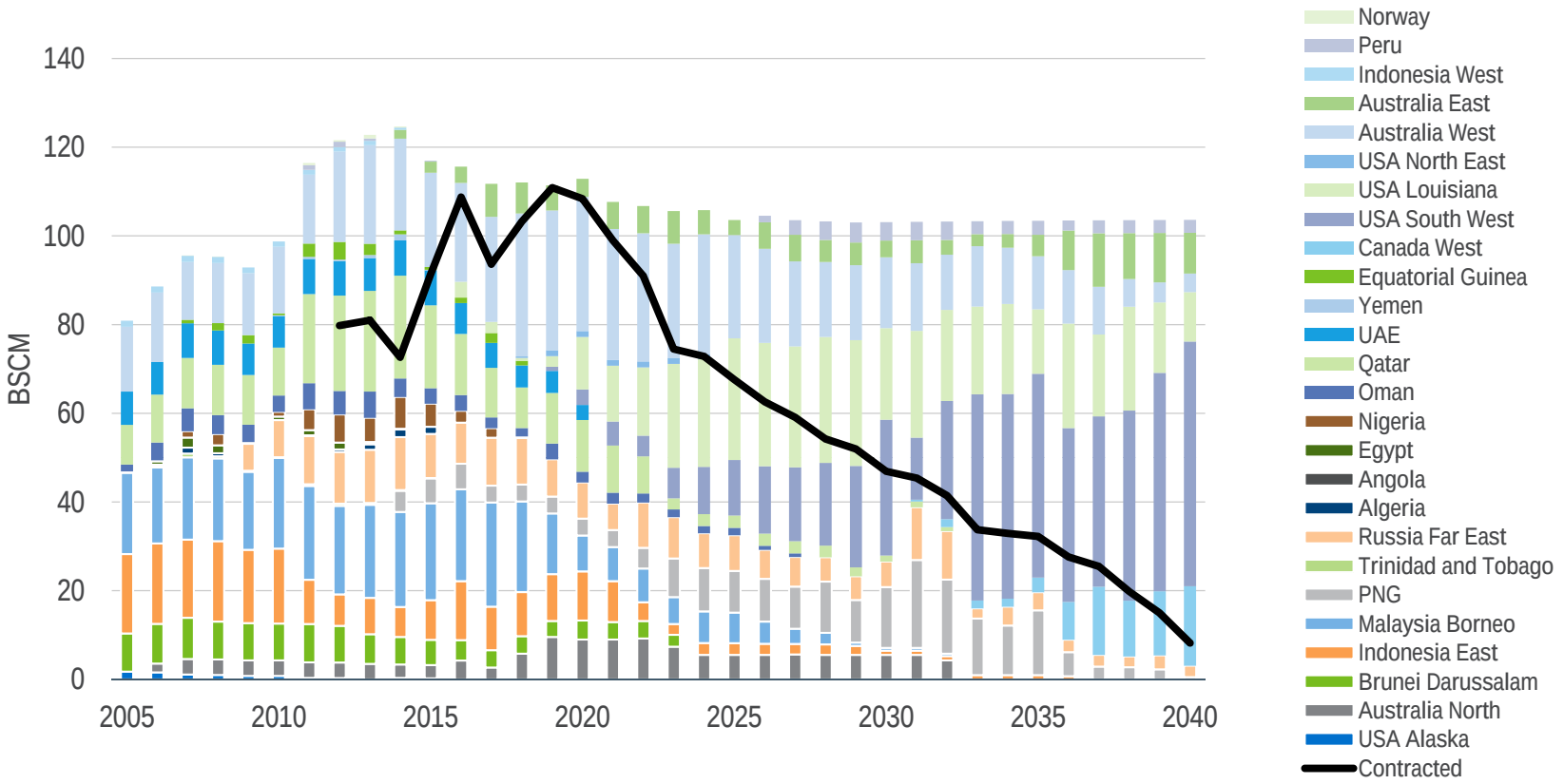
## Asia Pacific Imports and Exports – 2005 to 2040




- The Asia Pacific both imports and exports LNG from/to other regions. The Asia Pacific also imports small volumes of Asian pipeline gas.
- The region's current LNG imports are chiefly sourced from the Middle East, but this changes dramatically over the forecast period.
- Middle Eastern LNG imports are displaced by deliveries from North America, new African LNG projects, and eventually, flows from expanded and new ventures in Russia's advantageously-located Far East.
- Current inter-regional Asia Pacific pipeline receipts more than double after 2030, when additional flows from Myanmar (Asia) commence.
- Inter-regional Asia Pacific natural gas exports chiefly comprise Australian LNG flows to Asia. These grow significantly over the forecast period.
- The Asian market may help underwrite future expansions of Australasian LNG export capacity.

# Japan LNG Imports to 2040

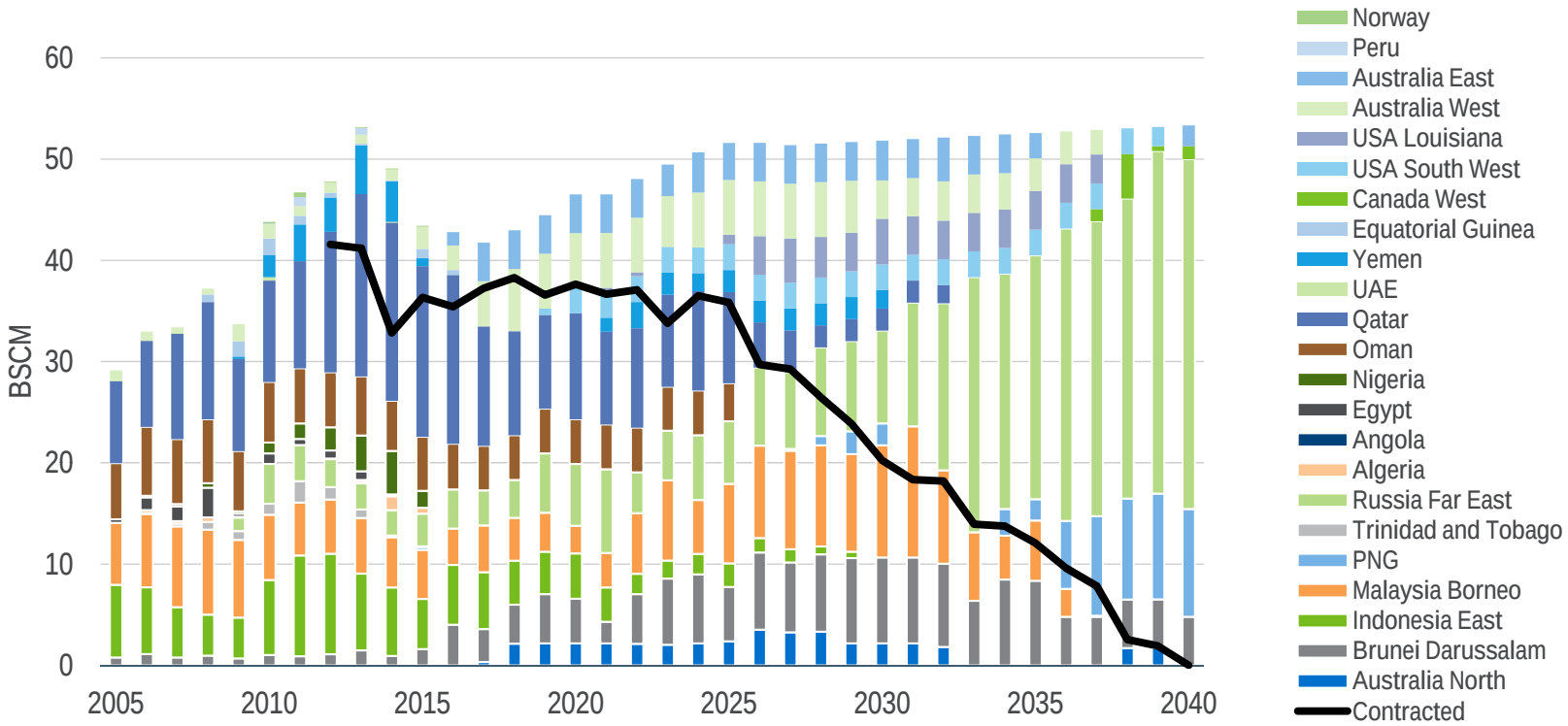
## Japan LNG Imports – 2005 to 2040




- Japan heavily contracted through 2020, even some undertakes on contracts.
- As Qatar contracts fall away, Australia and USA fill the gap.  USA especially later in the period. Less from traditional Indonesia and Malaysia suppliers.
- Demand levels out at 100 bscm – more optimistic than IEA – just under 75 mtpa

# Korea LNG Imports to 2040

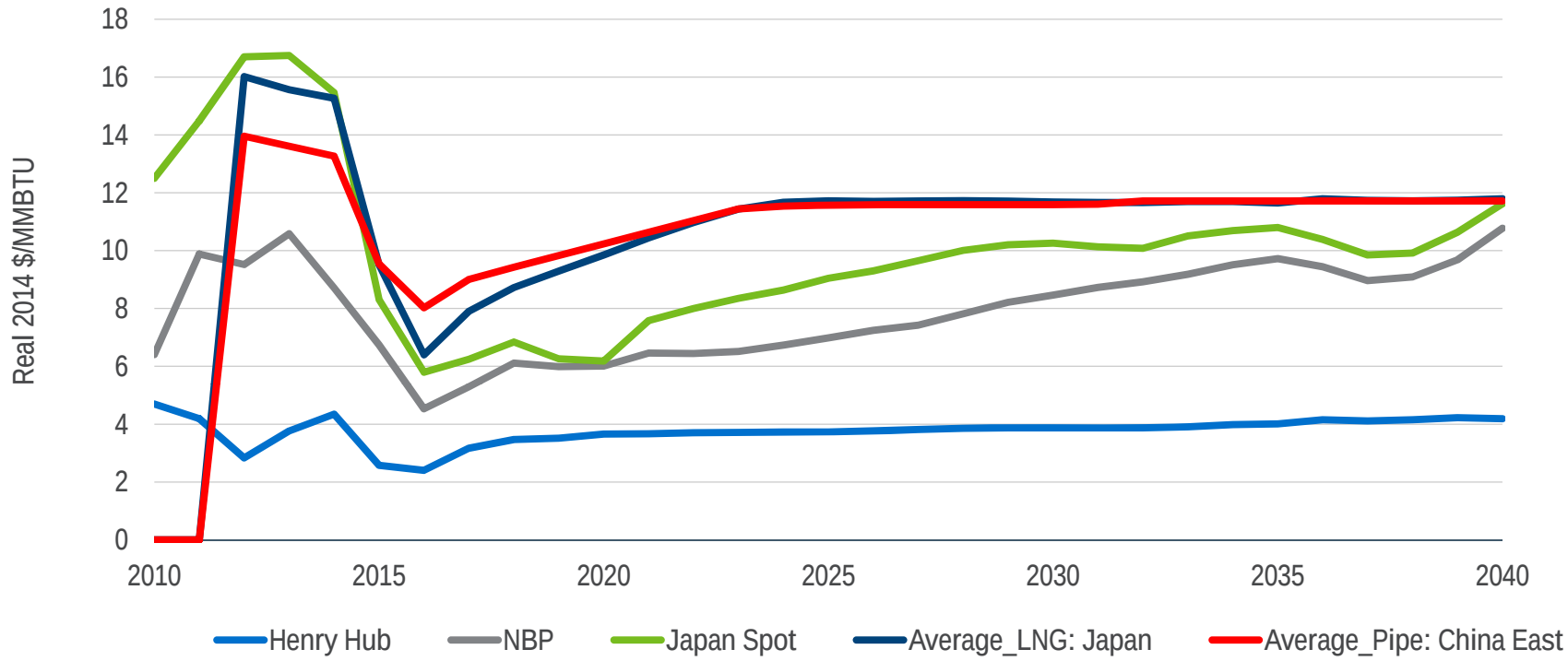
## Korea LNG Imports – 2005 to 2040




- Demand expected to recover over time from current lows – consistent with IEA
- As contracts fall away Russia takes bigger share of market, with PNG supply also
- Assumes most contracts not renewed, but if they were even with different volumes and pricing then supply patterns would change

# Spot and Contract Prices

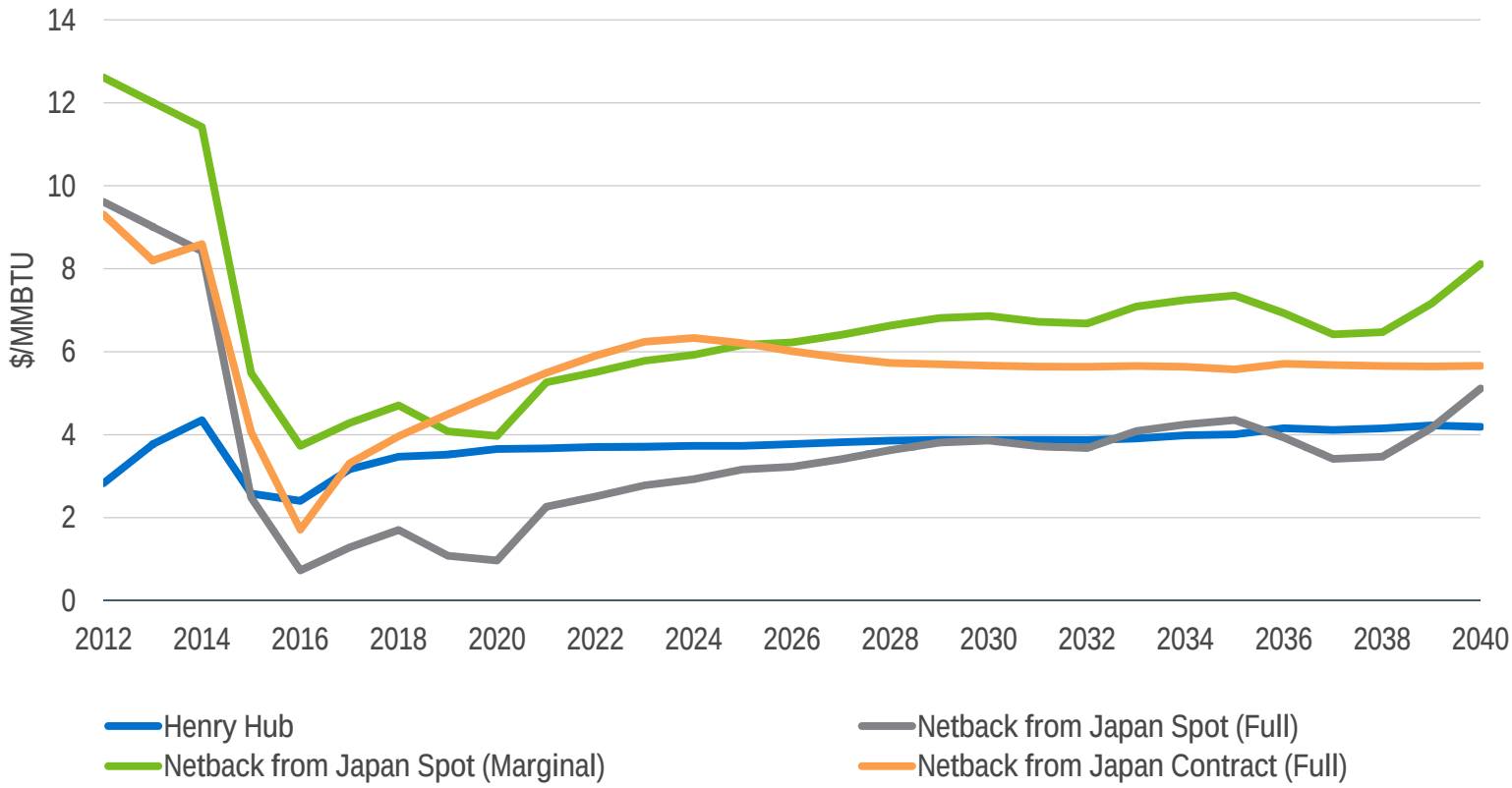
## Spot and Contract Prices – 2010 to 2040




**Long term contract prices in Japan and China steady at $12 per MMBTU at $85 oil. There is a large gap between spot and contract prices in 2020 which narrows over time as the market tightens and more expensive gas is required to satisfy demand. HH levels out as around $4 per MMBTU**

# Netback Prices to Henry Hub

## Netback Prices – 2012 to 2040




**Netback to HH from Japan contract more than covers the full cost of delivery at oil prices over $70 a barrel. The netback from Japan Spot covers the full cost around 2030.**

# The Changing European Gas Market

**Quarter 1 2017**

www.nexantthinking.com

# The Changing European Gas Market - Agenda

1. Introduction
2. Industrial Structure
3. European Gas Pricing
4. Removing Destination Clauses
5. TPA in LNG Receiving Terminals

# Introduction

# Introduction

**Two part presentation – Changing European Gas Market and Global LNG Outlook**

**Changing European Gas Market – Requested Scope**

1. **Impacts of market liberalization to industrial structure in Europe (merger to gas & power company, market oligopoly by a limited number of large companies, etc)**
2. **How natural gas price is determined in in sub-regions of Europe (oil price link in continental countries, hub link in UK or Belgium, etc)**
3. **Responses of market players to the EU's decision of free destination, such as Qatar's acquisition and utilization of receiving capacity in European market.**
4. **Actual implementation and operation of third party access of LNG receiving terminals in Europe (we understand that some of new LNG receiving terminals are exempted from TPA regulation).**

# Industrial Structure

# Industrial Structure

**Impacts of market liberalization to industrial structure in Europe (merger to gas & power company, market oligopoly by a limited number of large companies, etc)**

**The old model saw large producers selling gas to merchant gas transmission companies who then sold on the gas to LDCs who were the main sellers to end users. In some countries the gas transmission company also owned the LDCs e.g. British Gas in the UK market.**

**Market liberalisation has led, along with privatisation, to essentially 4 groups of companies:**

1. Producers and exporters of gas as a commodity
2. Suppliers and traders of wholesale and retail gas
3. Generation, regasification and storage asset owners
4. Network owners and operators – transmission and distribution

**A number of companies are involved in more than one element of the chain – a few in all of the first three.**

**Companies also move into other commodities, especially electricity, wholesaling and retailing both gas and electricity. In addition network owners and operators, such as National Grid in the UK, cover both electricity and gas networks. What network owners and operators generally cannot do is to become involved in the commodity side of the business wholesaling and retailing of gas.**

**Network operators, however, are often also owners of regasification assets in particular and storage assets and sometimes generations assets.**

# Industrial Structure – British Gas Case Study

- **After privatisation in 1986 British Gas retained its monopoly of transportation and wholesale and retail supply in the UK market, as well as gas storage assets**
- **As the market moved to full liberalisation British Gas divided itself into 3 separate entities, eventually as fully stock market listed companies:**
  - Transco – covering transmission, distribution and storage assets
  - Centrica – wholesale and retail supply plus the Morecambe Bay gas field
  - BG Group – all exploration and production plus all other international assets – transmission and distribution
- **Transco was bought by National Grid – the electricity transmission operator**
- **Centrica expanded internationally and into more upstream production, power generation and gas storage – buying the Rough gas storage facility from Dynegy, who had previously bought it from Transco. Centrica also almost invested in nuclear power in the UK**
- **BG Group developed international LNG business comprising liquefaction, regasification, shipping and portfolio trading**
- **National Grid developed the Isle of Grain regasification facility, separated the distribution network into 8 businesses and sold off 4 – recently sold 2 more**
- **BG Group recently bought by Shell**

- **Many European companies followed similar restructuring and unbundling although some remain wholly or partly state owned.**
- **The main unbundling is splitting the network operations from the wholesale and retail supply – the infrastructure versus the commodity**

# European Gas Pricing

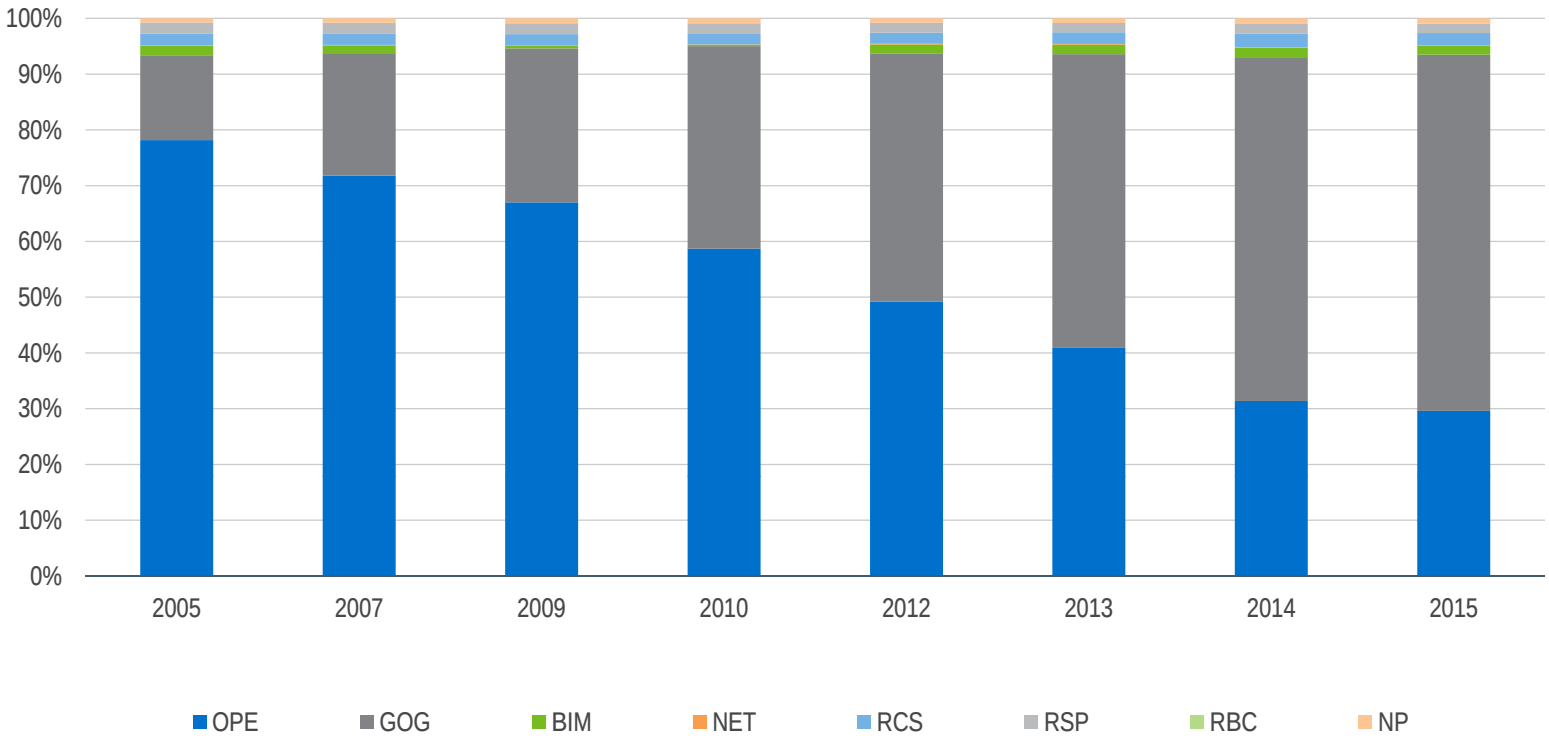
# European Gas Pricing

**How natural gas price is determined in in sub-regions of Europe (oil price link in continental countries, hub link in UK or Belgium, etc)?**

**IGU Wholesale Price Survey has been monitoring prices and price formation mechanisms since 2005**

**European gas pricing has gone through a transformation in last 10 years**

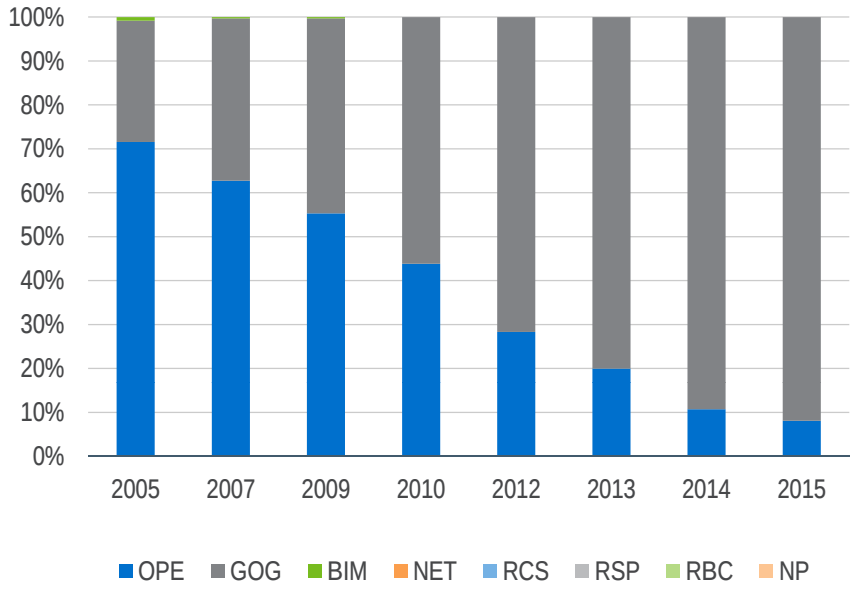
# Europe Wholesale Price Formation – 2005 to 2015



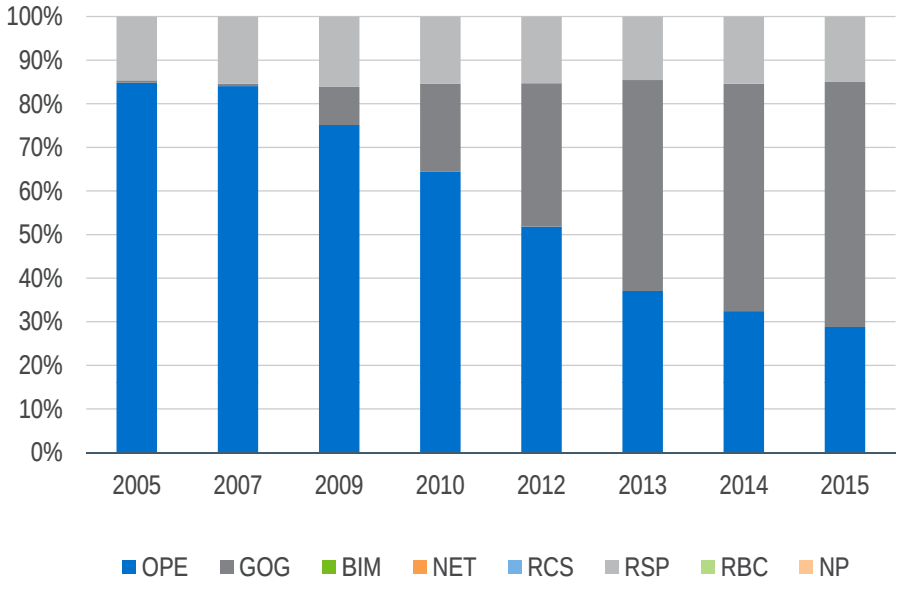

**Continued rise in GOG – 15% in 2005 to 64% in 2015 at expense of OPE**

# Europe Regional Wholesale Price Formation – 2005 to 2015

## Northwest Europe




## Central Europe

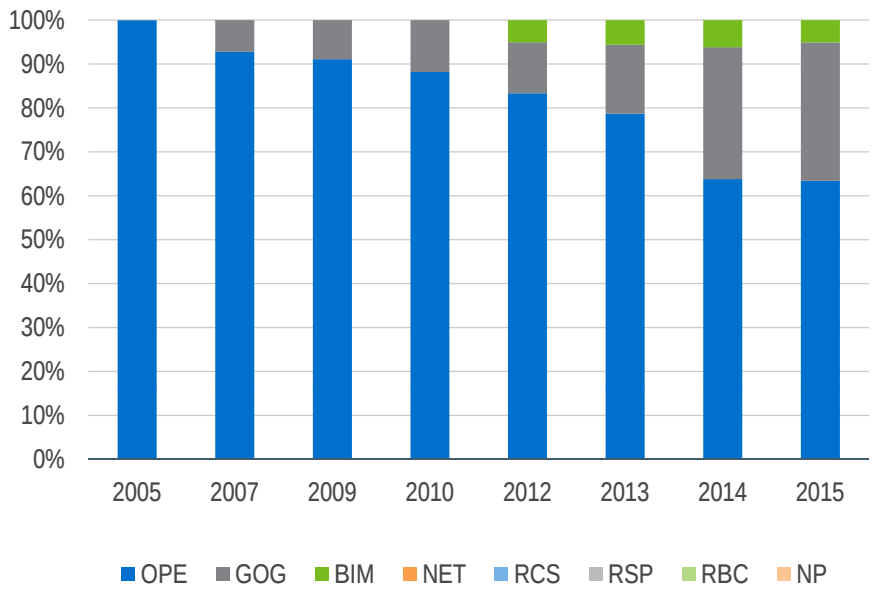



**GOG dominates in Northwest Europe with a 92% share in 2015**

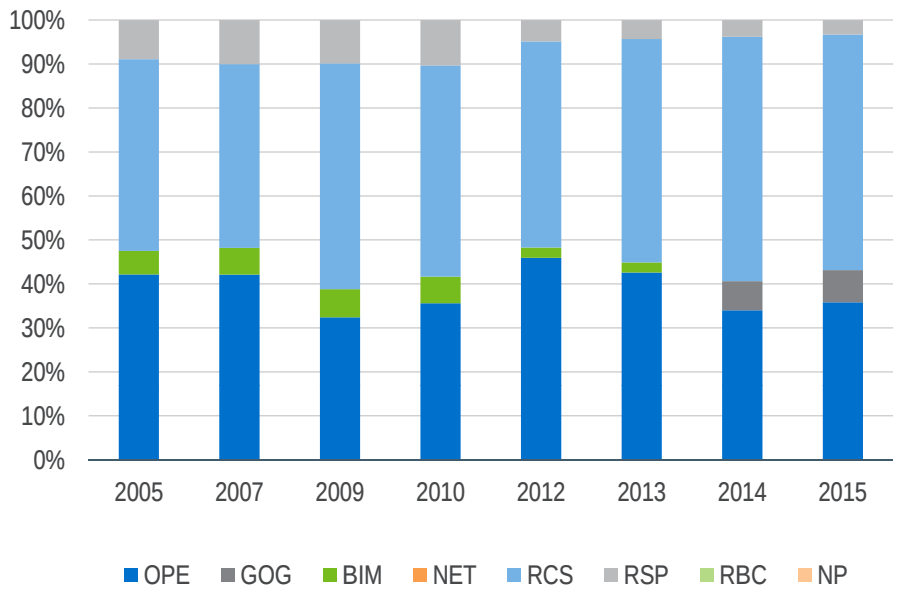
**Largest share at 56% in Central Europe.**

# Europe Regional Wholesale Price Formation – 2005 to 2015

## Mediterranean




## Southeast Europe

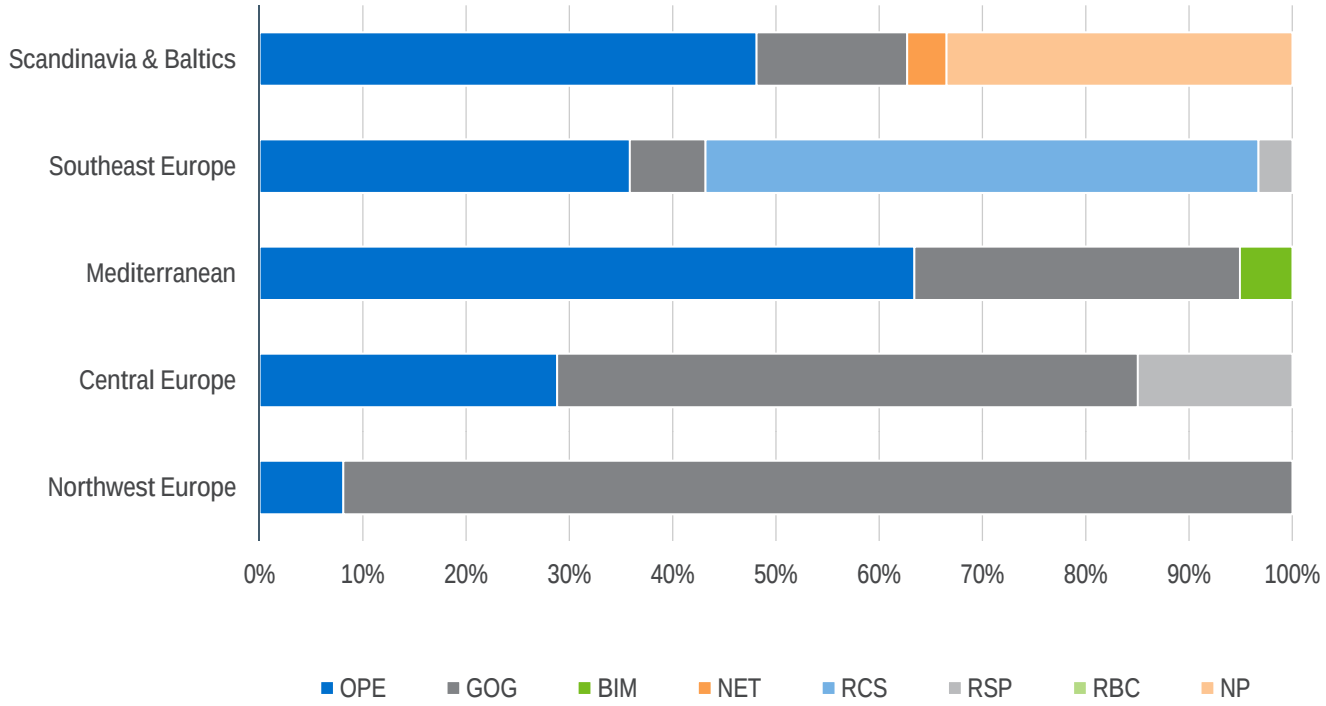



**Elsewhere GOG shares are smaller – some 32% in Mediterranean (principally in Italy)**

**Almost non-existent in Southeast Europe.**

**OPE dominates still in Mediterranean – Spain and Turkey, and shares Southeast Europe with the RCS category in Romania.**

# Europe Regional Wholesale Price Formation 2015




**Snapshot of 2015**

**Scandinavia and Baltics has some GOG**

**2016 survey will be out in May – expected to show further move to GOG**

# Removing Destination Clauses

# Removing Destination Clauses

**Responses of market players to the EU's decision of free destination, such as Qatar's acquisition and utilization of receiving capacity in European market.**

**In the EU, destination clauses that prevent onward sales within the EU are considered 'hardcore' restrictions of competition and prohibited under the EU competition rules. Alternative mechanisms, such as profit-sharing mechanisms (PSMs) have been permitted where the LNG is sold on a delivery ex ship (DES) basis.**

**Destination clauses were removed for pipeline contracts more than 10 years ago when, following legal proceedings by the EU, the gas producers agreed to remove them.**

**The enforcement of destination clauses in DES contracts, especially by Algeria to Spain, prompted the rise in the re-export market.**

**Qatar (as QP) really only holds actually capacity in South Hook which it owns and at Zeebrugge – a 20 year contract. It sells LNG to Edison who have the capacity at Rovigo and to PGNIG in Poland and also to Spain and France on contracts. The buyers of Qatar LNG at these plants will be the capacity holders.**

**Qatar also sells LNG on a spot basis into the European market, and in terms of the way it uses South Hook in the UK is that apart from a contract with Centrica – which doesn't actually require LNG to be delivered as they can source it at the NBP – they self contract into the UK market, bringing cargoes in and selling the regasified gas on a daily, weekly or monthly basis.**

# TPA in LNG Receiving Terminals

# TPA in LNG Receiving Terminals

**Actual implementation and operation of third party access of LNG receiving terminals in Europe (we understand that some of new LNG receiving terminals are exempted from TPA regulation).**

**There are currently 25 large-scale LNG import terminals in Europe. Of these, 23 are in EU countries (and therefore subject to EU regulation), two are in Turkey (which is a candidate for EU membership), 22 are land-based import terminals, and three are floating storage and regasification units (FSRUs).**

**The Third Gas Directive anticipates a system of regulated third-party access to LNG receiving terminals, and requires LNG terminals in the EU to provide transparent and nondiscriminatory access arrangements. Developers of new import facilities and existing import facilities for which new capacity is being developed may obtain an exemption to such TPA requirements from the national regulator if the project satisfies certain criteria. So far, exemptions to the TPA regime have been granted to six of the EU's operating LNG regasification terminals: three in the United Kingdom (Grain LNG, Dragon LNG and South Hook LNG), one in France (Dunkerque), one in Italy (Rovigo) and one in the Netherlands (Gate).**

**The conditions and tariffs of third-party access (TPA) to regulated LNG terminals must be published by terminal operators, as well as approved by the national regulator.**

**Where a TPA exemption has been granted, the owner of the LNG terminal can negotiate contracts directly with its primary shippers/customers; however, the national regulator monitors anti-hoarding mechanisms, and ensures that shippers have access to a sufficiently transparent secondary market.**

# TPA in LNG Receiving Terminals


**TPA exempt terminals tightly clustered in Northwest Europe – all are TPA exempt apart from Zeebrugge – the oldest terminal**

**Rovigo is on Italy east coast**

# TPA in LNG Receiving Terminals

**TPA exempt terminals are all in or close to the key trading markets and hubs.**

**Notable that 2 recent terminals – in Poland and Lithuania are not TPA exempt.**

**In the UK market, the LNG terminals were regarded as being similar to the beach terminals where gas was brought ashore from the North Sea. UK is the key trading market along with Netherlands.**

**In Spain in contrast, the terminals are much older and would probably not have been eligible for TPA exemption but Spain is a relatively isolated market with no real liquid trading hub, although there are multiple terminals.**

**In the TPA regulated terminals usually plenty of primary capacity is available, but in the TPA exempt terminals the primary capacity is often all booked e.g in South Hook in UK an affiliate of the owners has booked all the capacity but there is a strong secondary capacity market.**

# Wrap Up

# Q & A

# Model Detail

# World Gas Model

## Overview

Mike Fulwood

**February 2017**

www.nexantthinking.com

# World Gas Model - Overview

**WGM is supplied with a comprehensive database on gas production, LNG and pipeline infrastructure, trade routes as well as long term contracts, storage facilities and demand projections**

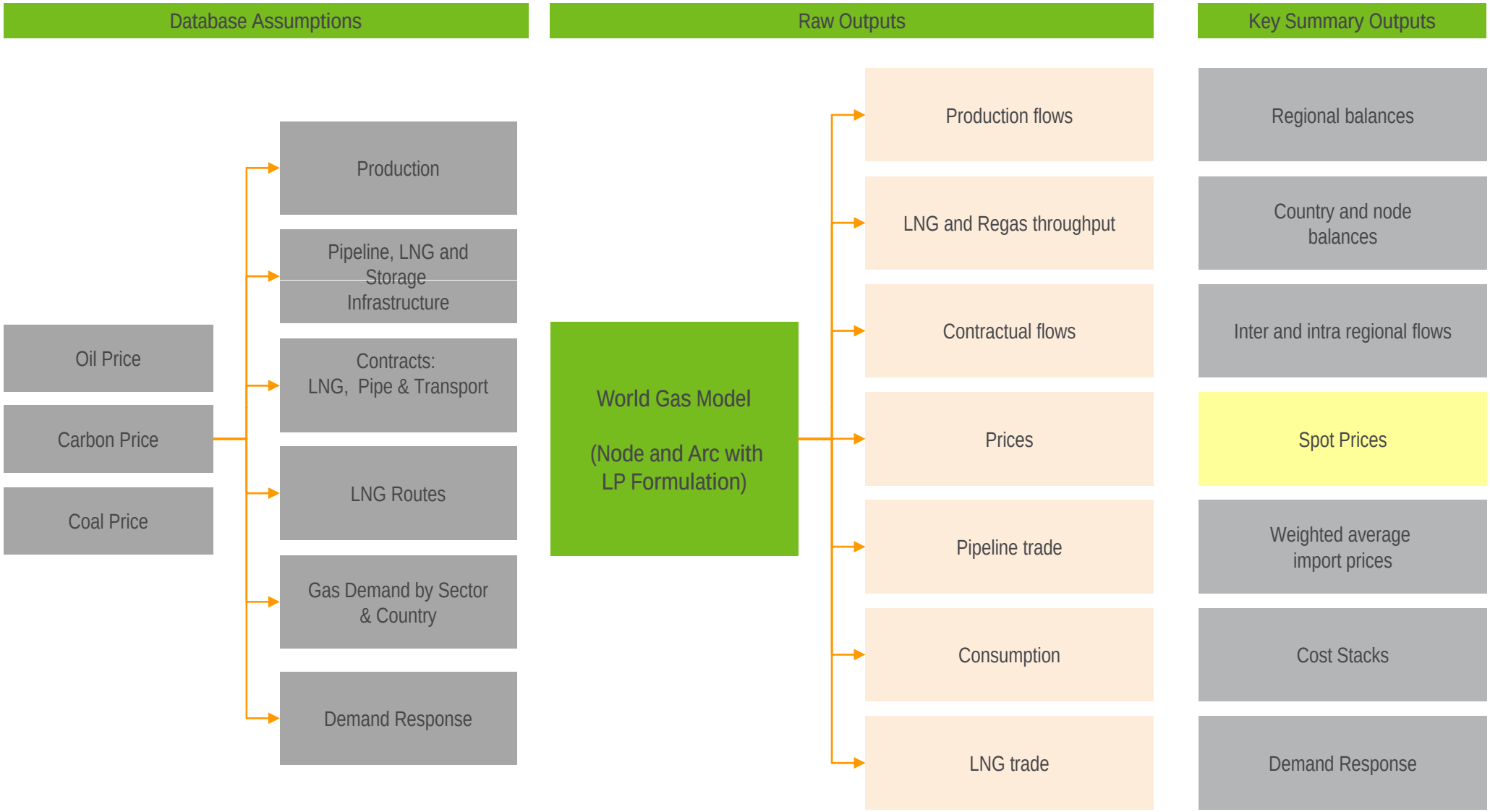
**Key outputs include spot and contract prices, production and consumption, trade flows and infrastructure utilisation**

**WGM is an excel-based linear programme, with an optimiser add-in, and can be run on a standalone laptop**

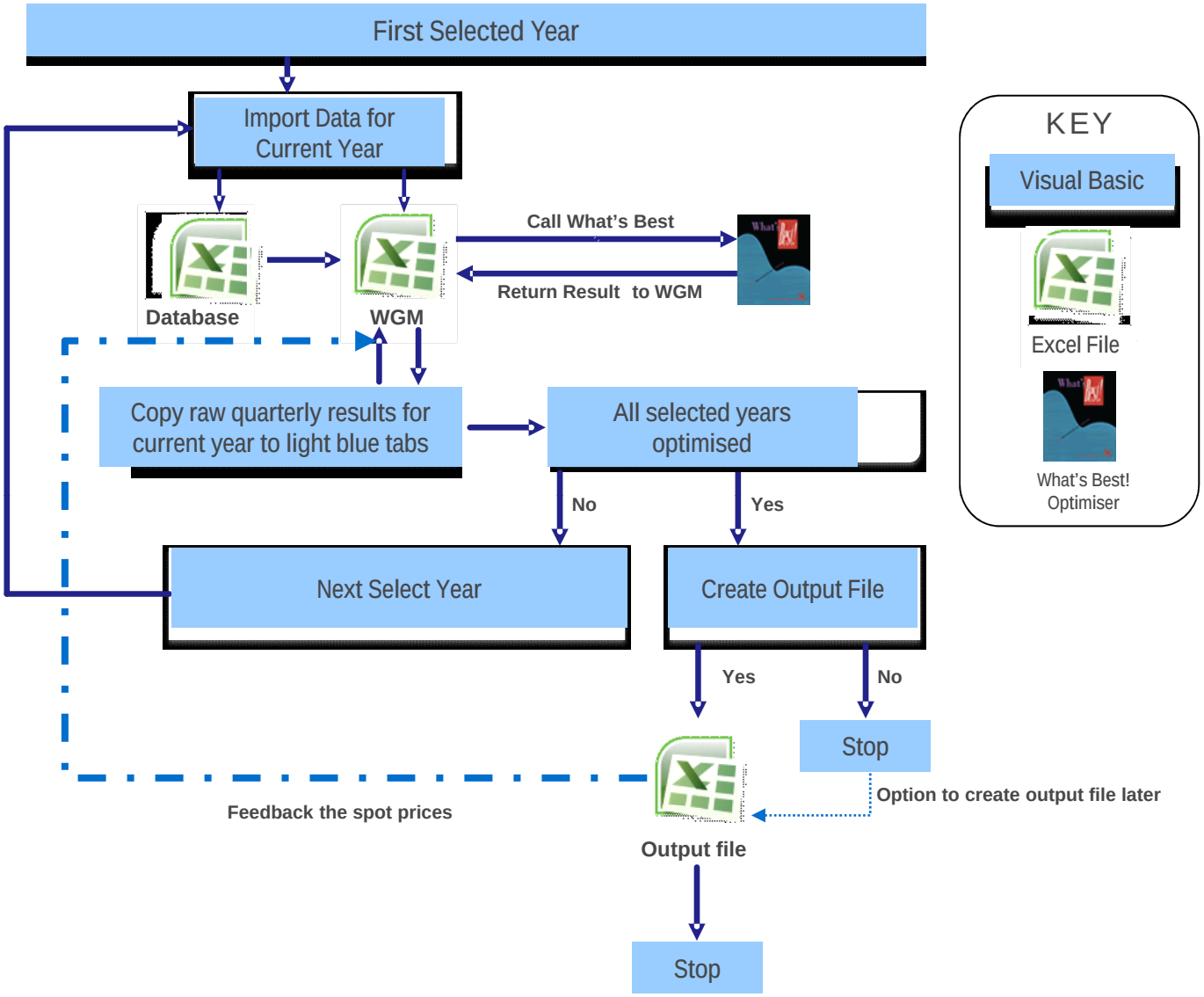
**WGM can be accessed by clients in a number of ways:**

- Licensed and installed on client's own computers, with quarterly updates from Nexant
- Customised scenarios of client's choosing
- Intensive scenario weeks
- Subscribe to quarterly World Gas Analytics Service

# WGM – Inputs and Outputs



# Functioning of the World Gas Model



# Unique Feature – Modelling Spot Prices

**Spot prices, either at hubs or for spot LNG cargoes, are considered to be a function of three factors:**

- The marginal cost of supply;
- Prices of competing fuels; and
- The tightness of the market which includes local production capacity as well as the availability of pipeline and LNG supply.

**The level of market tightness for the particular market determines whether the forecast spot price is closer to the marginal cost of supply or to the competing price.**

**The tighter is the market then the closer the spot price is to the competing price. In a less tight market the spot price might be expected to be closer to the marginal cost of supply.**

# Appendix: WGM Specifications

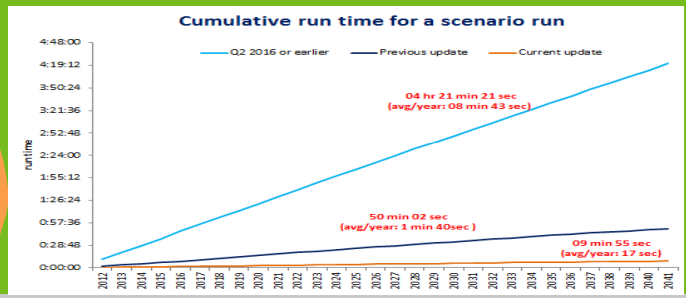
# WGM – What it does?

WGM is supplied with a comprehensive database on gas production, LNG and pipeline infrastructure, trade routes as well as long term contracts, storage facilities and demand projection. All data needed to run the model is supplied by Nexant and users are free to add or overwrite the supplied assumptions to construct scenarios of interest to their organisations.

WGM is based on excel and with the system configuration below:

- Win 7 (8 GB RAM)/ Win 10 (16 GB RAM) [64 bit systems)
- Office 2010 / Office 13 [64 bit versions]
- Linear Programming solver – What's Best (64 bit)

Run time: We have optimised run time to under 10 min for a full scenario run




Database

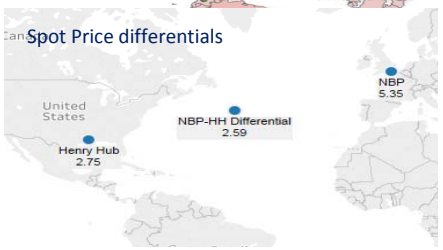
System requirement and run time

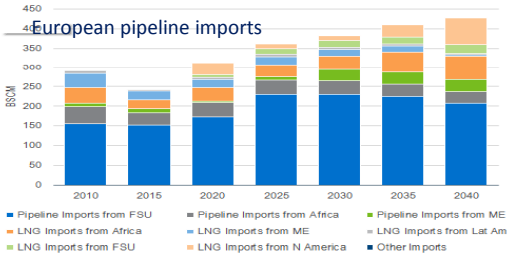
WGM

Outputs

Support

Key outputs include spot and contract prices, production and consumption, trade flows and infrastructure utilisation


WGM runs on a stand-alone computer or laptop. The Excel interface allows users inputs easily and incorporate outputs into other internal programs and systems.

Nexant provides comprehensive support services including initial installation and training, regular updates of data and technical support. All users benefit from a continuous programme of model development and enhancements.

# Optimisation – Linear Programming

**A linear programme is an optimisation problem consisting of:**

- input assumptions
- constraints
  - Physical variables such as production and flows by pipeline and LNG are constrained by capacity assumptions.
  - Gas and LNG contracts are modelled using constraints to represent contract volume terms.
- Objective: Objective function is to minimise costs including energy price assumptions and infrastructure and production LRMCs (which include both capex and opex)

**Solving this linear programme leads to forecasts of:**

- gas production at each source of supply (e.g. gas fields)
- flows
- spot prices

**Conceptually, the WGM LP is expressed as a network:**

- Nodes - containing the demand, production, storage, LNG and regas assumption
- Arcs - representing connections between the nodes (pipelines and shipping routes and also used to model LNG and pipeline contracts)

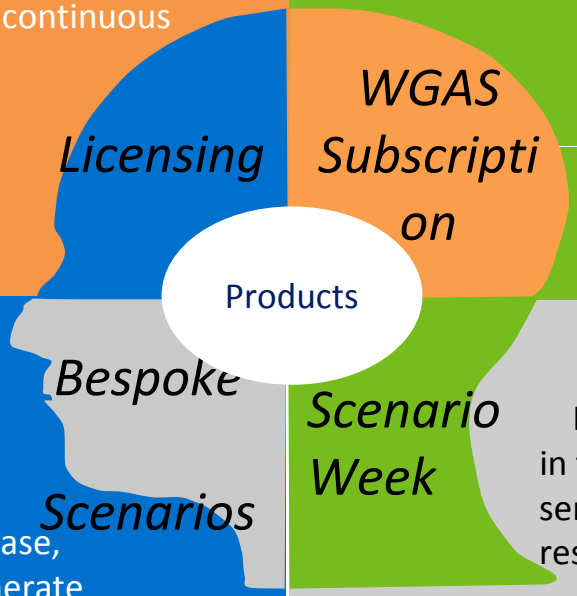
# System Requirements

| Hardware | Software |
|---|---|
| Standalone computer with 8 GB RAM recommended | Windows 7 (64-bit)<br><br>Office 2010 64-bit (English language version please)<br><br>What's Best! Add-in with the 64-bit Extended Base Version as minimum |
| Some clients have moved to Windows 10 and Office 2013. The model runs fine in this environment but as Windows 10 takes up a lot more RAM than Windows 7, 16 GB of RAM would be recommended | |

# Accessing the World Gas Model

The World Gas Model (WGM) is available to the clients to use under license on their own systems. The clients benefit from the database containing detailed Information about production, infrastructure and contracts, continuous support and global coverage in WGM.

WGAS is a subscription program that provides coherent forecasts for global, regional and national supply/demand and prices for natural gas and LNG.

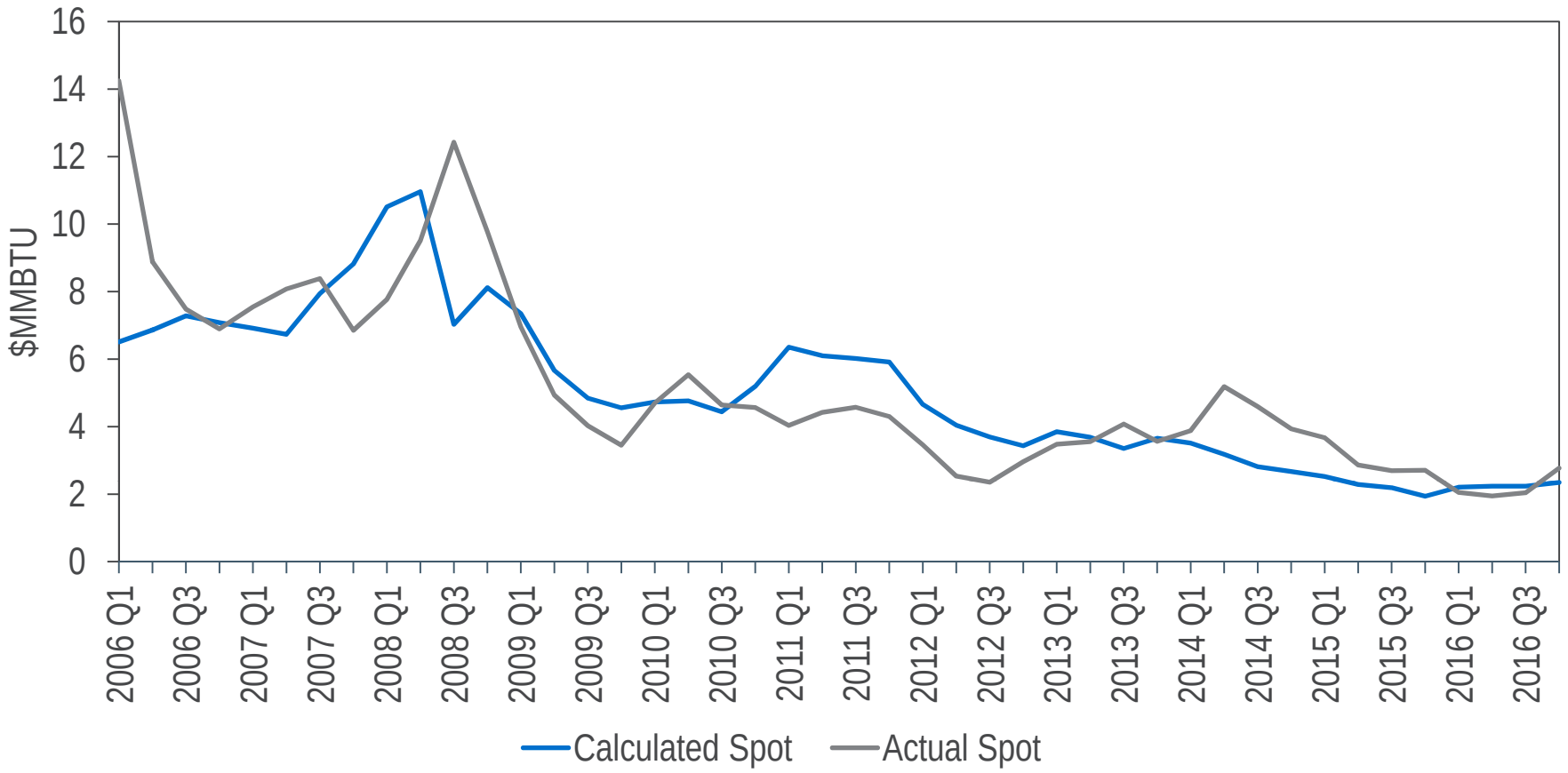



Clients can consult with Nexant to create bespoke scenarios starting with our base case, and then changing key assumptions to generate alternative scenarios and sensitivities.

In a Scenario Week – we sit with the client in their office running the scenarios and sensitivities in real time, providing the data, results and analysis from each scenario.

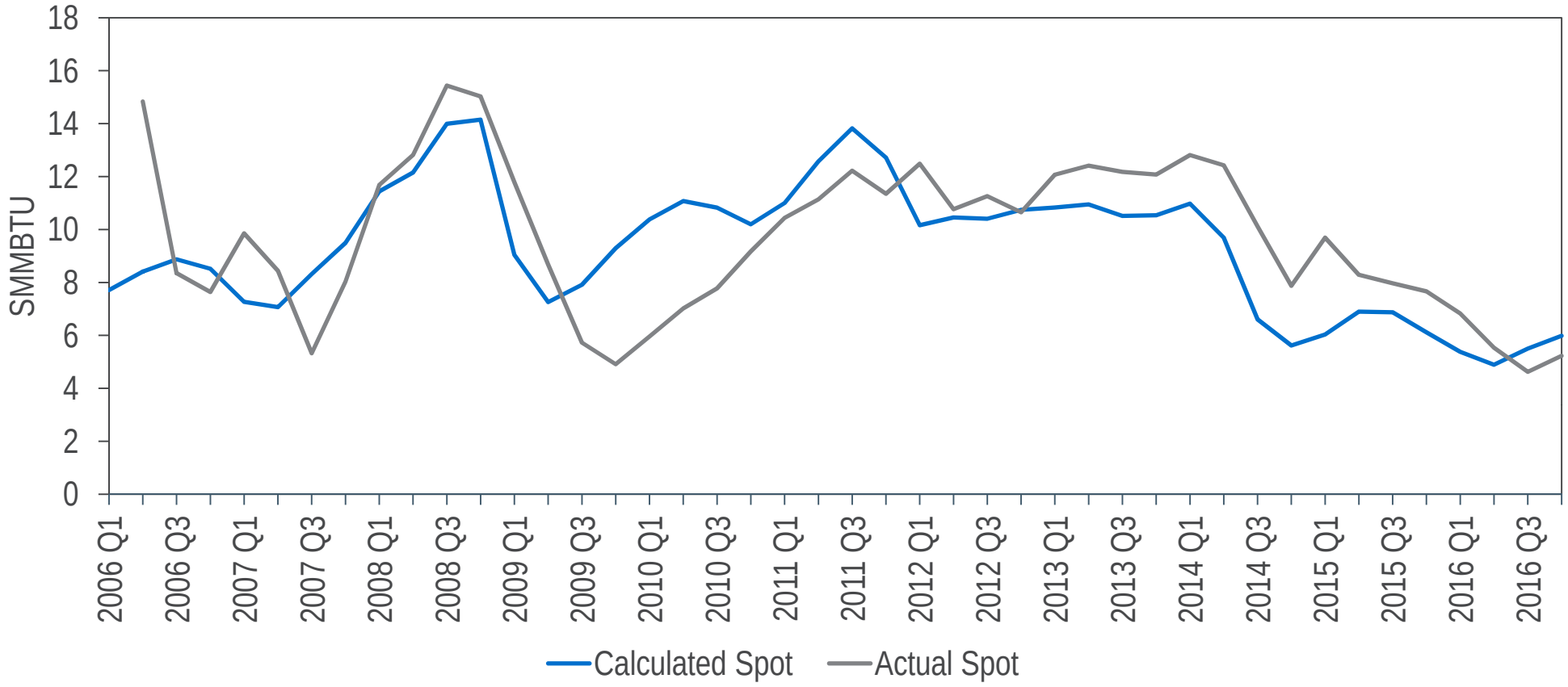
# Appendix: Spot Price Backcasting

# North America (Henry Hub)




**Tracks changes pretty well – 2011 and 2012 actual less than calculated**

# Europe Netherlands



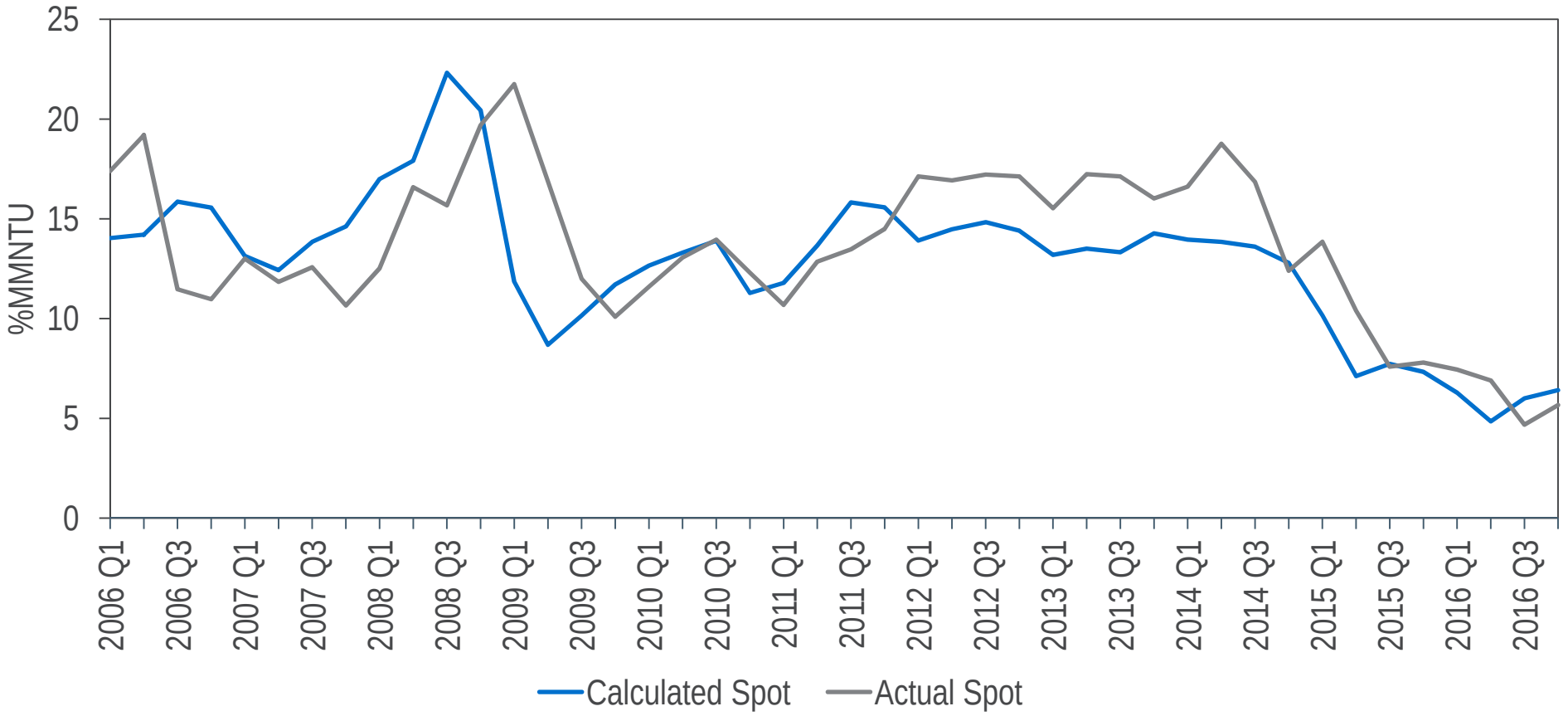

**Tracks changes pretty well – since 2011 calculated level generally less than actual level**

# Asia (China – Shanghai)


**Tracks changes pretty well – since 2011 calculated level slightly less than actual level**

**China spot LNG a pretty thin market though**

# Asia Pacific (Japan)




**Tracks changes pretty well since 2008 (spot market thin before that) – but post-Fukushima calculated level generally slightly less than actual level**

www.nexantthinking.com

1 King’s Arms Yard,
London, EC2R 7AF

Telephone: +44 20 7950 1600
Facsimile: +44 20 7950 1550

www.nexant.com



Nexant, Inc.

San Francisco
New York
Houston
Washington
London
Bahrain
Singapore
Bangkok
Shanghai
Kuala Lumpur