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Energy Value Chains

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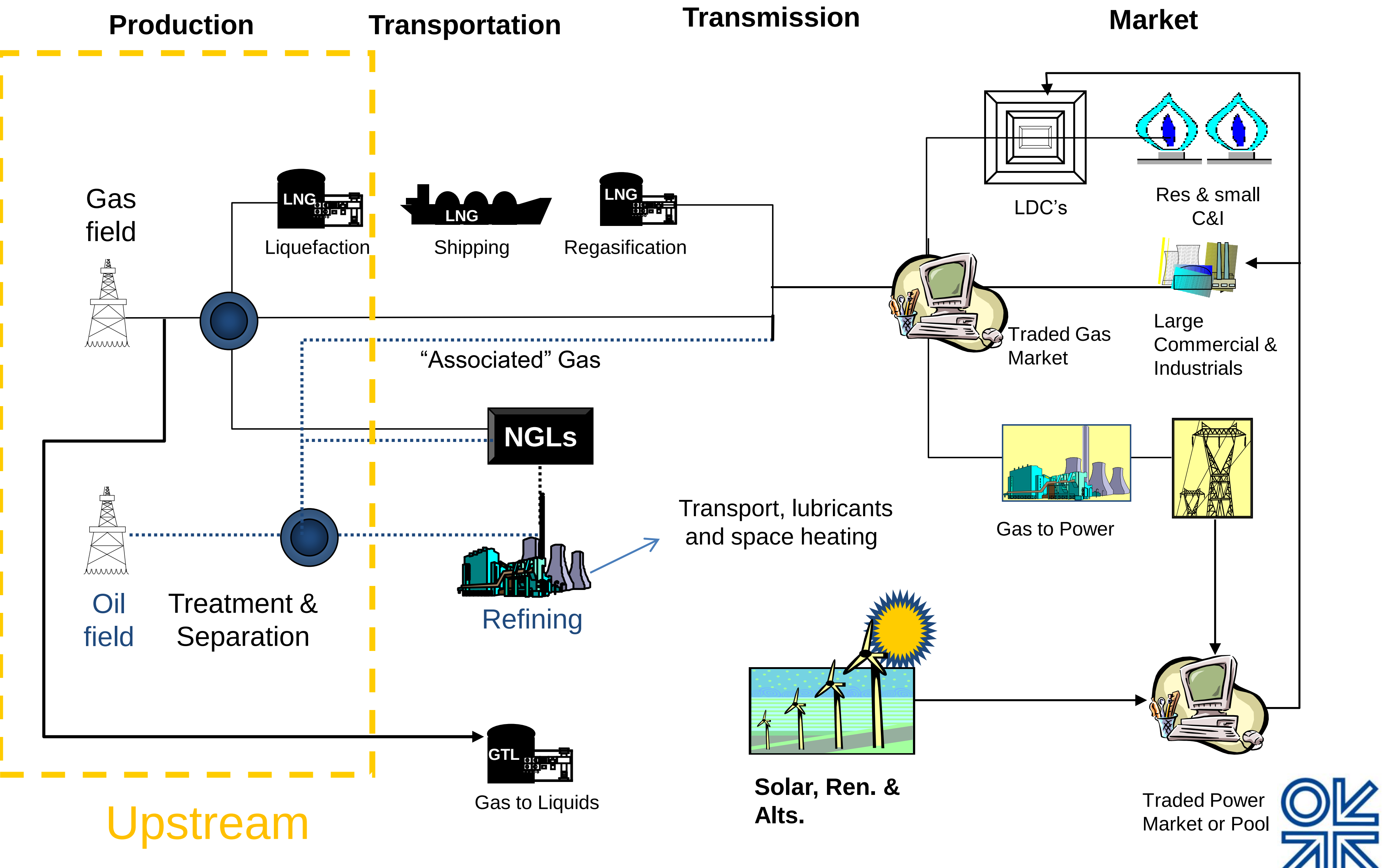
November 2018

The Oil & Gas Supply Chain



Oil and Gas Field Life Cycle

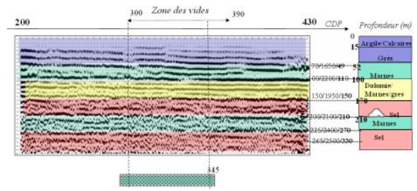
Resource Assessment

- Basin Evaluation
- Coarse Seismic
- Distribution of Resource Potential

Access

Rate at which prospective areas are made available by Host Governments for exploration activity by Oil & Gas companies

Exploration Evaluation



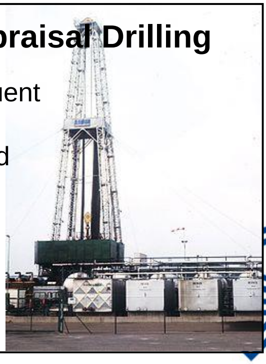
Potential Fields identified from Seismic data
Risked exploration economics (success rate 1 in 8)
Cost of exploration well \$5 - \$50 million

Viability

Determined by Prospectivity, Fiscal Terms, oil & gas price outlook, rig day rates and availability.

Reserves Assessment

Exploration & Appraisal Drilling

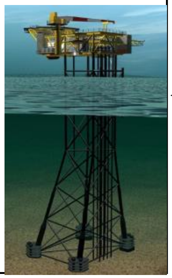


Drilling exploration & subsequent appraisal wells to establish presence of hydrocarbons and range of field reserves

Viability

Determined by Fiscal terms & price outlook, contractor rates, financing and transportation infrastructure.

Field Development



Production well drilling, platform & processing facilities, pipeline to shore & grid.
Hundreds of million to several billion dollars.

Field Production

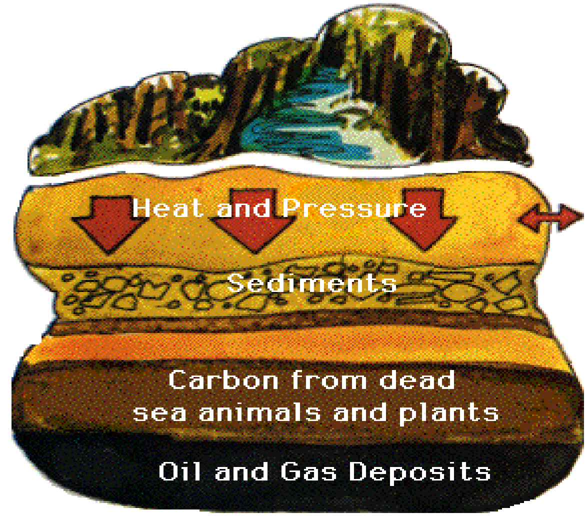
Field life typically 5 to 25 years.
Field will be in decline phase for last 30% to 50% of its life.

Field Abandonment

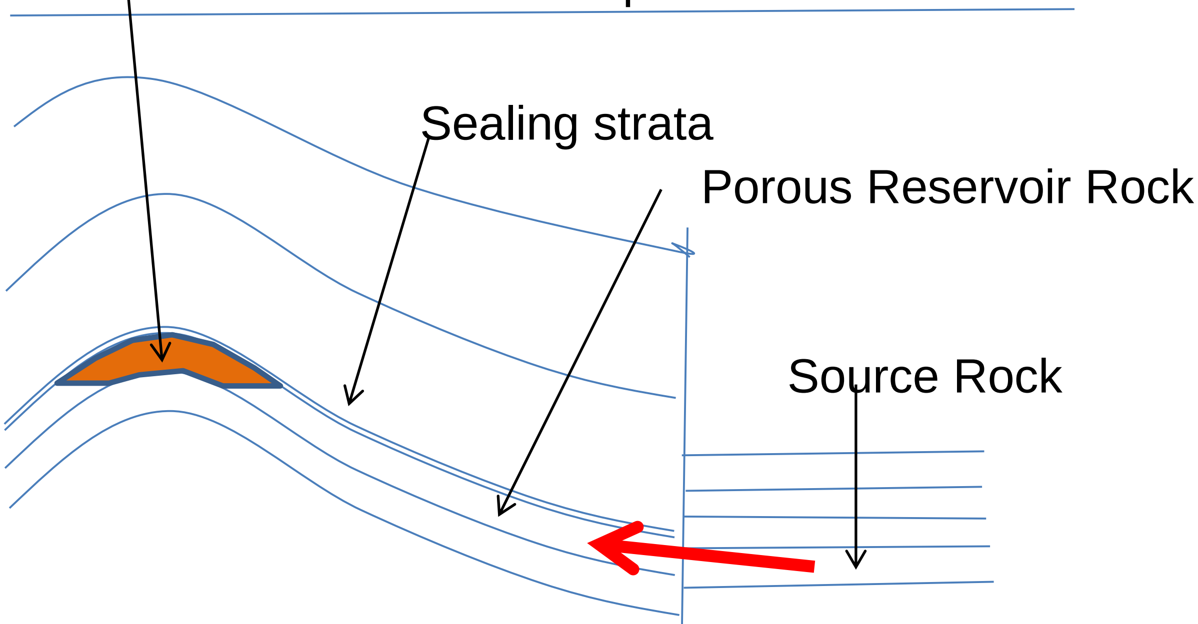
The Origins of Oil and Gas

Algae and plankton

Fossil Fuel Formation

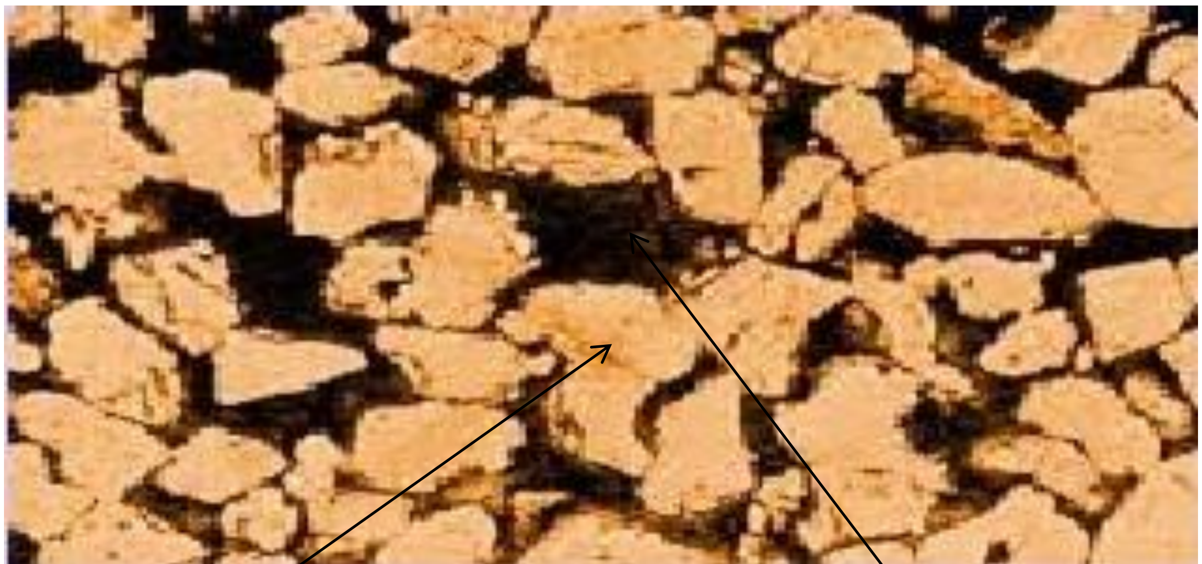


Oil Reservoir in Anticline Trap



Oil forms at temperatures between about 50°C and 175°C. At higher temperatures, gas is formed.

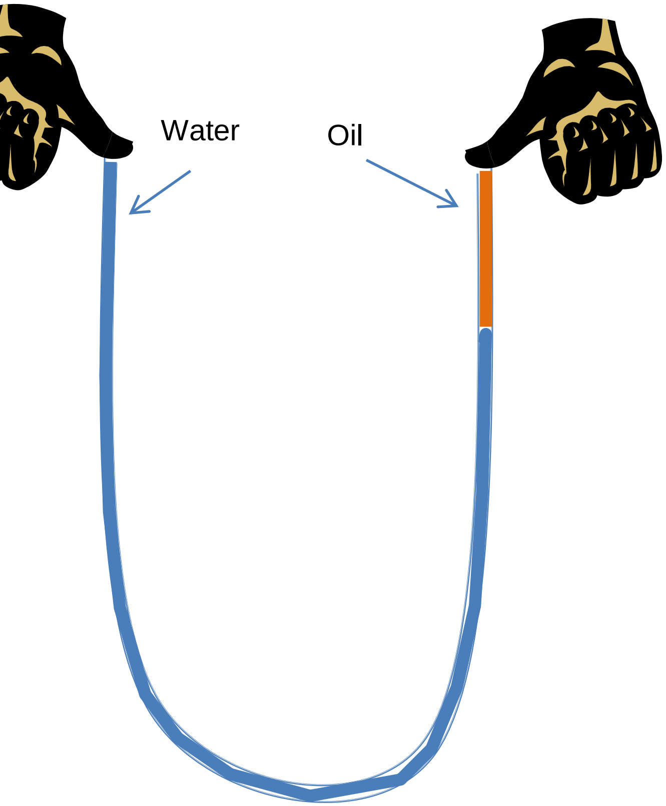
Oil within the Reservoir

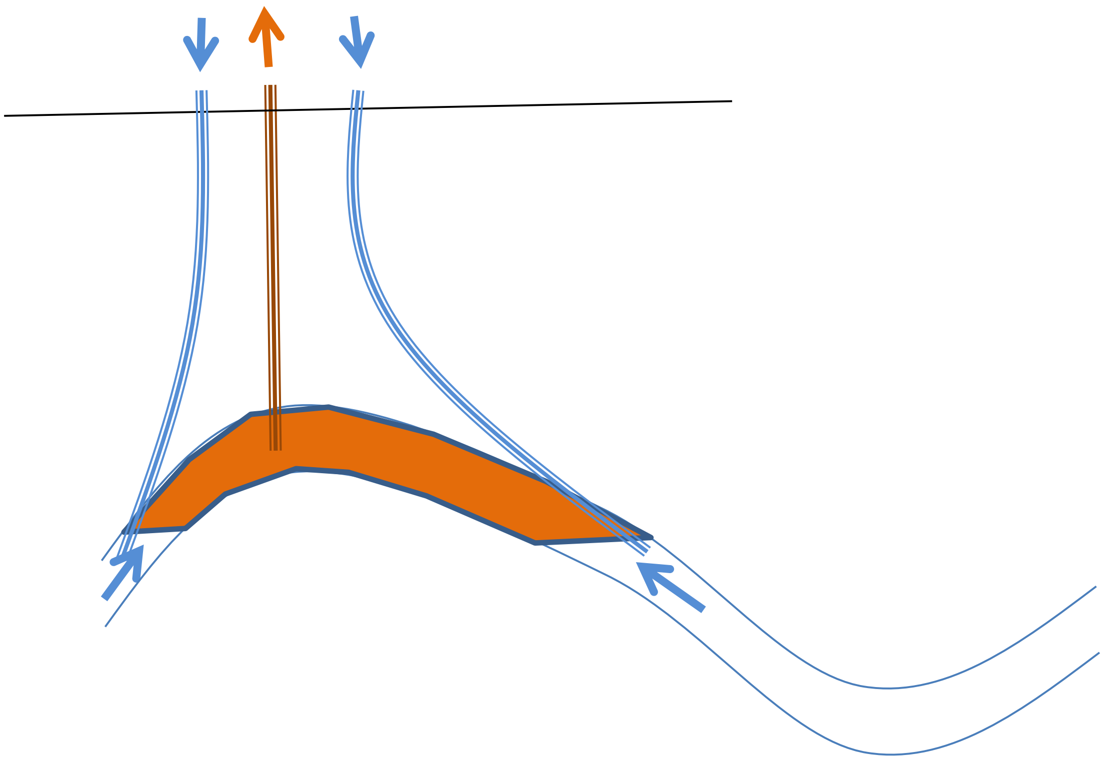


Oil in ‘pore’ between grains

Sandstone Grain

Oil Production Drive

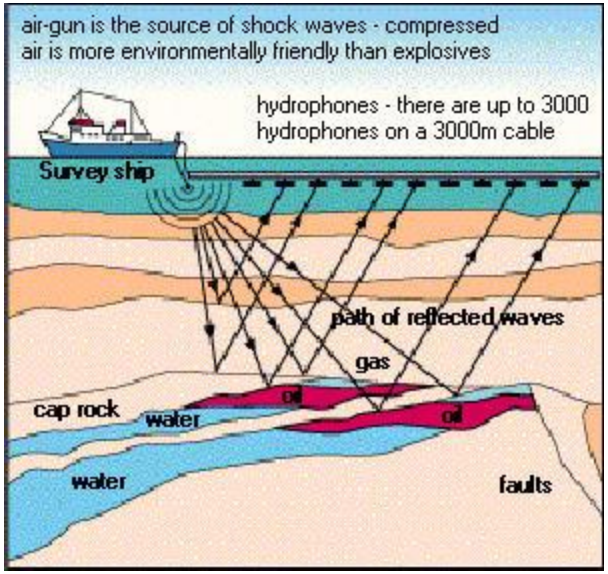


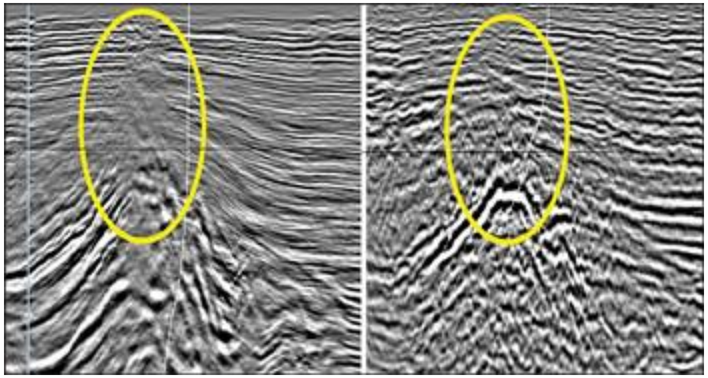


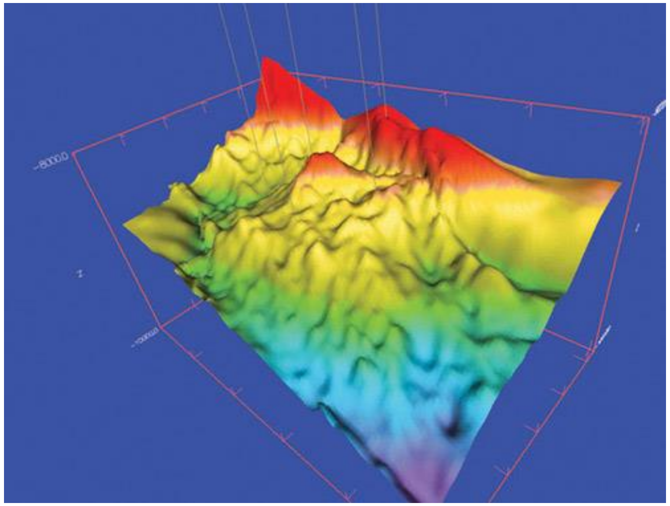
Exploration Activity

- Oil and Gas is an extractive industry. Companies aim to replace current production with new finds.
- Companies often explore in many different regions under differing fiscal regimes, onshore and offshore.
- Success rates for exploration wells may be as low as 1 in 5.
- Need to take a portfolio approach and a systematic means of evaluating and selecting exploration investments.

Finding Oil and Gas – Seismic Survey



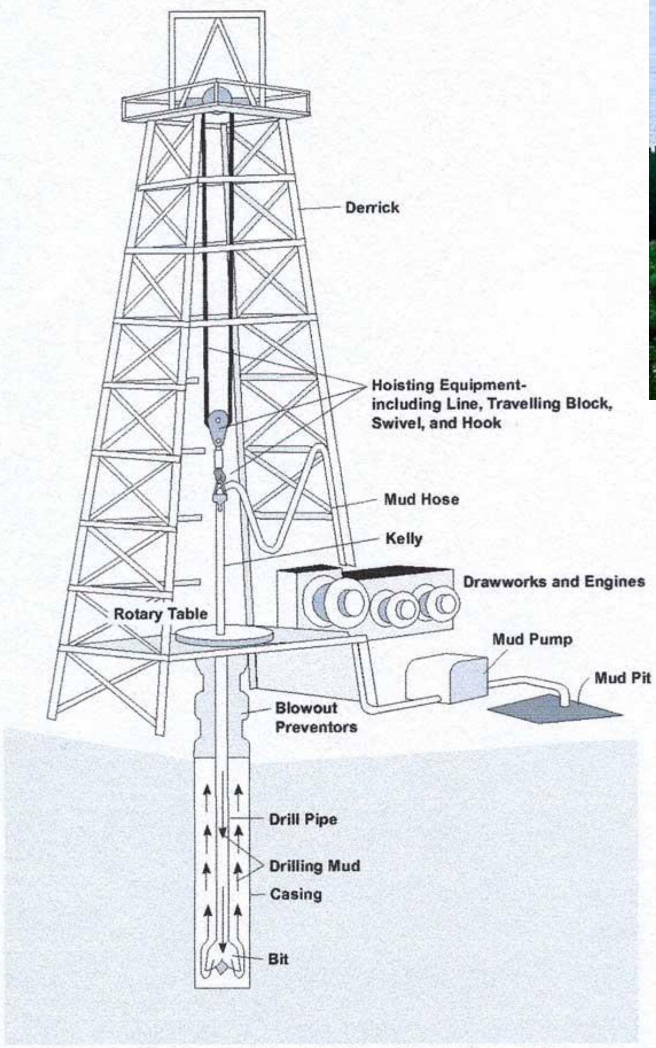




Finding Oil and Gas – Exploration Drilling

- Three Fundamental Questions:
  - Is there hydrocarbon in the target structure ?
  - If there is, is it oil or gas ?
  - If there is, how much is there ?

Exploration Drilling

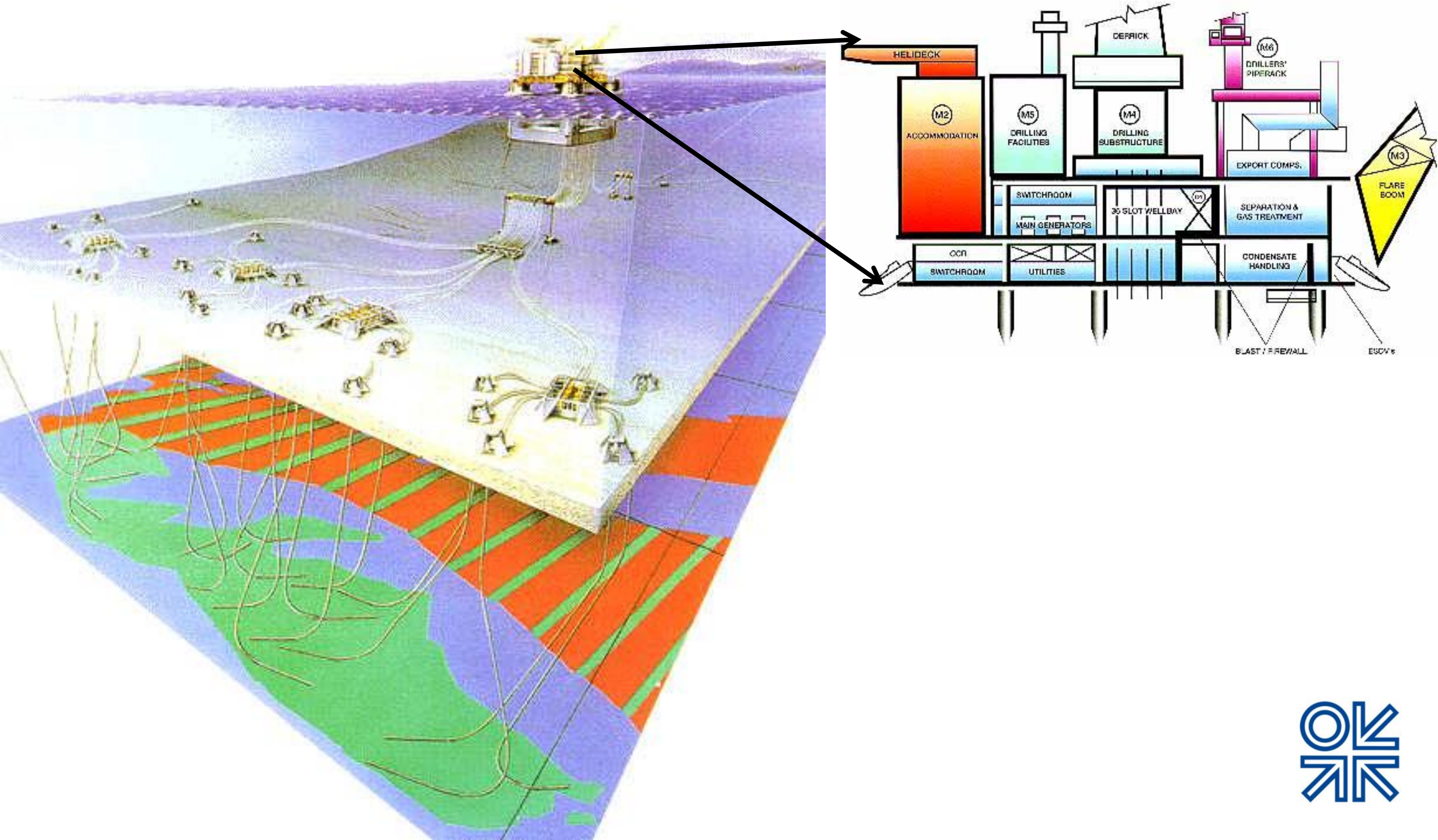


Source: Energy Information Administration, Office of Oil and Gas.

Onshore Well Cost:
$1million to $10 million.

Offshore Well Cost:
$20 million to $100 million

Facilities Concept and Production well schematic



Azerbaijan – field development cost $10bn +

Bovanenko Field, Yamal Peninsula, Development Cost ~ $100 bn

Production Profile

A conventional oil or gas field production profile

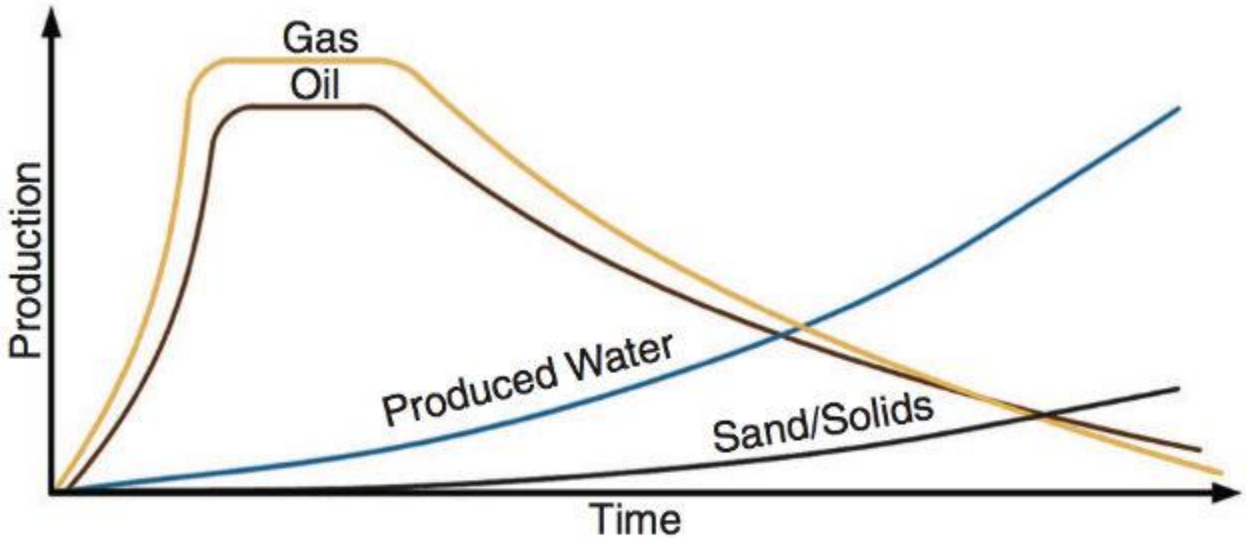
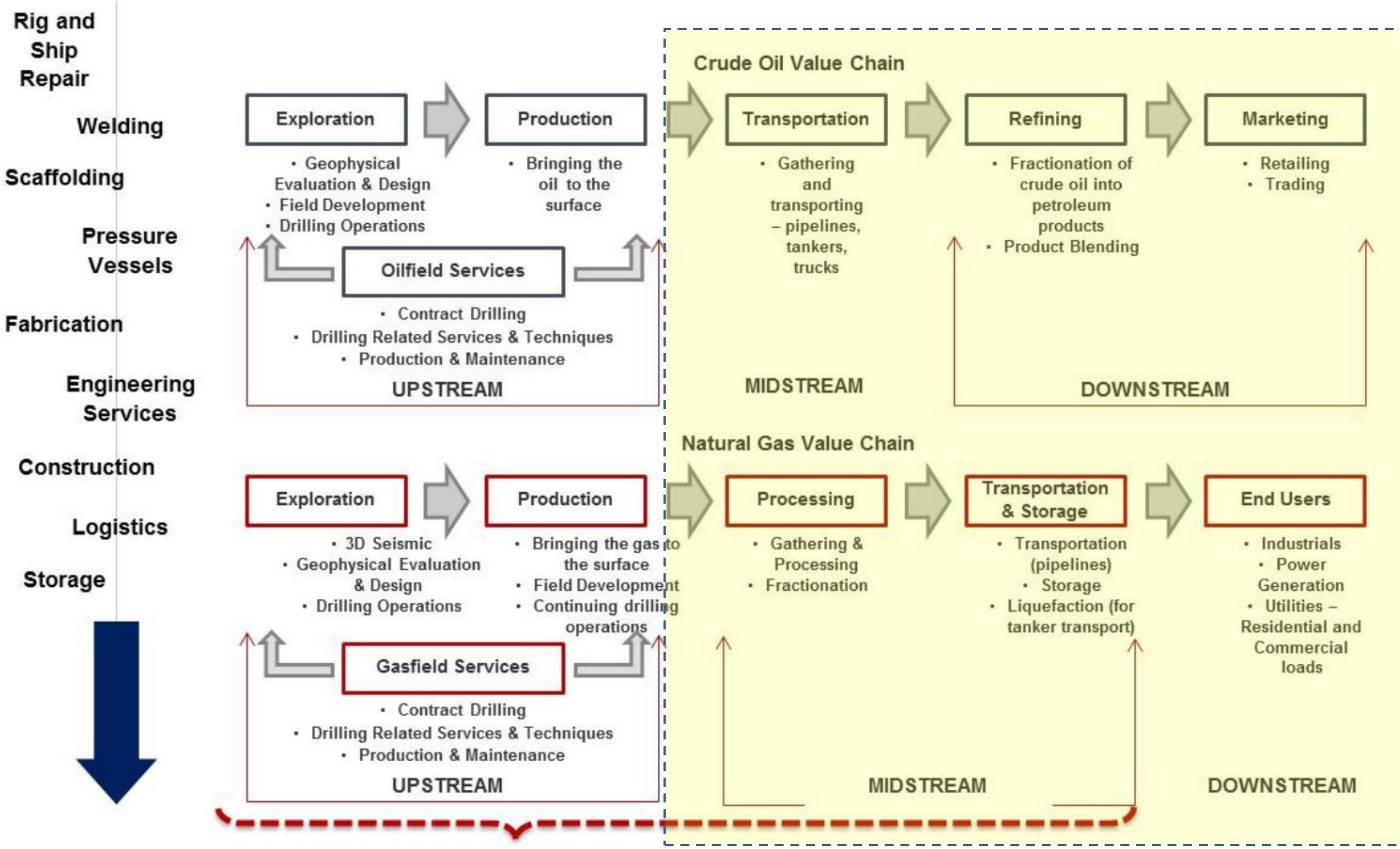


Fig. 1—A typical oilfield production profile.

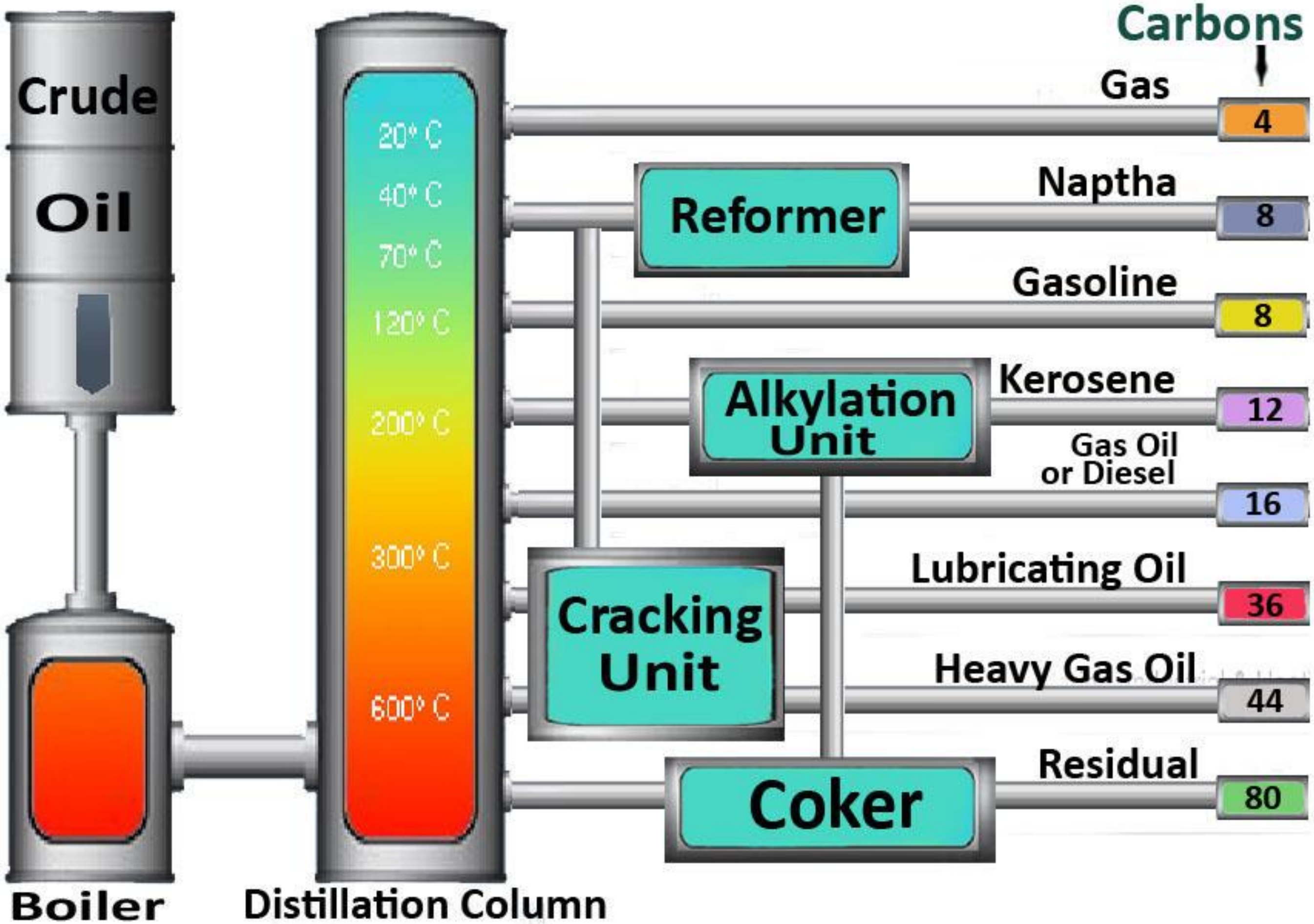
1. Initial surge to peak production
2. Plateau at peak for a number of years
3. Gradual decline towards abandonment
4. Water and solids production increases, undermining performance

Midstream and downstream – access to market



- Transportation and refining are vital elements of the oil value chain, in order to get products to customers
- Tariffs and margins are the key economic drivers in this segment
- Regulation and government control can be decisive

How a refinery works



- Crude oil is heated to high temperature to effectively distil it into different products at different temperatures
- Secondary processing units are then used to break the oil down into more specific products of varying quality

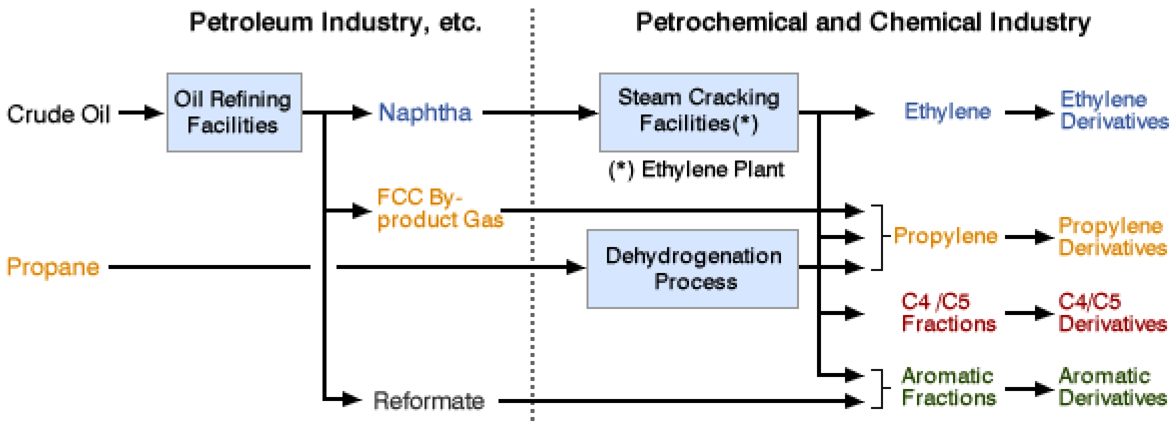
A small refinery in Africa

Markets for oil products

Retail gasoline and diesel

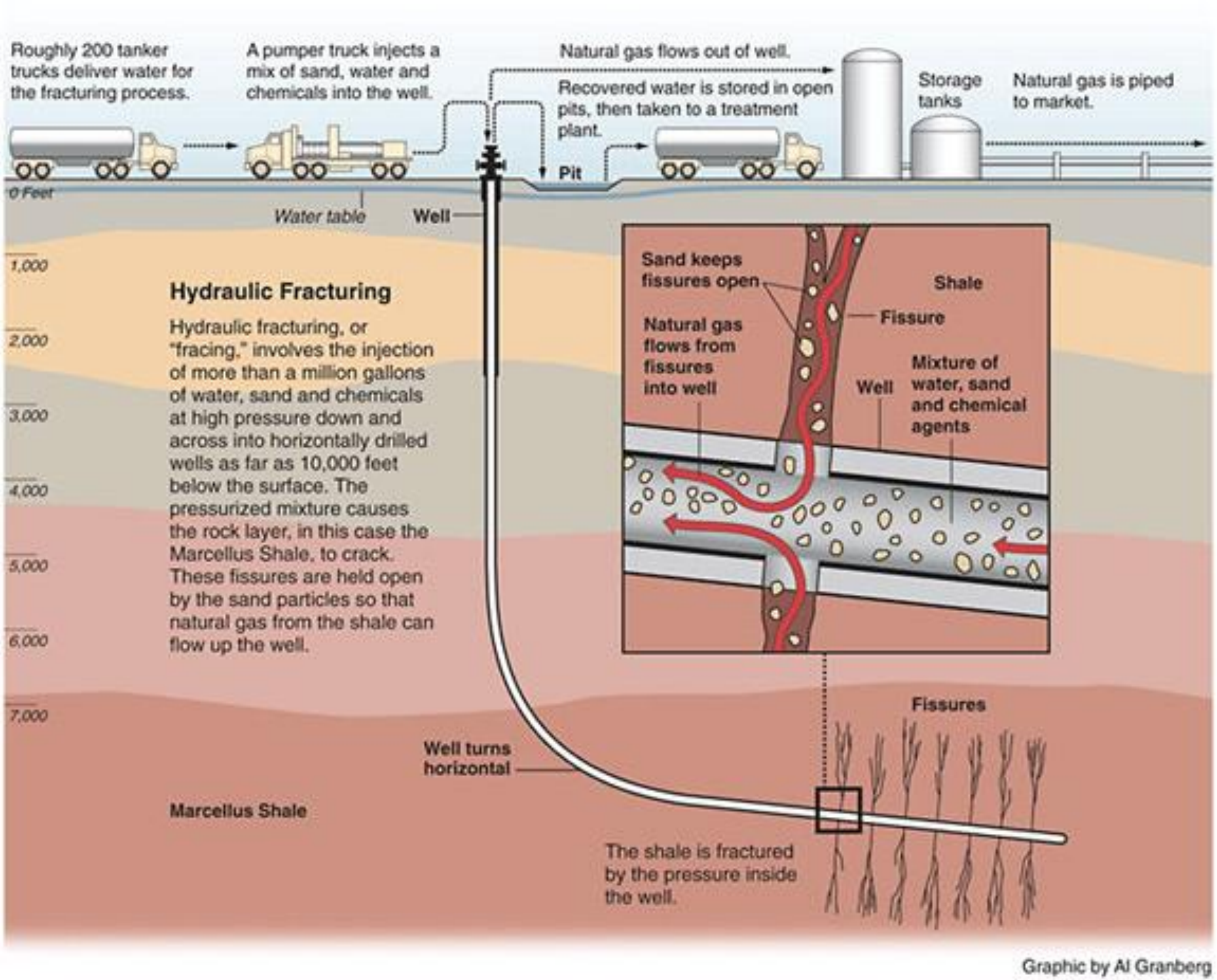
Jet Fuel

Petrochemicals and plastics



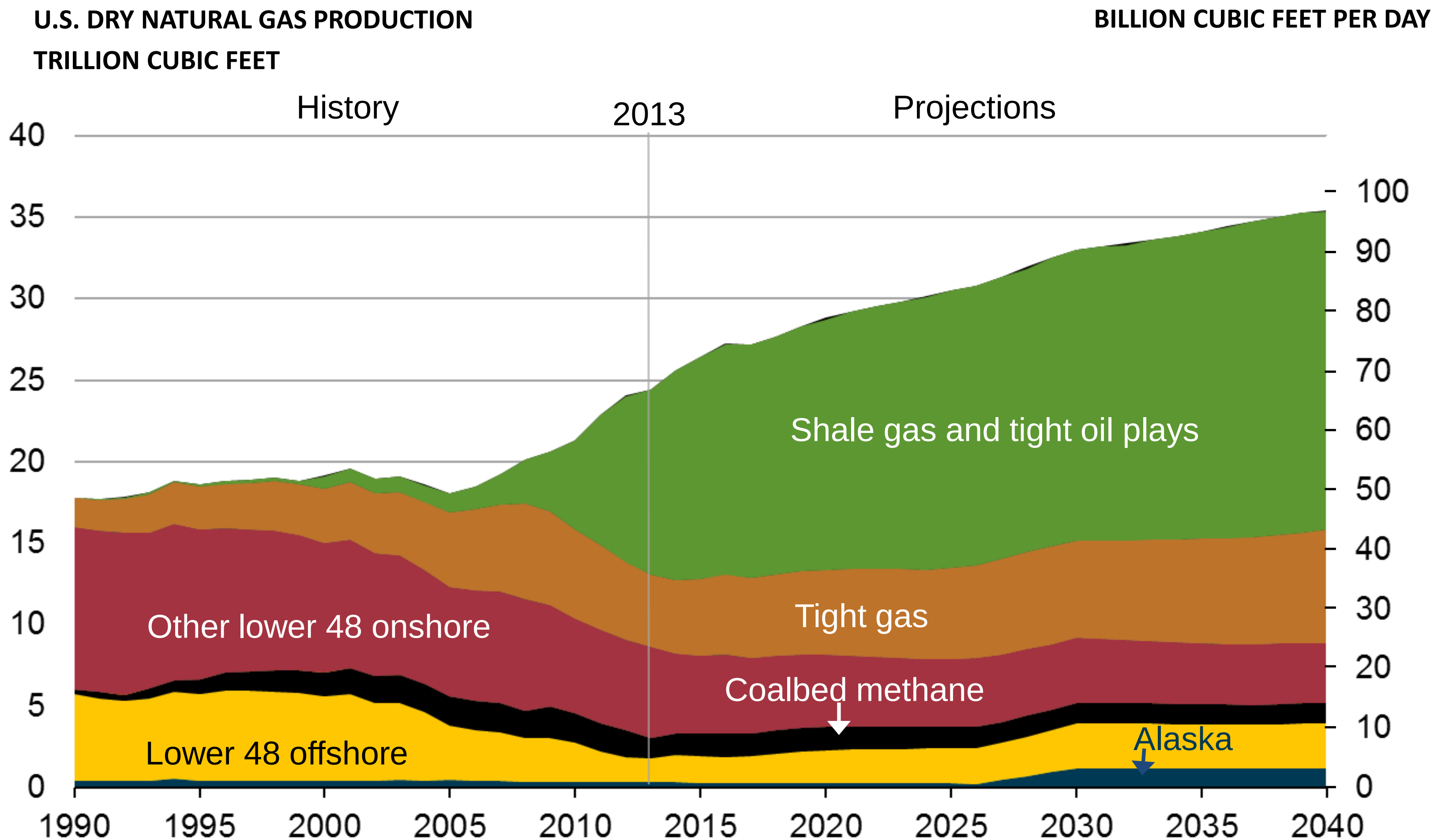
Lubricants and industrial oils

Shale Oil/Gas Extraction



Source: EIA

Shale resources remain the dominant source of U.S. natural gas production growth

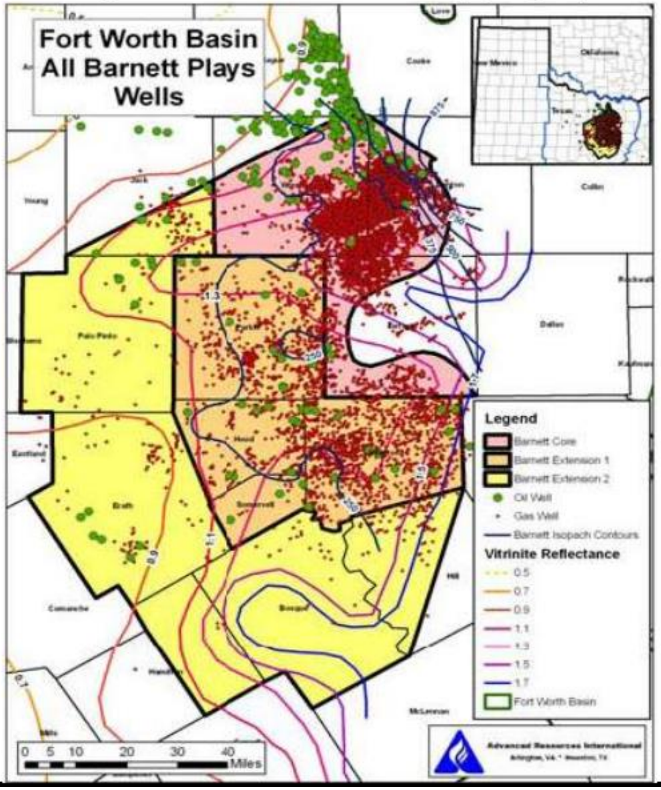


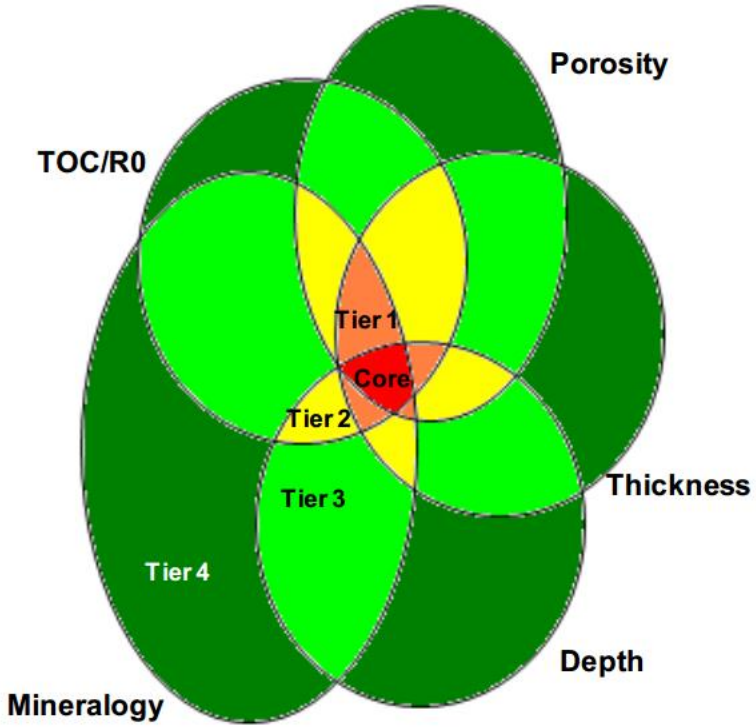
Source: EIA, Annual Energy Outlook 2015 Reference case

Homing into the Sweet-spots

Once You Know Where to Look – You Need to Define the Core

- Defining the core of a shale play post-development drilling is relatively easy – it is a statistical exercise based on mapping Initial Production rates for standardized completions e.g. Barnett
- Defining the core pre-drill is much harder – shale plays tend to be gradational in nature, so defining the core relies on mapping optimal convergence of various technical attributes





Source: Kimmeridge Energy, http://730926bc1eaea1361e79-997641d029b6764b67dd905fd3aab10c.r8.cf2.rackcdn.com/2-%20Finding%20Petroleum%20presentation.pdf

Specific Challenges for Shale

- Shale gas reservoirs show much more production variability than conventional gas reservoirs. Shale gas wells within a single field, completed using identical drilling and fracture stimulation programs frequently show a 2-5x variation in initial rate and/or recovery factor.

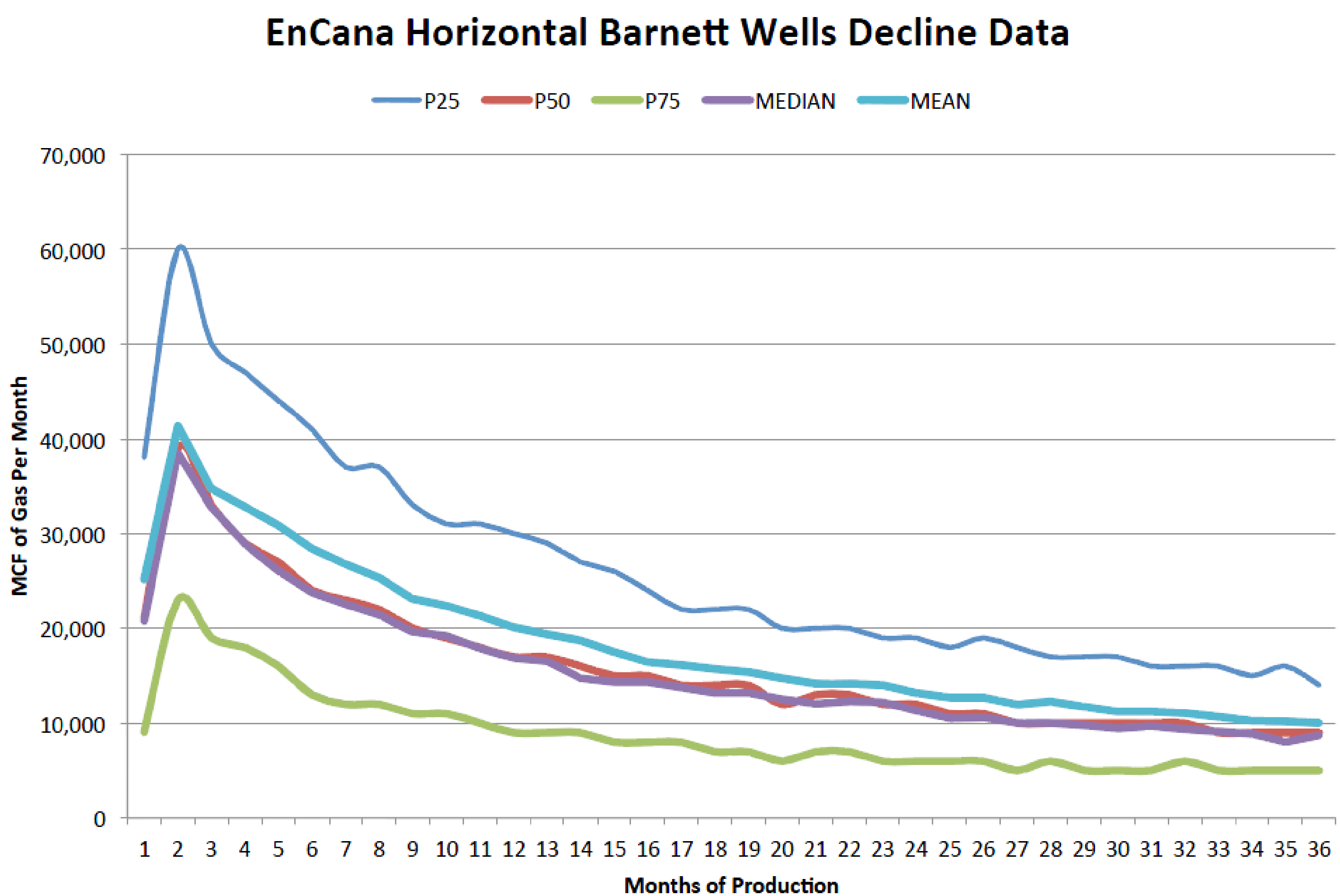
- Production ‘sweet spots' are very real and can change rapidly between adjacent well locations - or even between adjacent frack stages in the same horizontal well. When exploring for a new shale gas reservoir, this variation means that a number of test wells need to be drilled before a decision can be made about the commercial viability of that reservoir.

- This means that a significant portion of the development wells will be uneconomic or only marginally economic.

- There is no single explanation for these production sweet spots.

Source: D. Cooke, *University of Adelaide, Australia.*

Shale Gas Well Decline Curves



- 420 Barnett Shale wells suggest considerable variance in type-curve methodology.
- Mean over-predicts EUR by 10-15%.

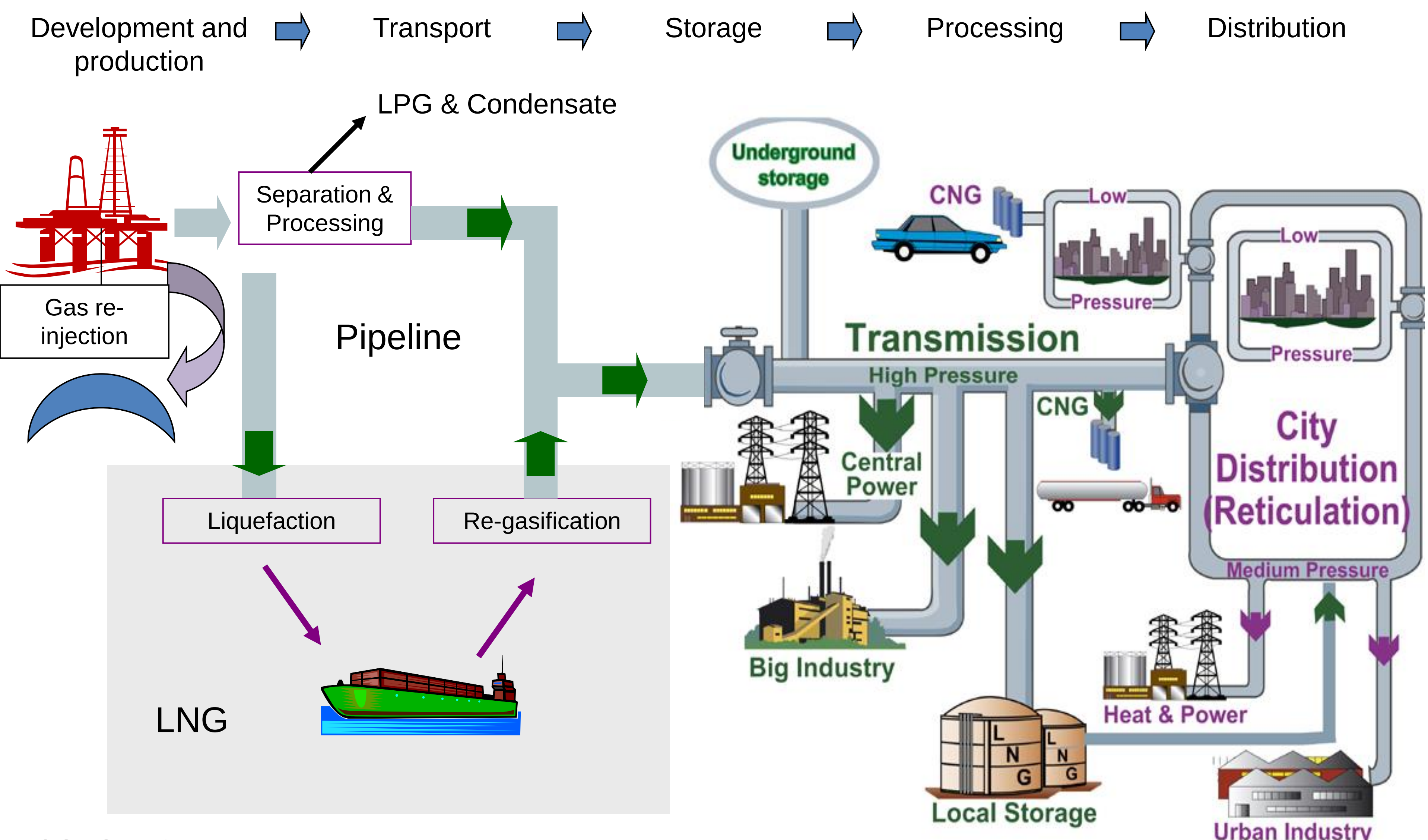
West Virginia Shale Gas Pad – Drilling Phase ..

Production Phase – Same Location

Shale Oil and Gas - Summary

- The US shale phenomenon reversed the decline trend of US production in the early 2000s. US became an oil and LNG exporter in 2016.
- US shale oil and gas has been successful in terms of production growth due to:
  - Multiple, extensive, highly prospective plays.
  - Regulatory system evolved during 100+ years of continuous conventional oil and gas activity.
  - Landowner mineral rights.
  - Many competing players in exploration & production and high-tech service sector.
  - Wide open spaces.
- To date industry has failed to replicate this model in Poland, China and UK.
- As much about population density, public opinion, regulatory style (and speed) and local industry dynamism as geology.

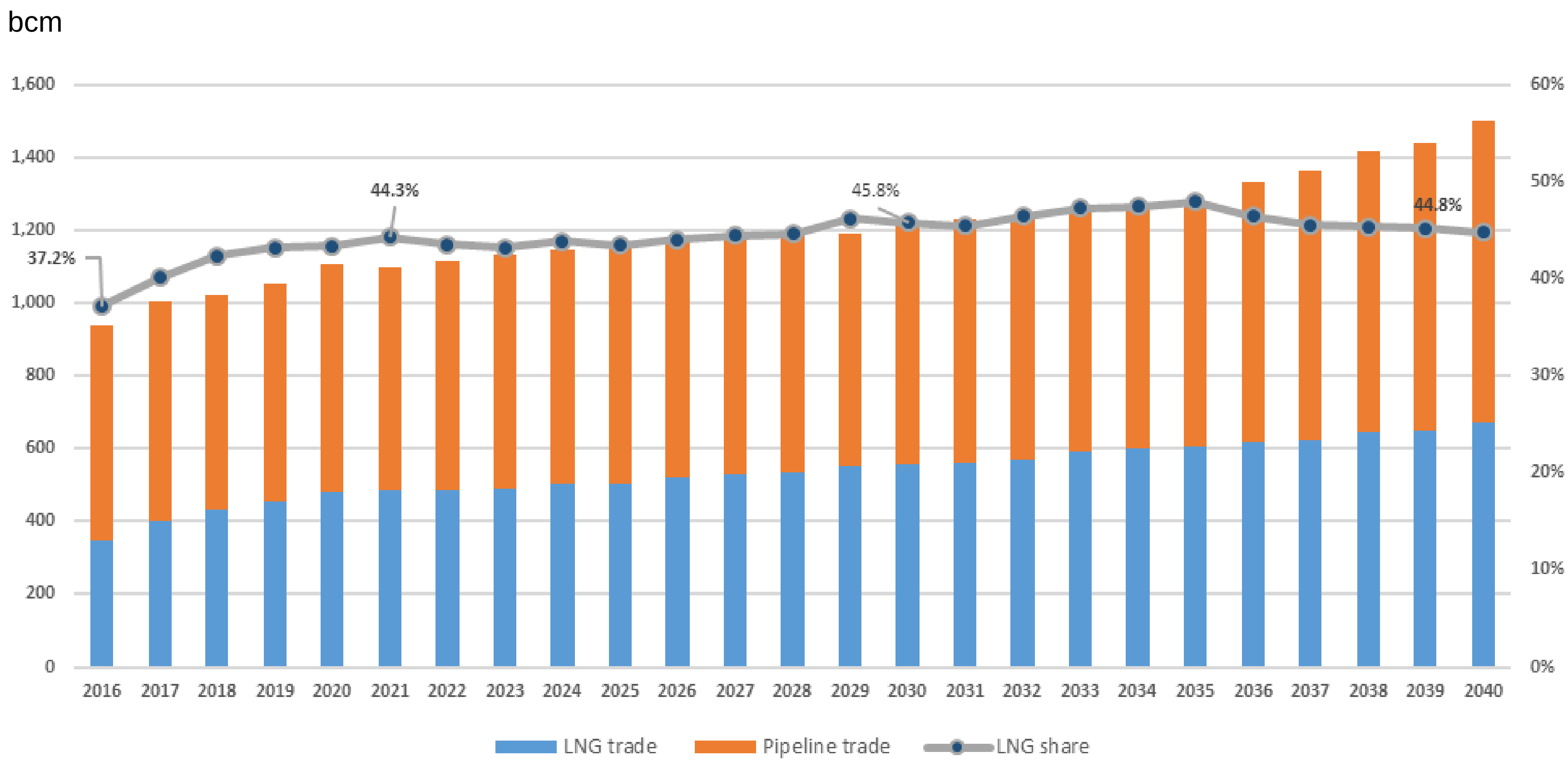
Gas Sector Commercial Value Chain



Bringing Gas to Market - Infrastructure

- Challenges:
  - Low energy density as a gas
  - Expensive to transport and store
  - High confidence of both reliable supply and demand needed prior to infrastructure investment.
- Long Distance (high pressure) pipelines
  - Supply and Market (initially) physically ‘locked’.
  - Subsequent network developments and amortised initial investment invites governments and regulatory bodies to enforce competition:
    - Third party access to pipeline and storage capacity
    - Removal of gas destination restrictions
- Liquefied Natural Gas (LNG)

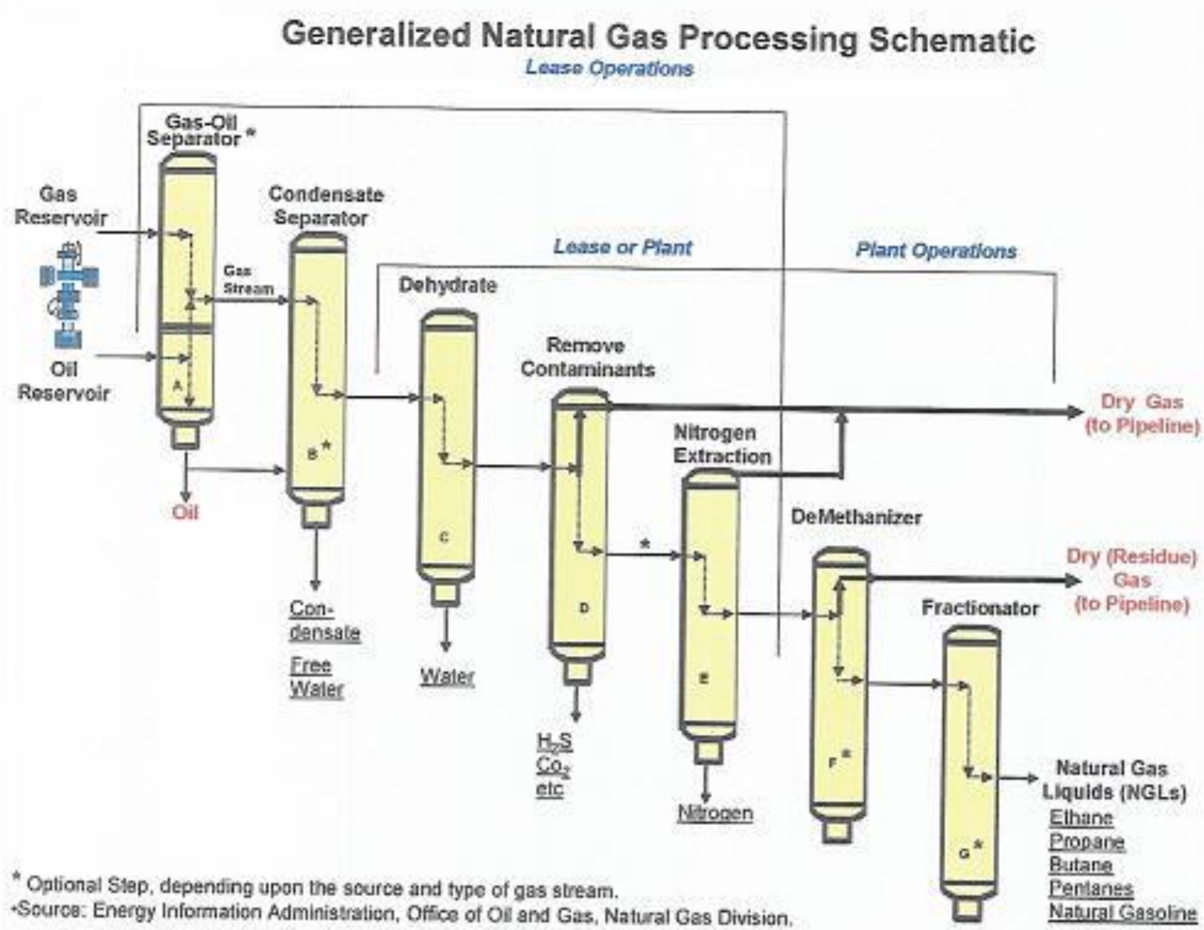
Long Distance Pipelines and LNG



Source: GECF Global Gas Outlook 2017

Gas Processing Facility

Gas Processing - Function

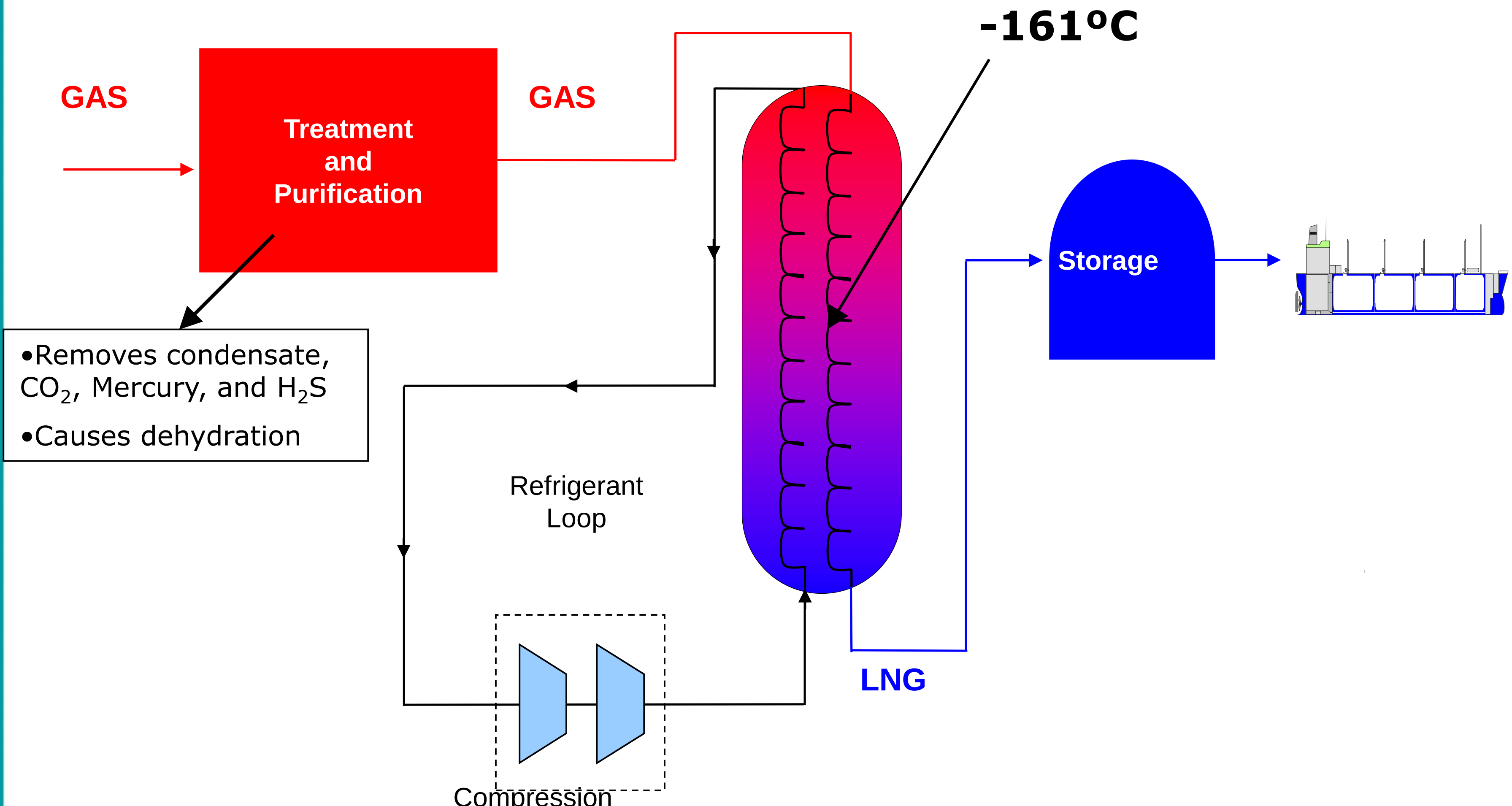


- Extract valuable Condensate (light oil, propane, butane and some ethane.
- Remove water & nitrogen
- Remove CO2 and H2S
- Must meet grid calorific value range and Wobbe index (calorific value divided by sqare root of density) – which determines flame stability.

Long Distance Pipeline

Yemen Liquefaction Facility

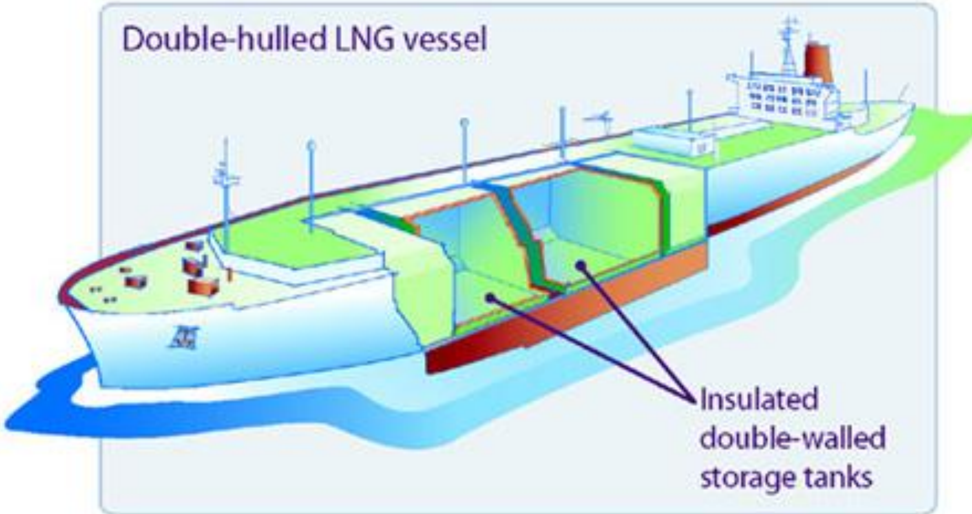
Liquefaction



Purified gas is cooled to minus 161 C at which temperature it becomes a liquid at atmospheric pressure. Volume reduced by a factor of 600 compared to gas at atmospheric pressure.

Source: Katherine D’Ambrosio

LNG Tankers


Double-hulled LNG vessel
Insulated double-walled storage tanks


WILENERGY

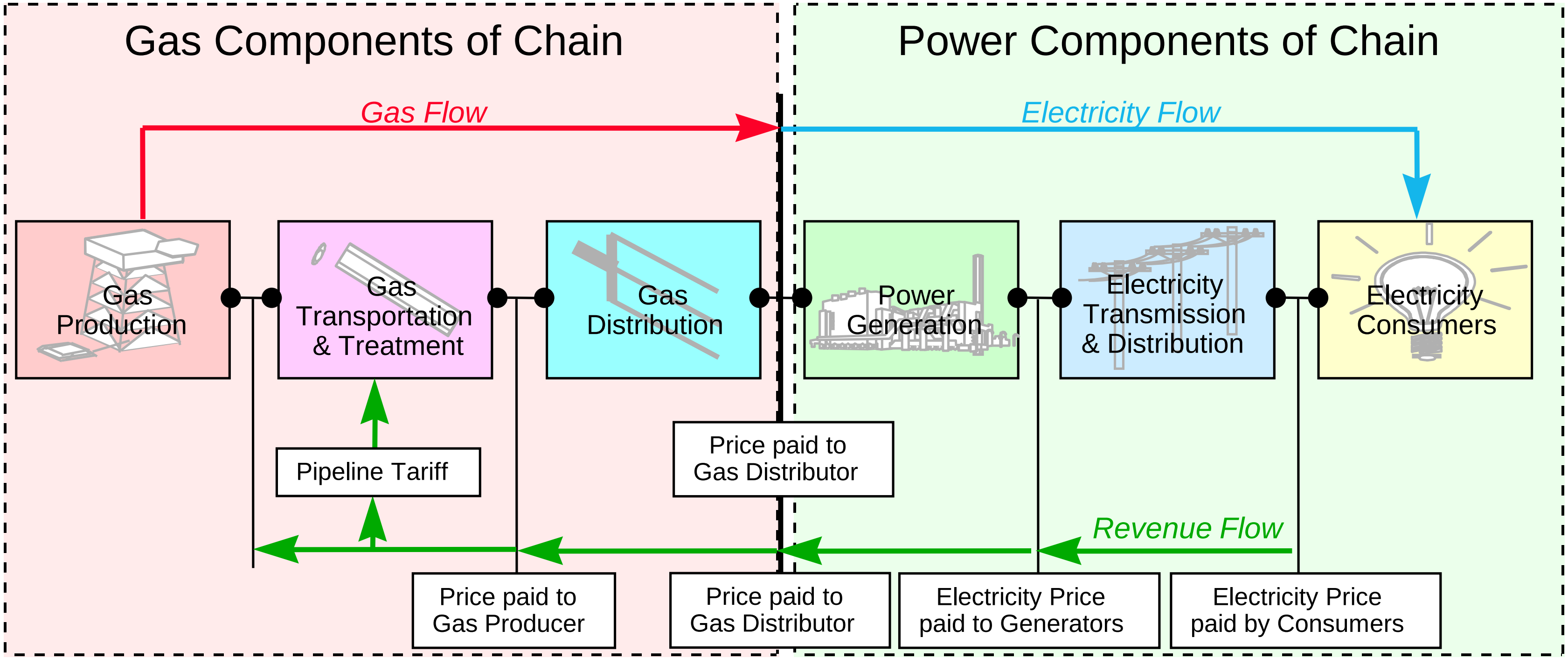

LNG
GOLAR MAZO

LNG Import and Regas Terminal
Jurong Island, Singapore

Industrial Consumers

Residential & Commercial

The Gas into Power value chain



Gas Fired Generation –
Combined Cycle Gas Turbine Kent, UK

Transporting Gas
- From Production Source to Market - Summary

As demand for gas has grown and in some cases nearby production sources have declined or not kept pace with consumption growth:

- Long distance pipelines have been constructed; notably:
  - From Norway to the UK and North Europe.
  - From Russia to Northwest, Eastern and South East Europe.
  - From Algeria and Libya to Spain and Italy.
  - Throughout US, Canada and Mexico.

  Less prominently in:
  - South America
  - Asia
  - Africa
- LNG was a key channel of gas supply in Asia (Japan, Korea, Taiwan & more recently India and China) and is becoming more widespread:
  - European periphery (UK, Spain, France, Italy, Turkey)
  - New markets for LNG are emerging with some frequency.
- The growing volumes of LNG which are not constrained in terms of destination by contractual terms represent a powerful force for price arbitrage between regional markets.

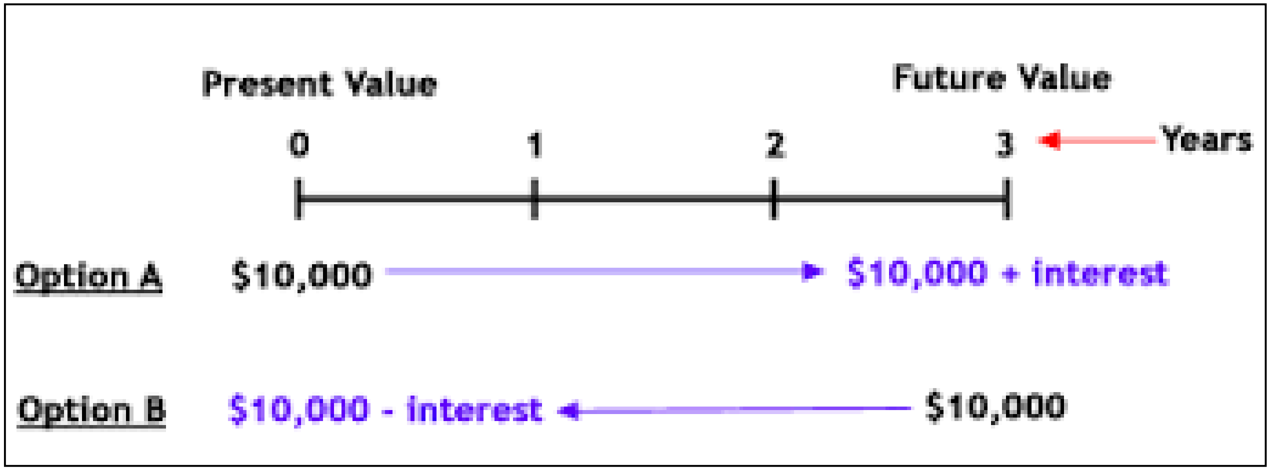
Investment Economics

- Risk versus Reward
  - Geological
  - Political/Fiscal
  - Technological
  - Market (demand) and Price
- Time value of money
  - High up-front (risk) investments, long field life, multi-year payback period.
  - Access to finance – cashflow, debt, equity
- Competing Opportunities
  - Global portfolios
  - Oil,Gas, (Tarsands), (Gas to Liquids)

The DCF Calculation as a foundation – companies' must earn an adequate return on investment

Time value of money

1.



Provided money can earn interest, any amount of money is worth more the sooner it is received

Money available at the present time is worth more than the same amount at a future time because of its earning potential

The DCF Calculation as a foundation – WACC concept

Weighted average cost of capital is corporate "interest rate"

2.

$$\text{WACC} = \frac{E}{D+E}(r_e) + \frac{D}{D+E}(r_d)(1-t)$$

Where:

E = market value of equity

D = market value of debt

r_e = cost of equity

r_d = cost of debt

t = corporate tax rate

WACC is the cost to a company of financing the capital for a project, including debt and equity

Cost of debt = average interest rate for company

Cost of equity is theoretical return to investors in the company

Cost of Equity = Risk free rate +Beta(Market return – Risk free rate)*

Essentially, how much return would an investor expect relative to putting his money with US Treasury stock, or in the stock market

The DCF Calculation as a foundation – WACC Calculation

Cost of Debt = 5%

Cost of Equity

Risk Free Rate – 4%
Market Return – 8%
Company Beta – 1.2

Calculation = 4%+(1.2*(8%-4%))
Cost of Equity = 4%+4.8%=8.8%

WACC
Share of Equity – 50%
Share of Debt – 50%
Corporate tax rate – 20%

Calculation = (8.8%*0.5)+[(5%*.5)*.8]
WACC = 4.4%+(2.5%*.8)=6.4%

Cashflow Analysis – Revenue Less Costs

Cashflow = Revenue less:

transport costs, royalty, state tax, federal tax, operating costs, capital costs, abandonment costs.

DCF – The Sum of Future Annual Discounted Cashflows

$$DCF = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \ldots + \frac{CF_n}{(1+r)^n}$$

CF = Cash Flow

r = discount rate (WACC)

A typical spreadsheet summary of a cashflow model

DCF Valuation	**Projected Free Cash Flow**					
Calendar Years ending December 31,	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**Year 5**	**Year 6**
($ in thousands)						
EBITDA	$8,954	$9,898	$10,941	$12,093	$13,367	$13,367
Less D&A	1,112	1,222	1,343	1,476	1,623	1,623
EBIT	7,842	8,676	9,598	10,617	11,745	11,745
Less: Cash Taxes (35%)	(2,745)	(3,037)	(3,359)	(3,716)	(4,111)	(4,111)
Tax-adjusted EBIT	**5,097**	**5,639**	**6,239**	**6,901**	**7,634**	**7,634**
Pluss: D&A	1,112	1,222	1,343	1,476	1,623	1,623
Less: Capital Expenditures	(1,750)	(1,750)	(1,750)	(1,750)	(1,750)	(1,750)
Less: Change in Net Working Investment	(318)	(350)	(384)	(423)	(465)	(465)
Unlevered Free Cash Flow	**$4,141**	**$4,762**	**$5,447**	**$6,205**	**$7,042**	**$7,042**

$$\$19{,}845 = \frac{\$4{,}141}{(1+.11)^1} \quad \frac{\$4{,}762}{(1+.11)^2} \quad \frac{\$5{,}447}{(1+.11)^3} \quad \frac{\$6{,}205}{(1+.11)^4} \quad \frac{\$7{,}042}{(1+.11)^5}$$

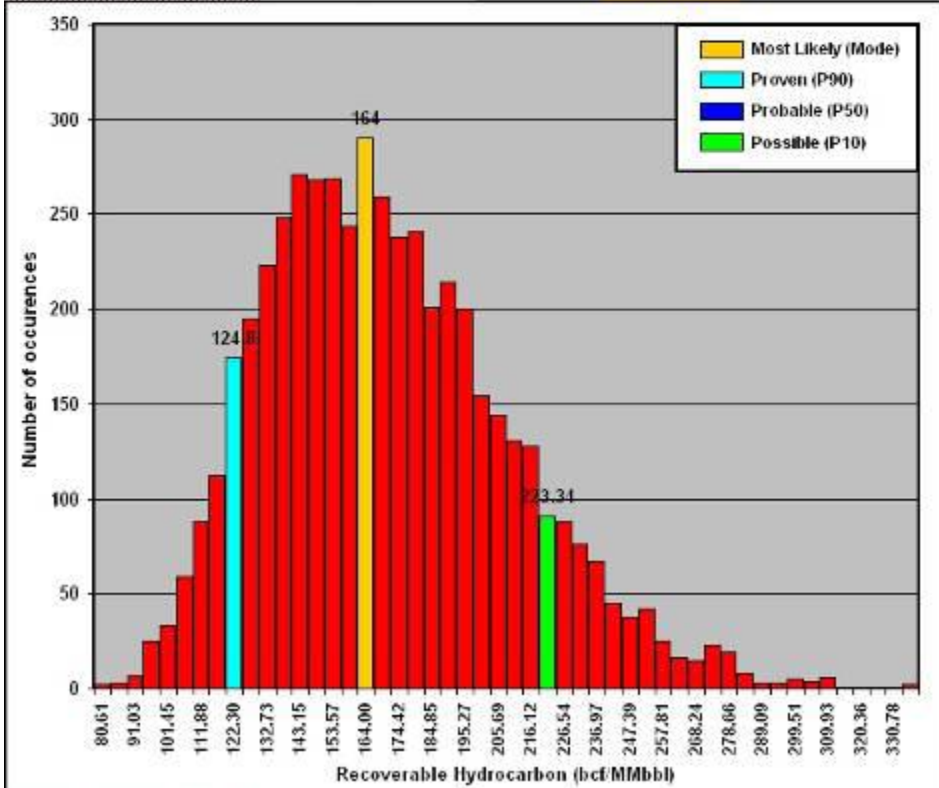
Analysis to Support the Decision to drill an exploration well

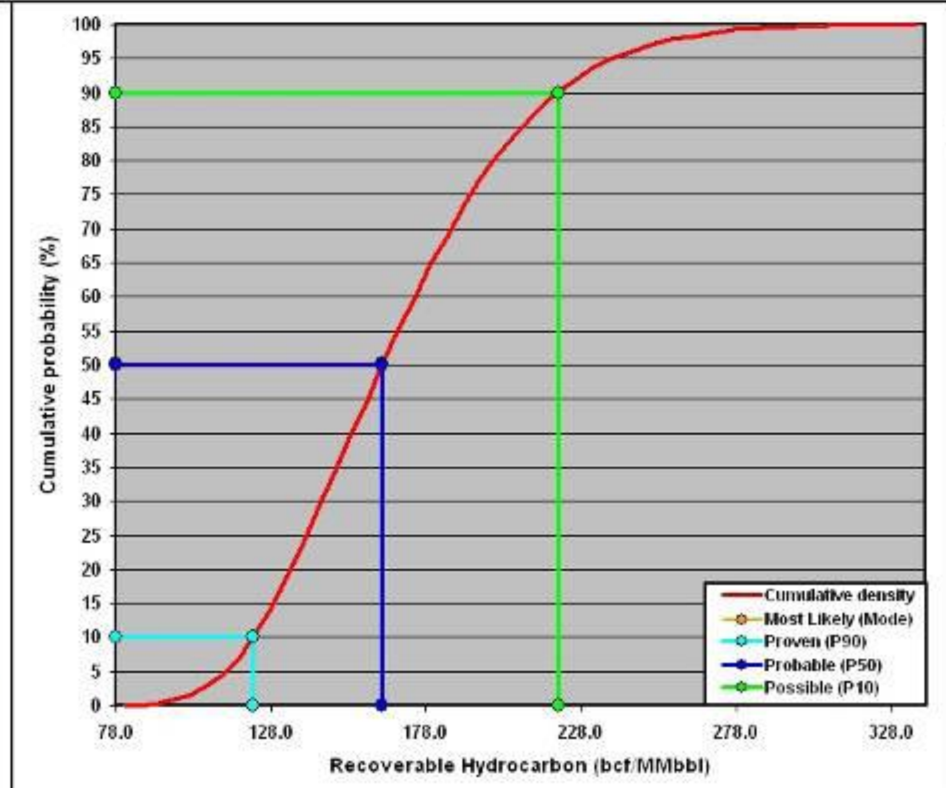
- **Geologists/Geophysicists:**
  - Interpret Seismic data and assess reservoir size probability distribution.
  - Assess the probability of source, reservoir and trap.
- **Reservoir Engineer:**
  - Assess the recoverable reserves and reservoir properties for the 90%,50% and 10% cases.
  - Assess the number of production wells required.
  - Develop annual production profile for the life of the field.
- **Facilities Engineer:**
  - Creates conceptual design for min, mean and max cases with costing and cost phasing.
- **Petroleum Economist:**
  - Models the cashflow of the three reserve cases including tax or Production sharing effects. Derives the Net Present Value of Cashflows, the Internal rate of return and other metrics.
  - Integrates the NPV's over the reserve distribution range to derive the Expected Present value.
  - Performs decision tree analysis based on the probability of the exploration well being successful.
  - Presents the investment case to management.

Create a theoretical cashflow based on assumptions known to date

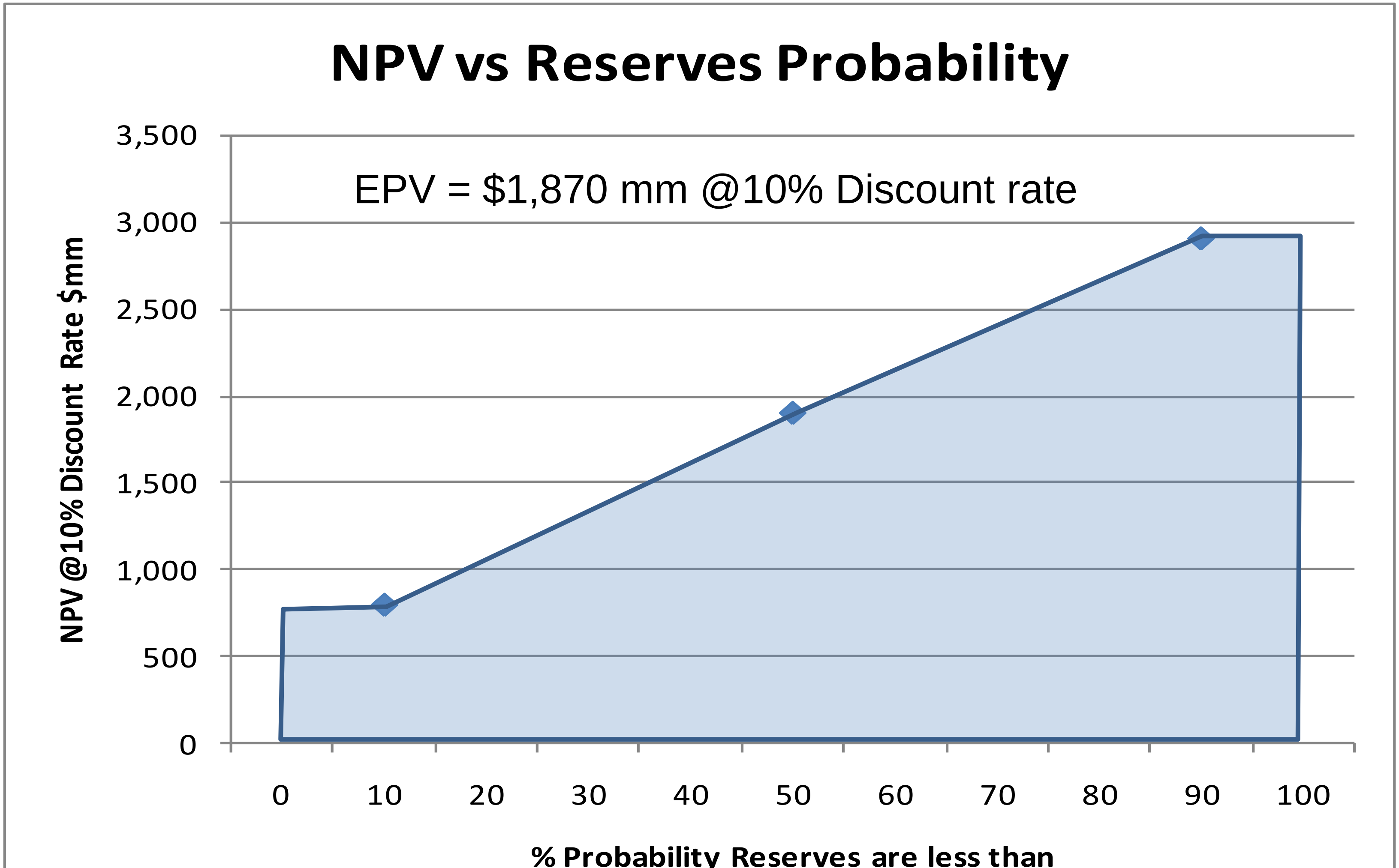
Monte Carlo reserve simulation: results and input parameter summary

Prospect Name	Modelling and structural parameters			Statistics	Recoverable hydrocarbon (bcf/MMbbl)	Volumetric parameters				Petrophyisical parameters				PVT parameters			Field development parameters
	Number of Iterations	Reservoir Type	Trap Type			OWC/GWC depth (m)	Reservoir thickness (m)	Reservoir area (km^2)	GRV (10^6 m^3)	Φ (%)	Sw (%)	S_{hc} (%)	Area N/G	Reservoir Pressure (MPa)	Reservoir Temperature (°C)	Expansion Factor (Sm^3/Rm^3)	Recovery factor
M11-1 Preliminary results	5000	GAS	Simple Layer	Minimum	78.13	2800.01	18.25	8.002	148.12	9.52	20.15	60.30	1.00	46.08	97.00	322.00	0.604
				Most Likely	164.00	2803.41	25.29	8.070	224.85	12.23	30.15	69.85	1.00	46.08	97.00	322.00	0.704
				Maximum	338.45	2849.96	39.77	11.171	412.92	14.09	39.70	79.85	1.00	46.08	97.00	322.00	0.849
				P90	124.80	2804.86	21.79	8.158	193.22	10.66	24.55	64.52	1.00	46.08	97.00	322.00	0.650
				P50	166.48	2824.61	27.01	8.947	245.14	12.02	29.97	70.03	1.00	46.08	97.00	322.00	0.714
				P10	223.34	2844.68	34.13	10.192	315.06	13.19	35.48	75.45	1.00	46.08	97.00	322.00	0.790





At exploration stage add risk to calculate an Expected Present Value (integration over range of reserves uncertainty)



N.B. If the field is viable over the entire range then assume the NPV of the 50% case equals the EPV

Decision Tree Analysis

Cost of Exploration Well =$50mm

Oil Case

Probability of oil case =100%

Min NPV $800mm

Mean NPV $1,870mm

Max NPV $2,900mm

EPV $1,870mm

Probability of finding hydrocarbon = 20%

EPV $1,870mm

Probability of gas case = 0%

Gas Case

(not evaluated)

0.2 *(1870 – 50) = 364

0.8 *(– 50) = -40

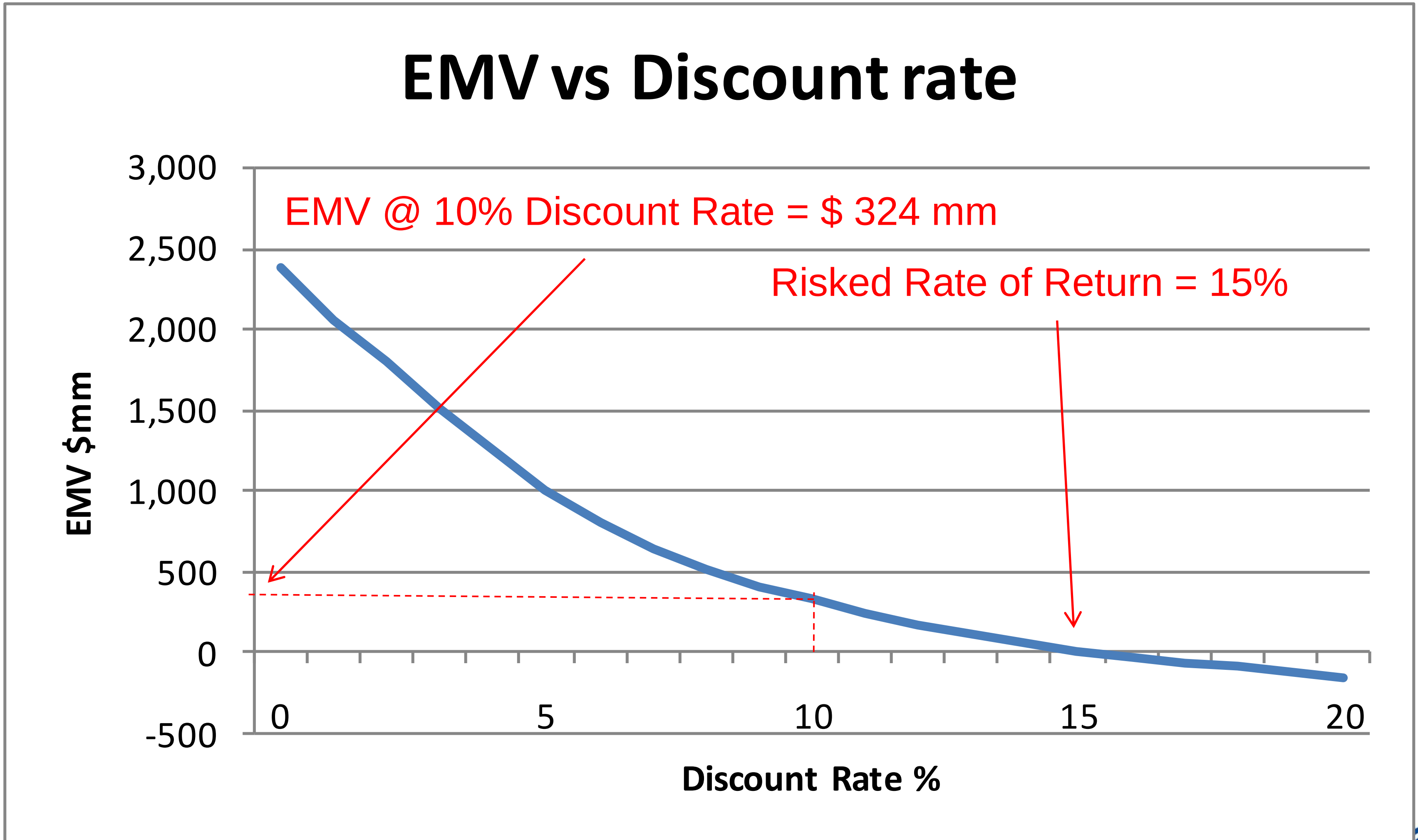
$324 mm

Probability of not finding hydrocarbon = 80%

Dry Well

This is called the Expected Monetary Value (EMV) at the discount rate used.

Risked Rate of Return



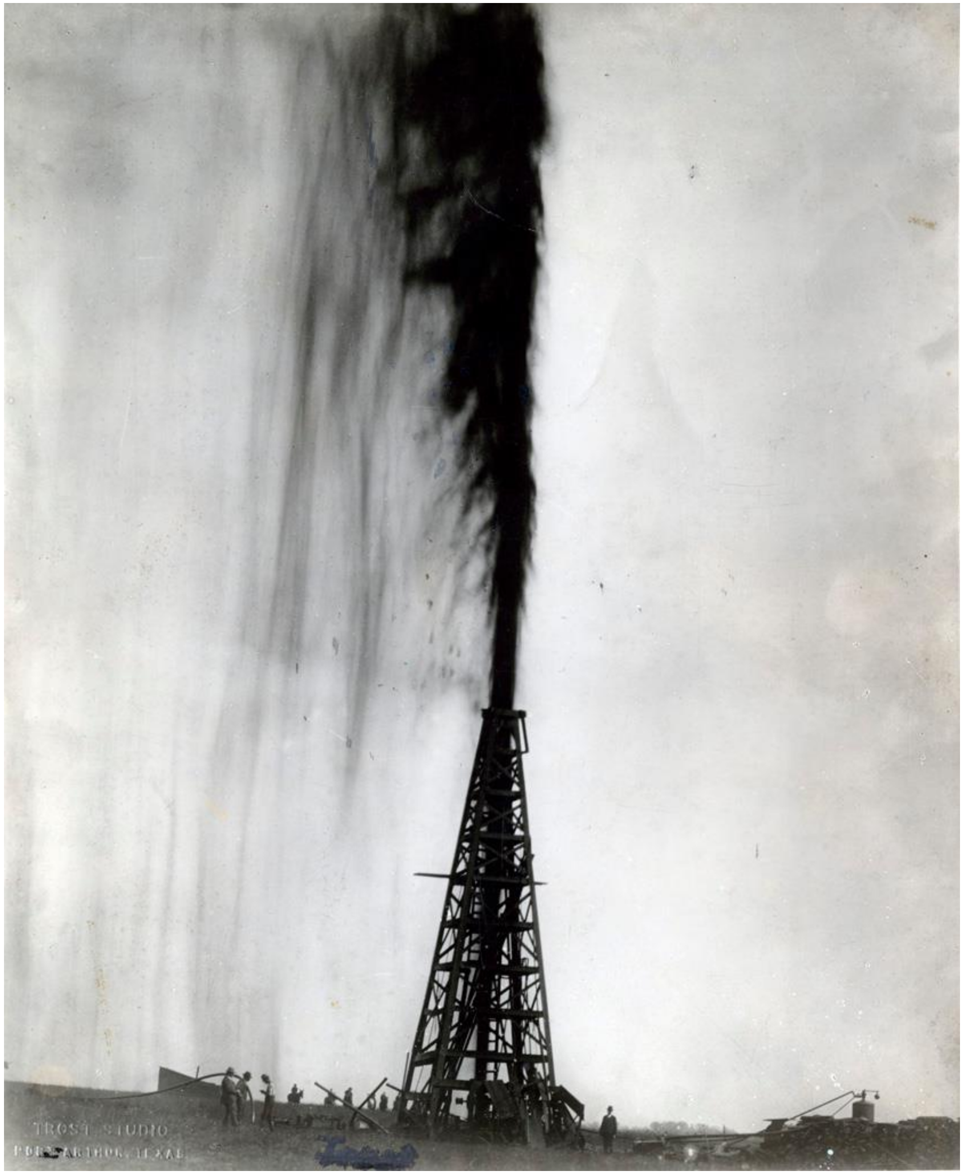
Exploration Proposal

‘It is recommend that the company drill an exploration well on the prospect at a cost of $50mm.

The probability of discovering oil is 20% (in in 5). The mean discovery case has a recoverable reserves level of 900 million barrels of oil and a NPV @ 10% discount rate of $1,900mm.

Risked exploration economics indicate an Expected Monetary value of $324mm @ 10% discount rate and a Risked Rate of Return of 15%.’

Exploration Success!



The Lucas Gusher, Spindletop, Texas, 1901

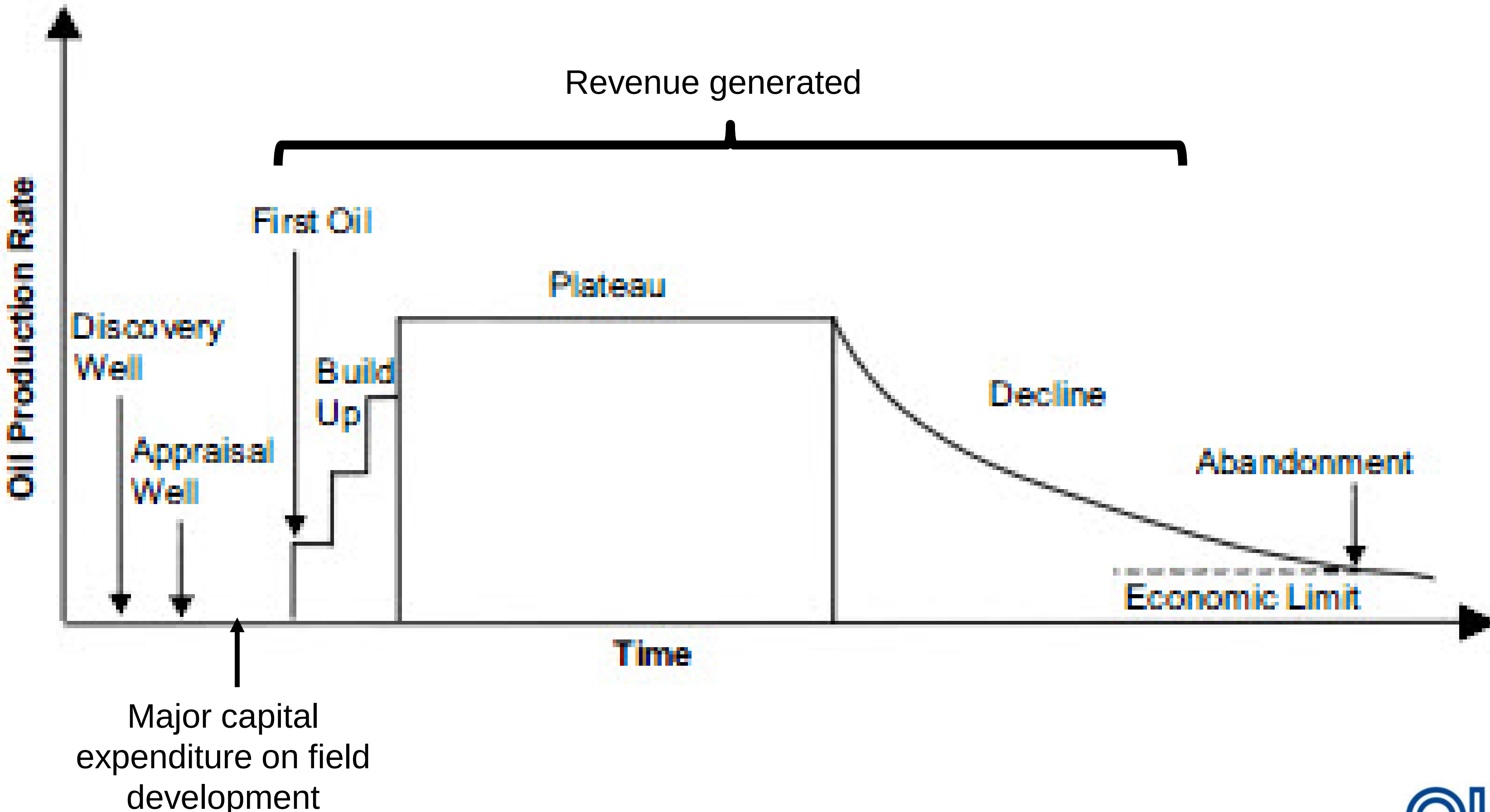
The Development Decision

Congratulations – you discovered oil at a level just above the mean reserves case.

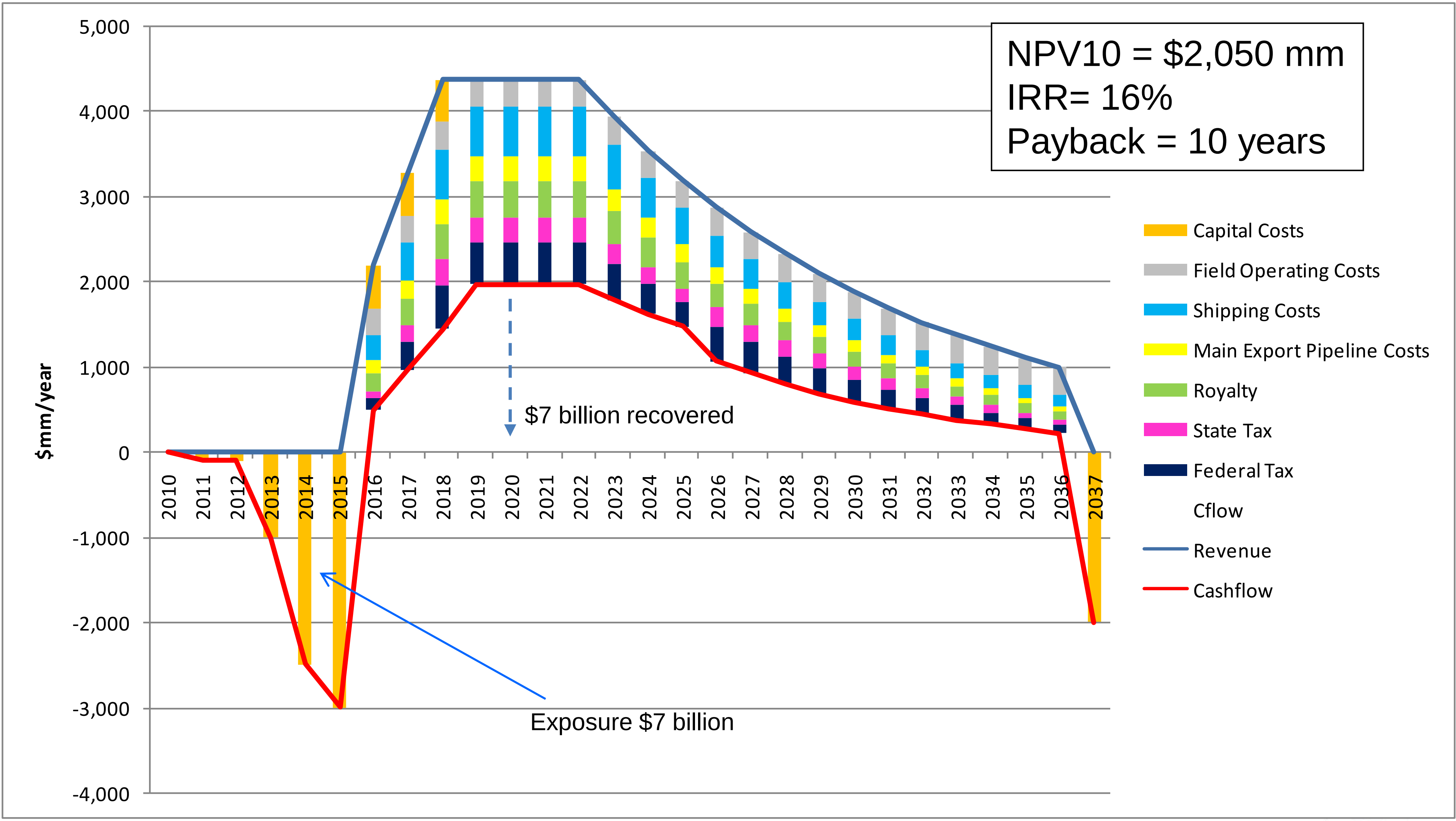
The exploration well, in addition to confirming a discovery, has provided useful information on reservoir quality, well flow rate and oil quality.

Your share price has soared but you now need to drill four appraisal wells to narrow the uncertainty on the reserves range, work out what it will cost to develop the discovery and what the economics of the project are before you go to the banks and your shareholders to raise more capital.

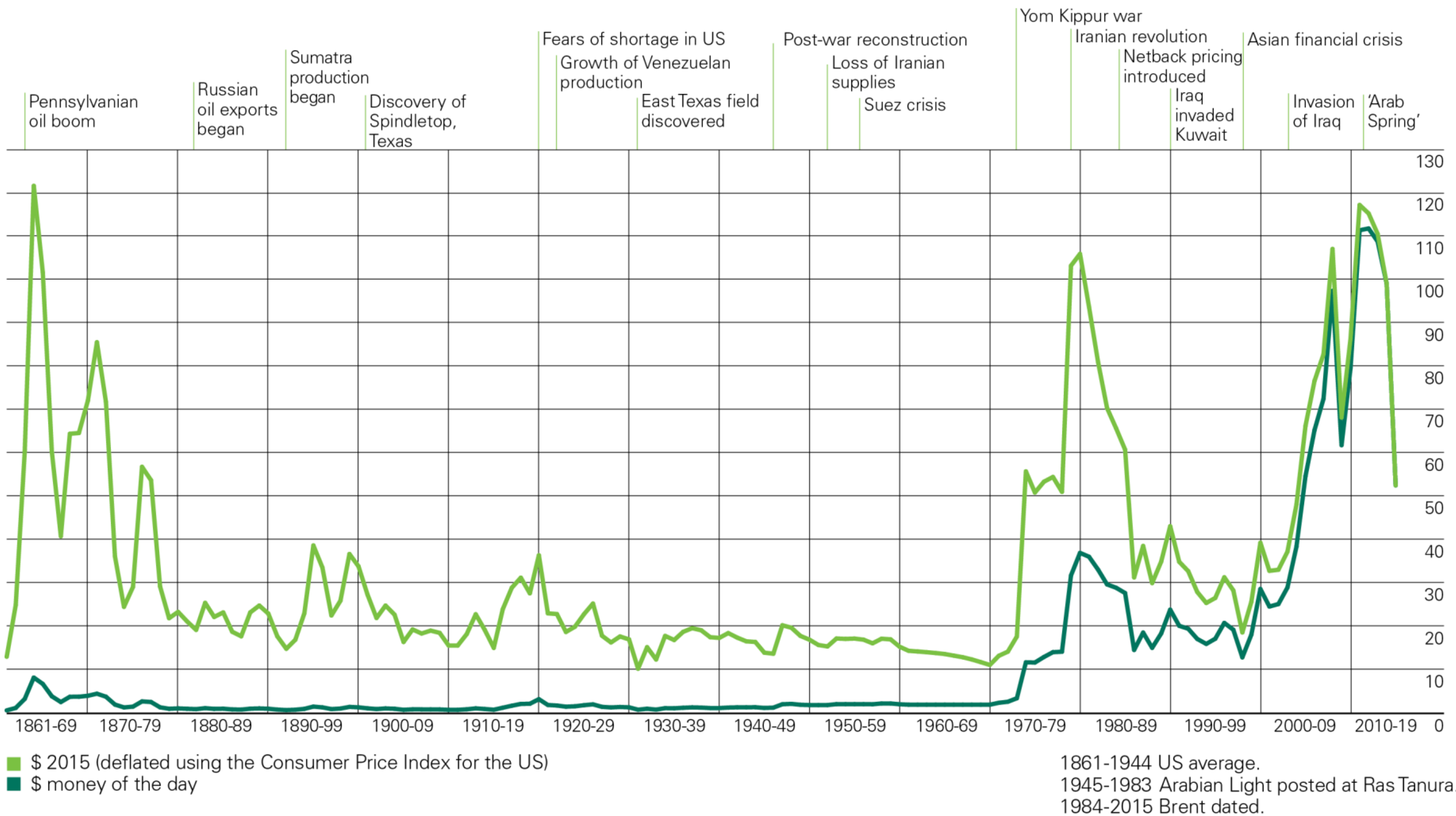
Production Profile



A graphical output from a DCF model



The Oil Price since 1860



- Average price over the past 150 years has been around $30-40 in real terms
- Recent high levels have been an anomaly
- Key question going forward is whether the OPEC cartel can keep the price above long-run marginal cost

Demand is a primary driver

Table 1.1 Global oil demand (mb/d), 2015-21

	2015	2016	2017	2018	2019	2020	2021	2015-21
OECD Americas	24.4	24.4	24.5	24.4	24.4	24.3	24.2	-0.1
OECD Asia Oceania	8.1	8.0	8.0	7.9	7.9	7.9	7.8	-0.3
OECD Europe	13.7	13.7	13.6	13.5	13.4	13.3	13.1	-0.5
FSU	4.9	4.9	4.9	5.0	5.0	5.1	5.2	0.3
Other Europe	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.1
China	11.2	11.5	11.9	12.4	12.8	13.2	13.6	2.5
Other Asia	12.5	13.0	13.5	14.0	14.4	14.9	15.3	2.8
Latin America	6.8	6.8	6.8	6.9	6.9	7.0	7.1	0.3
Middle East	8.2	8.3	8.5	8.7	9.0	9.2	9.5	1.3
Africa	4.1	4.2	4.4	4.5	4.7	4.8	5.0	0.9
World	**94.4**	**95.6**	**96.9**	**98.2**	**99.3**	**100.5**	**101.6**	**7.2**

- OECD countries dominate oil demand at present, especially the US
- Non-OECD is where all the growth is, especially in Asia with China leading the way
- A key question is whether "peak oil demand" is near

Two main groupings of oil suppliers – OPEC and Non-OPEC

Table 2.1 Non-OPEC supply (mb/d)

	2015	2016	2017	2018	2019	2020	2021	2015-21
OECD	**23.8**	**23.3**	**23.3**	**23.8**	**24.4**	**25.0**	**25.8**	**2.0**
Americas	19.9	19.4	19.4	19.9	20.6	21.1	21.8	1.9
Europe	3.5	3.3	3.3	3.3	3.2	3.2	3.3	-0.2
Asia Oceania	0.5	0.5	0.6	0.7	0.7	0.7	0.7	0.2
Non-OECD	**29.3**	**29.2**	**29.0**	**29.0**	**29.0**	**28.9**	**28.8**	**-0.5**
FSU	14.0	13.9	13.8	13.8	13.8	13.8	13.8	-0.2
Europe	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-0.0
China	4.3	4.3	4.2	4.2	4.2	4.1	4.1	-0.2
Other Asia	2.7	2.7	2.7	2.7	2.6	2.6	2.5	-0.2
Americas	4.6	4.6	4.7	4.8	4.9	5.0	5.1	0.6
Middle East	1.3	1.2	1.2	1.2	1.2	1.1	1.1	-0.1
Africa	2.3	2.3	2.3	2.3	2.2	2.1	2.1	-0.3
Non-OPEC ex PG and biofuels	**53.1**	**52.4**	**52.3**	**52.8**	**53.4**	**53.9**	**54.6**	**1.5**
Processing Gains	2.2	2.3	2.3	2.3	2.3	2.4	2.4	0.2
Global Biofuels	2.3	2.4	2.5	2.5	2.6	2.7	2.7	0.4
Total-Non-OPEC	**57.7**	**57.1**	**57.0**	**57.6**	**58.3**	**58.9**	**59.7**	**2.0**
Annual Change	1.4	-0.6	-0.0	0.6	0.7	0.6	0.8	0.3
Changes from last *MTOMR**	1.1	0.1	-0.5	-0.6	-0.5	-0.4		

*

- North America is the largest non-OPEC region, primarily the US
- Russia is another key player in the global supply mix
- All other regions are relatively marginal

OPEC accounts for around 40% of global oil supply

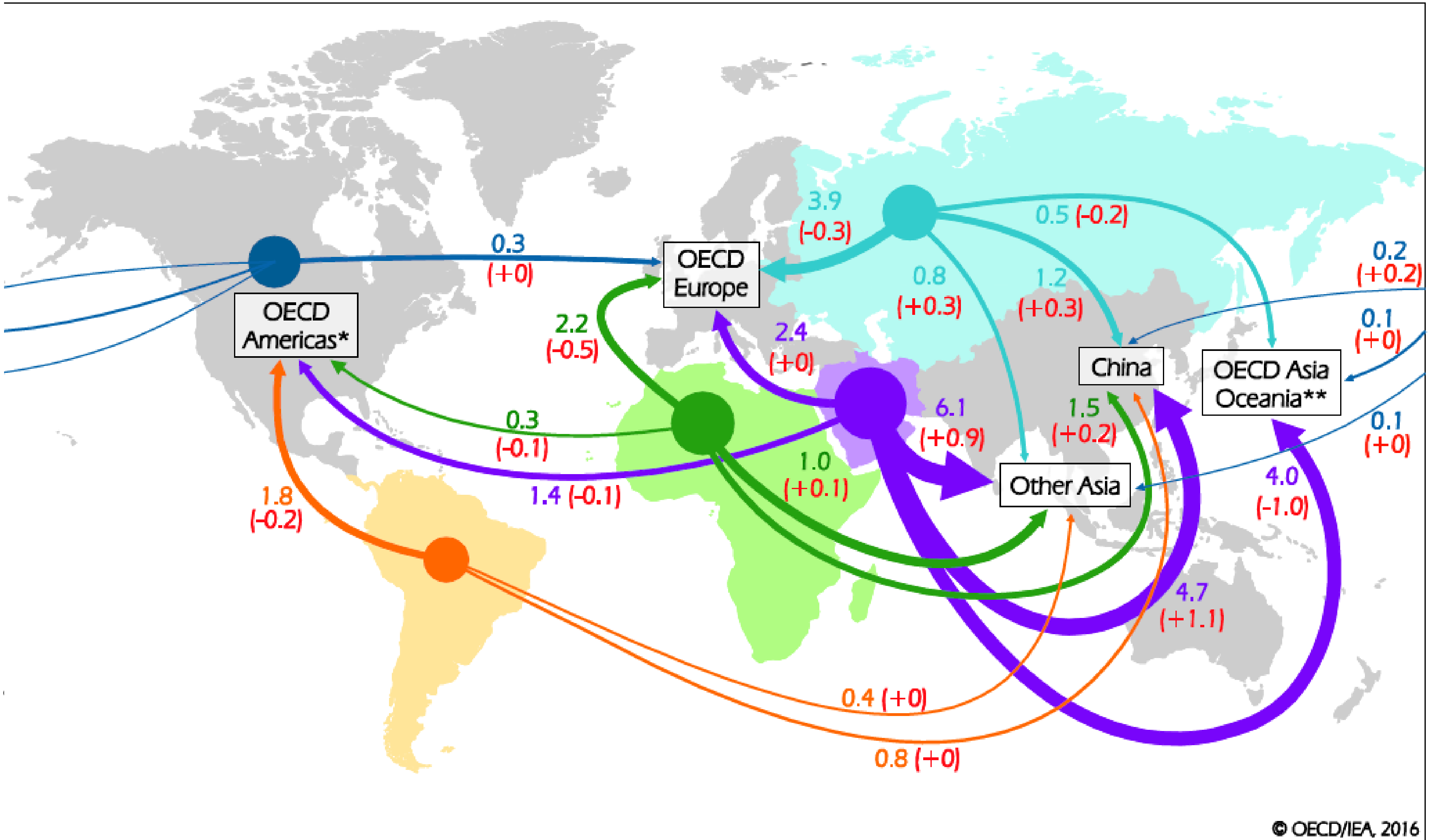
Table 2.2 Estimated sustainable crude production capacity (mb/d)

	2015	2016	2017	2018	2019	2020	2021	2015-21
Algeria	1.15	1.12	1.09	1.06	1.04	1.01	0.99	-0.17
Angola	1.81	1.81	1.77	1.81	1.78	1.76	1.8	-0.02
Ecuador	0.56	0.55	0.55	0.55	0.55	0.54	0.53	-0.03
Indonesia	0.69	0.71	0.71	0.69	0.67	0.65	0.63	-0.06
Iran	3.6	3.6	3.7	3.75	3.8	3.9	3.94	0.34
Iraq	4.35	4.35	4.36	4.4	4.45	4.53	4.62	0.27
Kuwait	2.83	2.87	2.91	2.93	2.94	2.9	2.88	0.05
Libya	0.4	0.4	0.43	0.46	0.49	0.53	0.59	0.19
Nigeria	1.91	1.9	1.84	1.75	1.78	1.85	1.85	-0.07
Qatar	0.68	0.67	0.66	0.66	0.66	0.66	0.66	-0.02
Saudi Arabia	12.26	12.31	12.43	12.45	12.44	12.39	12.33	0.07
UAE	2.93	2.97	3.02	3.07	3.12	3.17	3.2	0.27
Venezuela	2.46	2.46	2.44	2.43	2.45	2.44	2.42	-0.04
OPEC	**35.64**	**35.72**	**35.89**	**36.02**	**36.17**	**36.34**	**36.44**	**0.8**

- Saudi Arabia is the dominant force within the cartel
- The Gulf Cooperation Council members make up the biggest bloc
- Political and religious differences can create huge tension when the group meets to decide on oil price and production strategy

OPEC is vital because it is by far the largest exporter and so can influence global trade and prices

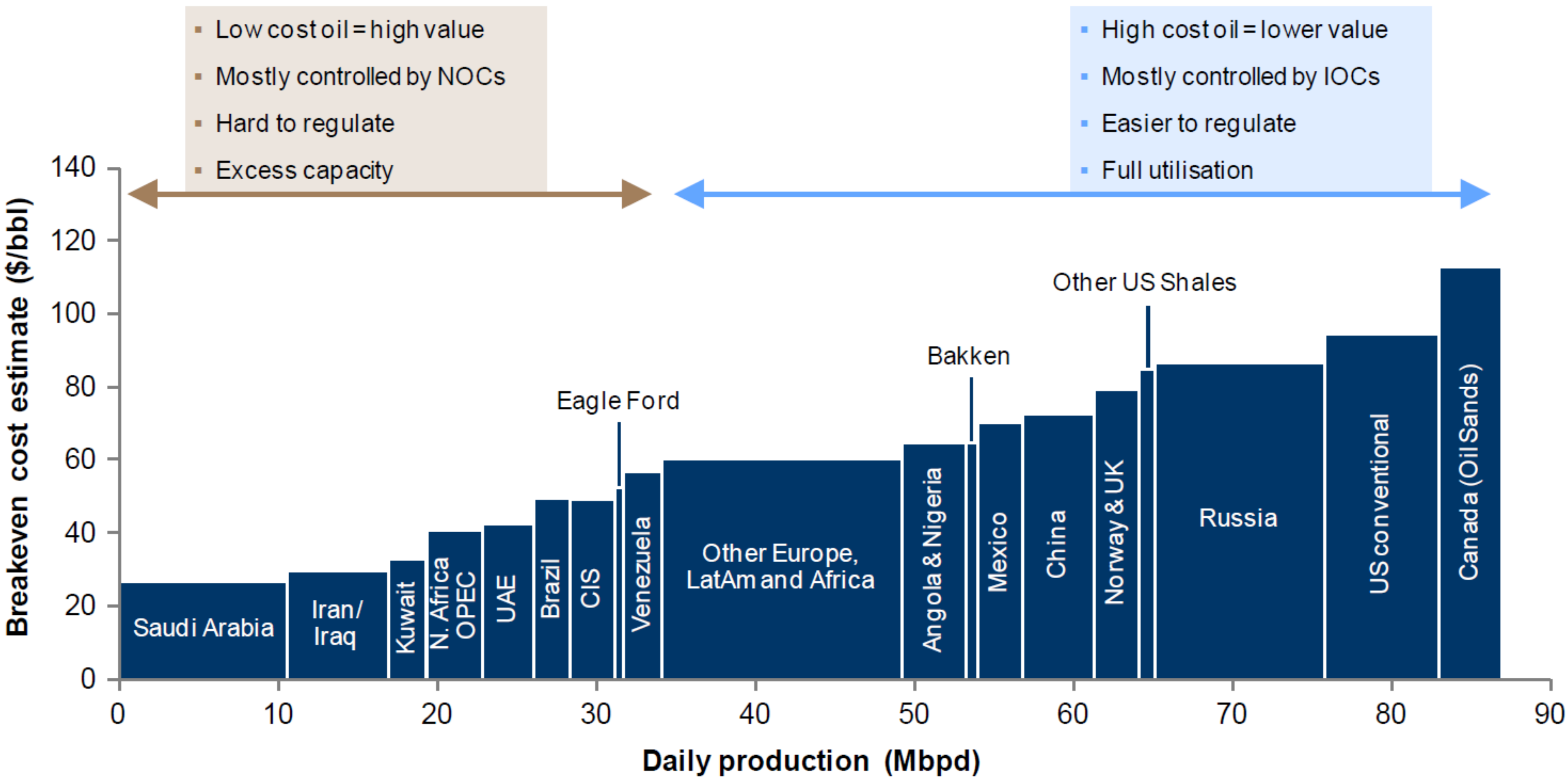
Map 3.1 Crude exports in 2021 and growth in 2015-21 for key trade routes
(million barrels per day)



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

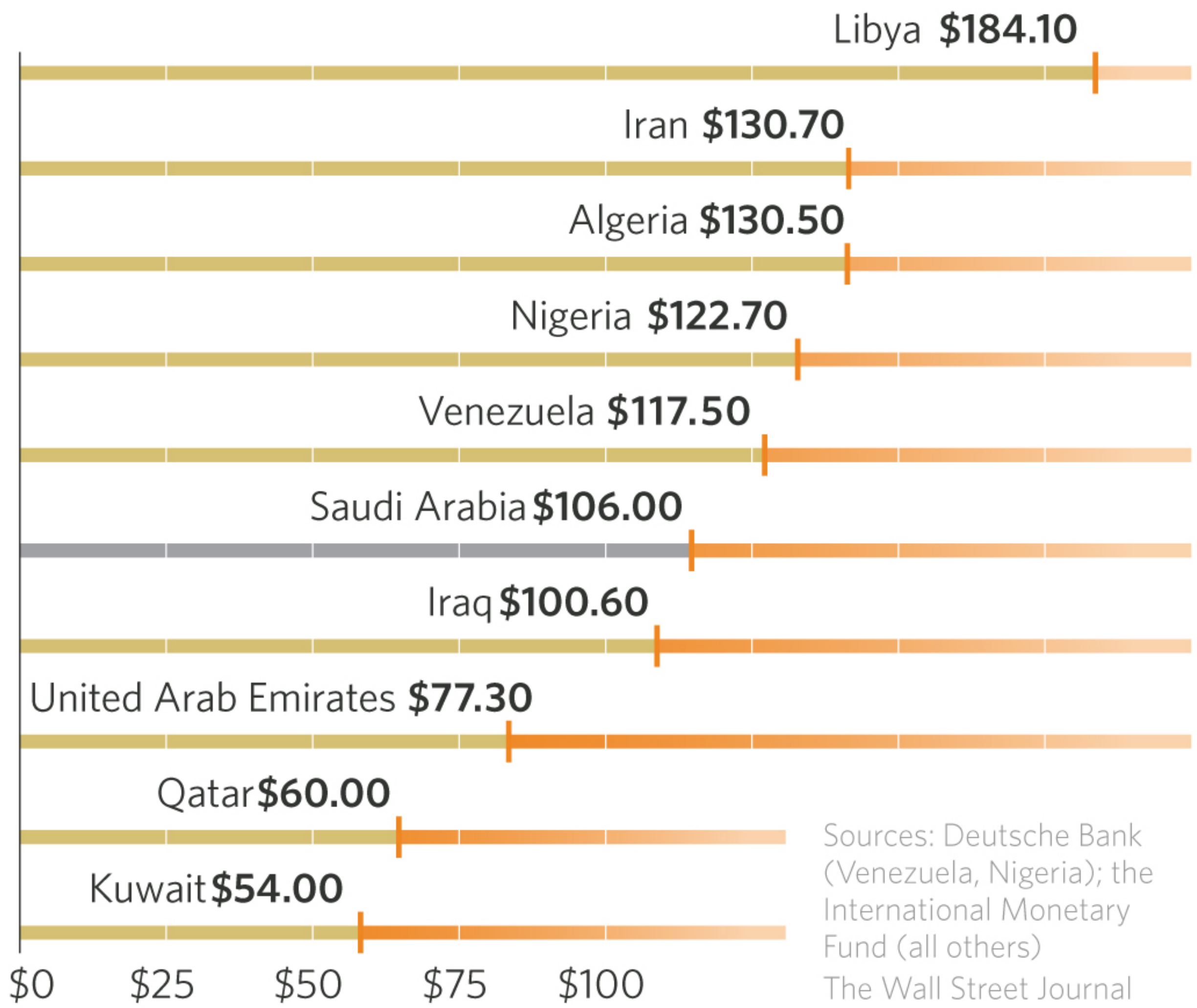
OPEC also has some of the lowest cost production in the world, and so can out-compete other producers

Estimated breakeven price for production



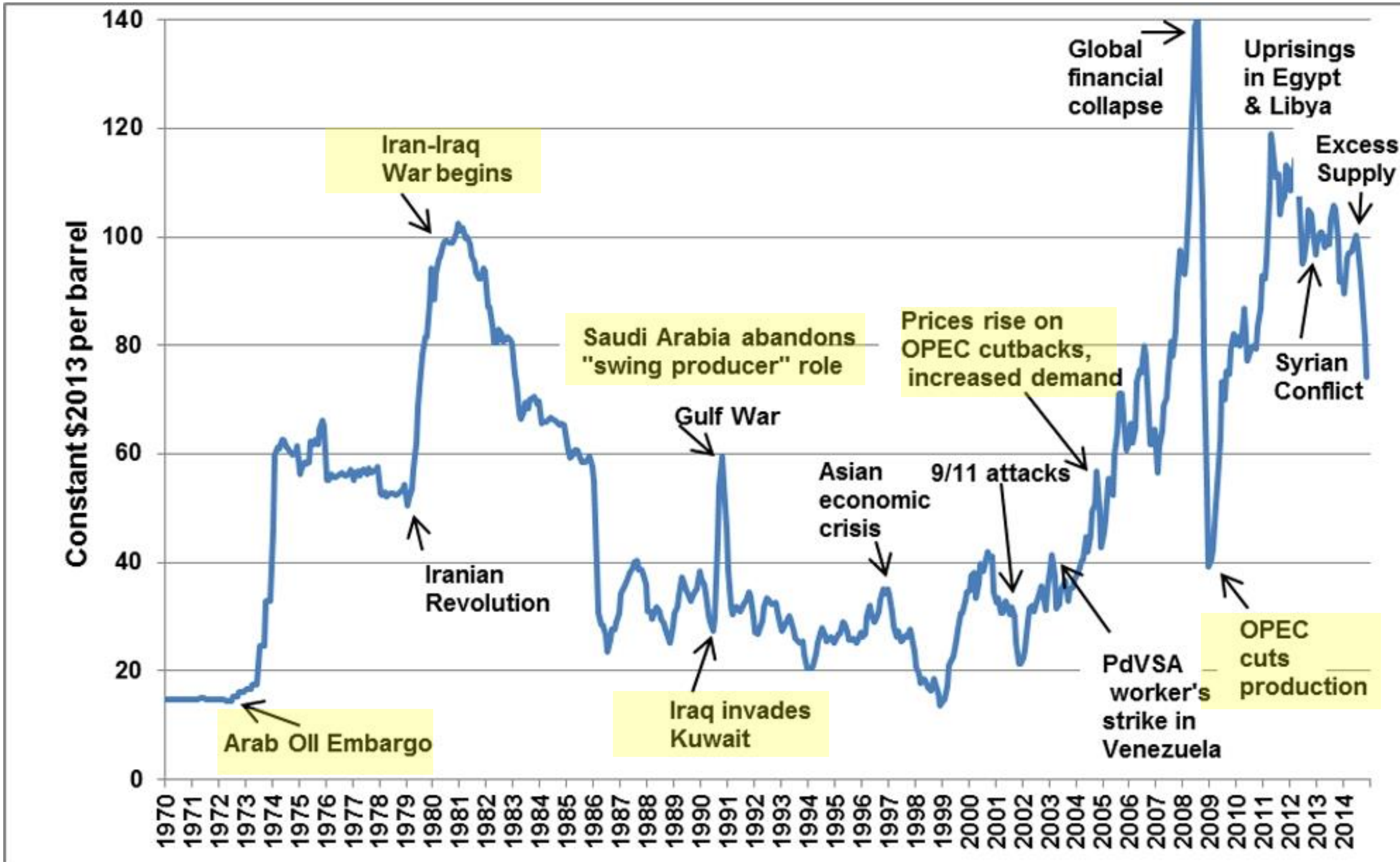
OPEC countries need to balance their budgets while ensuring that the population is kept happy

Estimated breakeven price for budget



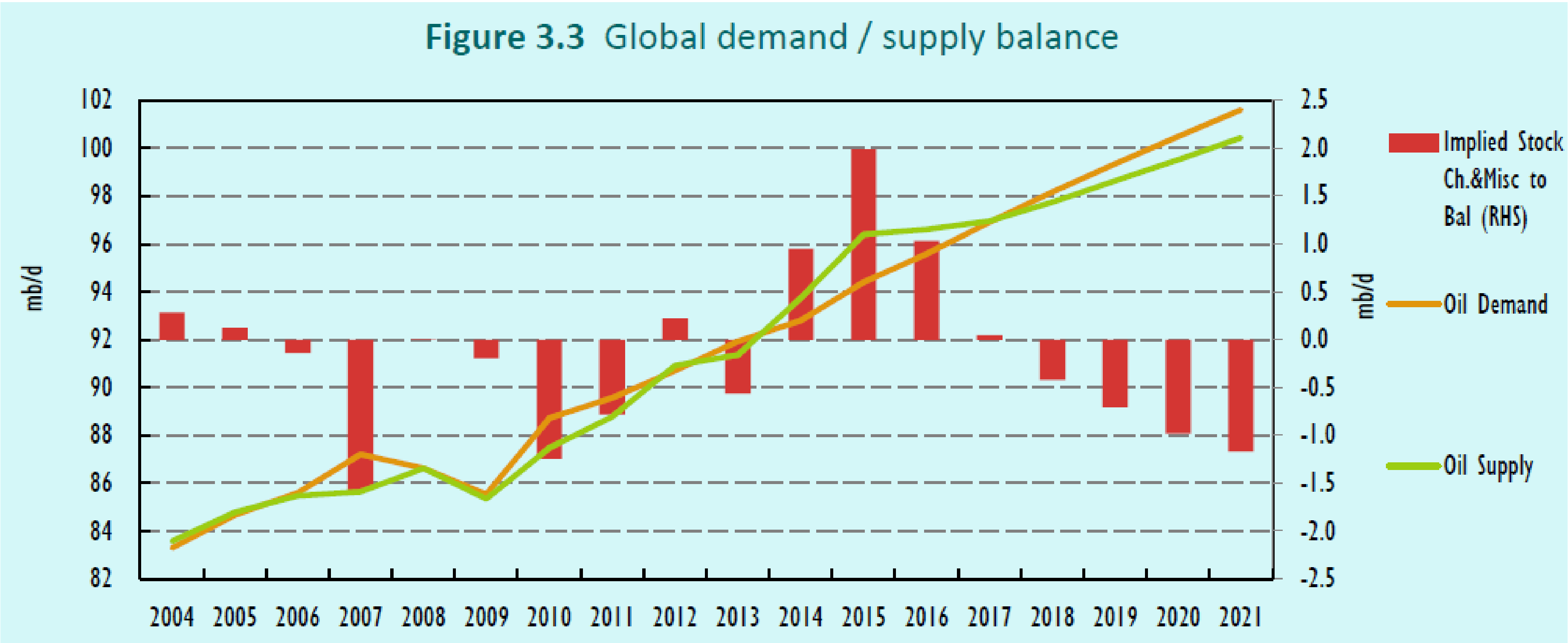
Sources: Deutsche Bank (Venezuela, Nigeria); the International Monetary Fund (all others)
The Wall Street Journal

OPEC interventions have been critical oil price events



- OPEC formed in 1960s to break the power of the “Seven Sisters”
- First attempt at intervention was in 1967 during the Arab-Israeli conflict

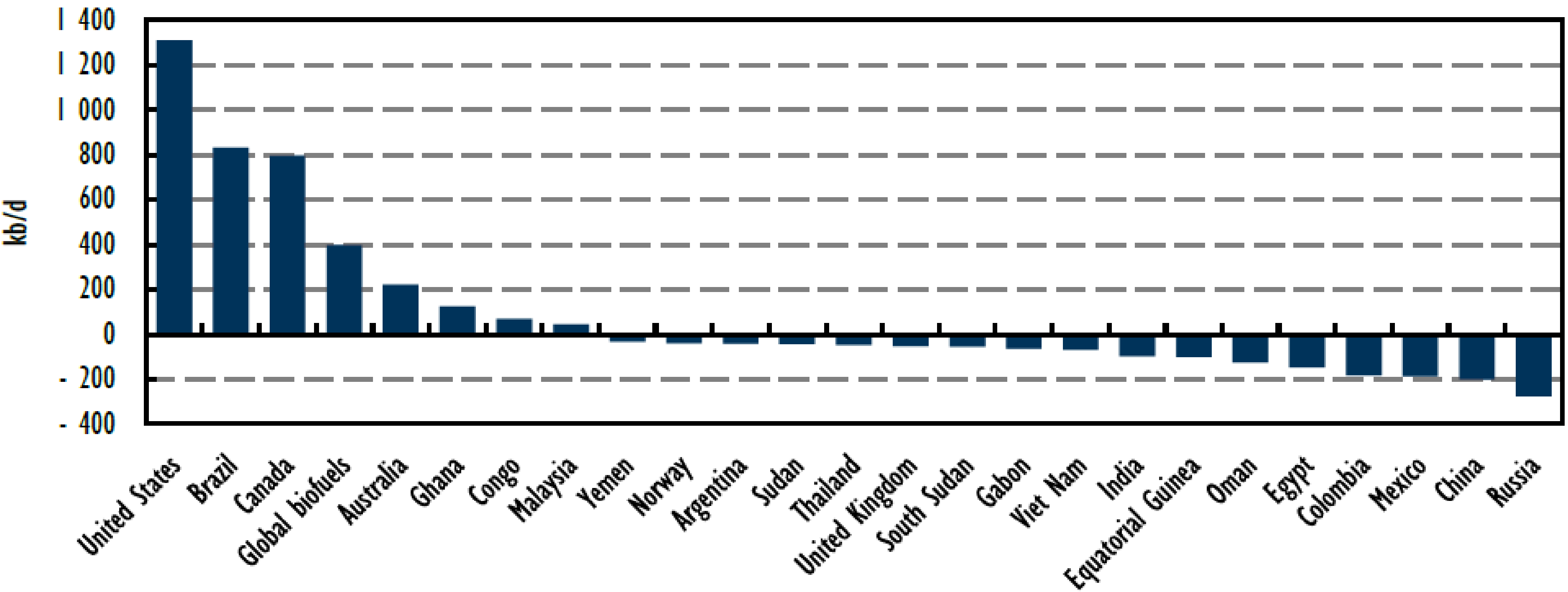
The oil market has been significantly out of balance



- Supply and demand saw a significant mismatch in the 2014-2016 period, mainly due to rising supply
- The change in stocks is a critical issue – if they are rising then there is too much oil in the market
- Stocks were close to record highs but are now rebalancing

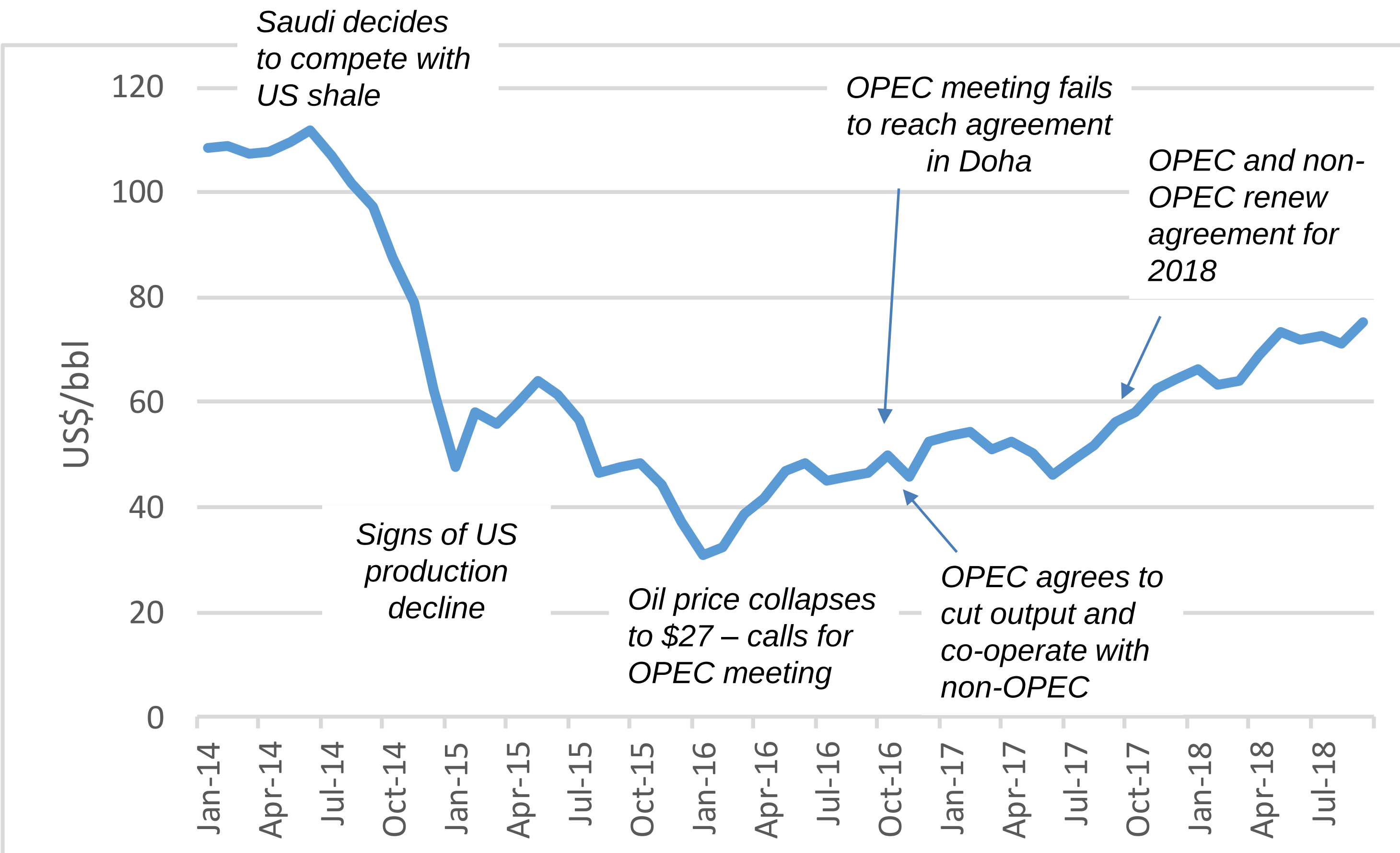
Significant Non-OPEC supply potential exists, especially in the US

Figure 2.6 Selected sources of non-OPEC supply changes, 2015-21



- The rise of US shale is the most important factor in the oil market at present
- The flexibility of output, and its responsiveness to price, is a very new phenomenon
- Other producers with longer-term investment horizons are struggling to react

OPEC manoeuvres since 2014

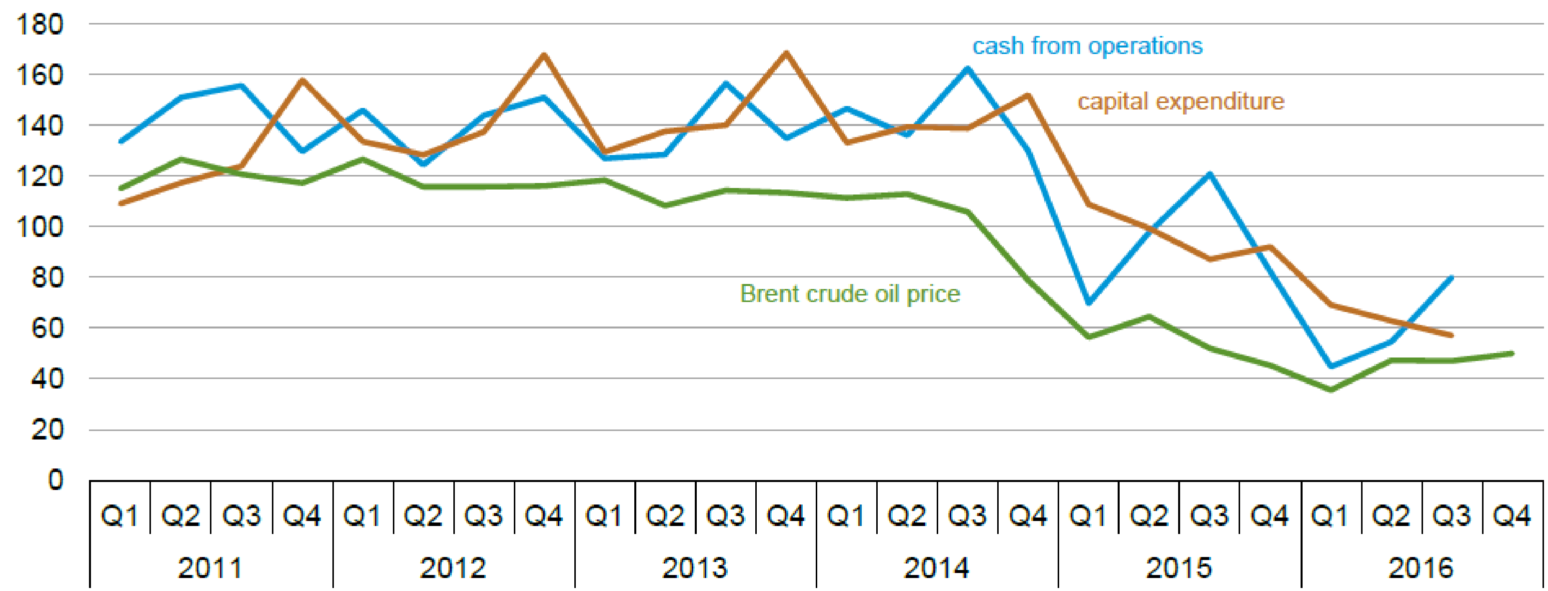


- The rise of US shale has raised questions about the continuing relevance of OPEC
- Saudi Arabia decided to compete for market share, to force out higher-cost producers
- However, the strategy was not very successful – OPEC + Russia have been forced to curb production to encourage an oil price recovery

Falling oil price = lower cashflow = lower investment

Capital expenditure declines slowed and cash from operations increased from the second quarter of 2016 as crude oil prices stabilized

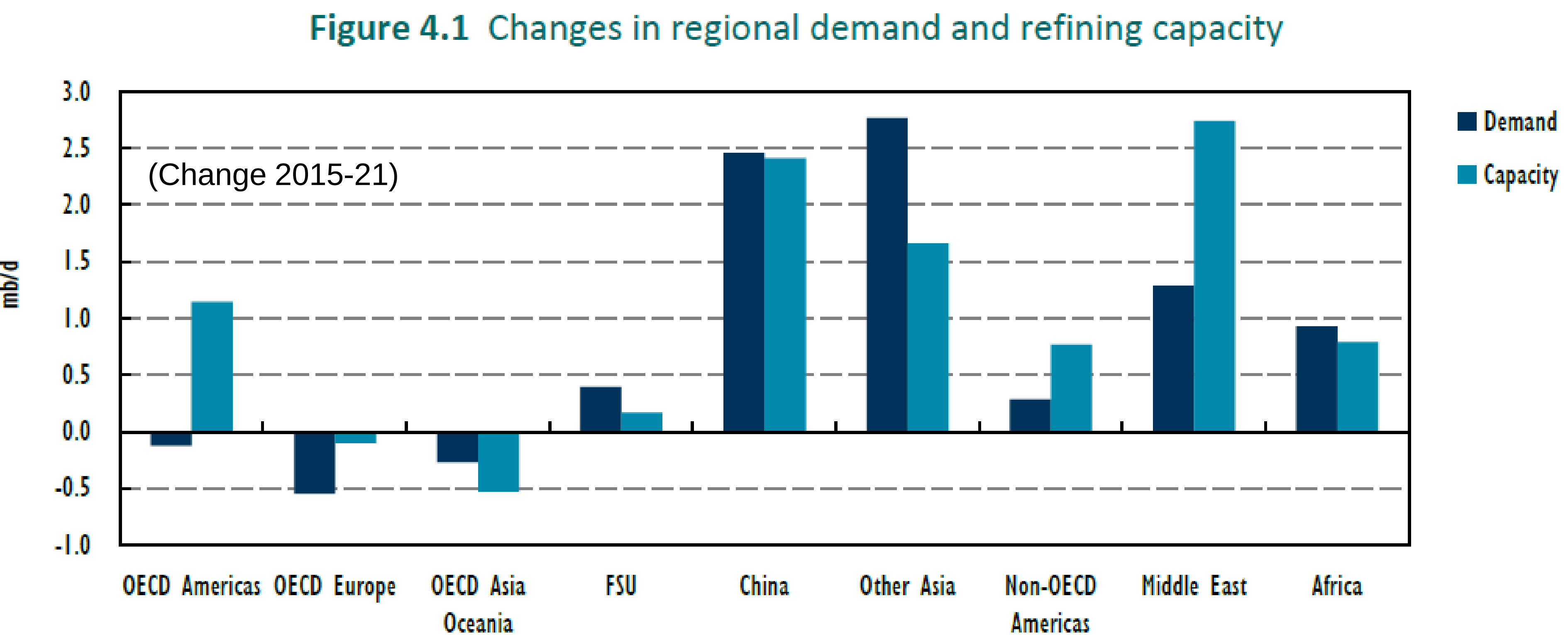
cash flow items and Brent price
billion 2016$; Brent in 2016 $/b



Source: U.S. Energy Information Administration, Evaluate Energy, Bloomberg
Note: b=barrel

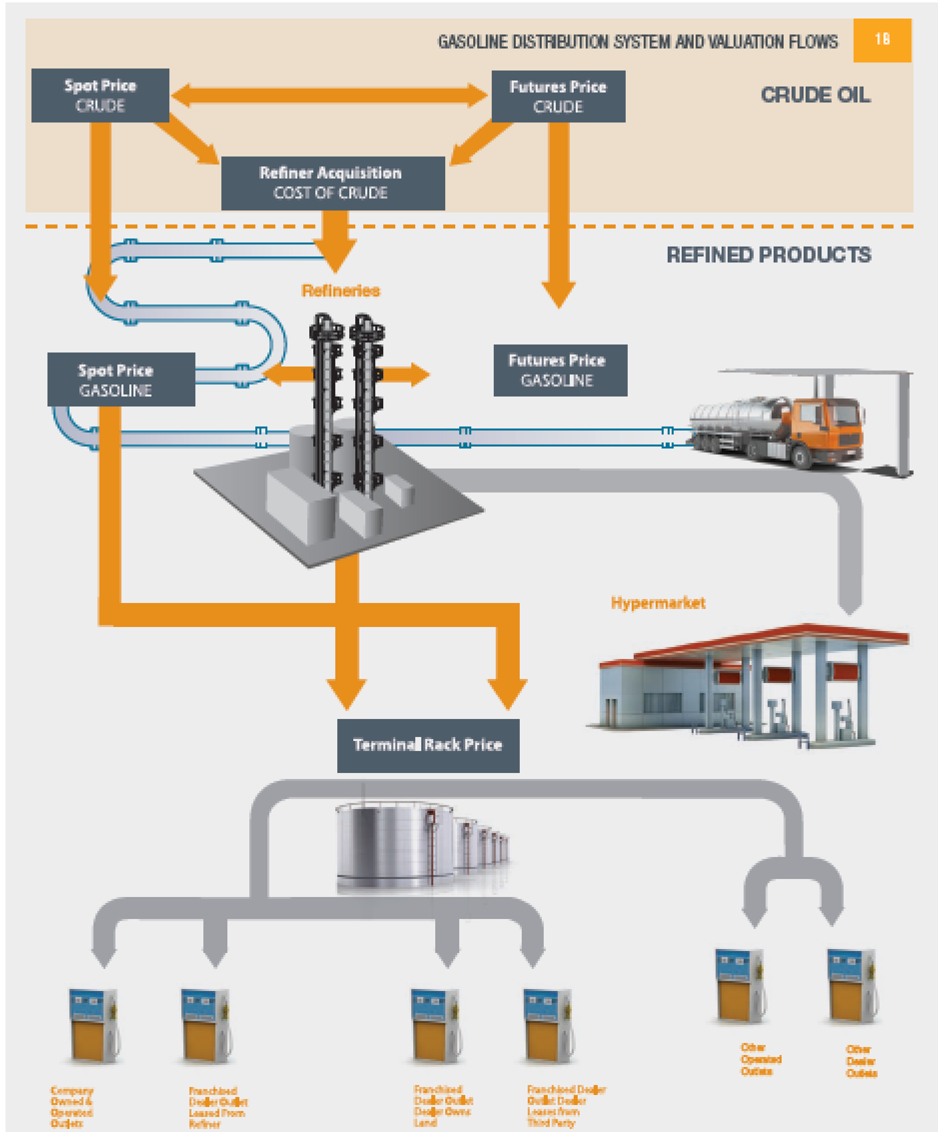
- Companies dramatically cut back investment in oil exploration and development during the period of low oil prices
- This inevitably led to a slowdown in supply – a classic commodity cycle
- The key question now is whether there will be a supply crunch and a price spike, and what impact this might have for the longer term

Oil products and refining capacity are also important



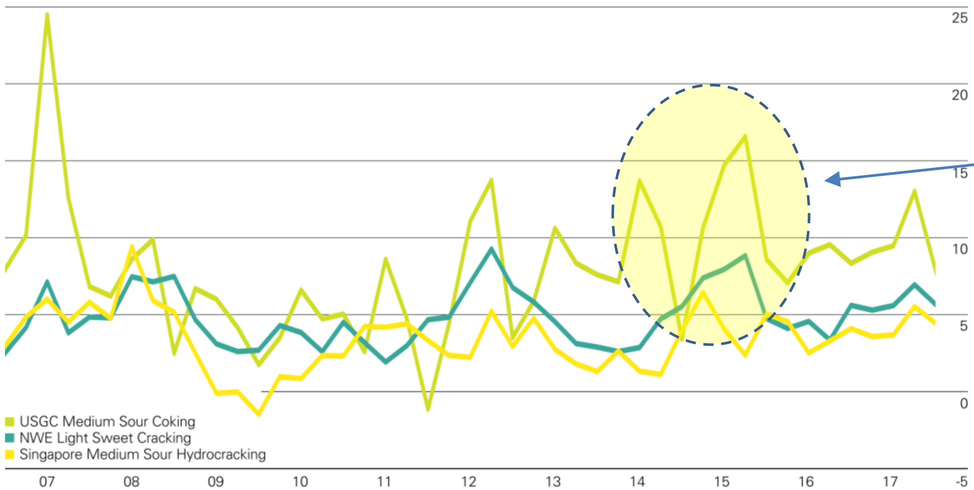
- Lower oil prices encourage higher refining margins as well as demand growth
- Refining capacity expansion is focused on developing markets in Asia and the Middle East
- Oil product prices move in tandem with crude prices, but tend to provide extra profit when oil prices are low

Downstream Oil Value Chain



The downstream oil business

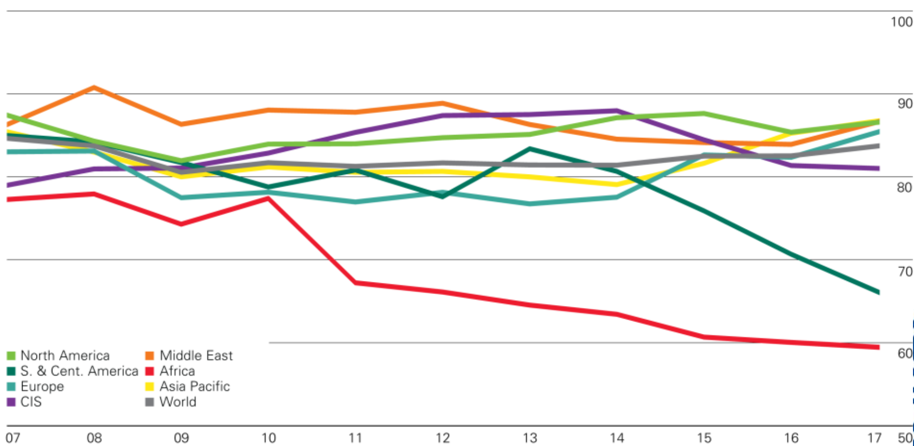
Refining margins (US$/bbl)



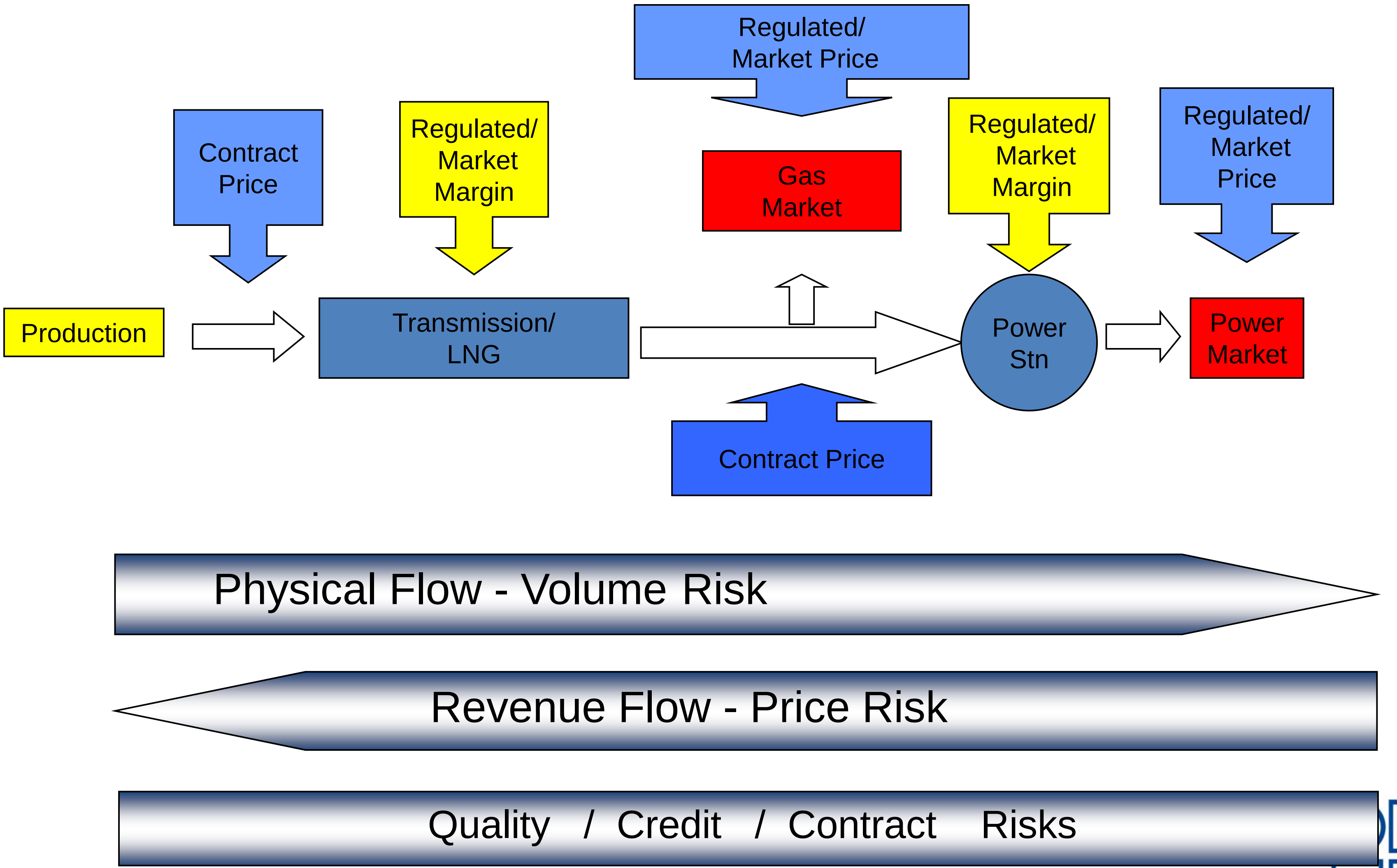
Refining margins rise as crude prices have fallen

Refining utilisation (% capacity

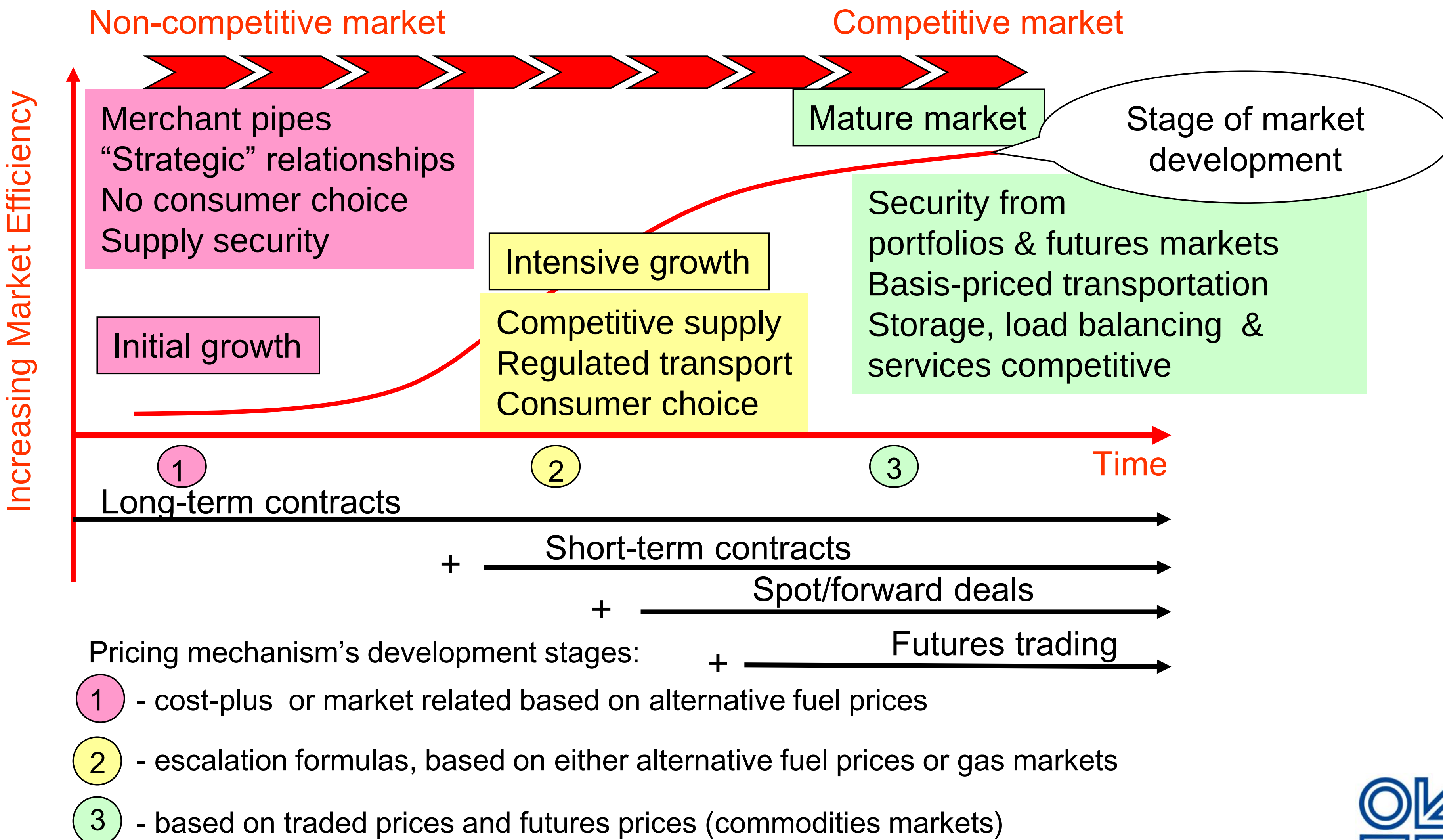
Refinery utilisation is a critical factor in oil economics – below 80% is a bad sign



The Gas Commercial Chain – Pricing & Risks

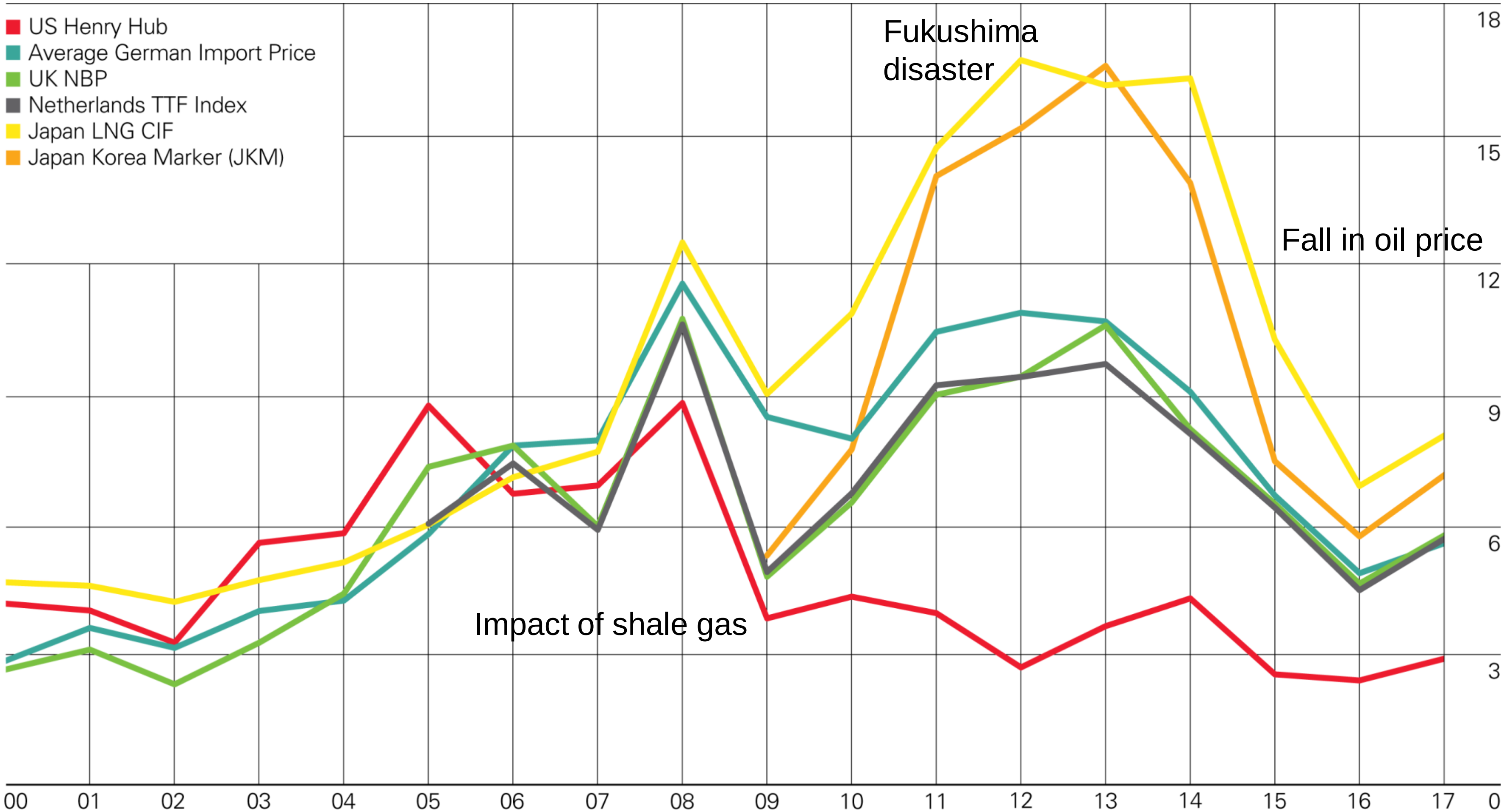


Gas Market Evolution – Away from long-term contracts to market-based pricing



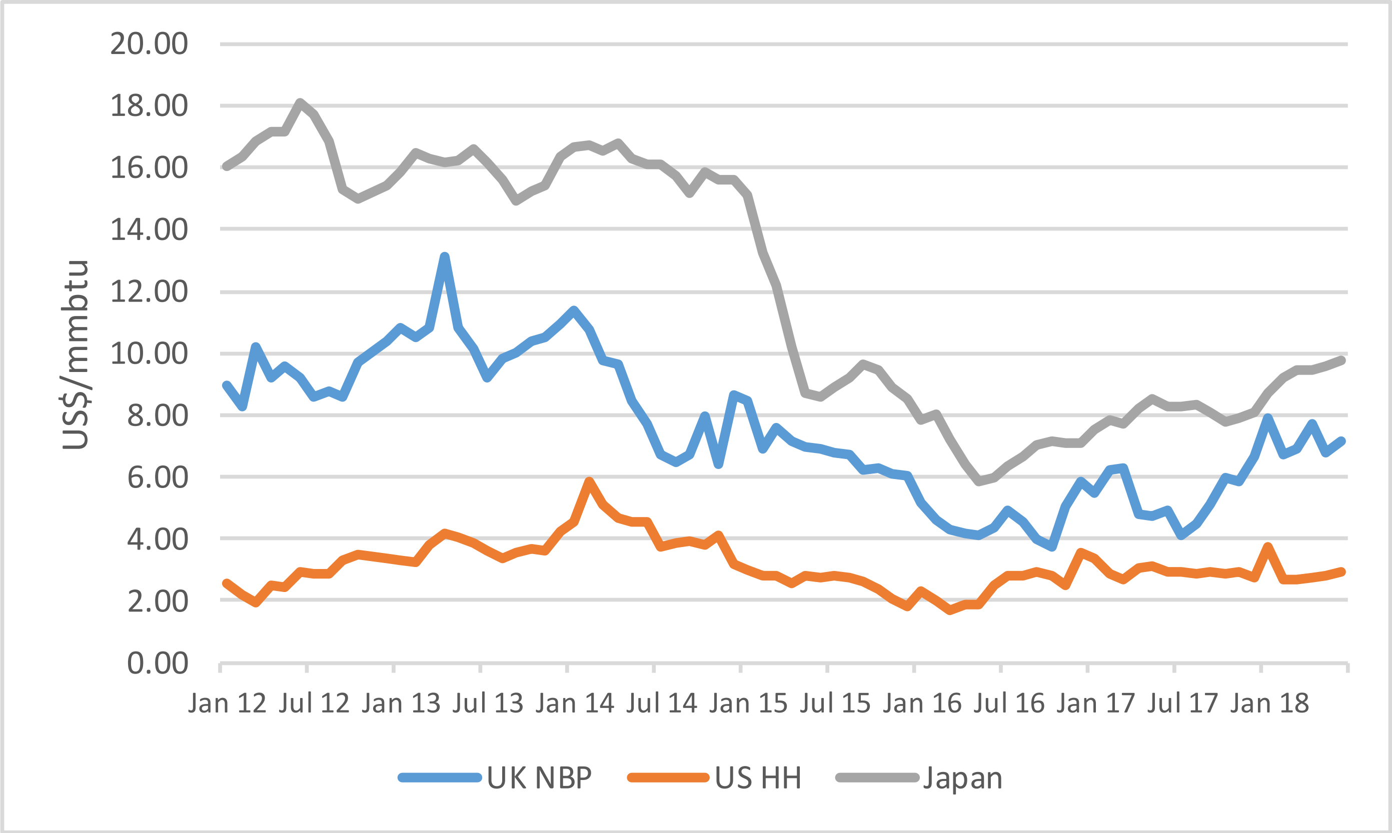
Source: Gas Strategies

Historically regional pricing has been prevalent



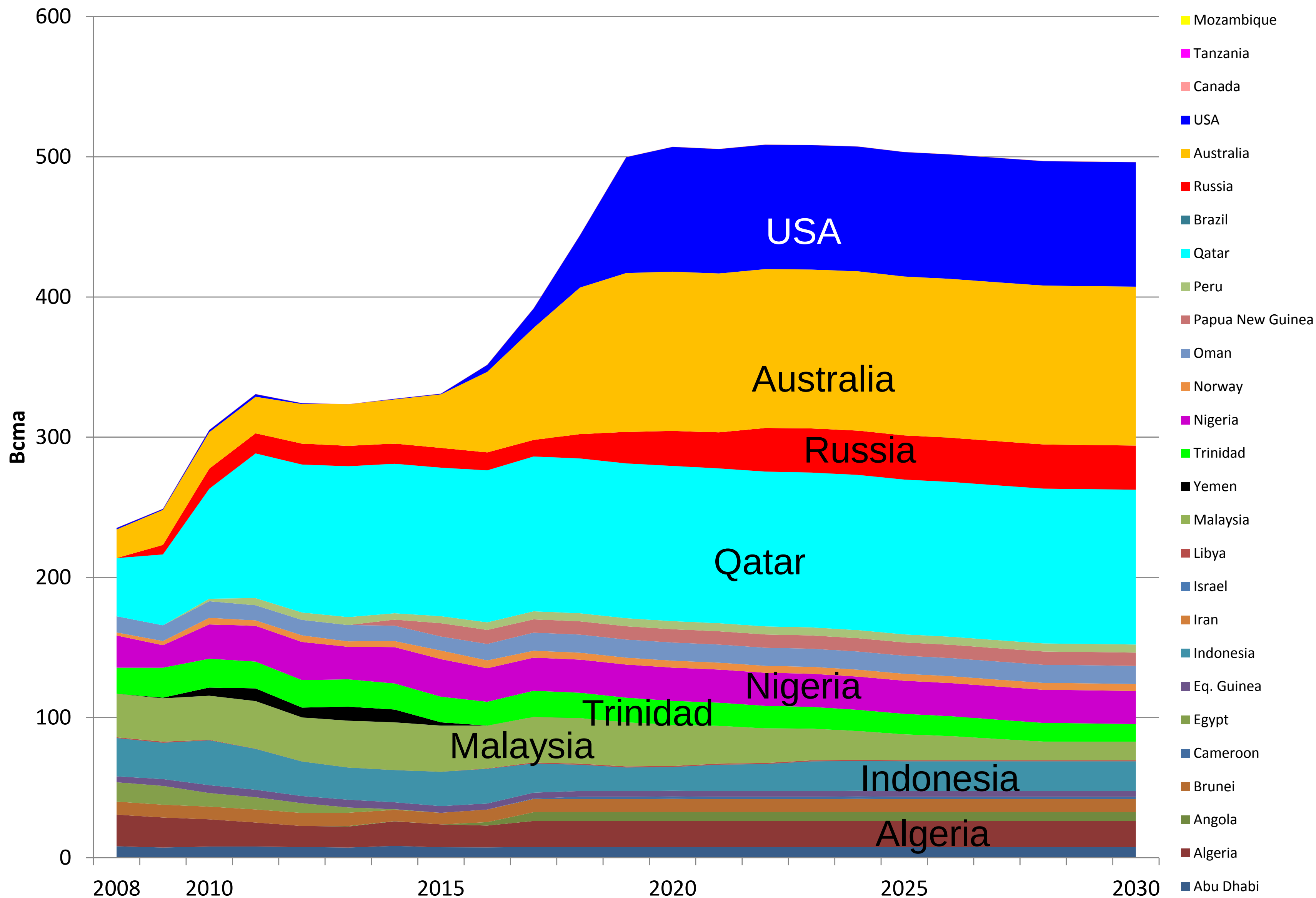
- For many years prices in different regions were close, despite limited interconnectivity
- A supply-demand imbalance from 2010 saw a huge disparity emerge, with Asia paying a significant premium

Global gas prices since 2012



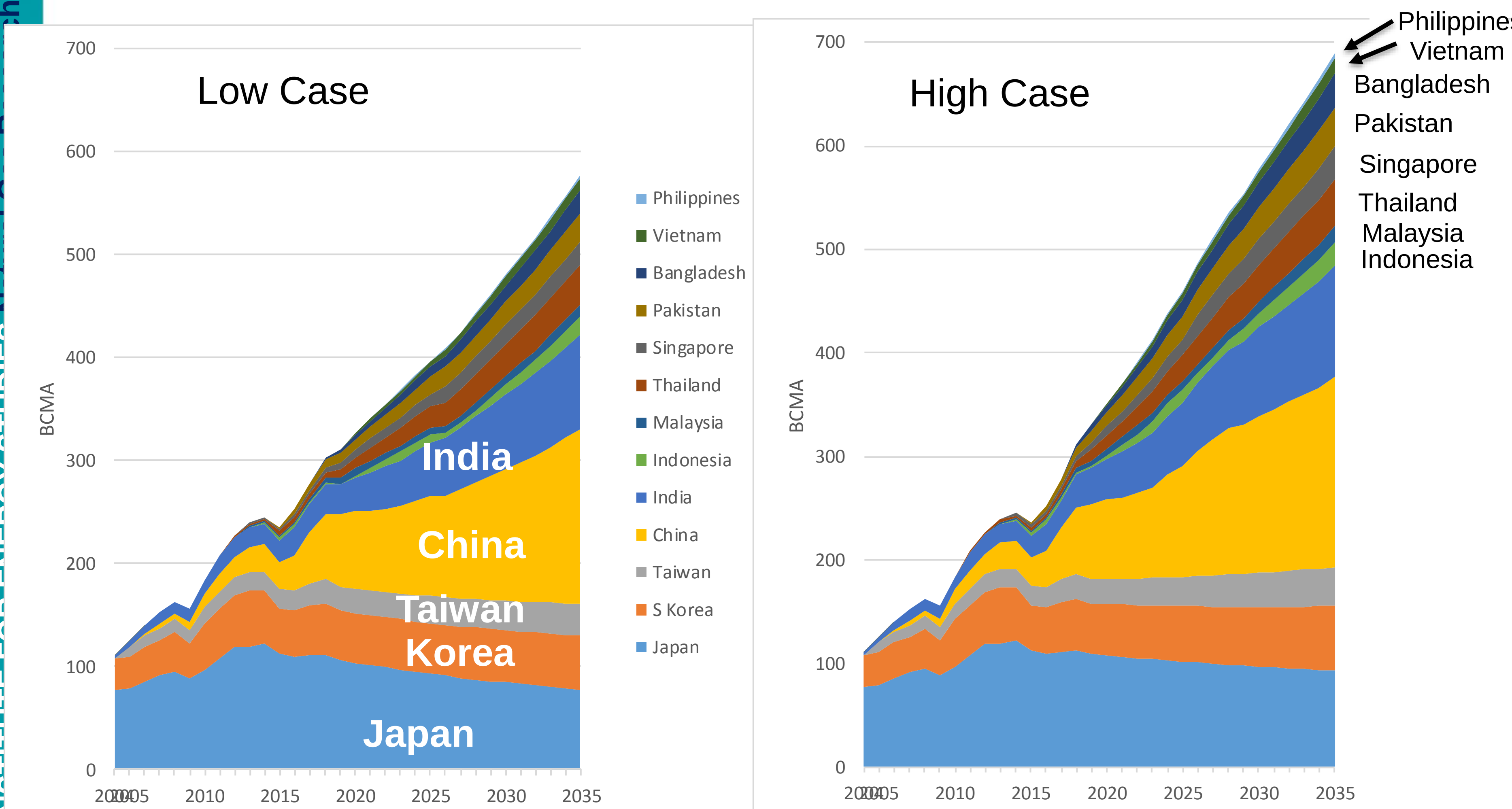
- Global gas prices have started to converge for four key reasons:
  - Supply and demand have been more balanced than expected
  - Increasing prevalence of LNG, which connects markets
  - Europe and Asia competing for gas, especially in winter
  - The availability of US LNG exports, which has introduced a new market-based pricing mechanism

Global LNG Supply 2008 – 2030 Existing, Under Construction & FID'd



Source: Author's Assumptions

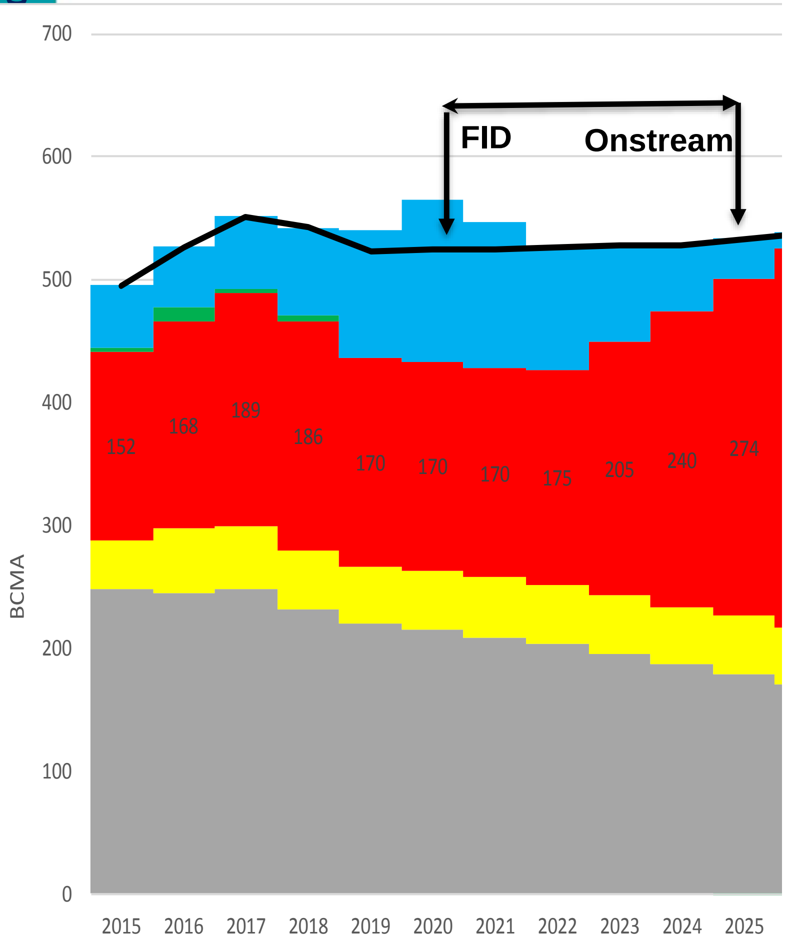
Asian LNG Demand – Large uncertainties but High Case now looks more likely



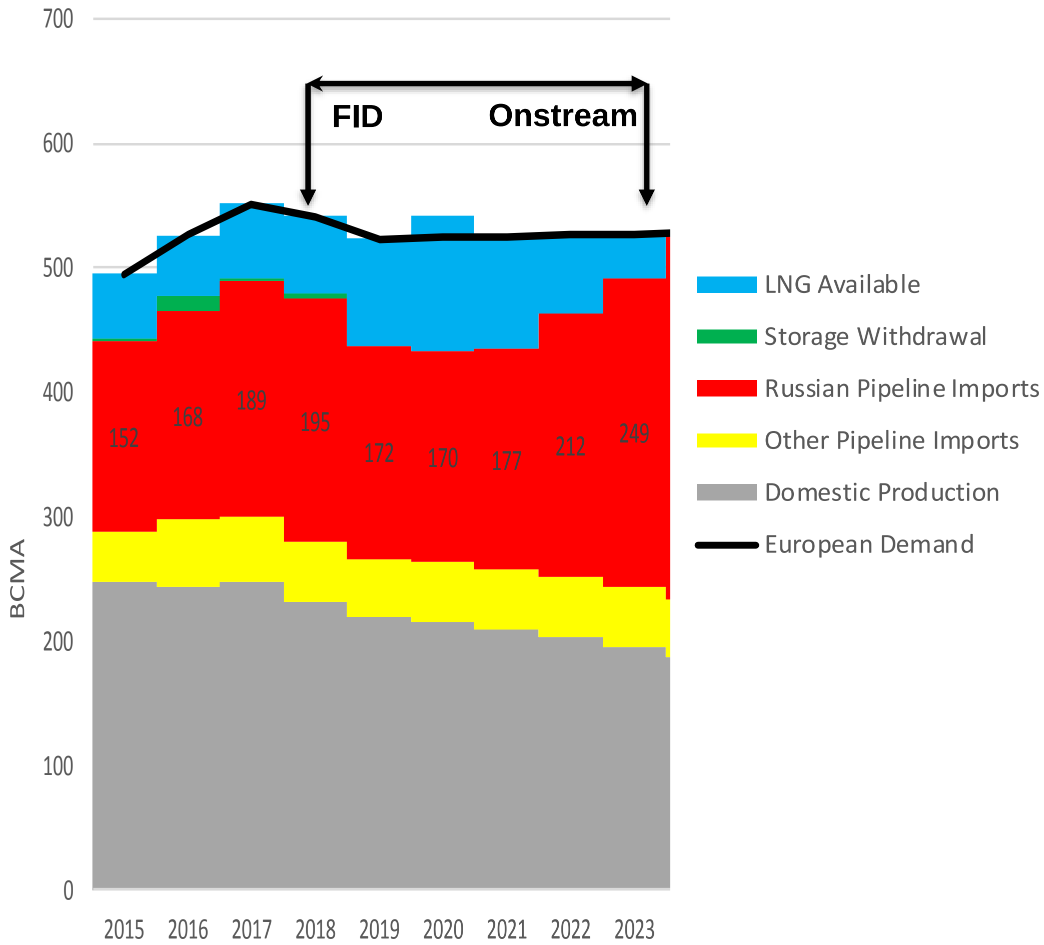
Source: Platts, Author's Calculations

European Balance – Low and High Asian LNG & European Gas Demand Case 2015 - 2030

Low Asian LNG Demand Case

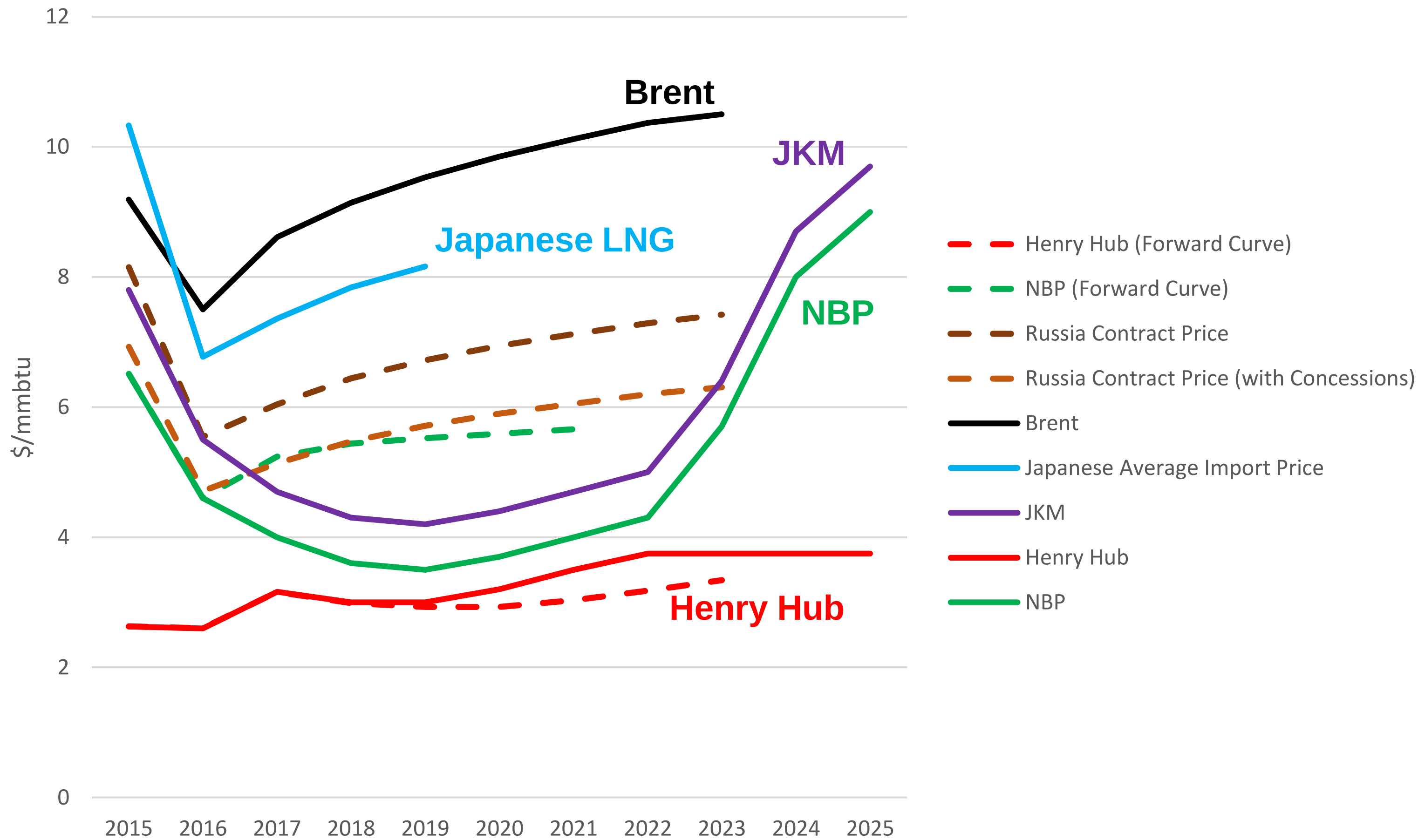


High Asian LNG Demand Case



Sources: IEA, Platts, Author's Analysis

Indicative Price Paths – Low Asian Demand Scenarios

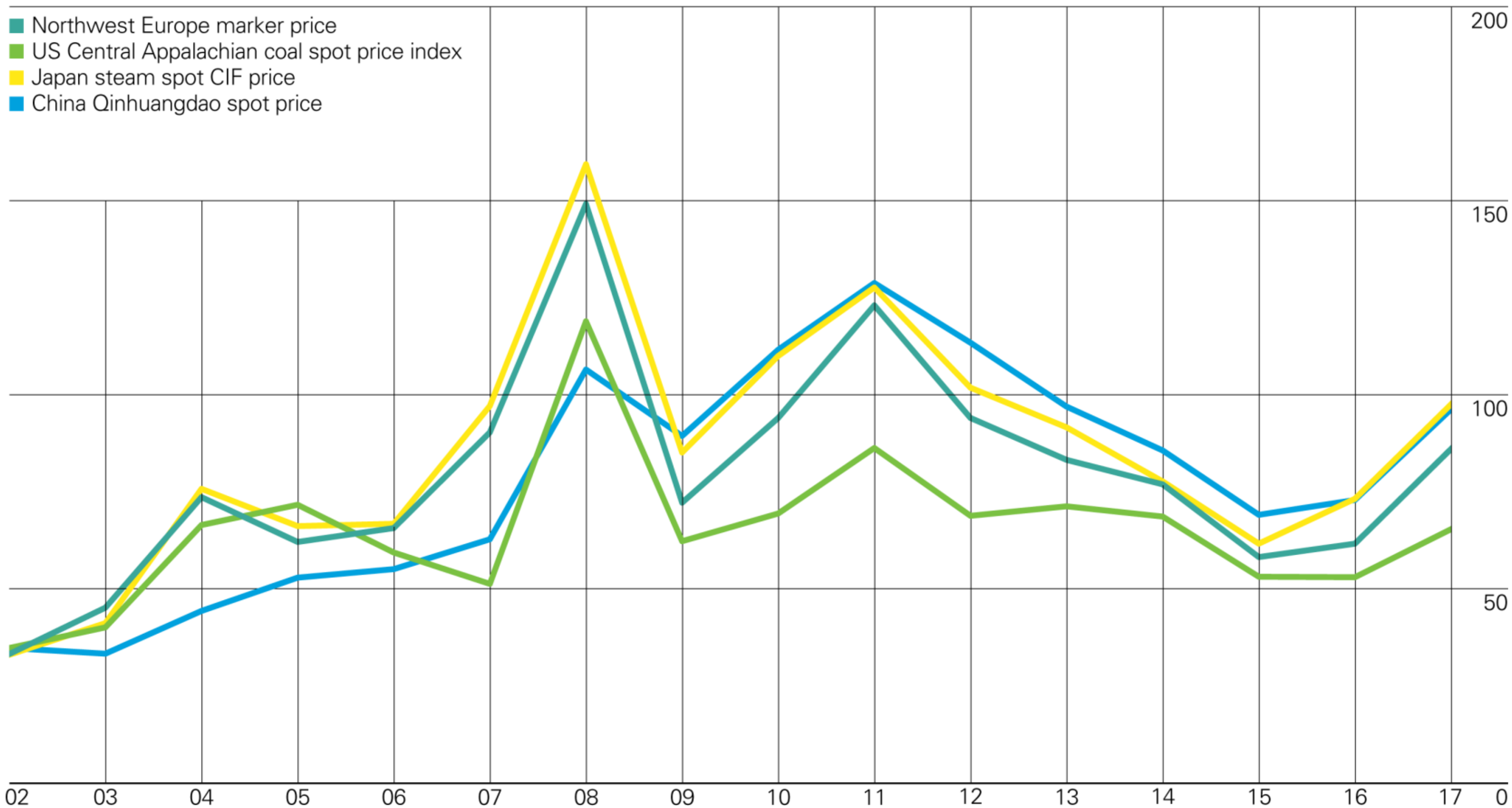


Europe does not need Russian Gas above 150 bcma until 2023. System needs new LNG beyond current supply under development in 2027, so prices rise to LRMC by then.

Gazprom's pipeline supplies to Europe are a significant competitive threat to LNG producers

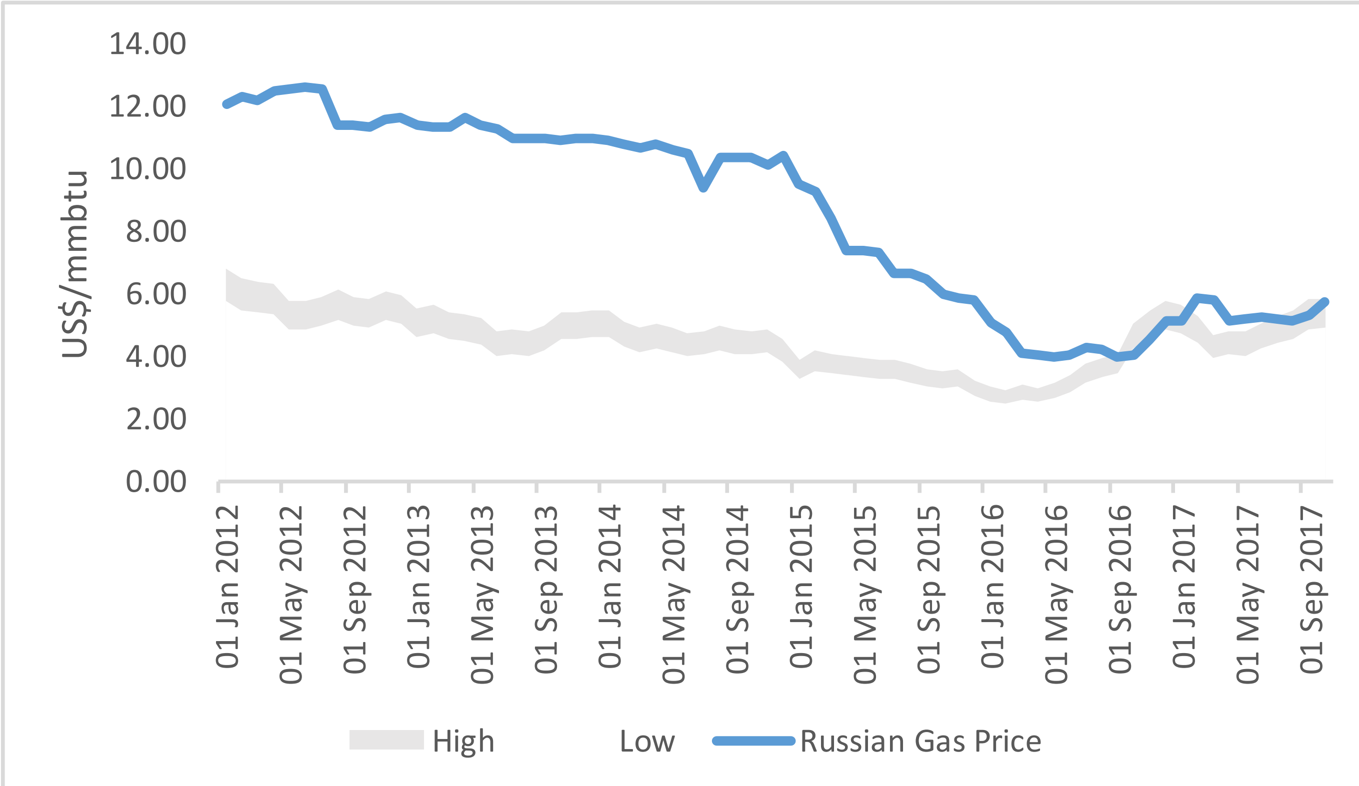
- Gazprom has surplus production potential in West Siberia
- It has a very low delivered cost in Europe
- Russia is essentially the Saudi Arabia of the gas market – its actions can determine price and volume for competitors

Coal prices (US$/t) show what happens when a fuel is in decline



- Coal prices fell sharply in the face of increasing environmental challenges
- In particular US coal producers have been put under pressure by shale gas
- Elsewhere, countries are questioning how much coal they can afford to burn
- Unfortunately, a lower prices also stimulated demand, but a price rebound is likely to undermine demand again

The Gas versus Coal dilemma in Europe



- The decline in coal prices meant that it was cheaper to use it in power generation than gas
- The carbon price, which should advantage gas, has been too low to make a difference
- Coal became the back-up fuel of choice for renewables in Germany
- Recent rebound in coal prices has helped gas to recover market share