Energy and the ‘shale revolution’

Presentation to the International Conference of Commercial Bank Economists

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Summary

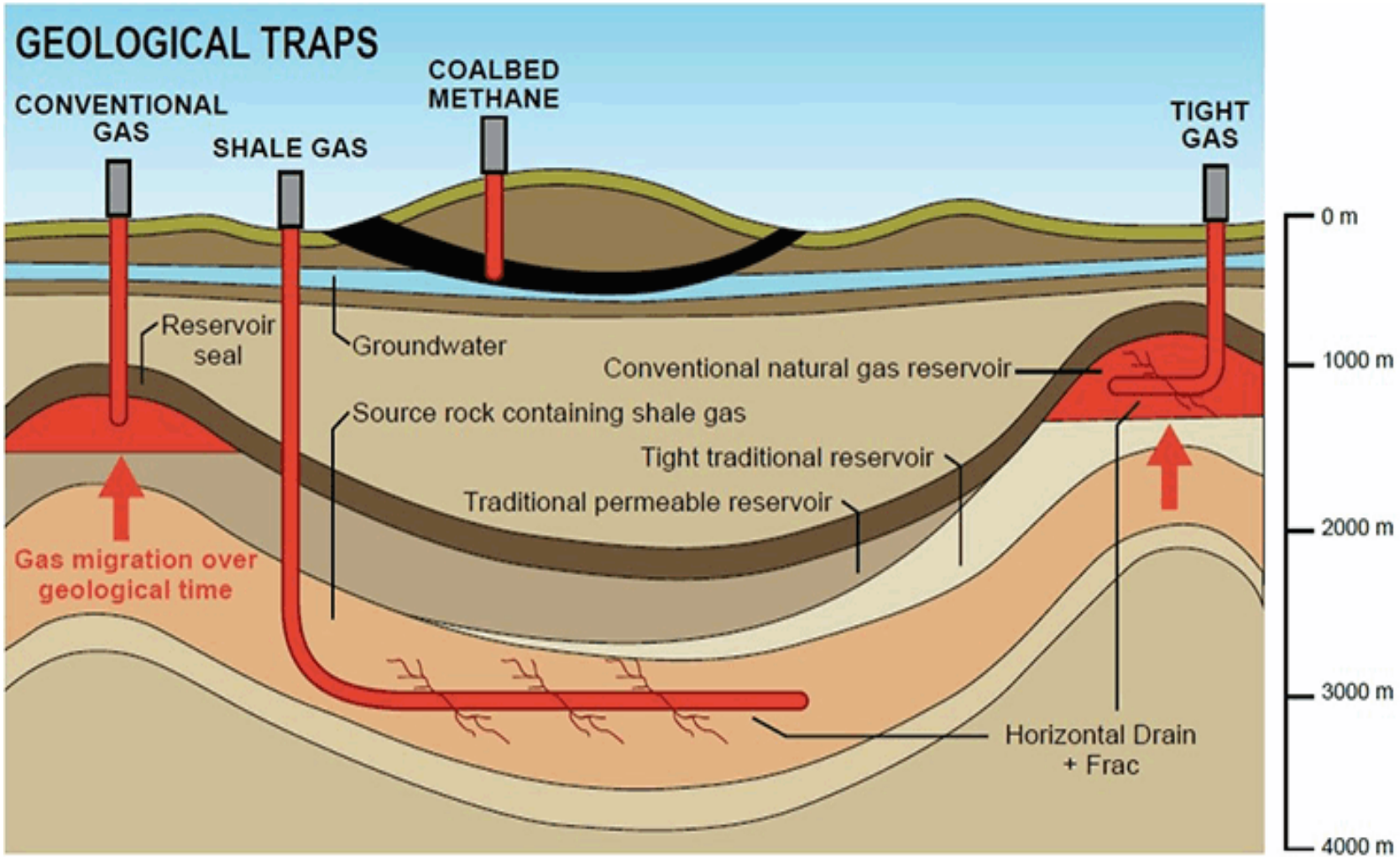
- The ‘shale revolution’ demonstrates the power of human ingenuity combined with ‘market forces’ (price signals) to solve problems of scarcity
  - ‘shale oil’ (or, more strictly, ‘tight oil’) has trumped ‘Peak Oil’
- To date, the ‘shale revolution’ has been a North American (and particularly a US) development scarcity
  - reflecting a combination of technological, infrastructure, market and legal factors
  - although many other countries have the potential to develop shale oil and gas
- The ‘shale revolution’ will bring significant benefits for the US economy
  - directly adding to production and employment
  - reducing net imports of energy (though suggestions that the US could gain complete ‘energy independence’ are far-fetched – especially in regard to petroleum)
  - enhancing the competitiveness of US manufacturing by lowering energy costs relative to other countries, boosting the ‘onshoring’ trend
  - lowering household energy costs and hence reducing inflation and boosting households’ capacity to save, or spend on non-energy goods and services
- Over time, gas markets should become more globally integrated
  - currently, less than one-third of global gas production is traded, cf. almost two-thirds of global crude oil production
  - this could eventually see the gap between North American and Asian/European gas prices narrow
- Oil prices are likely to decline modestly over the next two years integrated
  - reflecting increased production from shale resources and slower growth in demand from emerging economies
  - Increasing use of gas in North American electricity generation is also putting downward pressure on thermal coal prices

Petroleum geology and engineering for economists

- 'Conventional' oil and gas are extracted from 'reservoirs' contained within 'porous' or 'permeable' rock formations, into which hydrocarbons (oil and/or gas) have migrated from their original organic sources (marine or terrestrial organic debris compacted at high pressures and temperatures by layers of overlying rocks) over millions of years
  - 'conventional' hydrocarbons are 'trapped' or sealed by a 'non-porous' or 'impermeable' layer of rock into a specific area which can be reached by a traditional vertically-drilled well; and once tapped, the oil or gas usually flows, at least initially, to the well-head without requiring further action
- 'Tight' (or 'unconventional') oil or gas, by contrast, are contained within 'impermeable' rock formations, usually having formed elsewhere and migrated to limestone or sandstone formations over millions of years
  - because the hydrocarbons are diffused within the rock formation rather than 'trapped' in one place, extraction can't be undertaken by conventional (vertical) drilling, but instead requires 'horizontal' drilling into the rock formation, usually in combination with 'fracking' (see below)
- 'Shale' oil or gas are a particular type of 'tight' oil or gas, found within organic-rich shale rocks in which the hydrocarbons originally formed (usually at greater depth than 'conventional' formations
- 'Coal bed methane' or 'coal seam gas' is extracted from coal deposits, which are usually much closer to the surface than 'tight' or 'shale' gas (or oil) formations
- 'Hydraulic fracturing' or 'fracking' refers to the injection under high pressure of water, chemicals and sand into 'tight' or 'shale' formations in order to open cracks (fractures) in the rock, thereby allowing hydrocarbons to flow into the well
  - the pressurized mixture causes the rock layer to crack, while the sand particles hold the resulting fissures open so that the gas or oil can flow up to the well

Sources: US Department of Energy Office of Fossil Energy and National Energy Technology Laboratory, *Modern Shale Gas Development in the United States: A Primer* (April 2009); US Energy Information Administration, *What is shale gas and why is it important?*, Energy in Brief (December 2012)

Differences between ‘conventional’, ‘tight’, ‘shale’ and ‘coal bed methane’ or ‘coal seam’ gas



Source: Western Australian Department of Petroleum and Mines, *Gas Fact Sheet - Gas Resource Types*.

A depiction of ‘fracking’

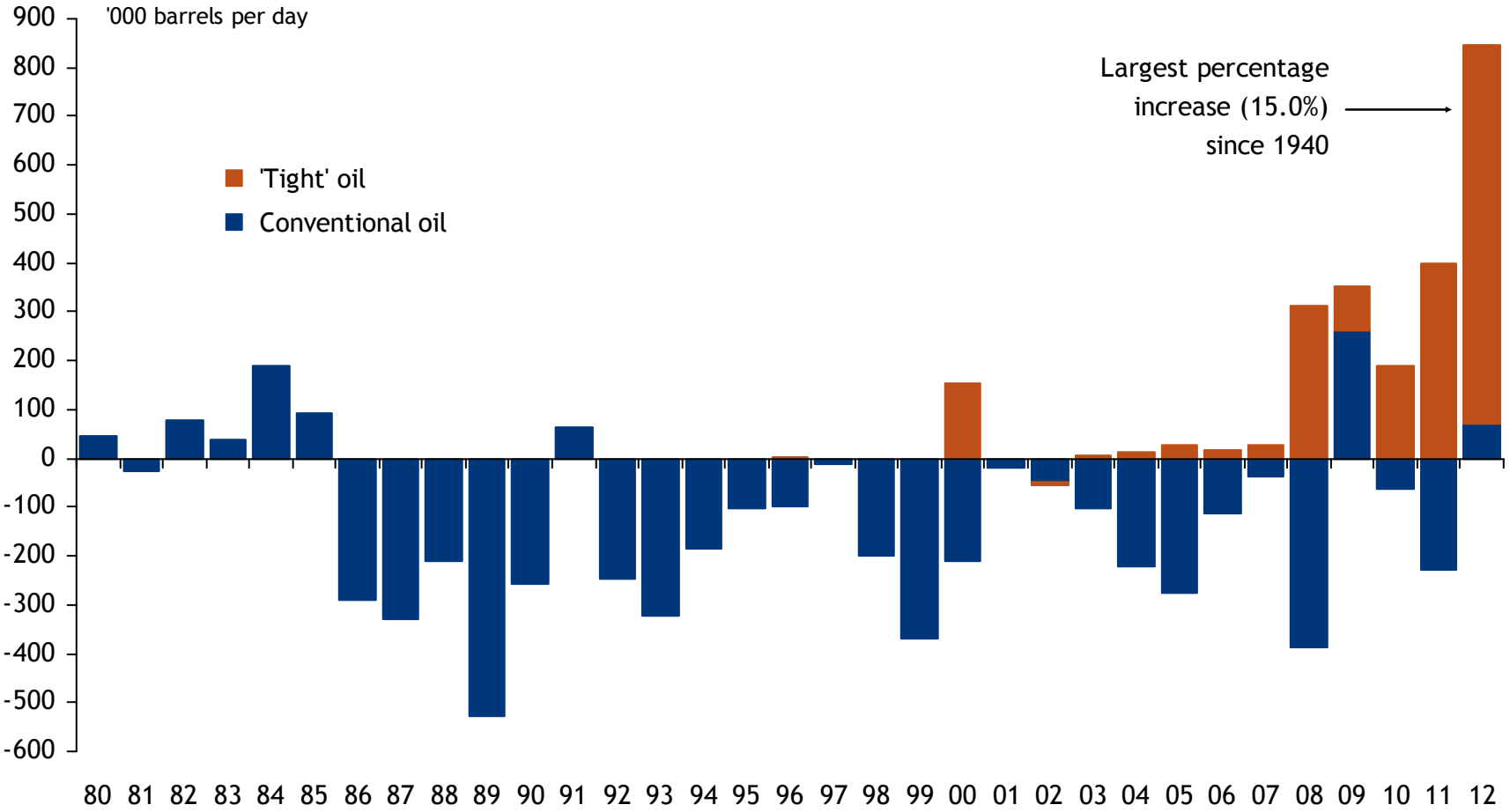
Source: Edwin Dobb, ‘The New Oil Landscape: The Promise and Risk of Fracking’, *National Geographic*, Vol. 223, No. 3 (March 2013), pp. 48-49.

A short history of ‘unconventional’ hydrocarbon extraction

- The idea of extracting gas or oil from shale deposits is not new. Indeed the first producing natural gas well in the United States was from a shale deposit at Canadaway Creek in Fredonia (on the Lake Erie shore, in upstate New York) in 1821
- However, unconventional gas or oil extraction did not become commercially feasible until the development of ‘fracking’ and horizontal drilling
  - hydraulic fracturing was first tried experimentally by Stanolind Oil in Kansas in 1947, and patented by Haliburton in 1949. Other versions of hydraulic fracturing were also carried out in the Soviet Union in the early 1950s
  - the first application of high-volume (or ‘massive’) hydraulic fracturing was undertaken by Pan American Petroleum in Oklahoma in 1968
  - in the 1970s, spurred by concerns about declining US production from conventional sources, the US Government sponsored the Eastern Gas Shales Project (pilot demonstrations) and industry research through the Gas Research Institute
  - horizontal drilling was first attempted by Mitchell Energy in Texas in the late 1980s, using advances in drilling motor technology and in telemetry, culminating in the first successful application combined with ‘fracking’ in the Barnett Shale (in north-central Texas) in 1991 – although large scale production did not commence there until 2000
- These technologies were not applied on a large scale until oil and gas prices moved substantially higher beginning in the middle of the first decade of the 21st century
  - since then, estimates of the amount of potentially recoverable ‘unconventional’ oil and gas reserves in the US have increased substantially
- Development of ‘unconventional’ oil and gas reserves has been more rapid in North America than elsewhere because of private ownership of sub-surface rights (in contrast to other countries where these belong to the state), the existence of large numbers of independent operators and contractors, pre-existing pipeline infrastructure, and the availability of water resources (for use in ‘fracking’), as well as technological advances

Last year saw the largest increase in US oil production ever, and the biggest % increase in 72 years

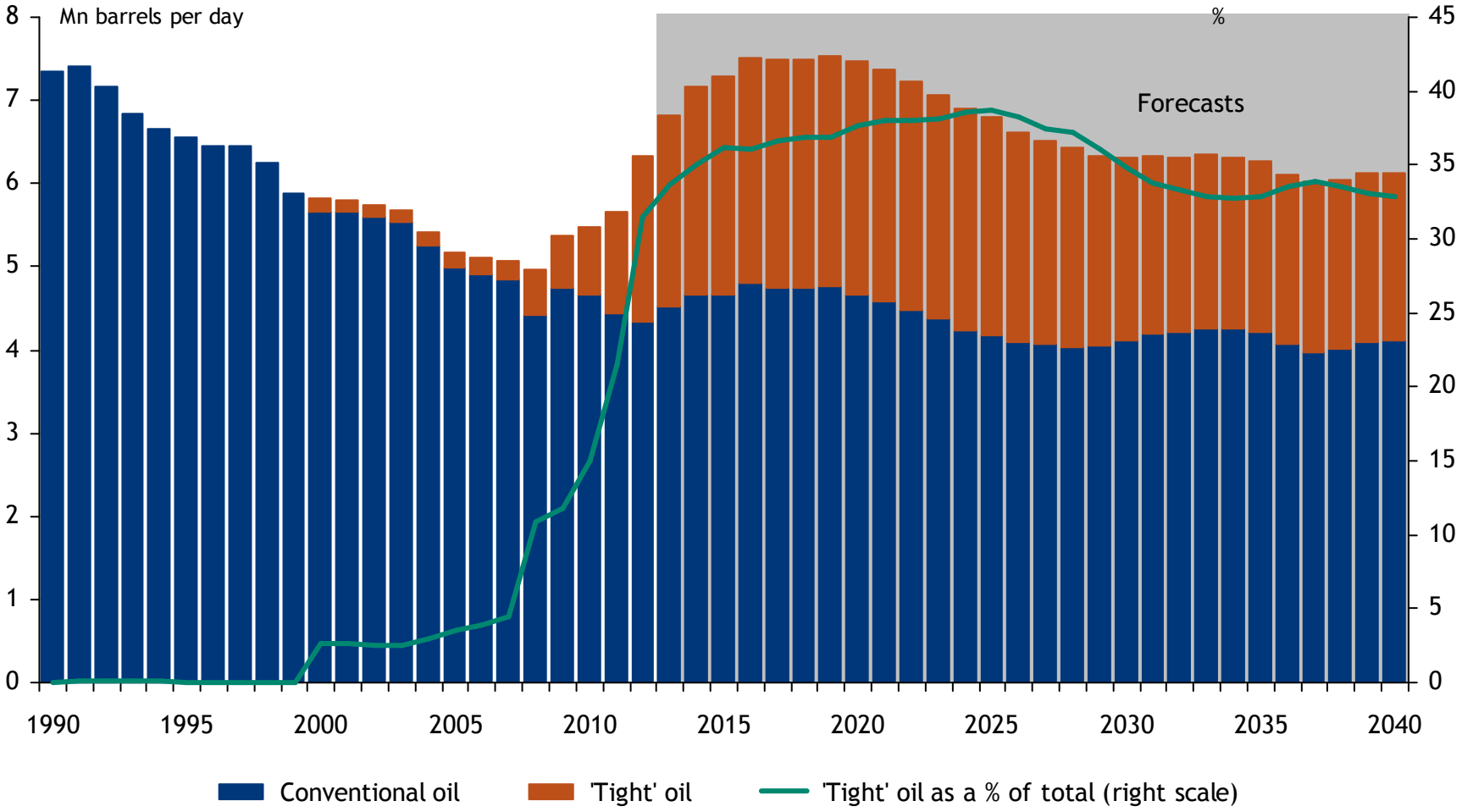
Annual changes in US crude oil production



Source: US Energy Information Administration crude oil production statistics; 'tight' oil production from EIA *Annual Energy Outlook* 2013.

‘Unconventional’ oil will account for over one-third of total US production over the next two decades

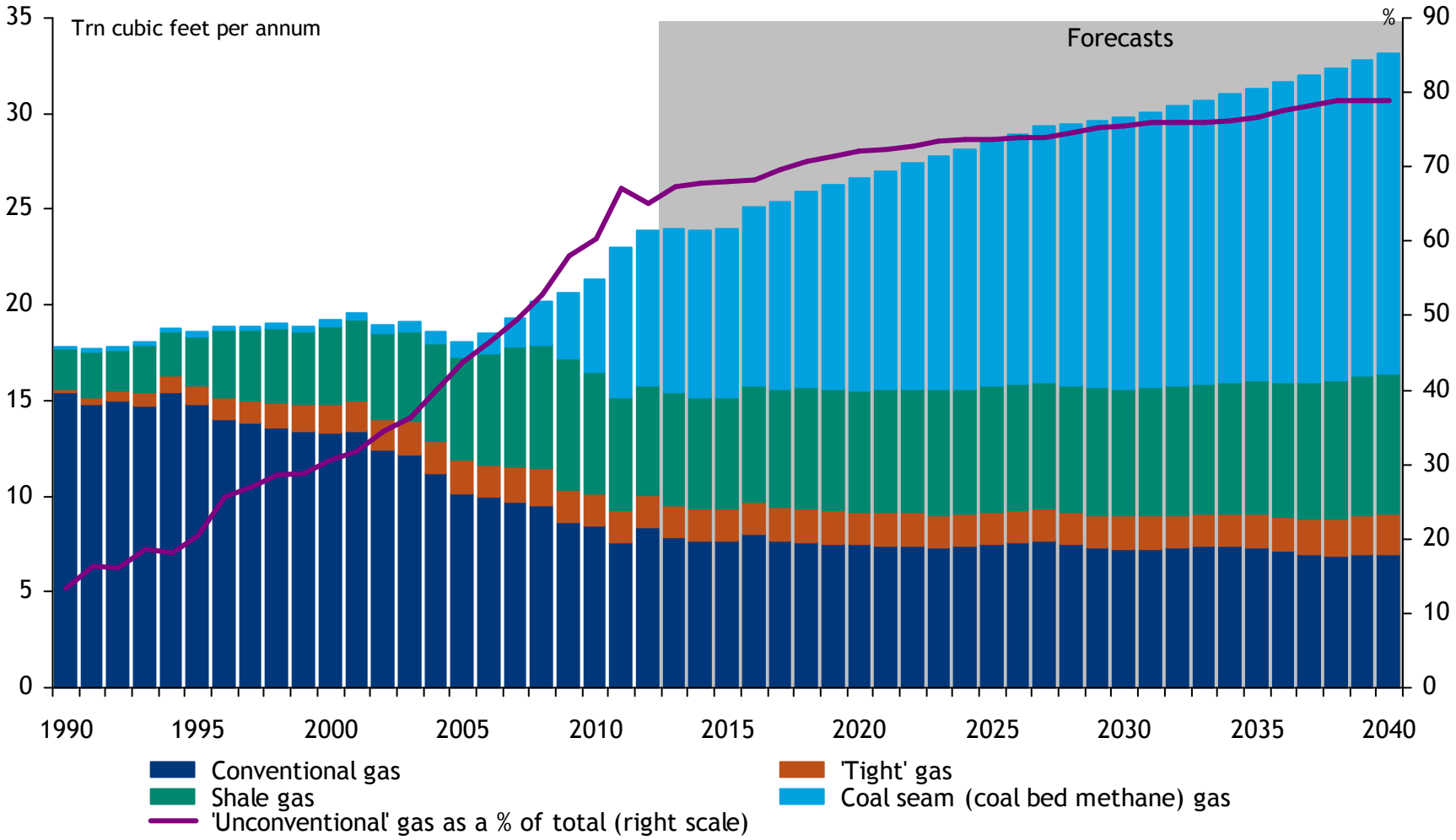
US oil production, by source



Source: US Energy Information Administration, *Annual Energy Outlook 2013*.

‘Unconventional’ gas will account for over 75% of total US production over the next two decades

US natural gas production, by source

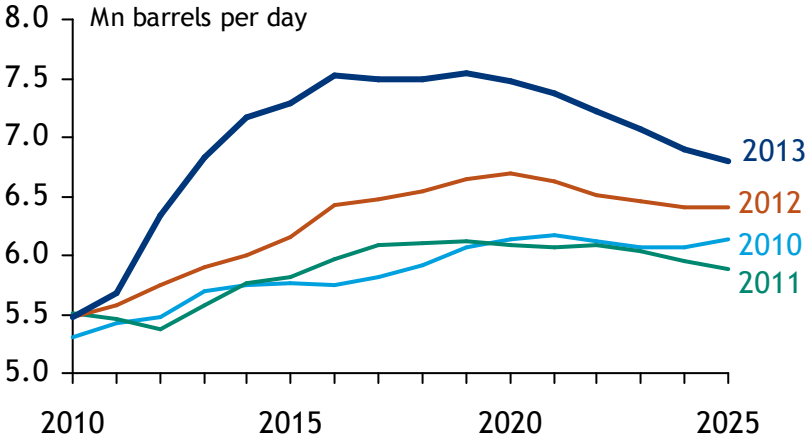


Source: US Energy Information Administration, *Annual Energy Outlook 2013*.

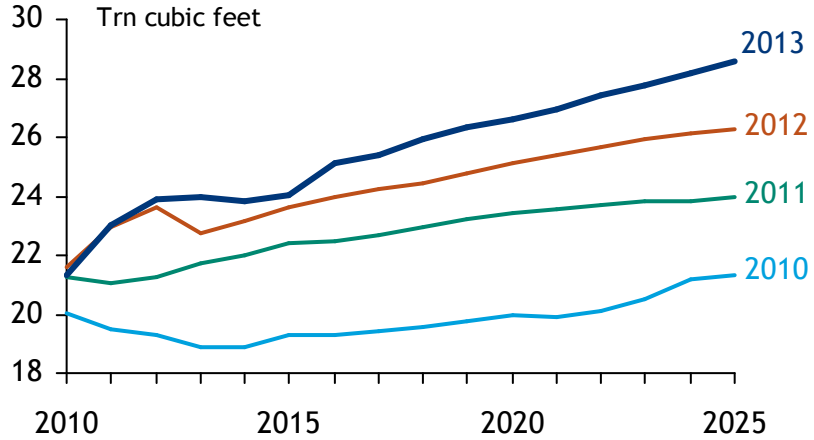
Production forecasts have been revised up, while price forecasts have been revised down, since 2010

Successive US oil & gas production and price forecasts

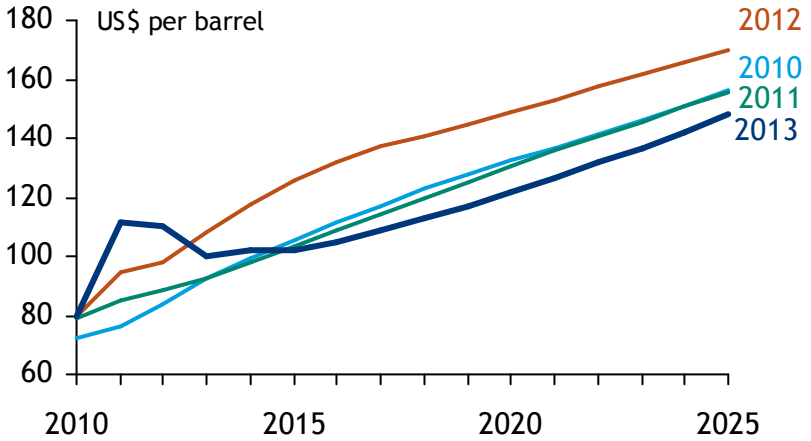
US crude oil production



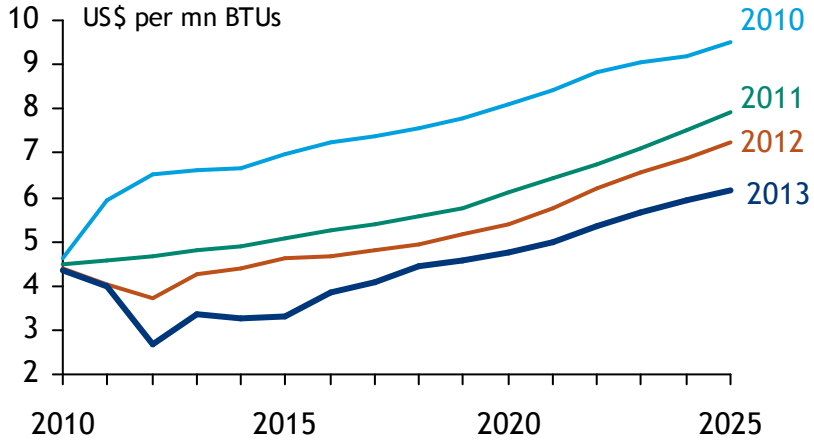
US natural gas production



Brent/low sulphur crude prices



'Henry Hub' gas prices



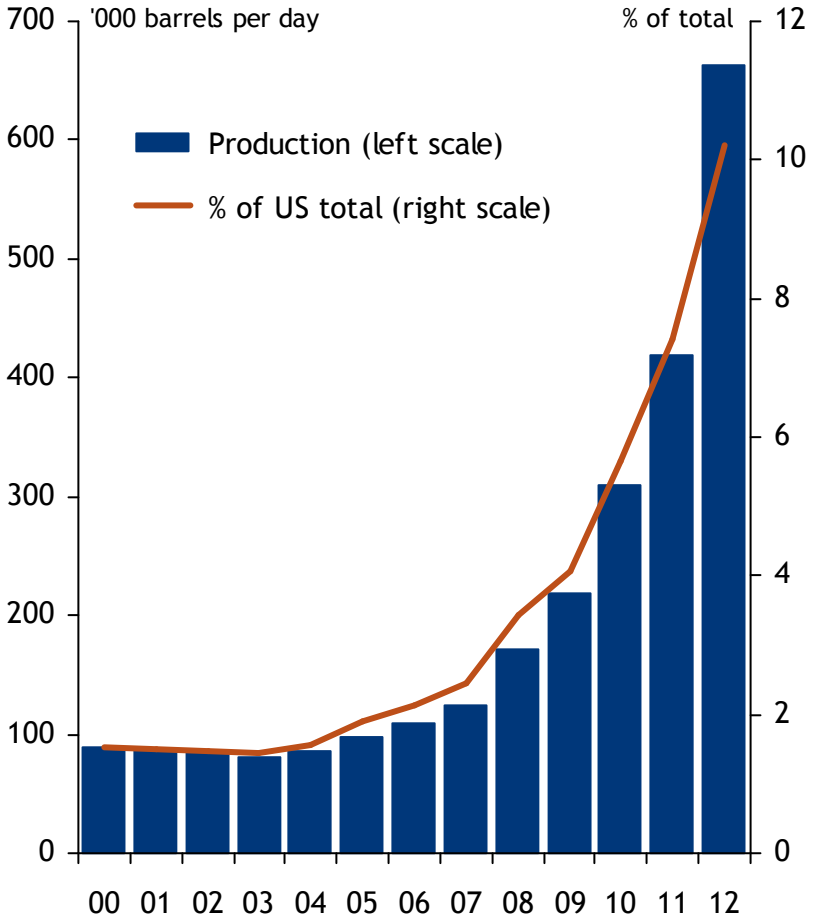
Sources: US Energy Information Administration, *Annual Energy Outlooks*, 2010-2013.

Location of major shale oil and gas ‘plays’ in the US

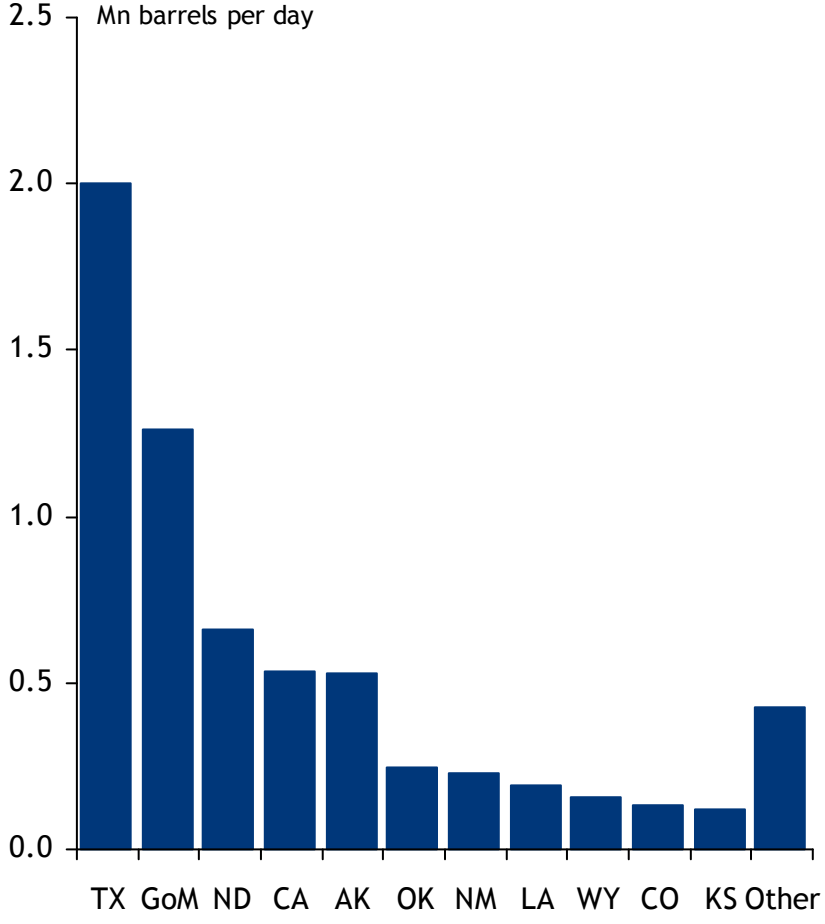
Source: US Energy Information Administration, *Energy in Brief: What is shale gas and why is it important?*, December 2012

North Dakota is now the second-largest onshore producer of crude oil in the US

North Dakota oil production



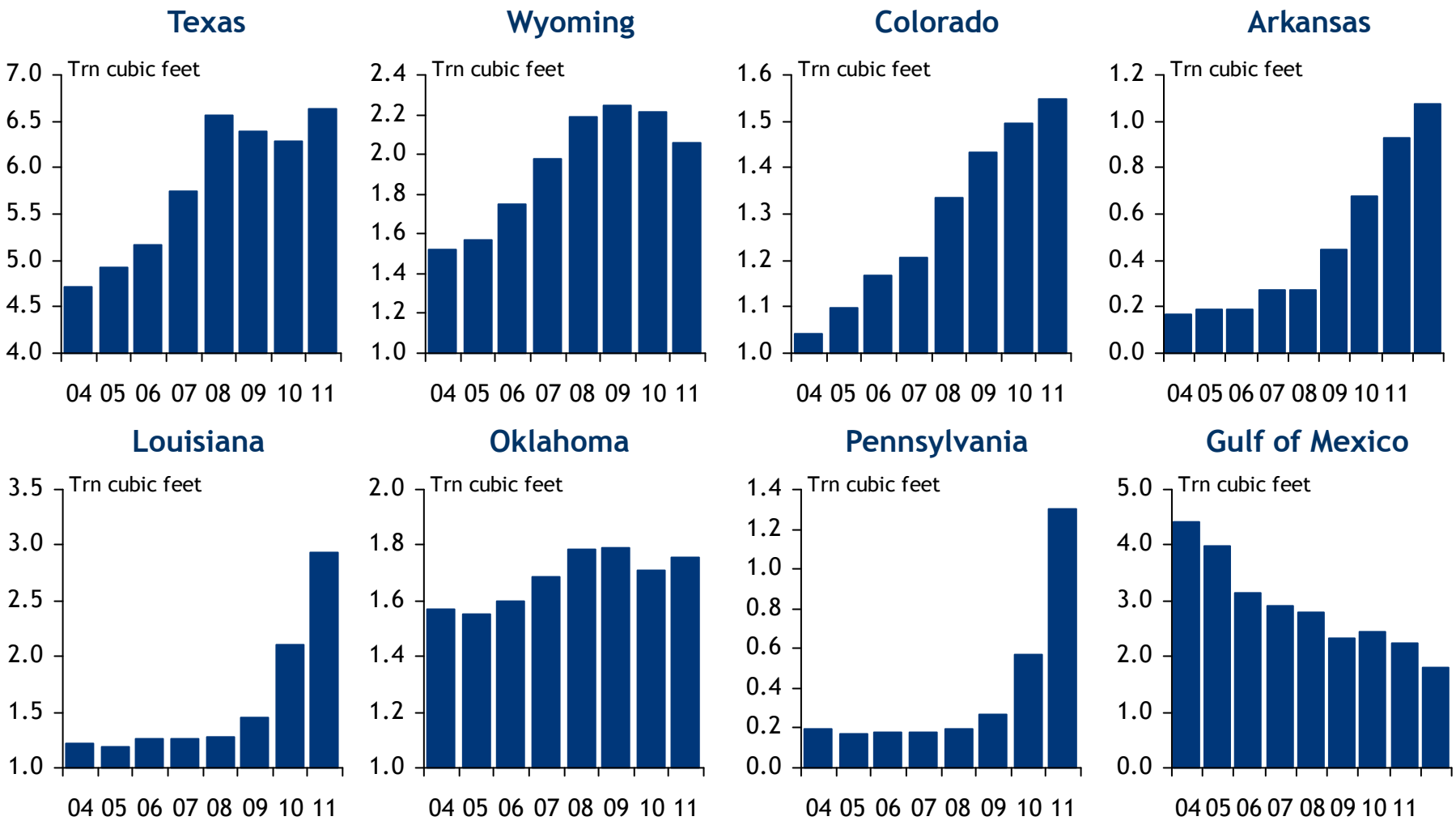
US crude oil production, by State - 2012



Note: 'GoM' = Gulf of Mexico offshore. *Source:* US Energy Information Administration.

Gas production is picking up in a number of States, including some not traditionally large producers

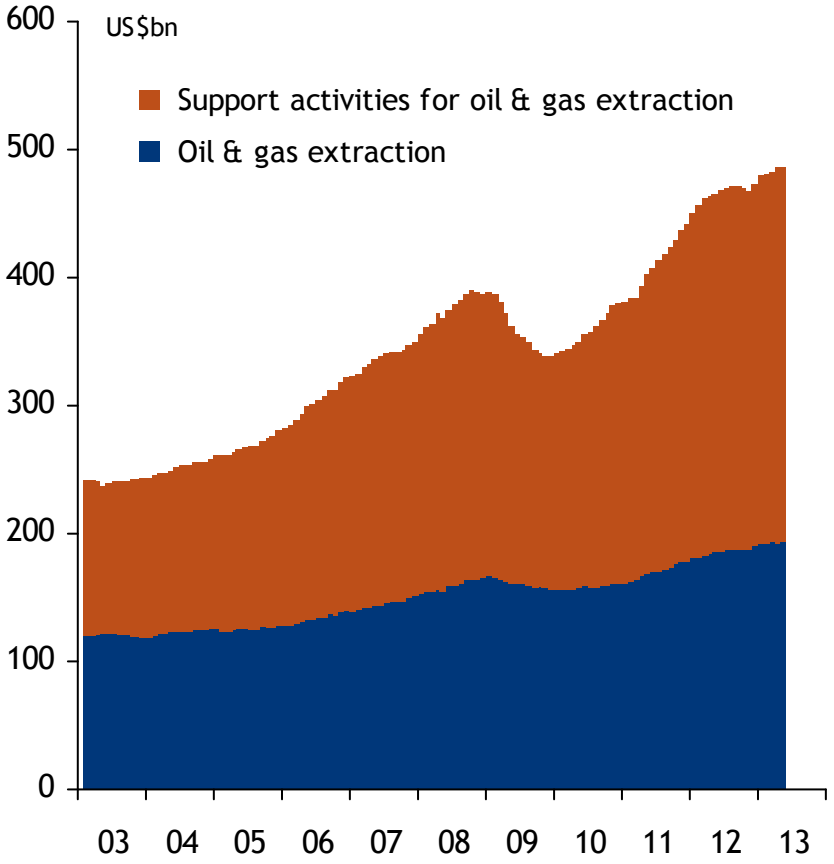
Natural gas production, by State



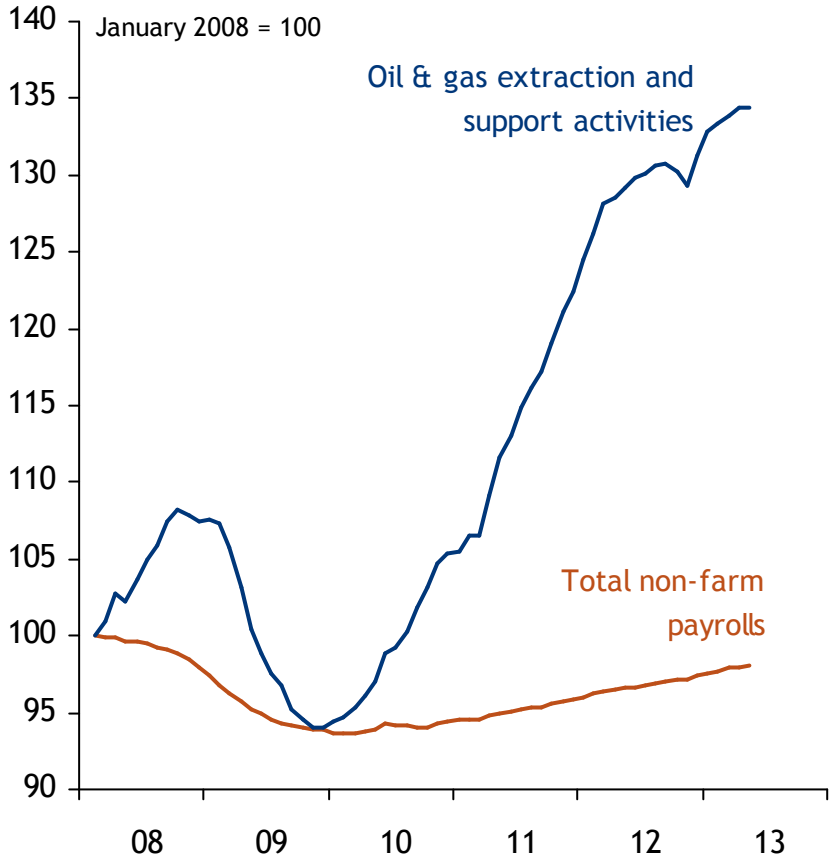
Note: States depicted in this chart + Gulf of Mexico accounted for 79.4% of US production in 2011. *Source:* US Energy Information Administration.

Employment in oil & gas production and associated support services is rising strongly

Employment in oil & gas extraction



Oil & gas employment vs total non-farm payrolls

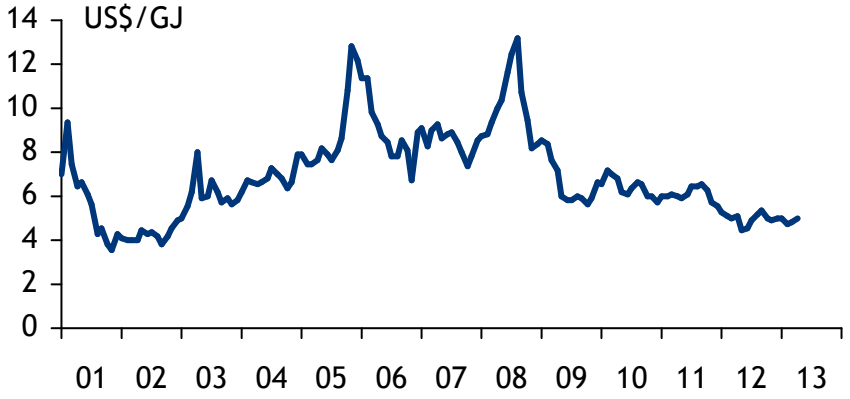


Note: January 2008 was the most recent peak in total non-farm payroll employment. *Source:* US Bureau of Labor Statistics.

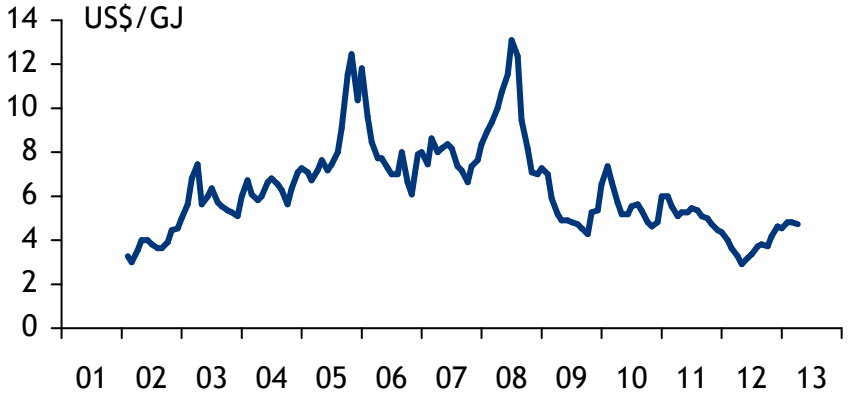
Natural gas prices have been trending lower since shale gas started to become widely available

US natural gas prices

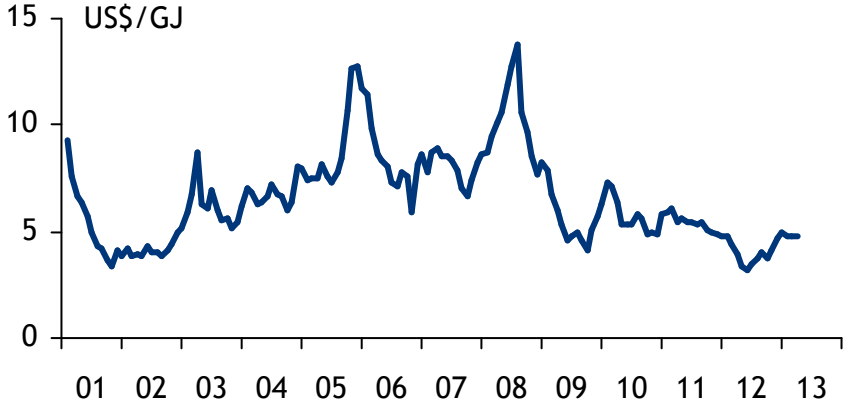
'Citygate'



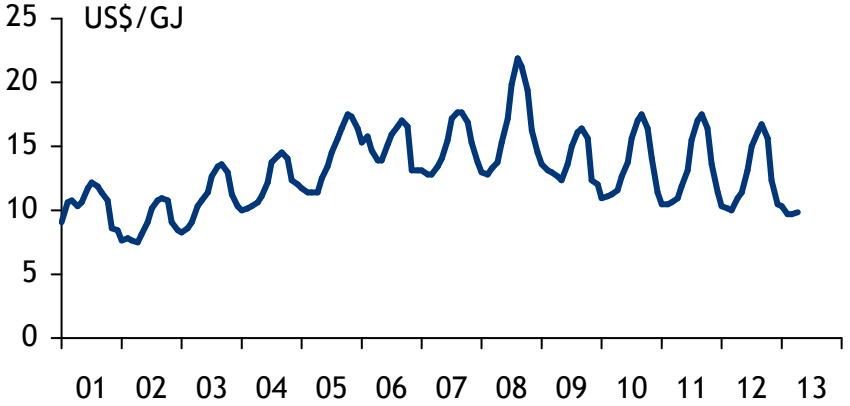
Electric power generation



Industrial



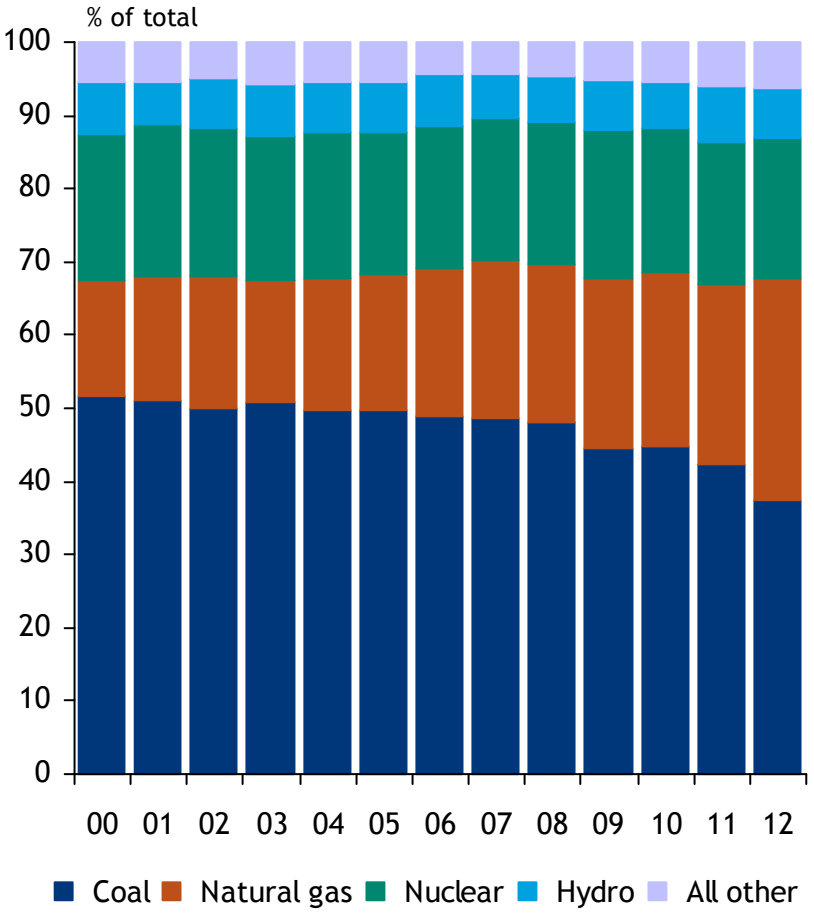
Residential



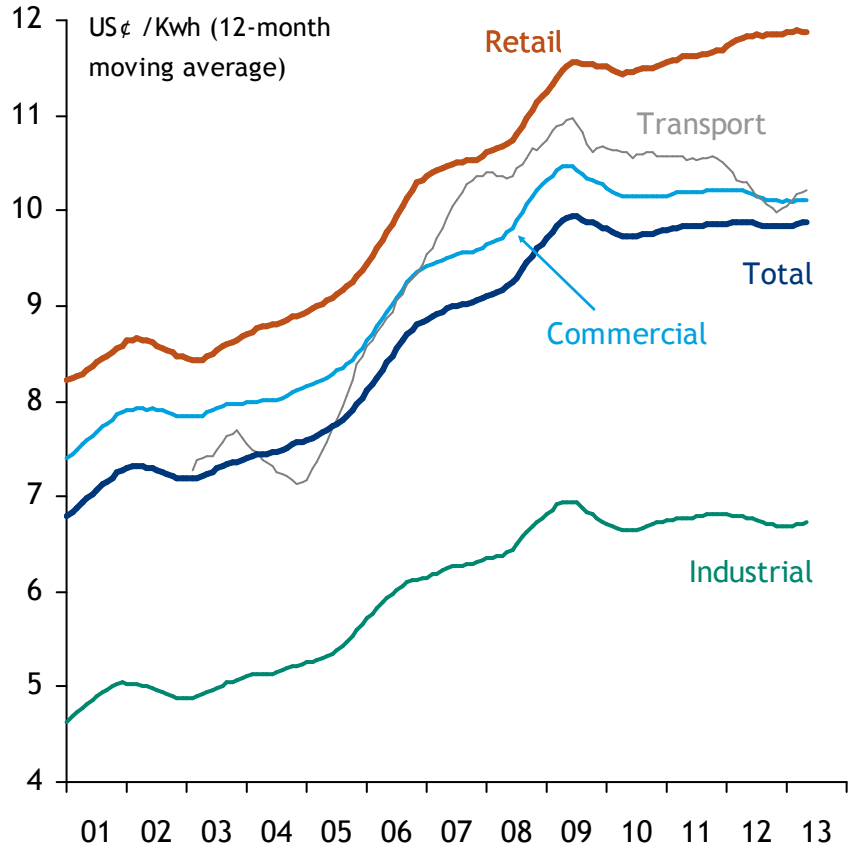
Source: US Department of Energy.

Electricity generators are turning to gas, and that is helping to hold down electricity prices

Sources of US electricity generation



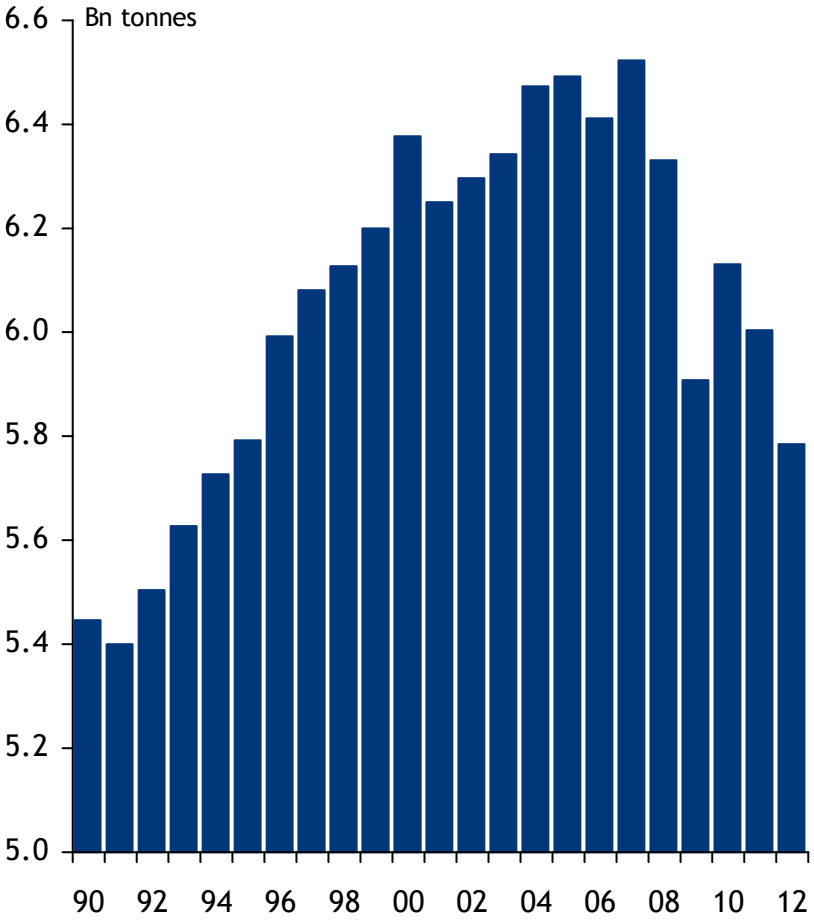
Average US electricity prices



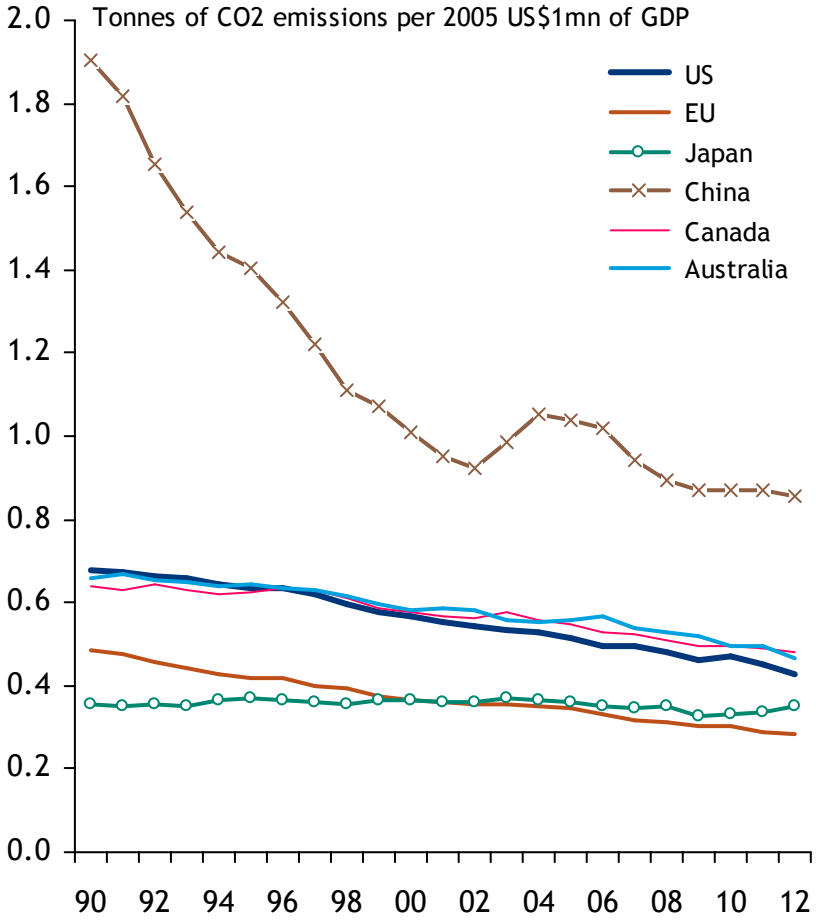
Sources: US Energy Information Administration, *Electric Power Monthly*.

Shale also seems to be helping the US reduce its CO_2 emissions

US CO_2 emissions



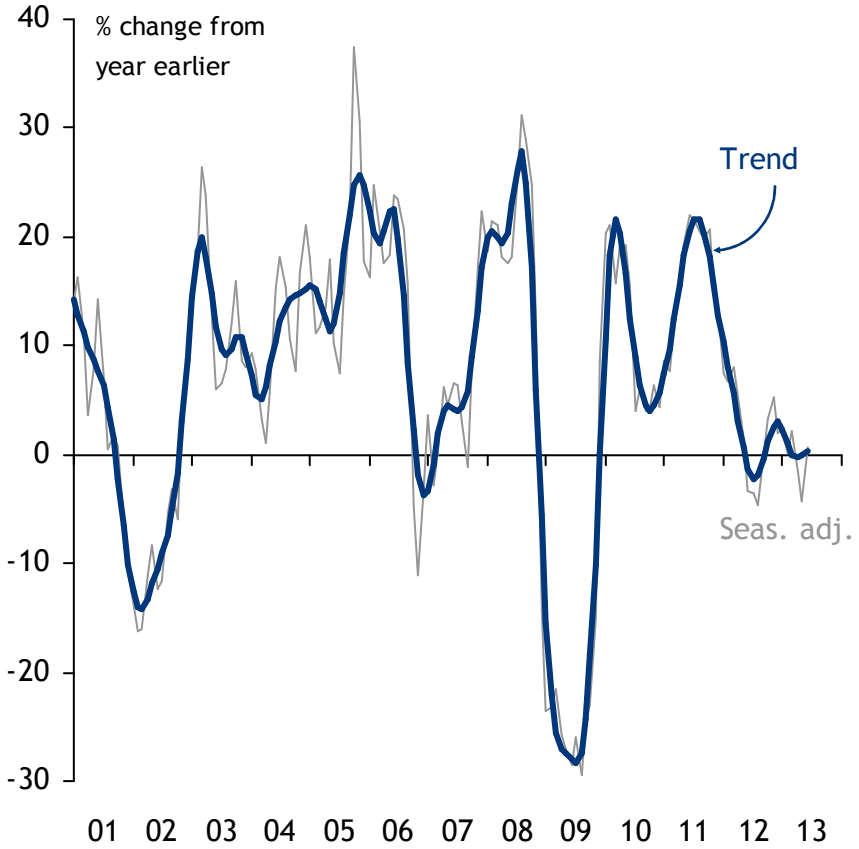
CO_2 intensity



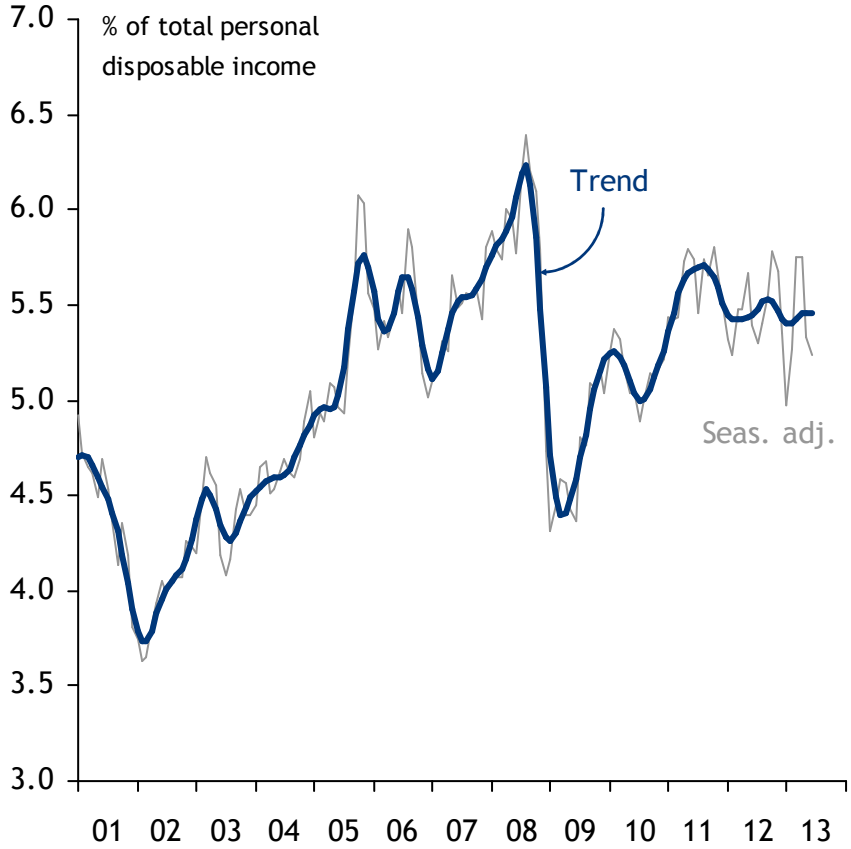
Sources: BP, *Statistical Review of World Energy* 2013; IMF, *World Economic Outlook* database, April 2013.

Cheaper energy is (at the margin) helping to hold down inflation and reducing pressure on household budgets

Price deflator of personal spending on energy goods & services



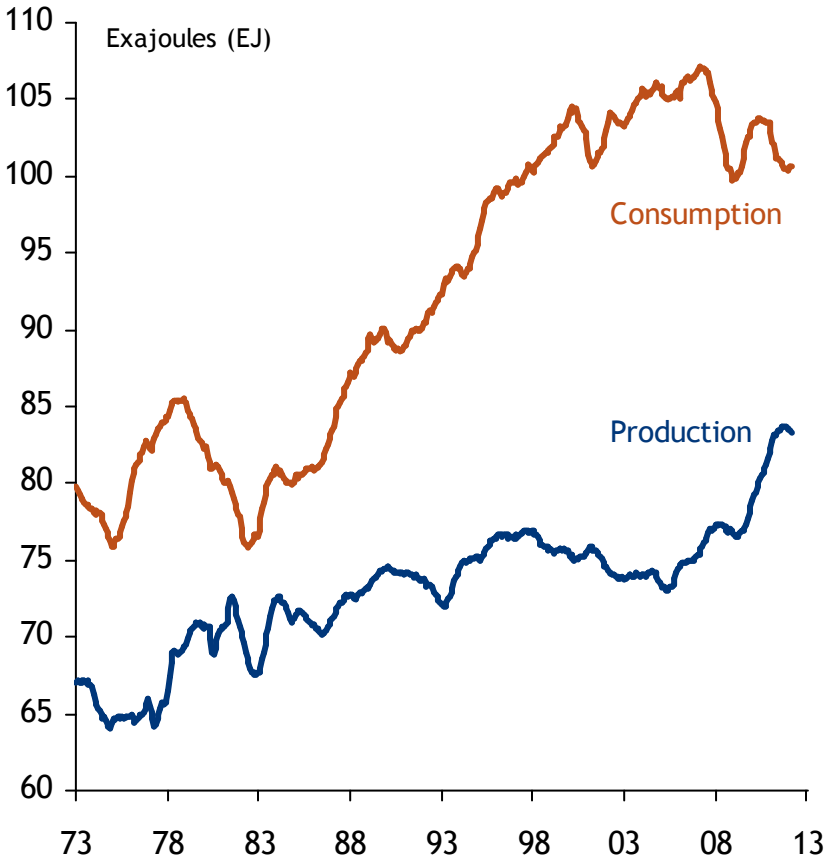
Spending on energy goods & services as a pc of disposable income



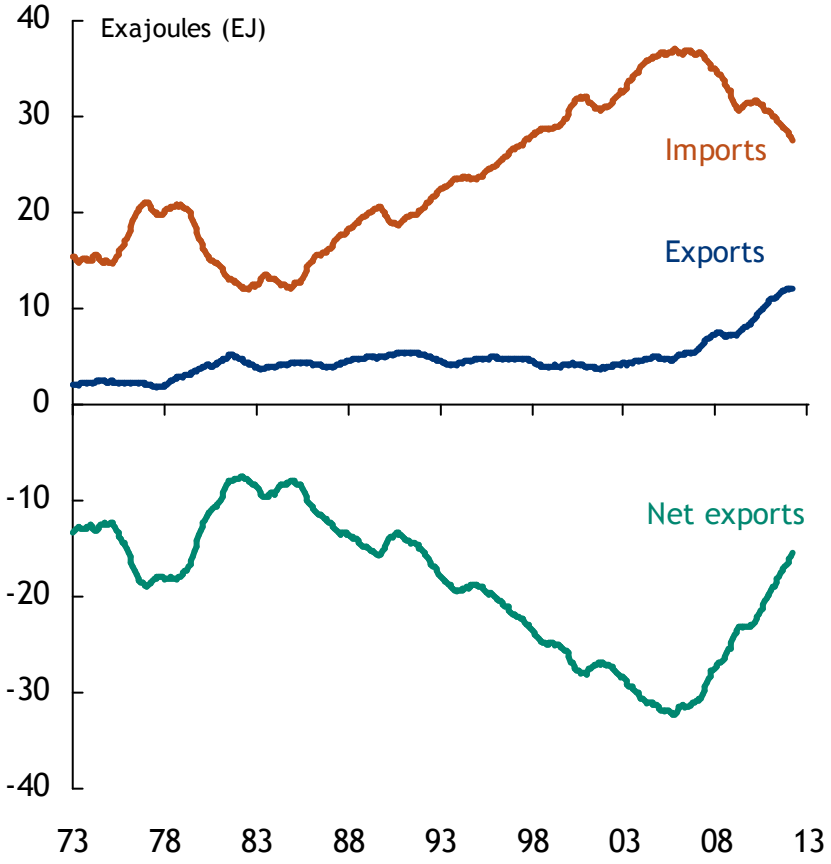
Source: US Bureau of Economic Analysis

The US is becoming less dependent on imported energy …

US energy production and consumption



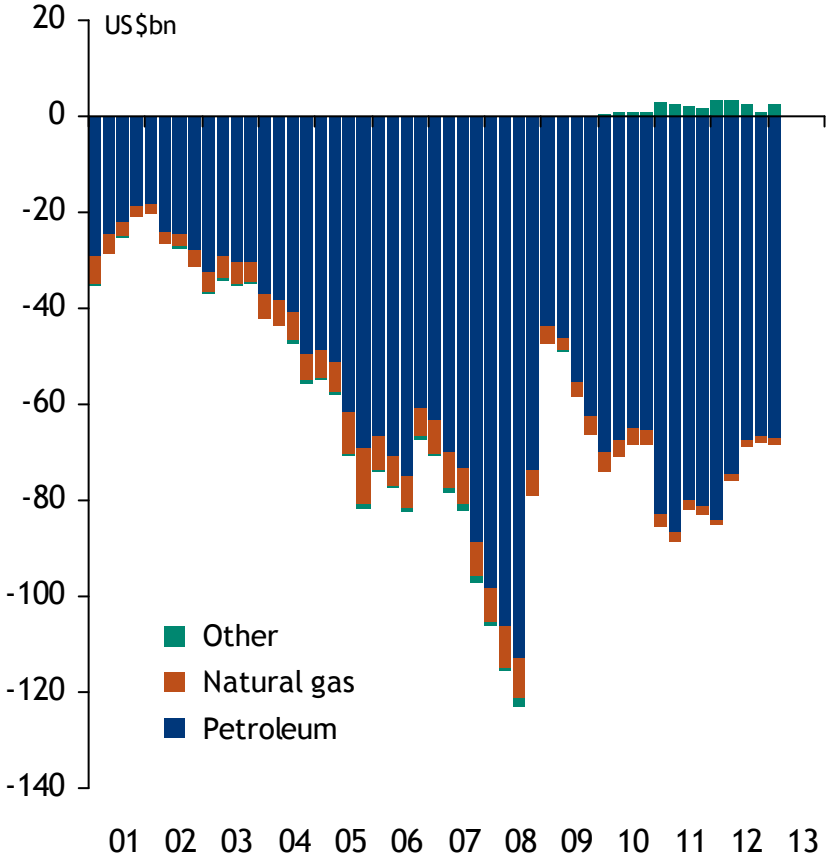
US energy exports, imports and net trade



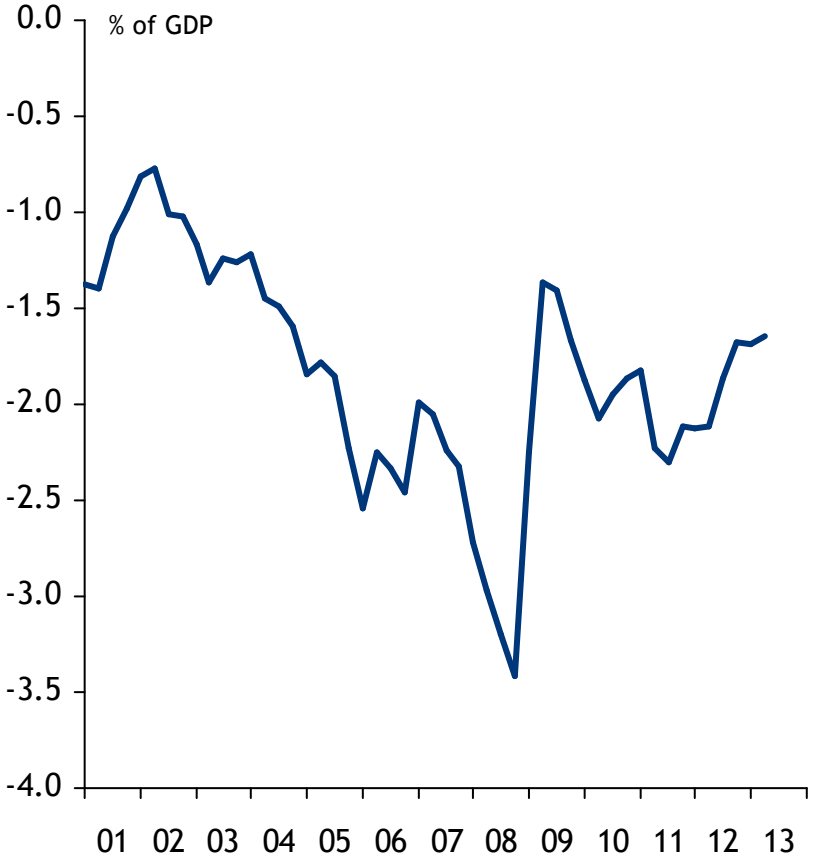
Note: 1 exajoule = 1000 petajoules, 1 bn gigajoules = 1055 quadrillion BTU. *Source:* US Energy Information Administration.

… which is contributing to an improvement in the US trade balance (and hence to GDP growth)

US energy trade balance by major product



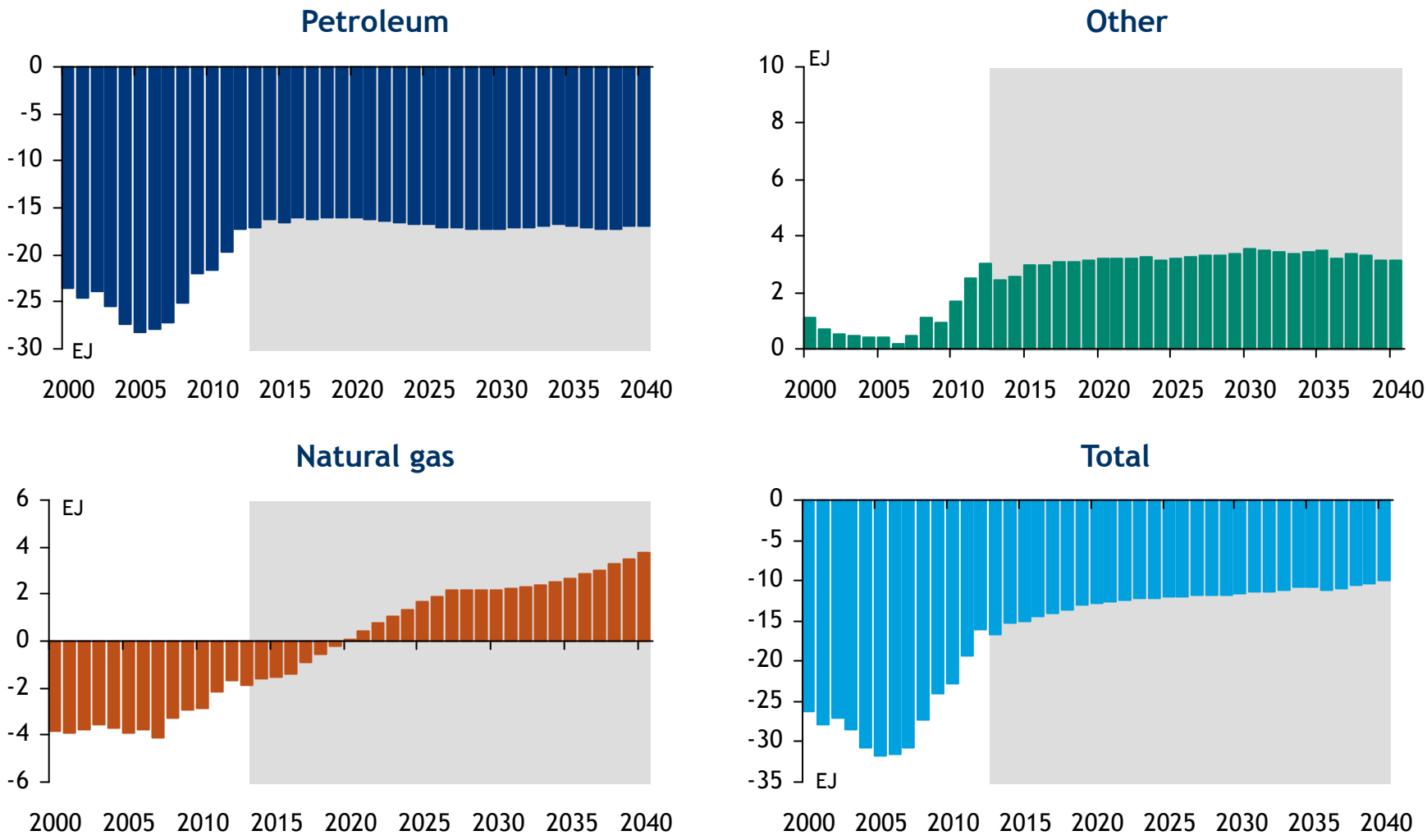
US energy trade balance as a pc of GDP



Source: US Bureau of Economic Analysis (Balance of payments statistics).

However talk of US ‘energy independence’ is a pipedream

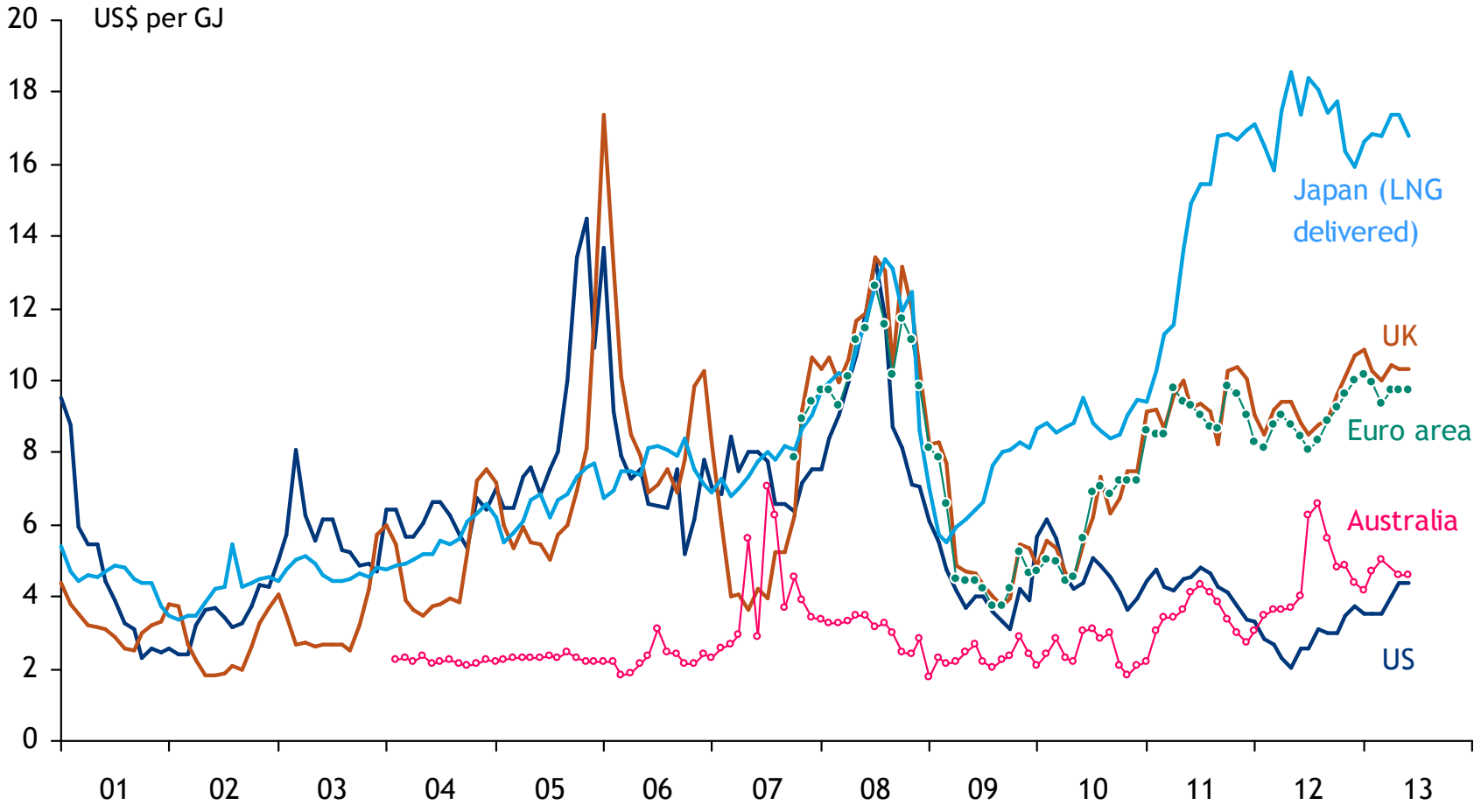
US net energy exports



Note: ‘Other’ energy exports are principally coal and electricity. *Source:* US Energy Information Administration, *Annual Energy Outlook 2013*.

Shale gas is also giving US gas users a significant competitive advantage vs other countries

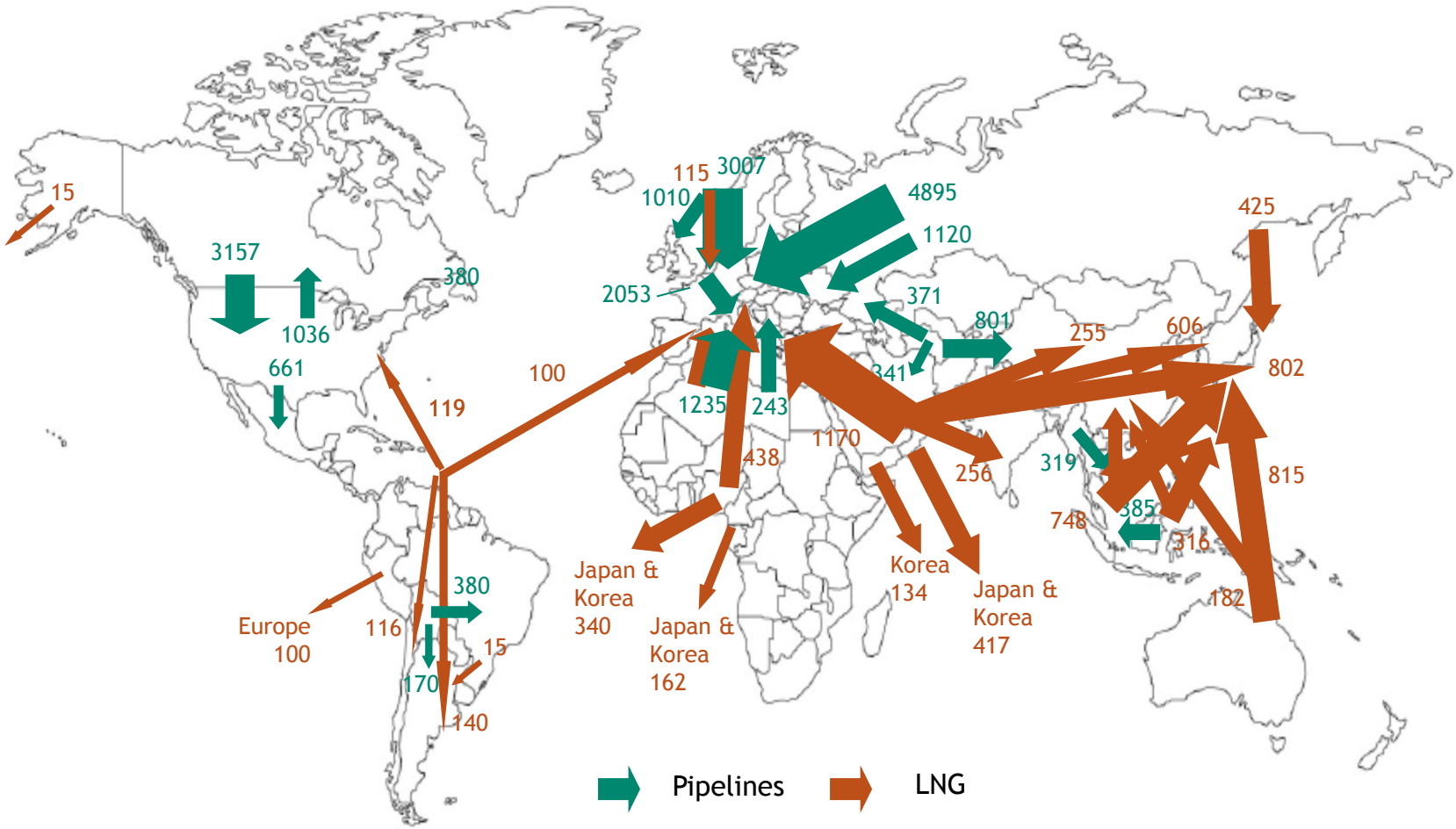
Wholesale natural gas prices



Note: Australian price is for Victoria only. *Sources:* IMF; Thomson Reuters Datastream; Australian Energy Market Operator.

Europe and North-East Asia are heavily reliant on imported natural gas

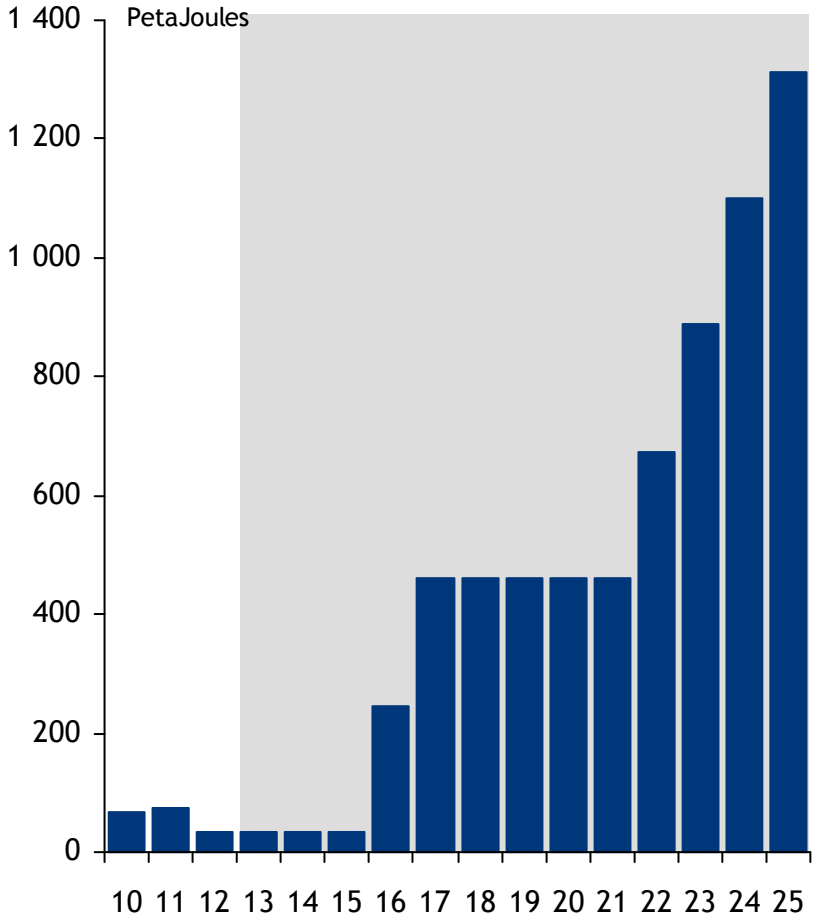
Trade in natural gas



Note: Numbers denote trade volumes in petajoules in 2012. *Source:* BP, *Statistical Review of World Energy* 2013.

US gas prices could eventually rise sharply if the US becomes a significant LNG exporter

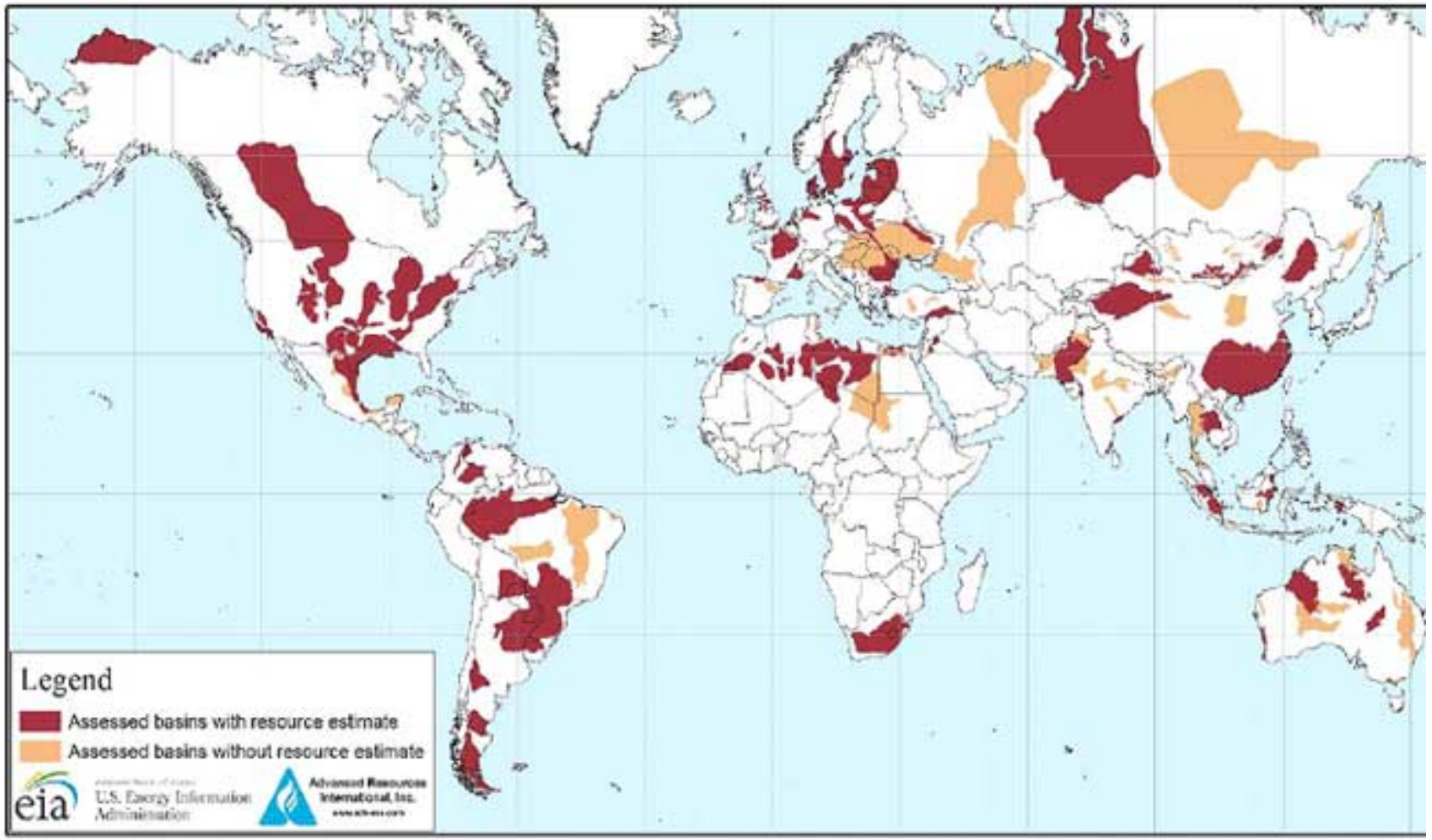
US LNG exports



- Only 31% of total world natural gas production is traded internationally, cf. 64% of oil production
- Roughly 70% of total international trade in gas goes through pipelines and the other 30% is LNG (see next slide)
- The US exports 1.5trn cf (1700 PJ) of gas through pipelines (to Canada & Mexico)
- However LNG exports from the US require case-by-case approval from the Dept of Energy, and so far there is only permitted LNG exporter shipping about 30PJ annually
- Allowing for liquefaction and transport costs, US exporters could land LNG in North Asia at around US$11-12.50/GJ, compared with the current prevailing price of US$14-15/GJ
- The EIA forecasts that US LNG exports will rise to 430bn cf (460PJ) in 2017, and to over 1trn cf (1,060 PJ) by the mid-2020s
- Rapid growth in LNG exports could see domestic gas prices converge towards 'export parity' (excl liquefaction & transport costs) – which is one reason why there is a strong domestic constituency opposed to US LNG exports

Sources: US Energy Information Administration.

There's plenty of shale oil and gas reserves elsewhere in the world



Source: US Energy Information Administration, *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations Outside of the United States*, June 2013, p. 5.

The top ten countries with technically recoverable shale oil and gas resources

Technically recoverable shale oil resources

	Bn barrels
Russia	75
US	58
China	32
Argentina	27
Libya	26
Australia	18
Venezuela	13
Mexico	13
Pakistan	9
Canada	9
Others	65
Total	345
Memo: conventional reserves	*3,012*

Technically recoverable shale gas resources

	Trn cubic ft	*Bn bbls of oil equivalent*
US	1,161	221
China	1,115	212
Argentina	802	152
Algeria	707	134
Canada	573	109
Mexico	545	104
Australia	437	83
South Africa	390	74
Russia	285	54
Brazil	245	47
Others	1,535	292
Total	7,795	1,481
Memo: conventional reserves	*22,812*	*4,346*

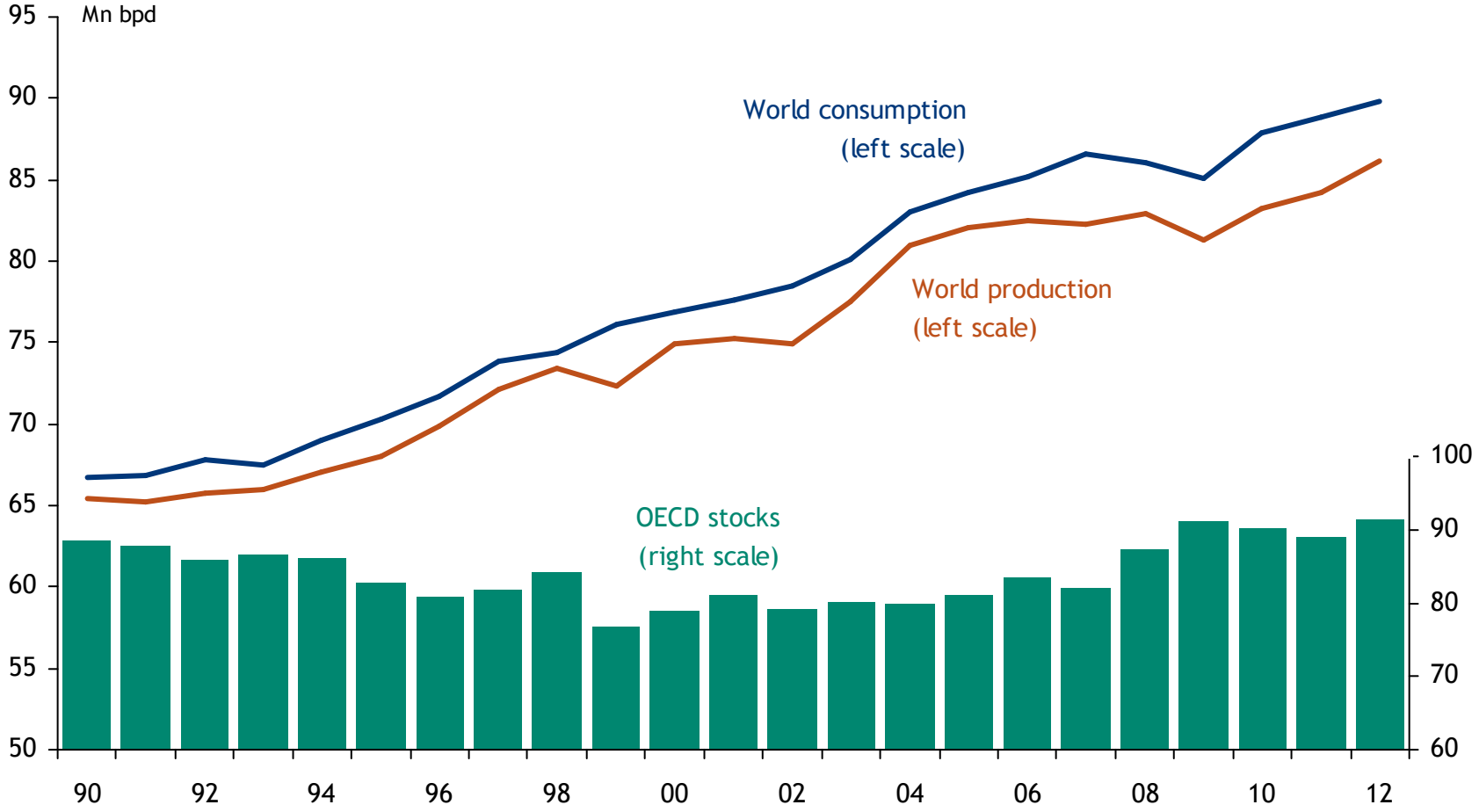
Note: 'Technically recoverable' resources are volumes that could be produced with current technology, but without taking account of prices and production costs. 'Economically recoverable' resources are volumes that can be profitably produced under current market conditions. *Sources:* US Energy Information Administration, *Technically Recoverable Shale Oil and Shale Gas Resources: An Assessment of 137 Shale Formations Outside of the United States*, June 2013; and BP, *Statistical Review of World Energy*, June 2013.

However many countries may have difficulty fully exploiting these resources

- In the US, private landowners also own the rights to minerals (including oil and gas) beneath their land, which has provided a strong incentive for exploration for and exploitation of mineral resources since the landowners receive royalties
  - in almost all other countries rights to sub-surface minerals belong to the state (which receives any royalties from the exploitation of mineral resources)
  - Canada is a partial exception: land originally purchased from the Dominion Government prior to 1887, from the Hudson Bay Company prior to 1907, or from the Canadian Pacific Railway (CPR) prior to 1902, also carries rights to 'all mines and minerals' (other than precious metals): and the mineral rights acquired by CPR in the 19th and early 20th centuries (covering 9.6mn acres, mostly in Alberta) are now owned by EnCana Corporation, a private company
- Exploitation of tight oil and shale gas requires the use of horizontal drilling rigs, which as yet are not widely available outside the US, and other supporting contractors
- Government policies in some countries would need to be changed before widespread exploration and drilling for shale reserves could occur
  - for example, product price controls (as in Argentina) or excise taxes (as in Russia)
  - foreign (mainly US) companies whose technology and expertise may be crucial to the development of shale reserves will be apprehensive about possible expropriation
- Another key requirement for commercial exploitation of shale reserves is pre-existing gathering and pipeline infrastructure, which exists in much of the US but is far less common in other countries

Growth in oil supply has been outstripping demand growth over the past five years

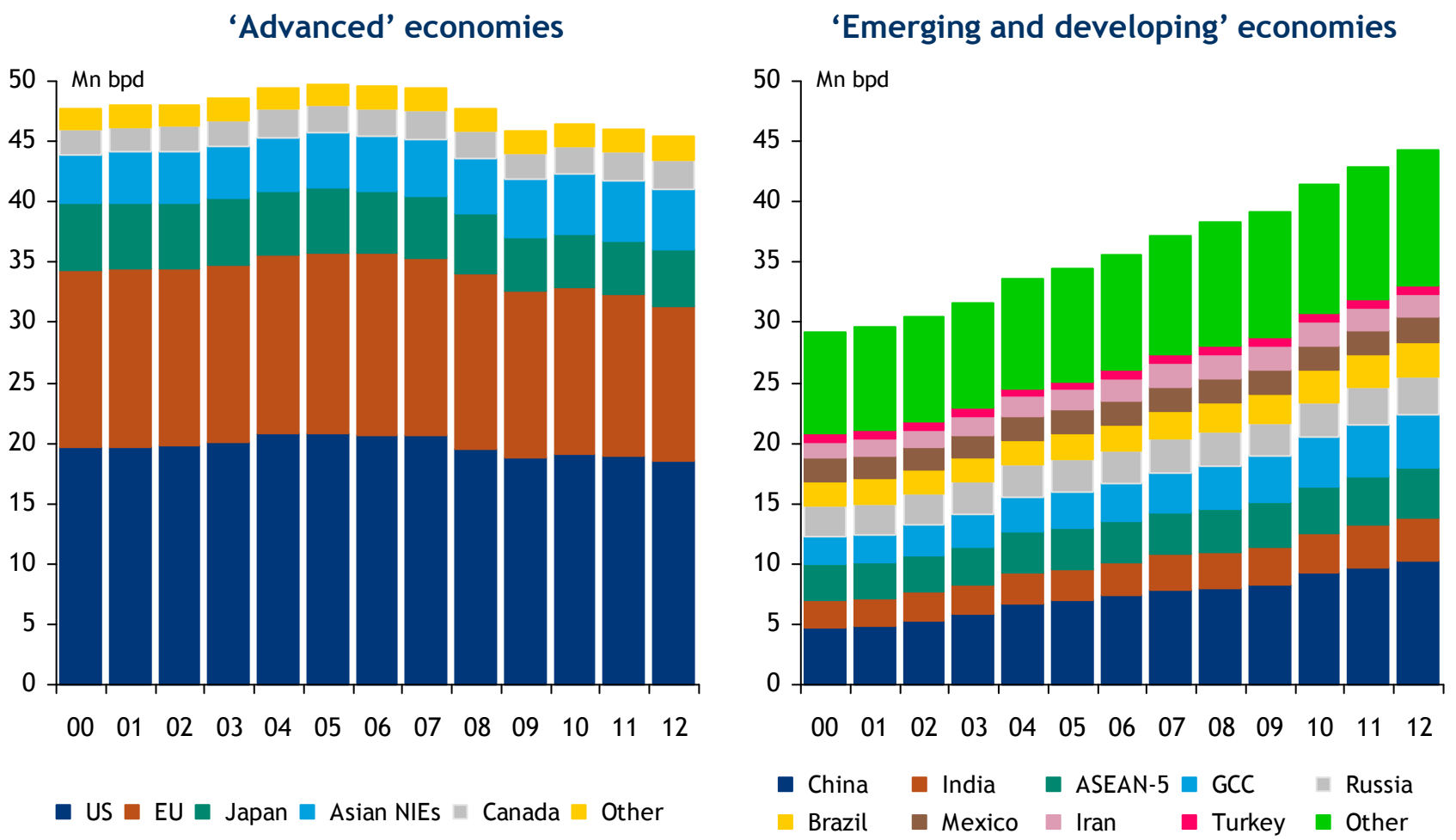
World crude oil supply and demand



Note: Difference between total consumption and production reflects production of liquids from other sources.
Sources: BP, *Statistical Review of World Energy* 2013; US Energy Information Administration *Monthly Energy Review* (for OECD stocks).

Oil demand has fallen 8% in ‘advanced’ economies but risen 19% in ‘developing’ economies since 2007

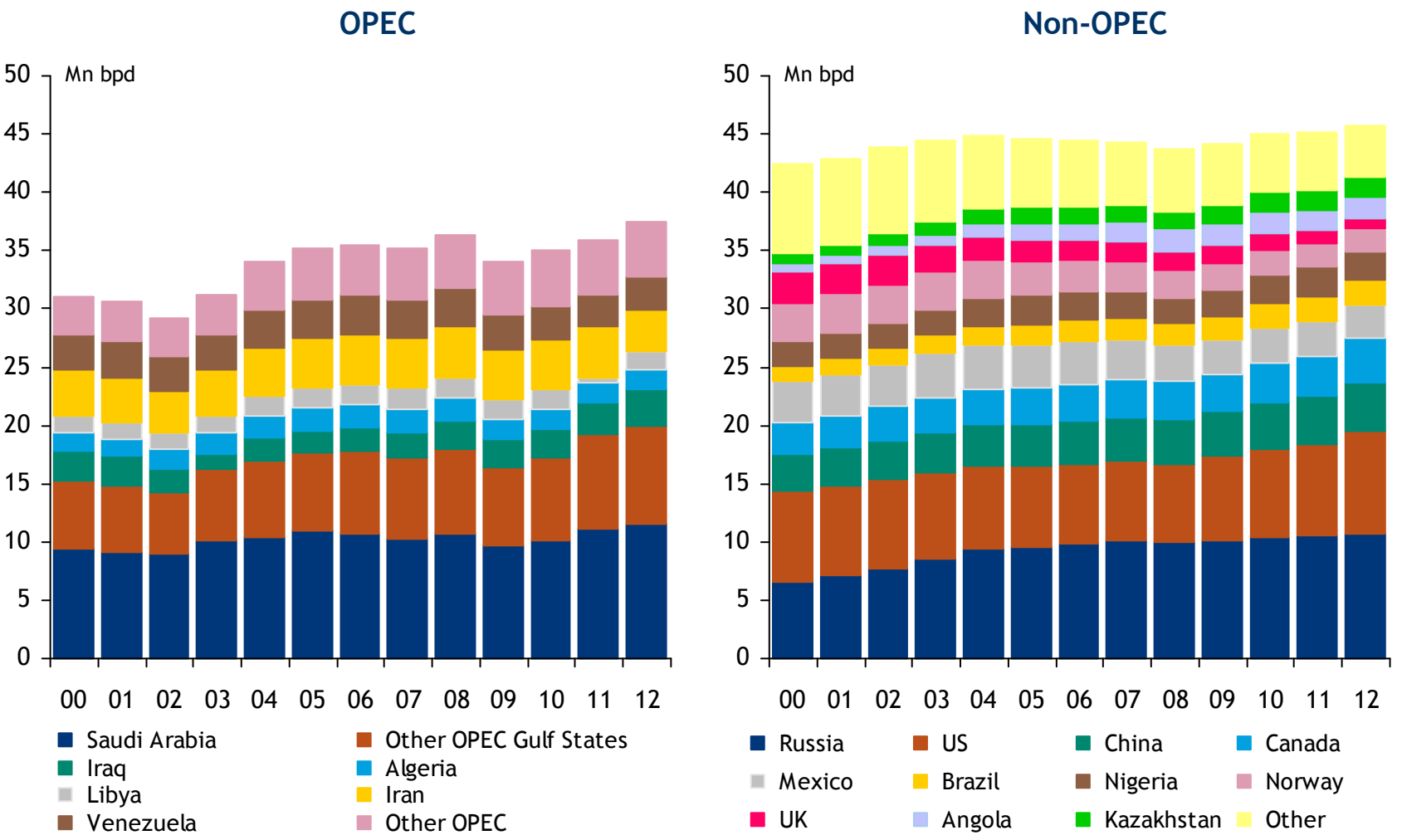
Oil consumption



Note: Asian NIEs are Korea, Taiwan, Hong Kong and Singapore; other advanced economies are Australia, New Zealand, Norway, Switzerland and Israel; ASEAN-5 are Indonesia, the Philippines, Thailand, Malaysia and Vietnam; GCC are Saudi Arabia, the UAE, Qatar and Kuwait.
Sources: BP, *Statistical Review of World Energy* 2013.

Saudi Arabia is trying to keep oil prices around $100/bbl balancing rising US output vs falling OPEC output

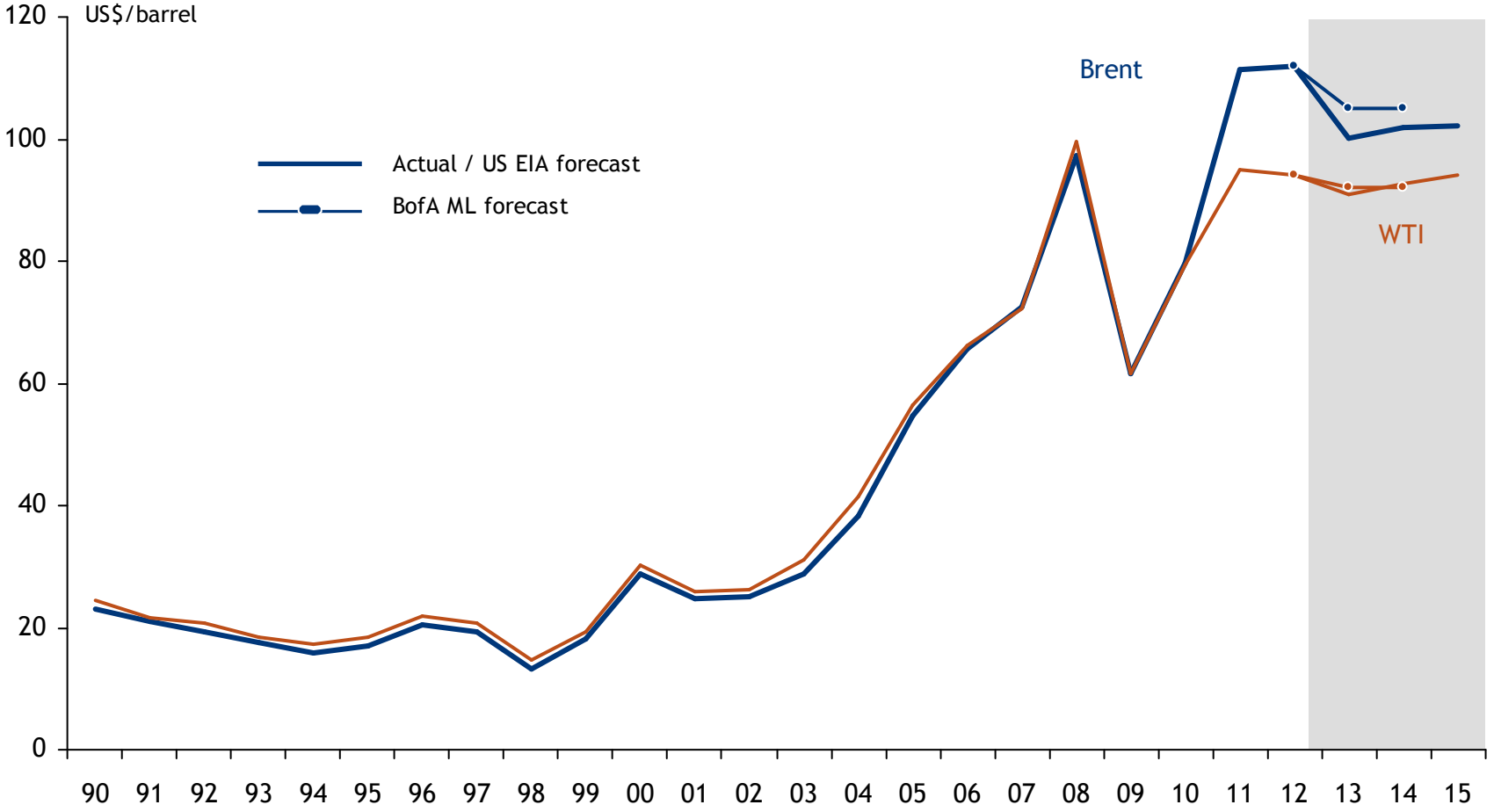
Oil production



Sources: BP, *Statistical Review of World Energy* 2013.

Oil prices are likely to be a little lower over the next few years

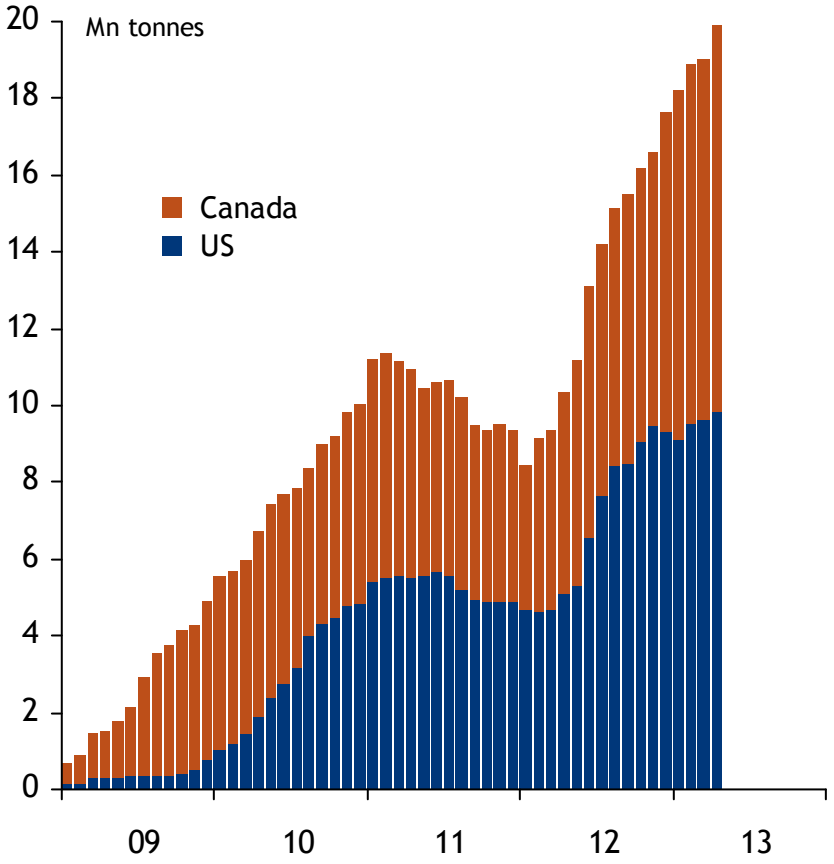
Crude oil prices



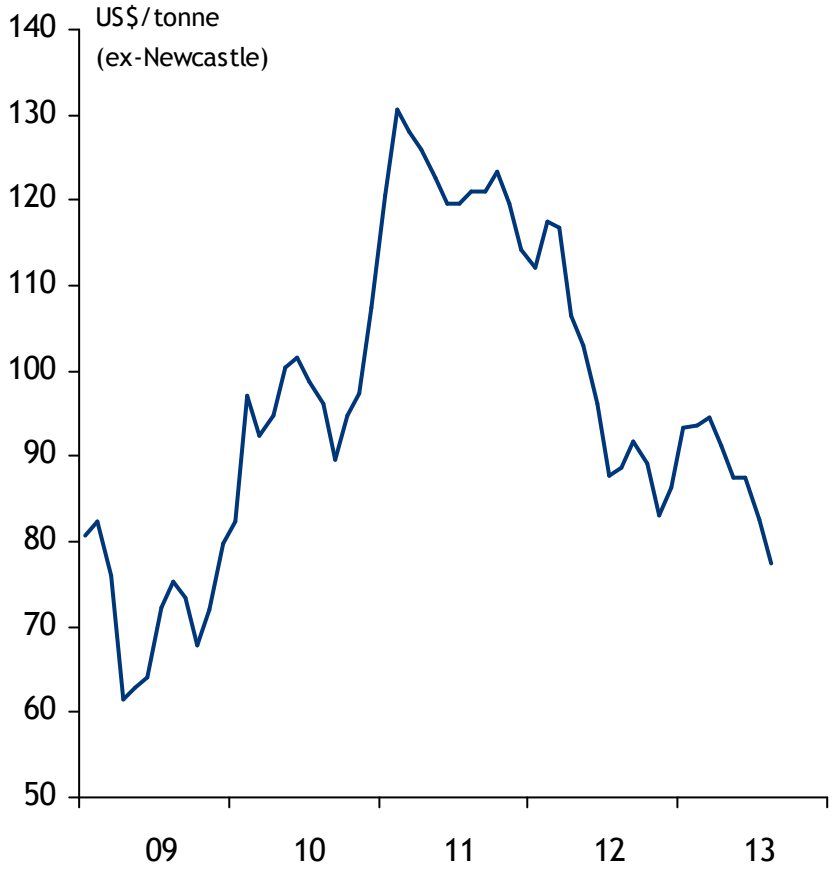
Sources: Thomson Reuters Datastream; US Energy Information Administration *Annual Energy Outlook 20113*; BofA Merrill Lynch Global Energy Research.

With demand from US electricity generators falling, North American coal is being diverted to China

Chinese coal imports from North America



Thermal coal prices

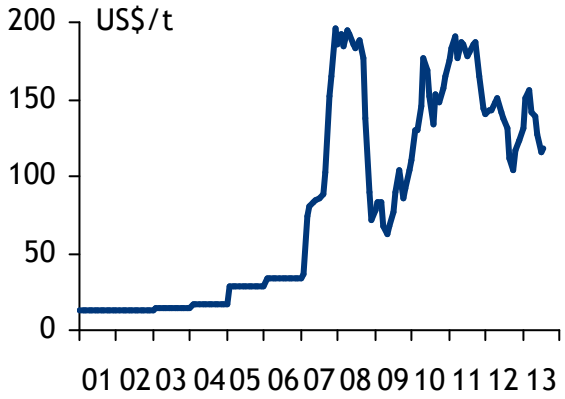


Sources: China National Bureau of Statistics; Thomson Reuters Datastream.

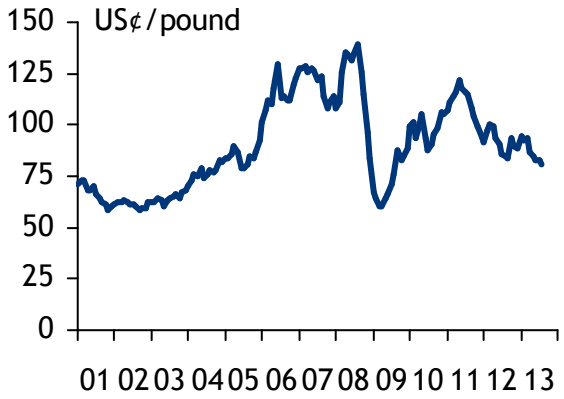
Most non-energy commodity prices also seem to be heading lower

Selected non-energy commodity prices

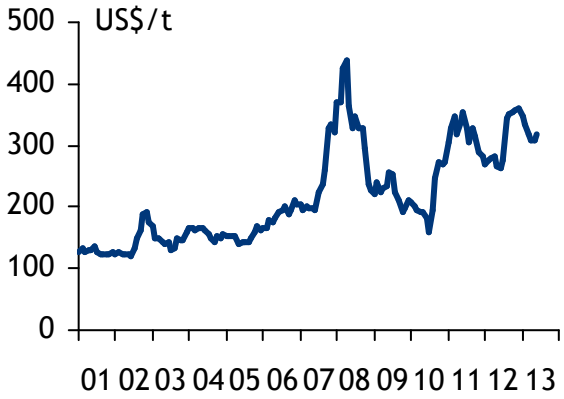
Iron ore



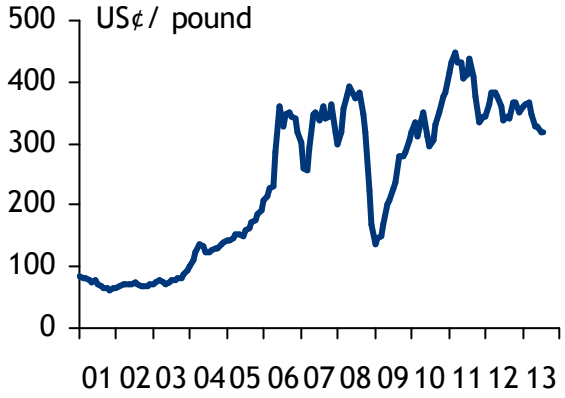
Aluminium



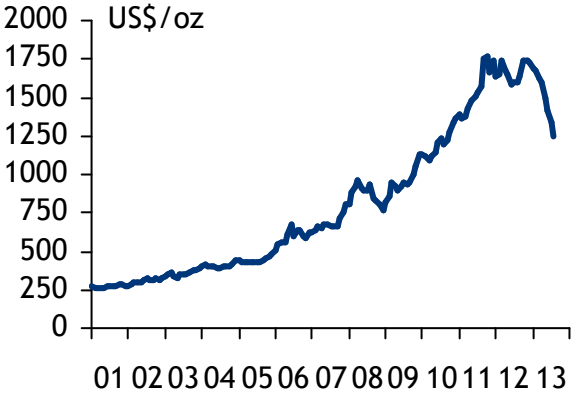
Wheat



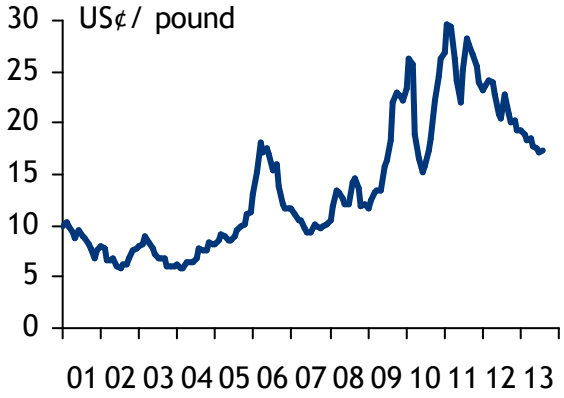
Copper



Gold



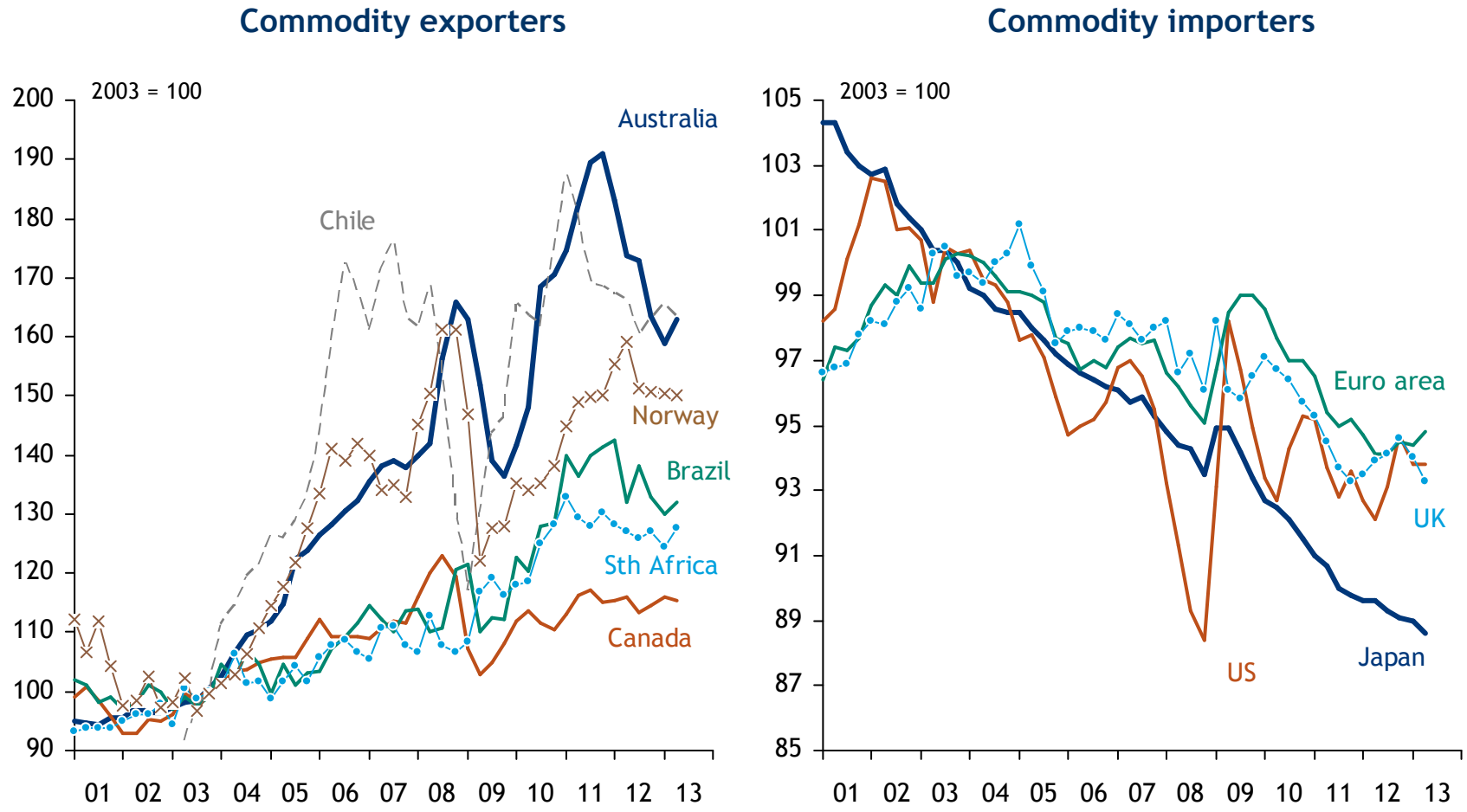
Sugar



Sources: Thomson Reuters Datastream; IMF.

Shifting terms of trade will redistribute income from commodity exporters to commodity importers

Terms of trade: commodity exporters and importers



Sources: National statistical authorities of countries shown; Thomson Reuters Datastream.

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