

Common or Differentiated Energy Futures?

IEF/KAPSARC Thought Leaders Roundtable

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Coal, oil & gas differentiated past, differentiated future

- The three fuels emerged over different time scales to fuel different technologies
- Historically, electricity propelled demand for all 3 fuels
- Now, a dependence on electricity as end use is a demand threat to that fuel
 - Oil has nearly been wrung out of electric system, losing >135 kb/d annually
 - Coal's fortunes mixed but annual growth declining 2015-2016
 - Natural gas was the bridge fuel, but is increasingly undercut by renewables/batteries
- Costs have declined for the fossil fuels and renewables
 - Fossil fuel cost reductions may get partially clawed back
 - Renewables cost declines are permanent and continue

Provocation- Is this the long term equation?



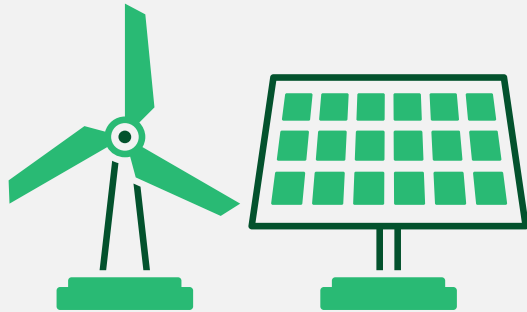
Carbon pricing



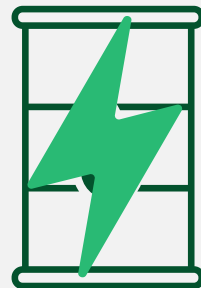
Electrification



Fewer fossil fuels?



Renewables

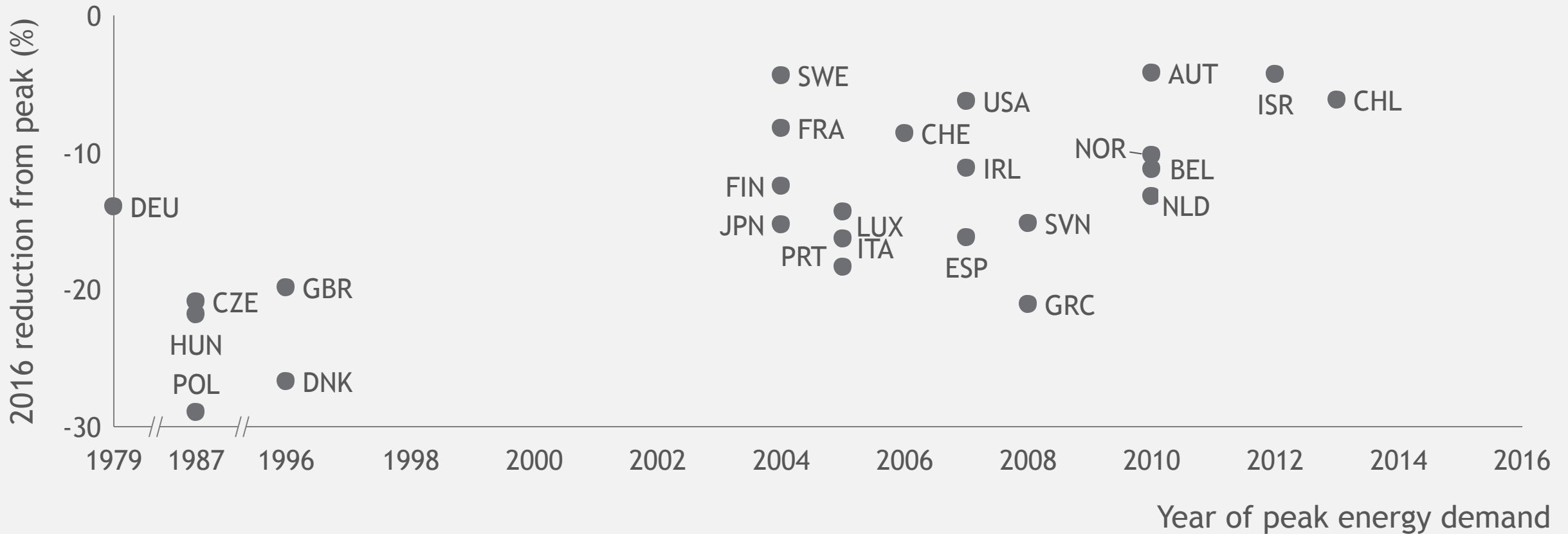


Batteries

But this long run is a misleading guide to current affairs. In the long run we are all dead.

John Maynard Keynes, *A Tract on Monetary Reform*

Peak total energy demand reached in developed world

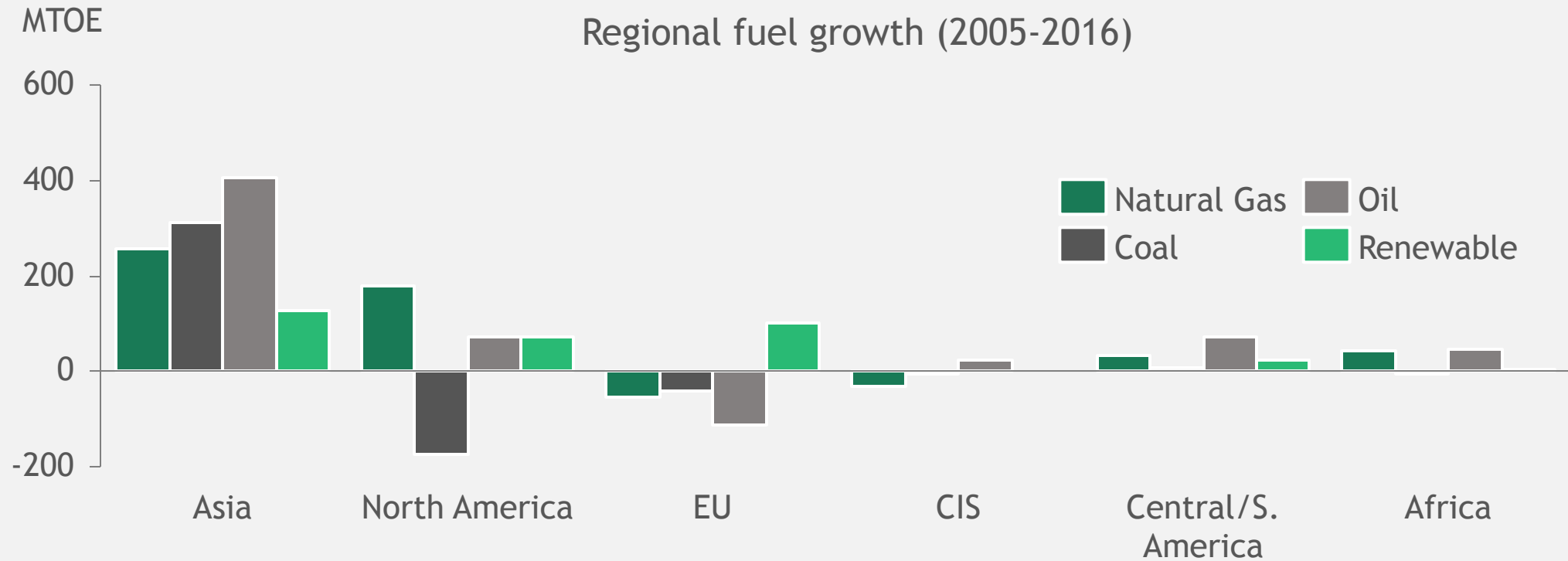


Note: Countries included are those for which there has been a drop of at least 5% in energy demand that has been maintained for at least two consecutive years

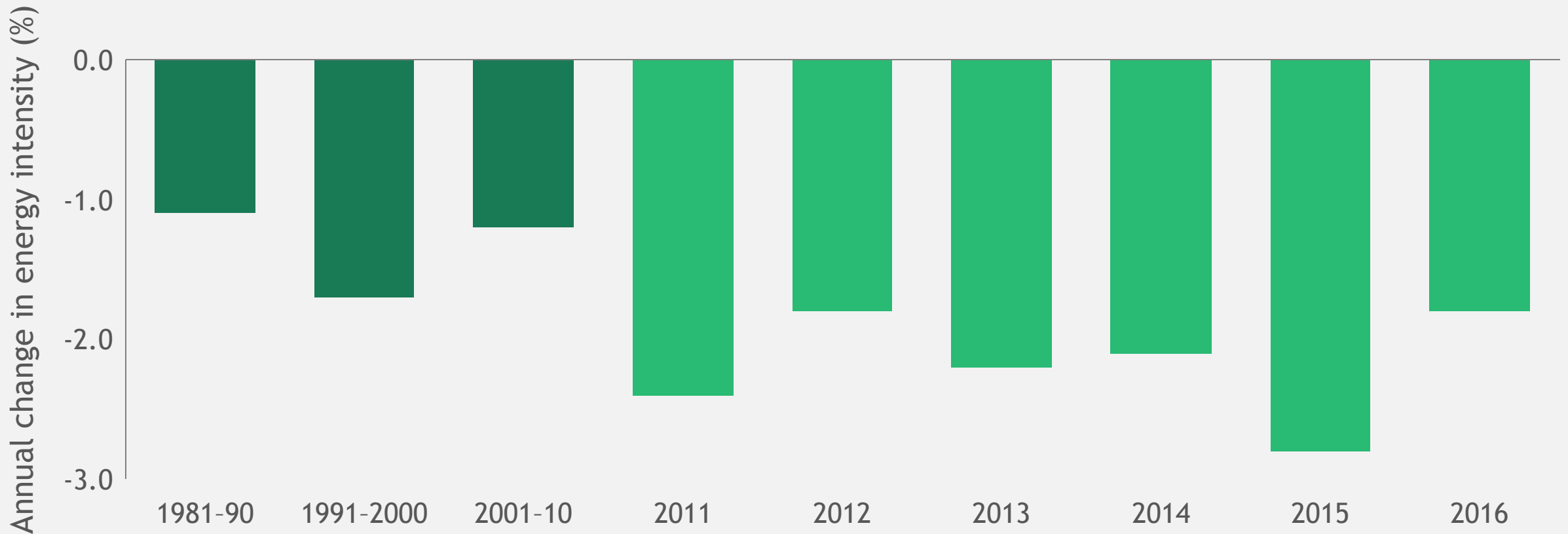
Source: Adapted from IEA (2017a), World Energy Statistics and Balances 2017 (database), www.iea.org/statistics

Fossil fuel primary opportunity set was Asia

Renewables growth most diffuse

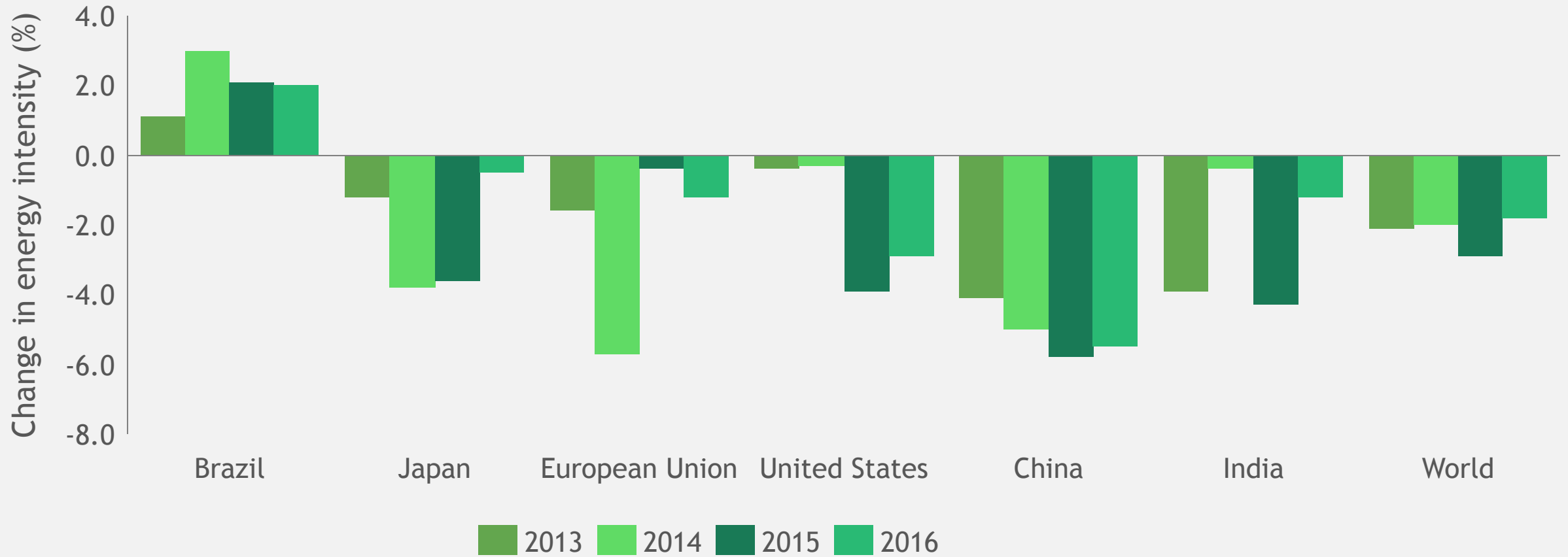


Pace of energy intensity increasing



Note: Energy intensity is calculated as primary energy demand per USD 1,000 of GDP prices at purchasing power parity.
Source: Adapted from IEA (2017a), World Energy Outlook 2016; and IEA (2017a), World Energy Statistics and Balances 2017 (database), www.iea.org/statistics

Greater efficiency seen in most regions



Source: Adapted from IEA (2017a) World Energy Outlook 2016; and IEA (2017a), World Energy Statistics and Balances 2017 (database), www.iea.org/statistics

Energy/technology/subsidy abundance increases competition

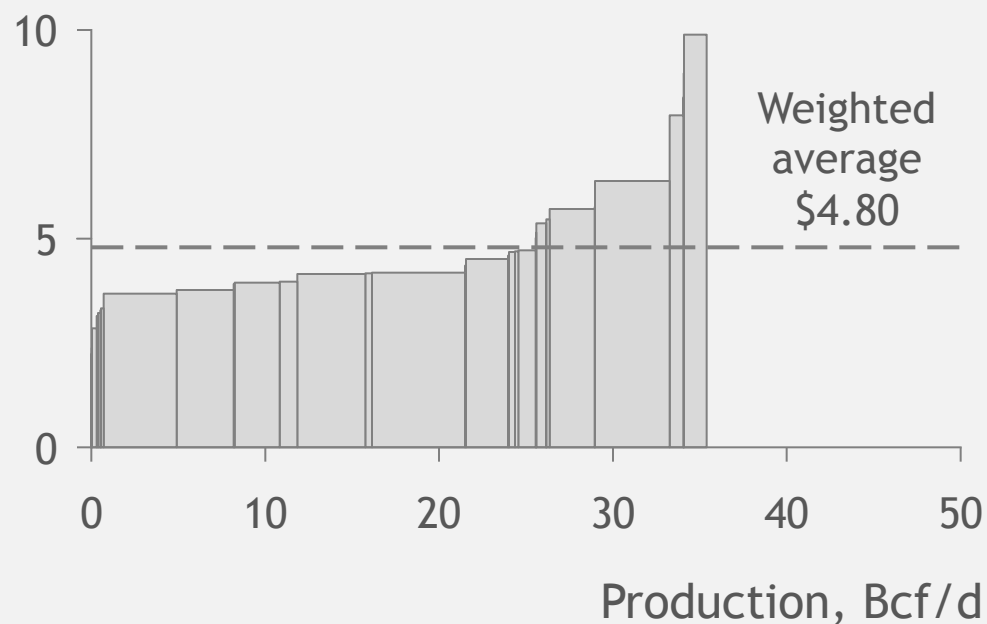
- US natural gas prices down 60% since 2016
- 2.5x more oil can now be found at \$60
- Renewables costs falling sustainably
- But...
 - Lower costs for oil and gas are not all permanent
 - Digitalization trends will skew benefits across fuels



US gas costs down 60%

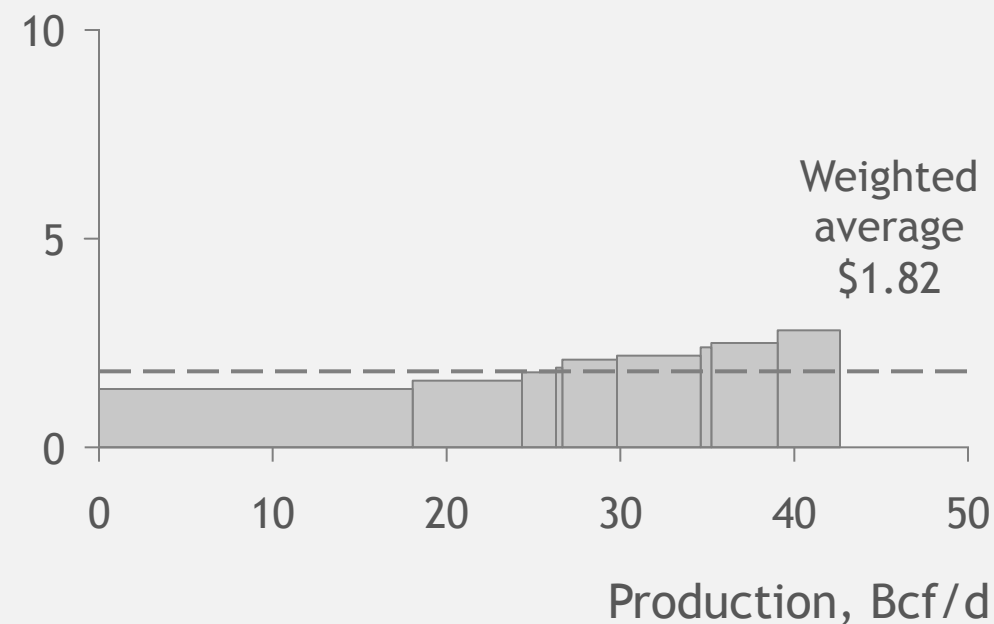
2012 shale gas supply costs

Breakeven (\$/mcf)



2016 shale gas supply costs

Breakeven (\$/mcf)

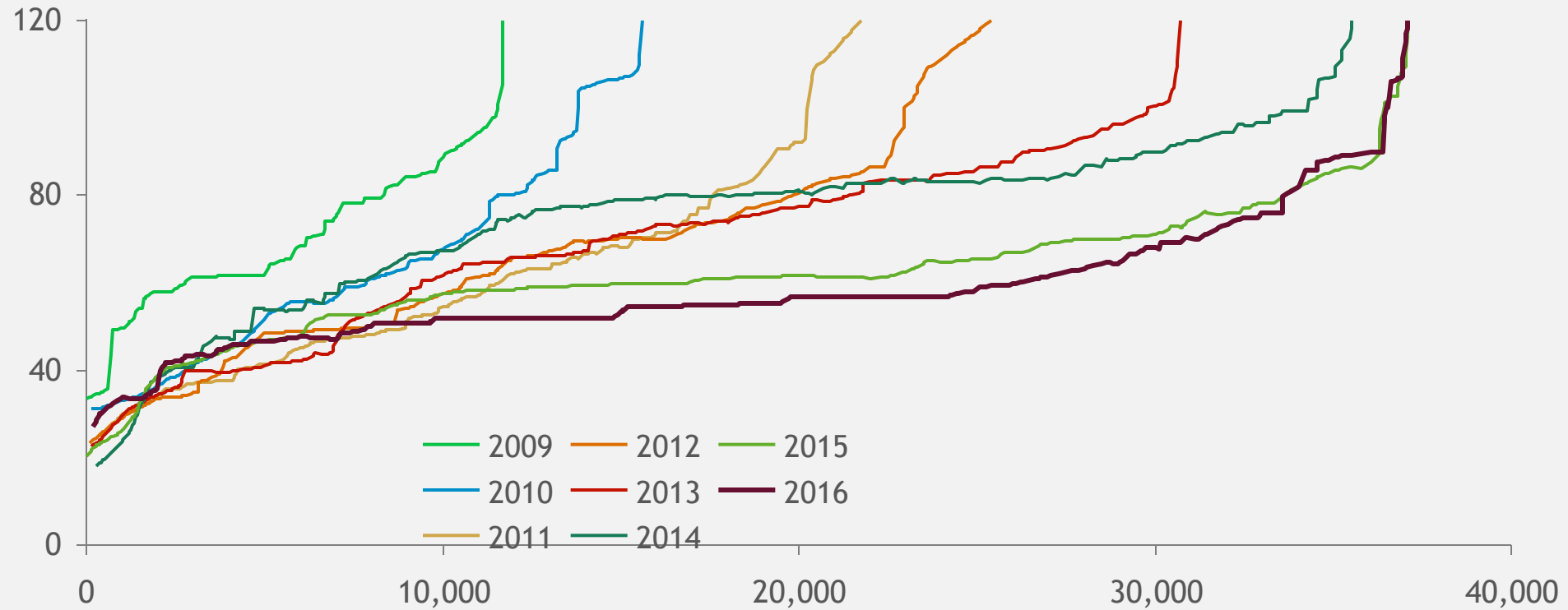


Note: Permian (Gas) includes wells targeting predominantly natural gas across Wolfcamp, Bone Spring/Avalon formations. Includes liquids rich portions of the Barnett, Utica, Marcellus and Montney. Breakeven range corresponds to weighted average breakevens.
Source: Rystad Energy, BCG Analysis

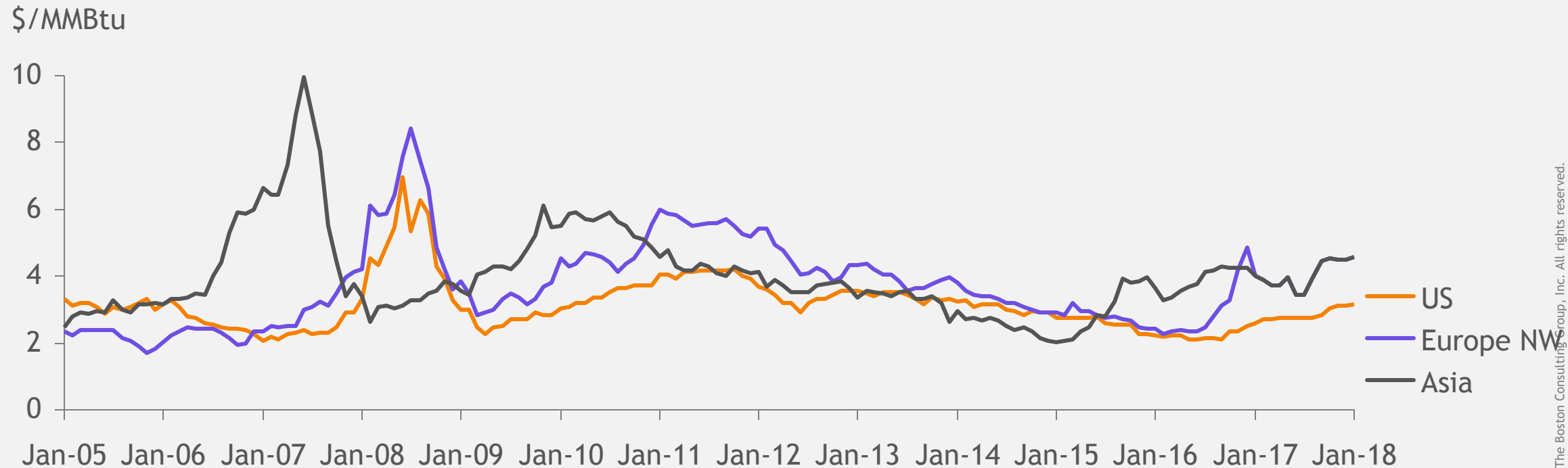
Oil project costs decline

2.5x more oil available at \$60/b over 5 years

Breakeven (vertical; USD/b) vs. cumulative production of identified projects (pre-sanction, under development and producing; thousand barrels per day)



Coal prices & costs show marginal, temporary declines



Notes: Monthly coal prices are averaged. US coal price is represented by Central Appalachia FOB. European coal price is NAR CIF ARA. Australia steam coal FOB is used to reflect Asia coal price
Source: Bloomberg and Reuters

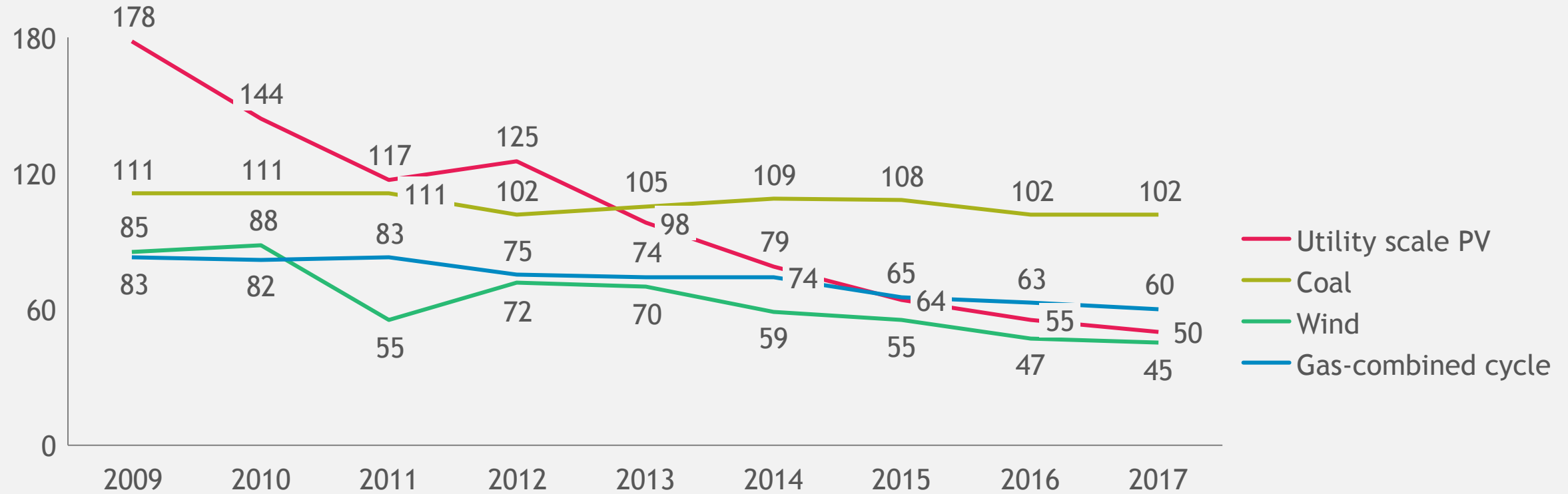


Renewable costs slide - permanently?

Renewables now beating gas new build on average

Selected historical mean LCOE value²

Mean LCOE \$/MWh



1. Primarily relates to North American alternative energy landscape, but reflects broader/global cost declines; 2. Reflects total decrease in mean LCOE since the later of Lazard's LCOE—Version 3.0 or the first year Lazard has tracked the relevant technology; 3. Reflects mean of fixed till (high end) and single axis tracking (low end) crystalline PV installations

Note: Reflects average of unsubsidized high and low LCOE range for give version of LCOE study

Source: Lazard estimated; BCG analysis

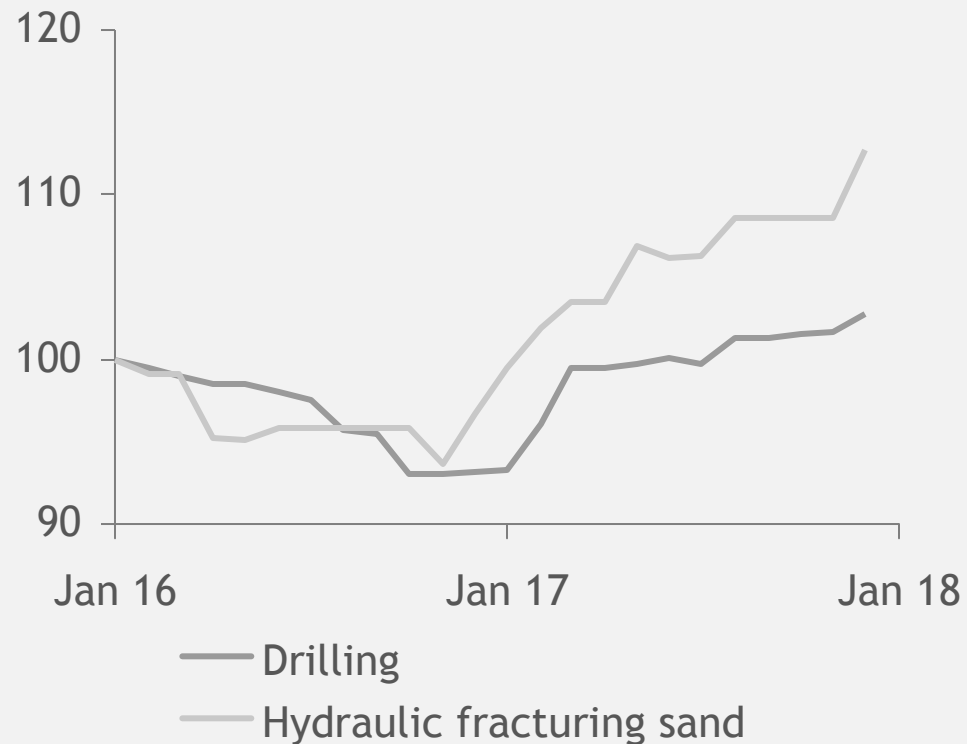


For oil, costs again rising

How much of the cost savings is permanent?

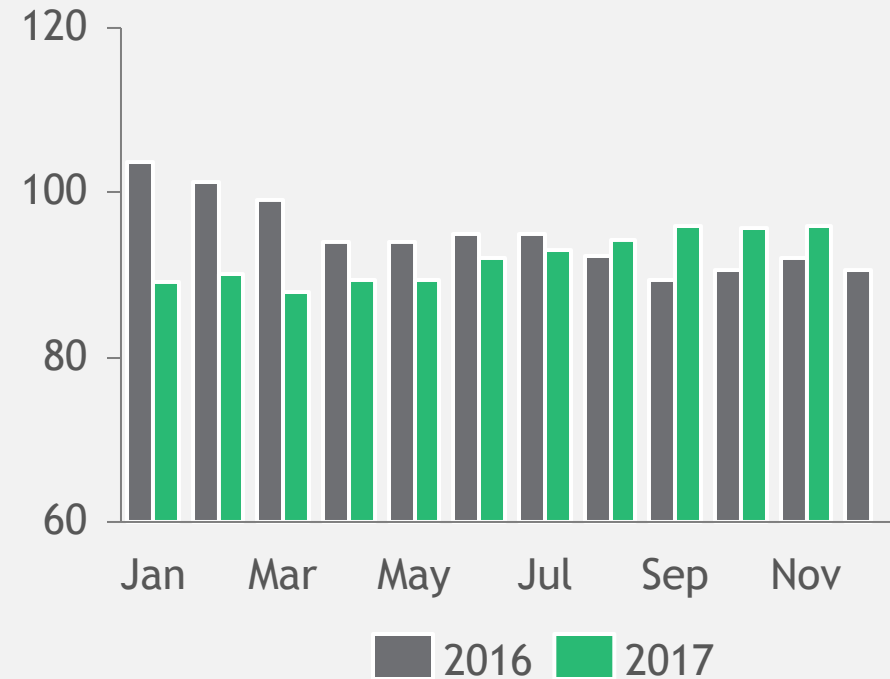
Shale costs increase with growth

Index: Jan 2016= 100



Hiring & wages increasing

'000 employees



Source: Census bureau data NAICS PCU213111213111, PCU213112213112, Bureau of Labor Statistics, BCG CEI



Case study: US power holds gas consumption risks

	Risk to gas	Timeframe
Gas peaking capacity	□ Battery storage cost declines beat existing capacity	□ Now-2025
Less efficient CCGTs	New renewables costs & scale beat existing gas baseload	□ 2020-2030
Modern CCGTs	~200GW (>50%) gas capacity expected to retire	□ 2030-2040

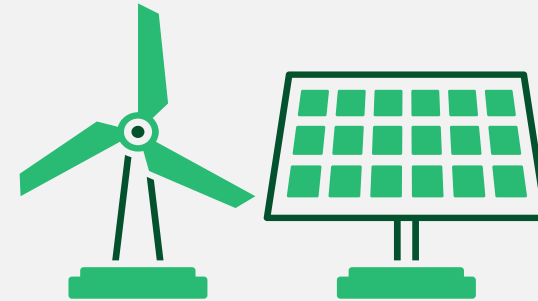
Long-term systemic factors help shape future of each fuel



Carbon pricing



Pace of electrification



Cost of Renewables

**The future is already here — it's just
not very evenly distributed**

William Gibson

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The background features a soft, light green bokeh effect on the right side, transitioning into a subtle grid pattern of small, light green circles that covers the bottom half of the image. The overall color palette is a range of light to medium greens.

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