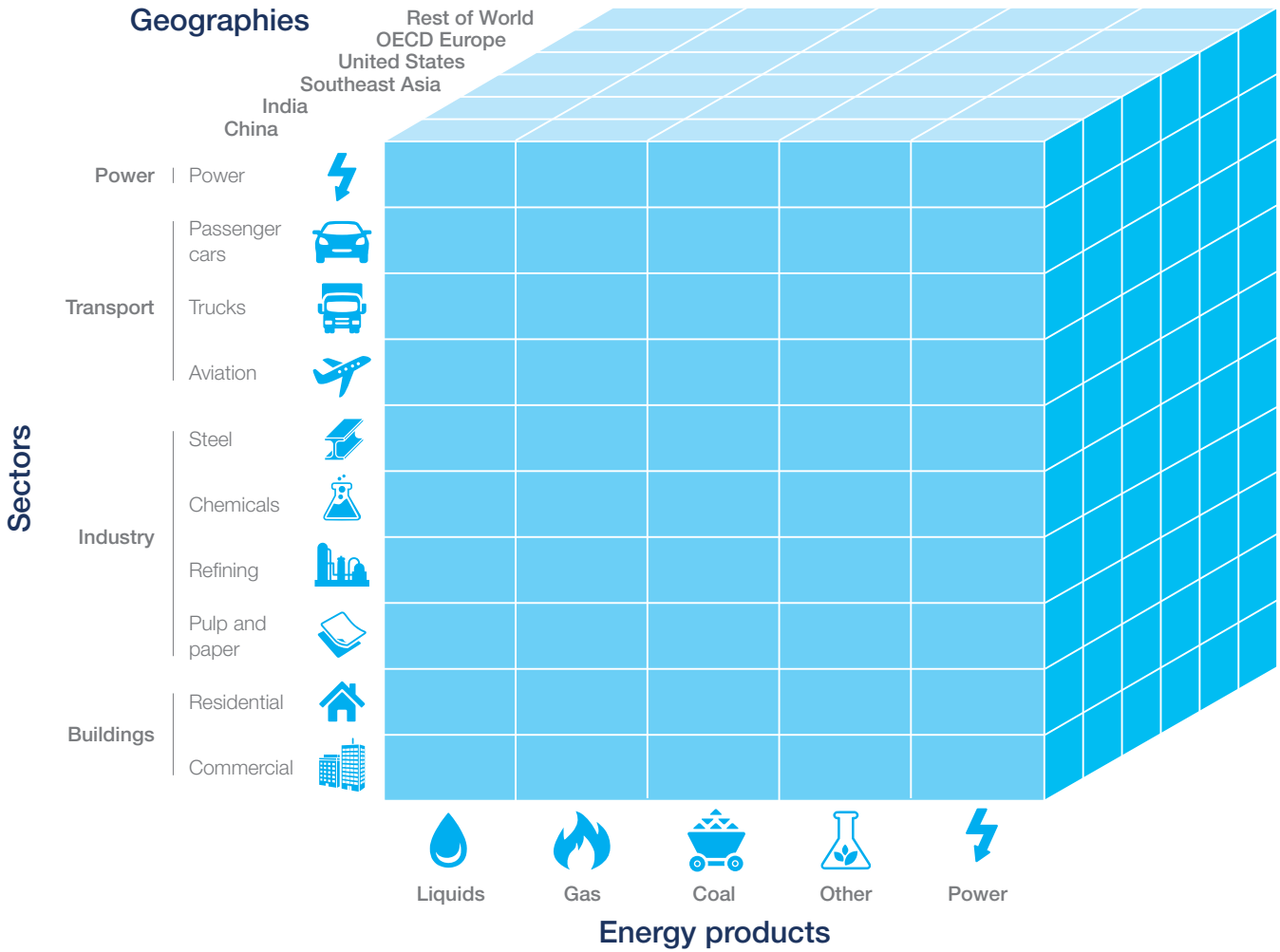
Global Energy Perspective: Reference Case 2018

December 2017

Energy Insights
By McKinsey

With our Global Energy Perspective, we built a fundamental energy demand outlook



Granular coverage

Long-term projections to 2050 across 145 countries, 28 sectors, and 57 energy products

Full transparency and flexibility

Access to all the detail of the demand drivers and ability to customize bespoke scenarios

Global reach, local expertise

Access to McKinsey's expertise from across over 100 local offices, more than 400 energy experts globally, and over 20 industry practices

Key insights

1 Global energy demand growth decelerates, following a structural decline in energy intensity

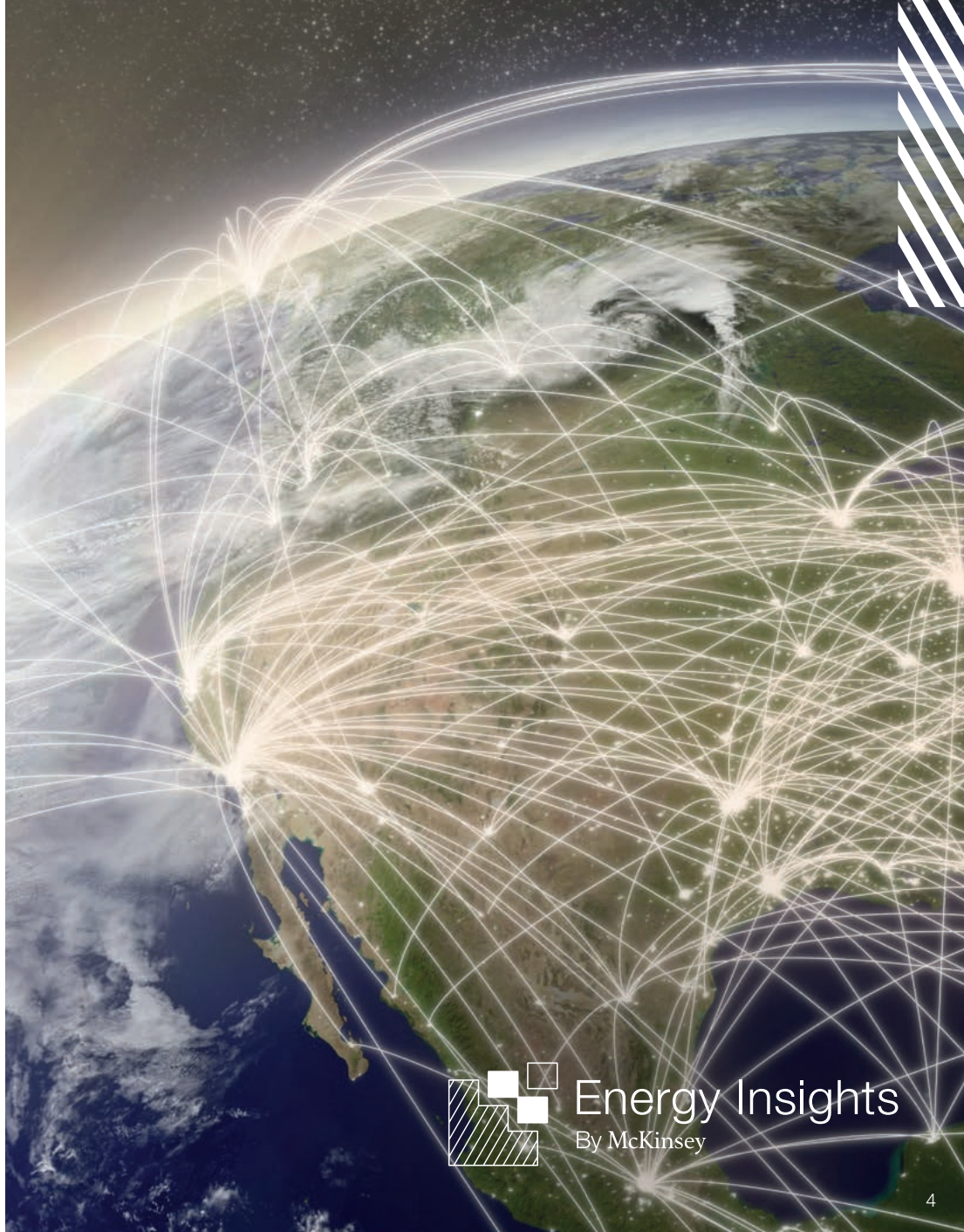
2 Electricity demand grows four times faster than all other fuels

3 Renewables' cost decline accelerates further, out-competing new-built fossil capacity today and existing capacity in 5-10 years

4 Coal demand peaks in next decade, oil in the next two; in contrast, gas continues to grow modestly

5 CO_2 emissions plateau by 2030 and remain far from a 2°C pathway

1 Global energy demand growth decelerates, following a structural decline in energy intensity



Global energy demand rises by one quarter over 2015-50, but the rate of growth slows to a pace not seen in the past 100 years

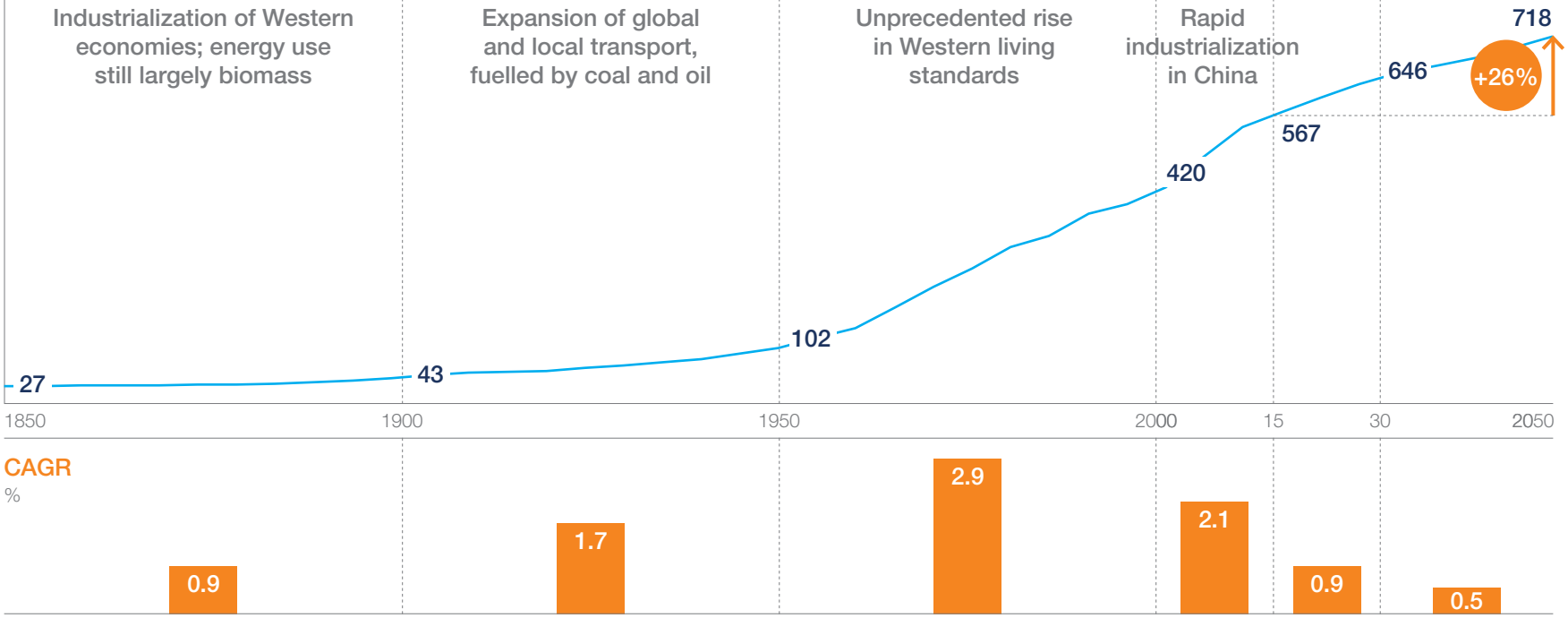
Global primary energy demand
Million terajoules

Industrialization of Western economies; energy use still largely biomass

Expansion of global and local transport, fuelled by coal and oil

Unprecedented rise in Western living standards

Rapid industrialization in China

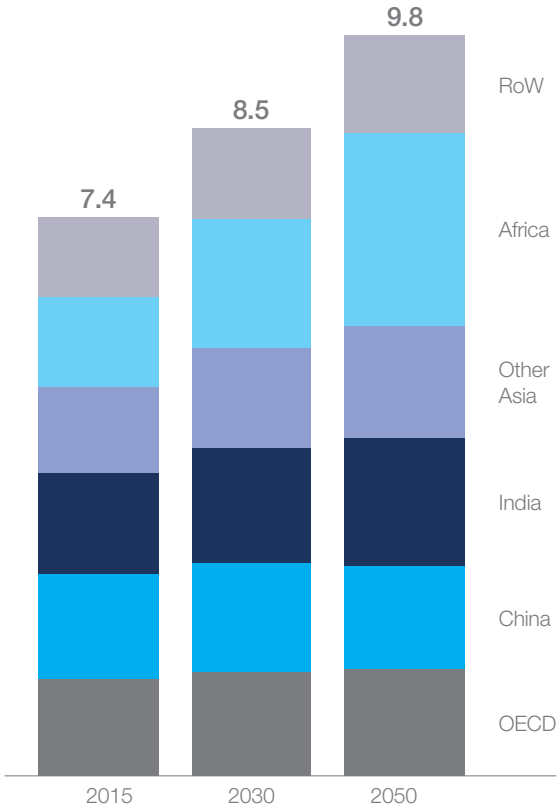


Sources: McKinsey Energy Insights' Global Energy Perspective, December 2017; IEA Energy Balances (Historical); Smil, V. (Historical)

Population and economic expansion underlie higher overall energy demand, but downward pressure on economic growth and falling energy intensity drive a deceleration of energy demand

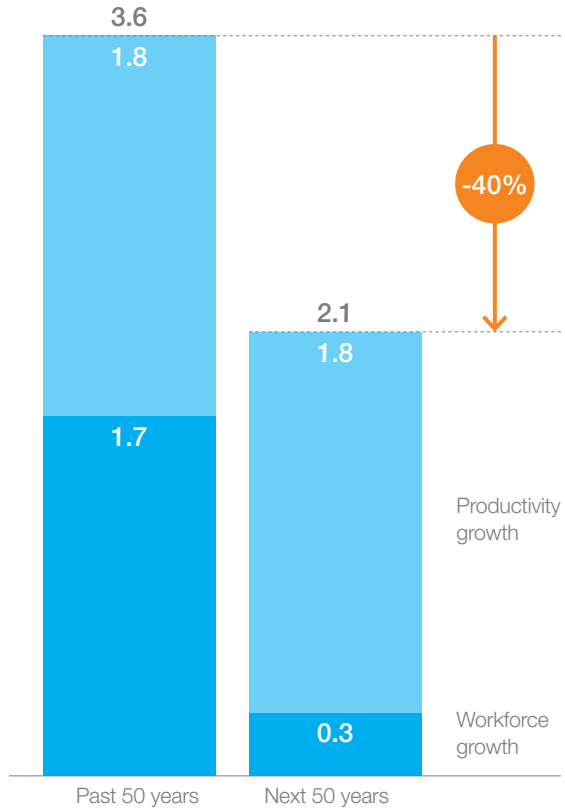
Population growth is concentrated in Asia (excluding China) and Africa

Population, billions



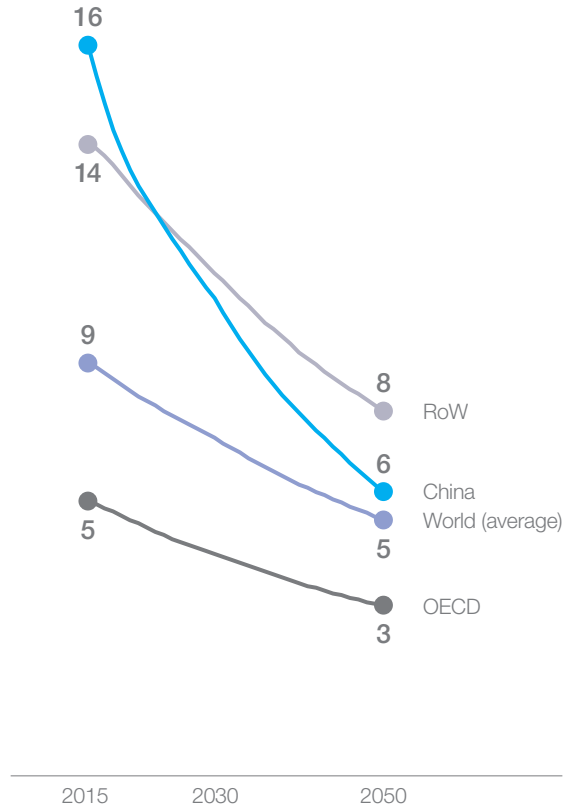
GDP growth relies on productivity gains due to an aging workforce

G19 and Nigeria GDP CAGR, %



Energy intensity declines with a shift to services and higher end-use efficiency

Energy intensity, MJ/$2015



Sources: McKinsey Energy Insights' Global Energy Perspective, December 2017; McKinsey Global Institute Global Growth Model, Global Deceleration Scenario; UN Population Division

Energy intensity is improving across regions and end-use sectors with switching to more efficient fuels and technologies

Change in sector energy intensity,[1] 2015-30

% reduction in energy use per selected sector/segment activity

>40% 20-40% 10-20% <10%

Sector	Segment	Activity unit	China	India	Non-OECD Asia	Africa	Other non-OECD	OECD Americas	OECD Europe	OECD Asia Pacific
Buildings[2]	Space heating	m^2 floor space								
	Lighting	m^2 floor space								
	Water heating	Household								
Transport	Passenger cars	km travelled								
	Trucks	km travelled								
	Aviation	Rev-passenger km travelled								
Industry	Chemicals	Ton produced								
	Iron and steel	Ton produced								

1 Energy intensity provides an indication of end-use efficiency. Underlying drivers include fuel switching, technology changes and service demand effects, e.g. more heat per m^2

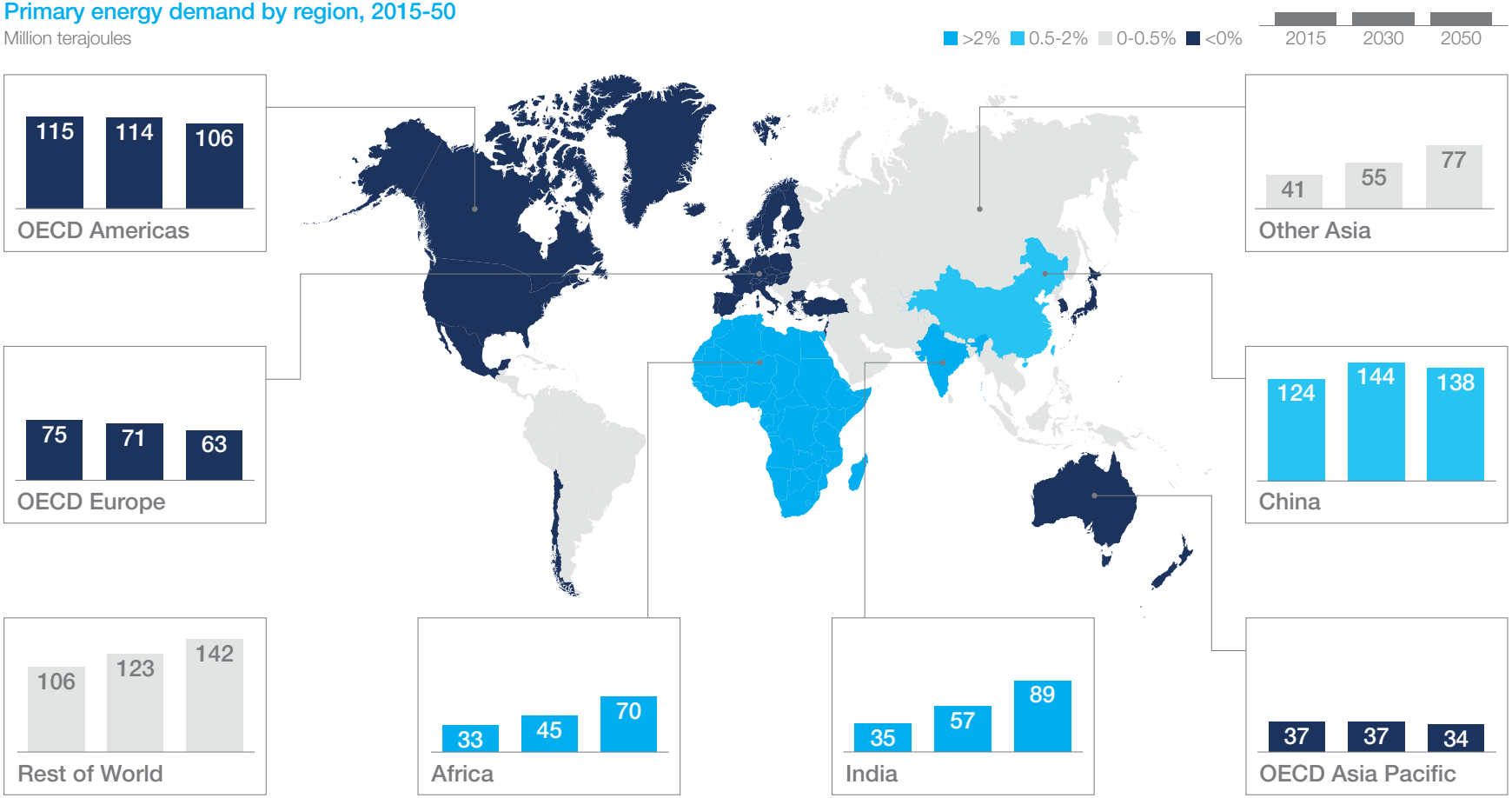
2 Residential buildings only, excluding commercial buildings

Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

India, Africa and other developing Asia lead energy demand growth over 2015-50, while China peaks and OECD markets decline

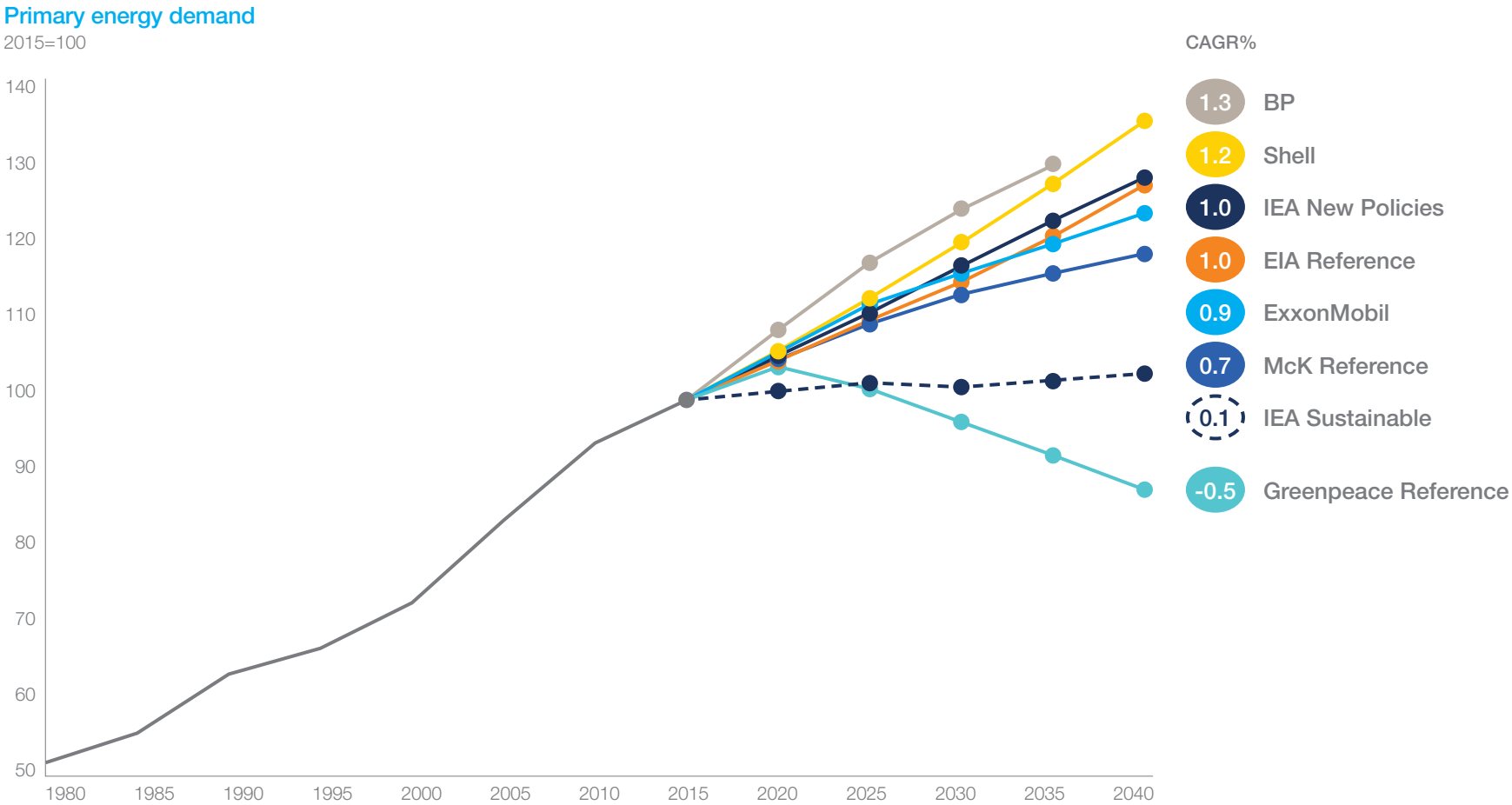
Primary energy demand by region, 2015-50

Million terajoules



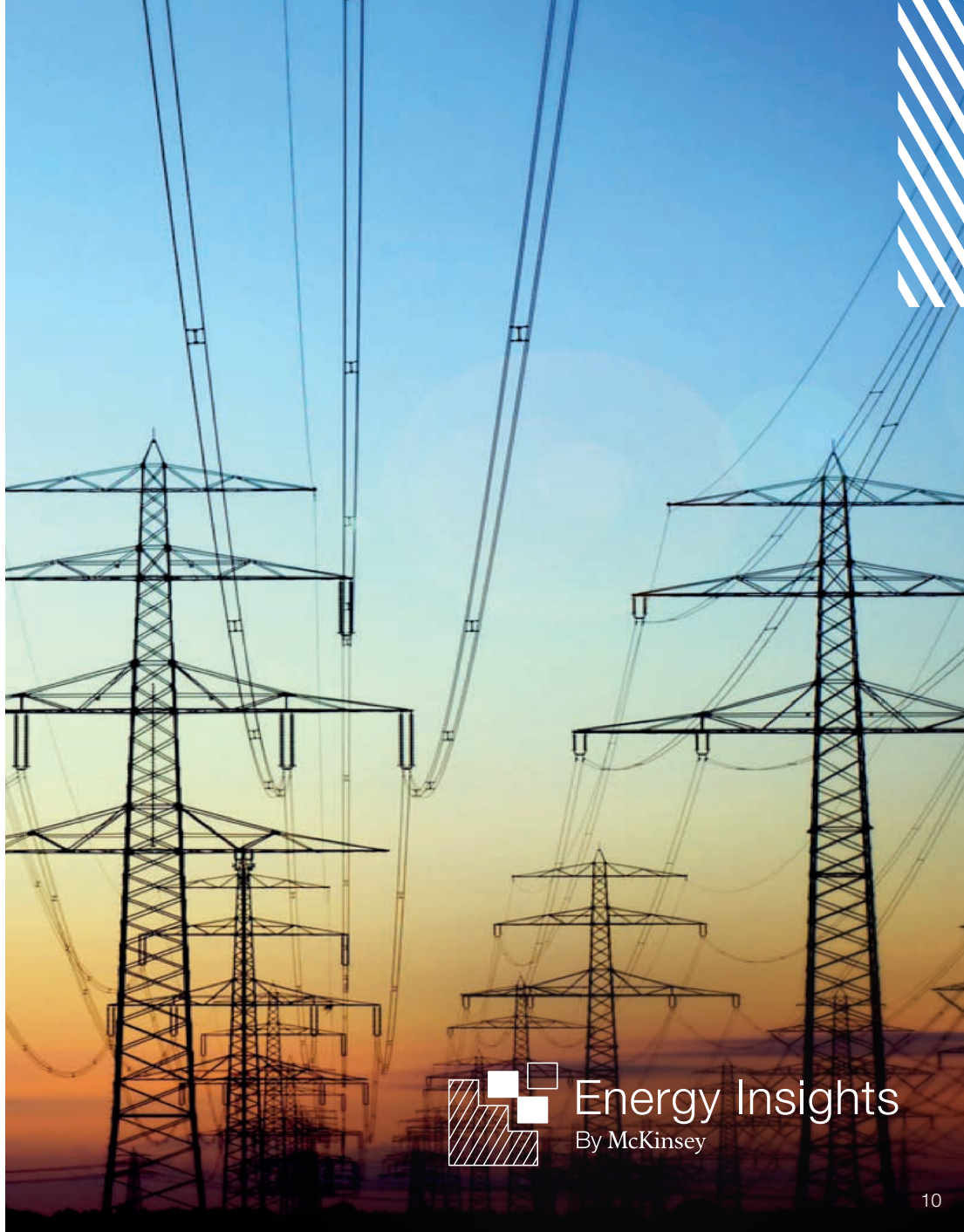
Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

The McKinsey Global Energy Perspective Reference Case projects slower energy demand growth than comparable long-term energy outlooks



Sources: McKinsey Energy Insights' Global Energy Perspective, December 2017; BP Energy Outlook 2017; ExxonMobil 2017 Outlook for Energy; IEA WEO 2017; EIA IEO 2017; Shell New Lens Scenarios

2 Electricity demand grows four times faster than all other fuels



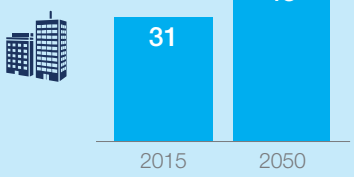
Electrification across key end uses – particularly in buildings and road transport – underlies an acceleration of electricity demand relative to demand for other fuels

Electrification[1]

Electricity % of final energy demand

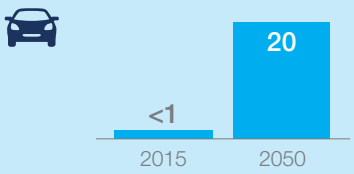
Deep dives

Buildings



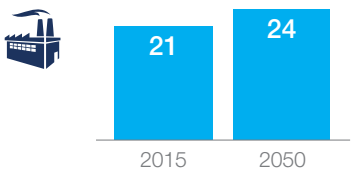
- Fast-rising demand for **electricity-based services** – appliances, space cooling – in developing regions
- Switching from gas to **electric heat pumps** in high-income countries

Transport



- Accelerating **uptake of EVs** in all road segments with regulation and improving competitiveness
- Other enablers include **infrastructure availability** and **shared mobility**

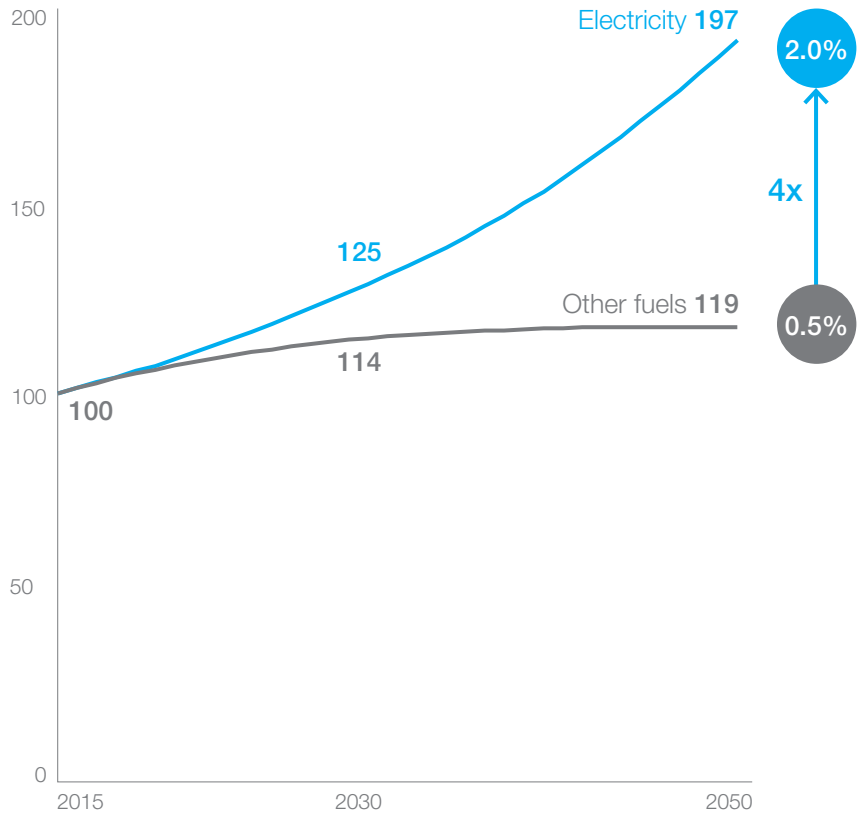
Industry



- Proliferation of electric heat pumps for **low-temperature heat** processes
- Limited adoption of electric/hybrid boilers in **medium-temperature heat** applications

Final energy demand

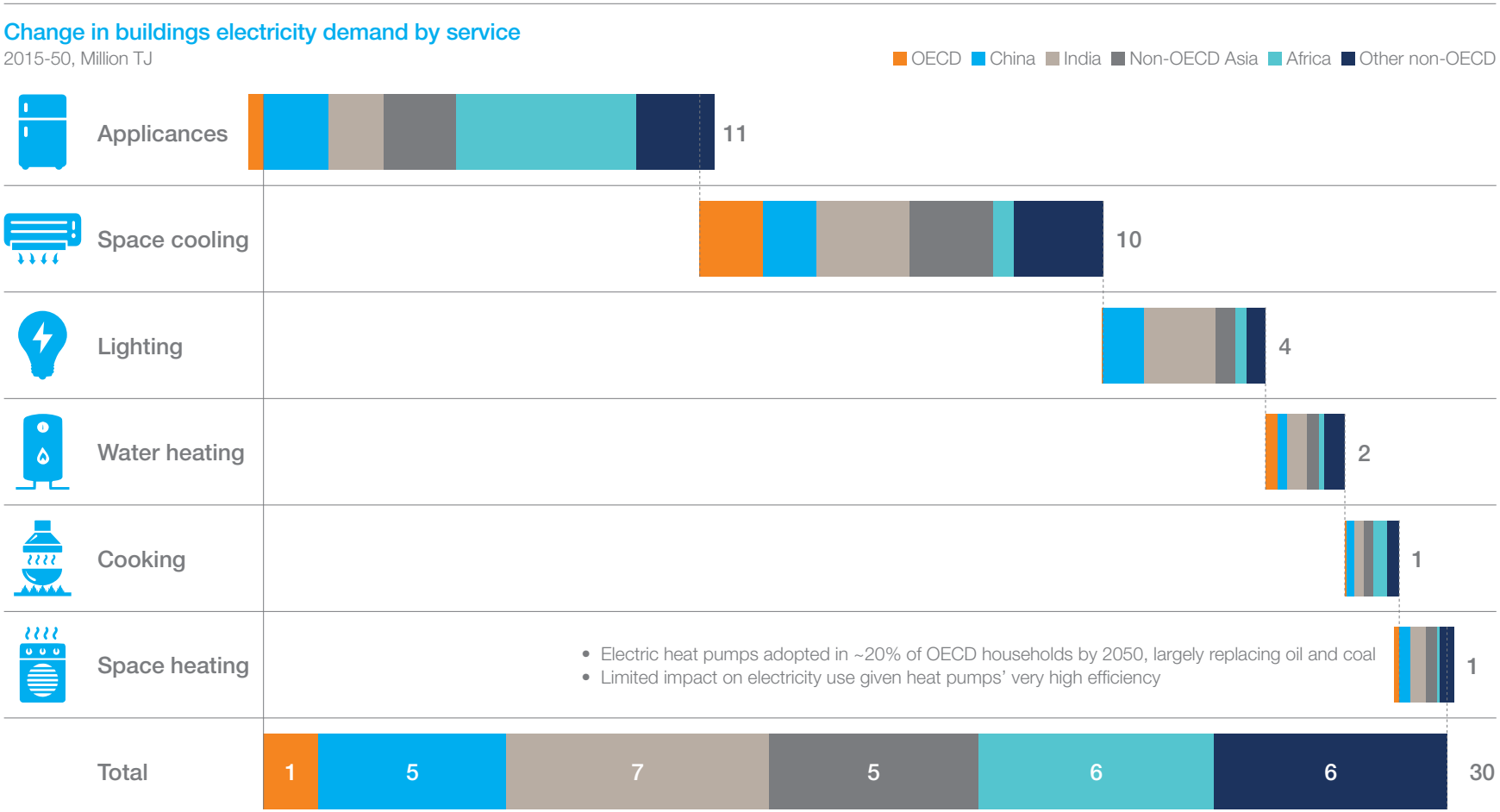
2015=100



1 Buildings includes residential buildings in OECD Europe and OECD Americas; transport includes passenger cars, trucks, vans, buses, and two- and three-wheelers

Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

In buildings, higher living standards in Asia and Africa support fast-rising demand for electricity-based services

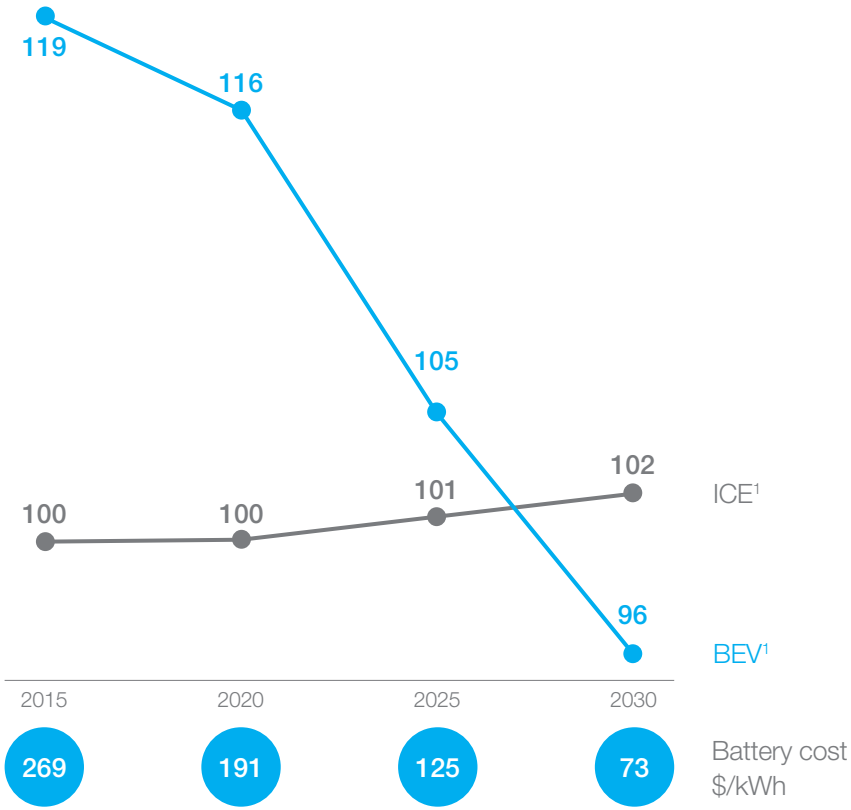


Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

Strong improvements in economics of electric vehicles trigger rapid uptake, for cars as well as trucks

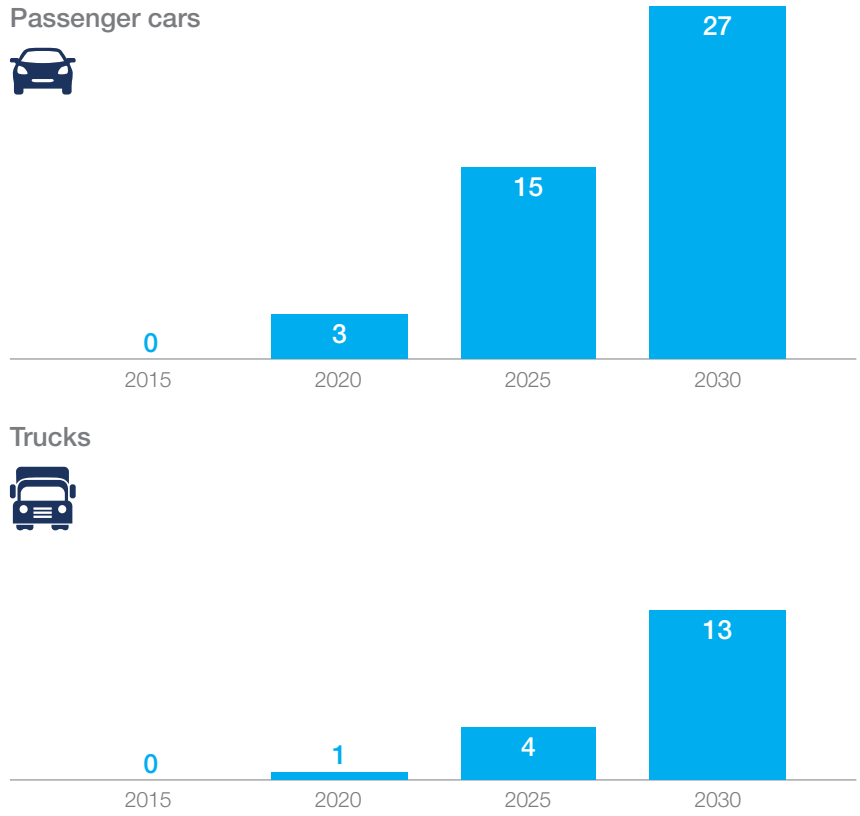
US total cost of ownership for medium-duty truck

Cost per kilometer normalized to 2015 ICE[1]



US share of battery electric vehicles

% of new vehicle sales



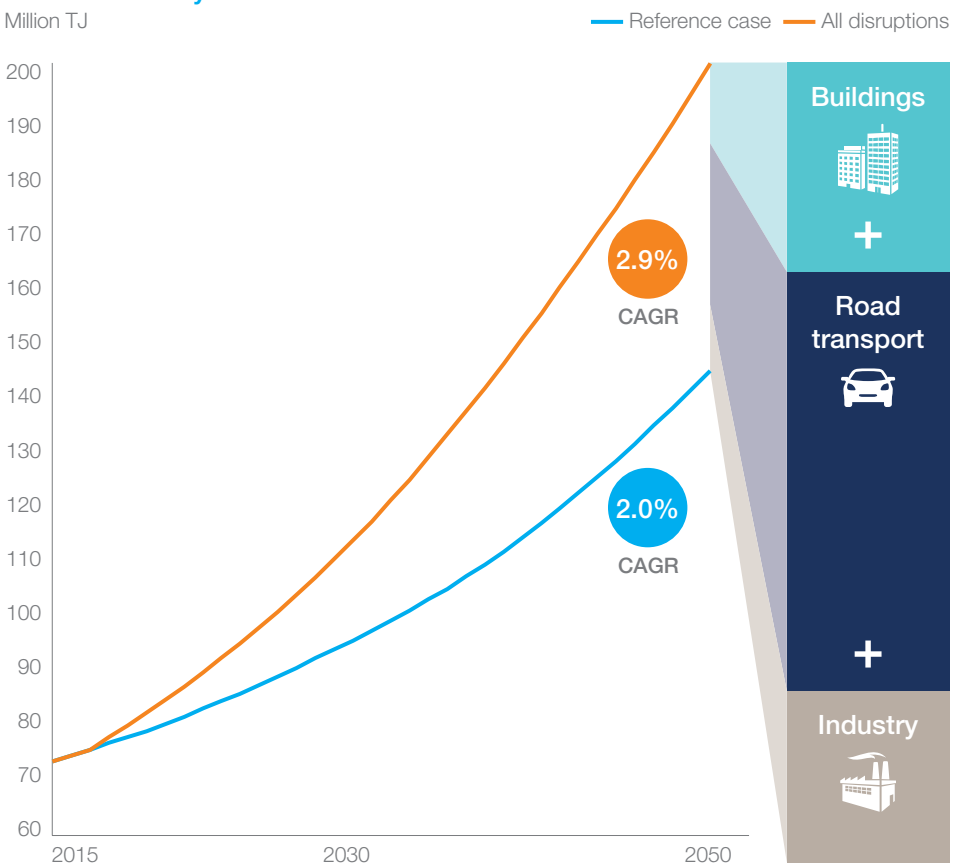
1 ICE: internal combustion engine BEV: battery electric vehicle

Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

In a disrupted case, electricity demand growth could be boosted to 2.9% per year

Global electricity demand

Million TJ



Reference case Additional with disruption

Residential heat pump adoption

% households with heat pumps[1]

2015	3		
2030	10	11	21
2050	24	14	38

EV passenger car penetration

EVs as % of global new passenger car sales

2015	<1		
2030	20	14	34
2050	73	17	90

EV commercial vehicle penetration

EVs as % of global new truck sales

2015	<1		
2030	12	12	24
2050	67	15	82

Electrification of industrial heat

% global process heat electrified

2015	14		
2030	14	31	45
2050	14	46	60

1 Only in OECD Americas and OECD Europe

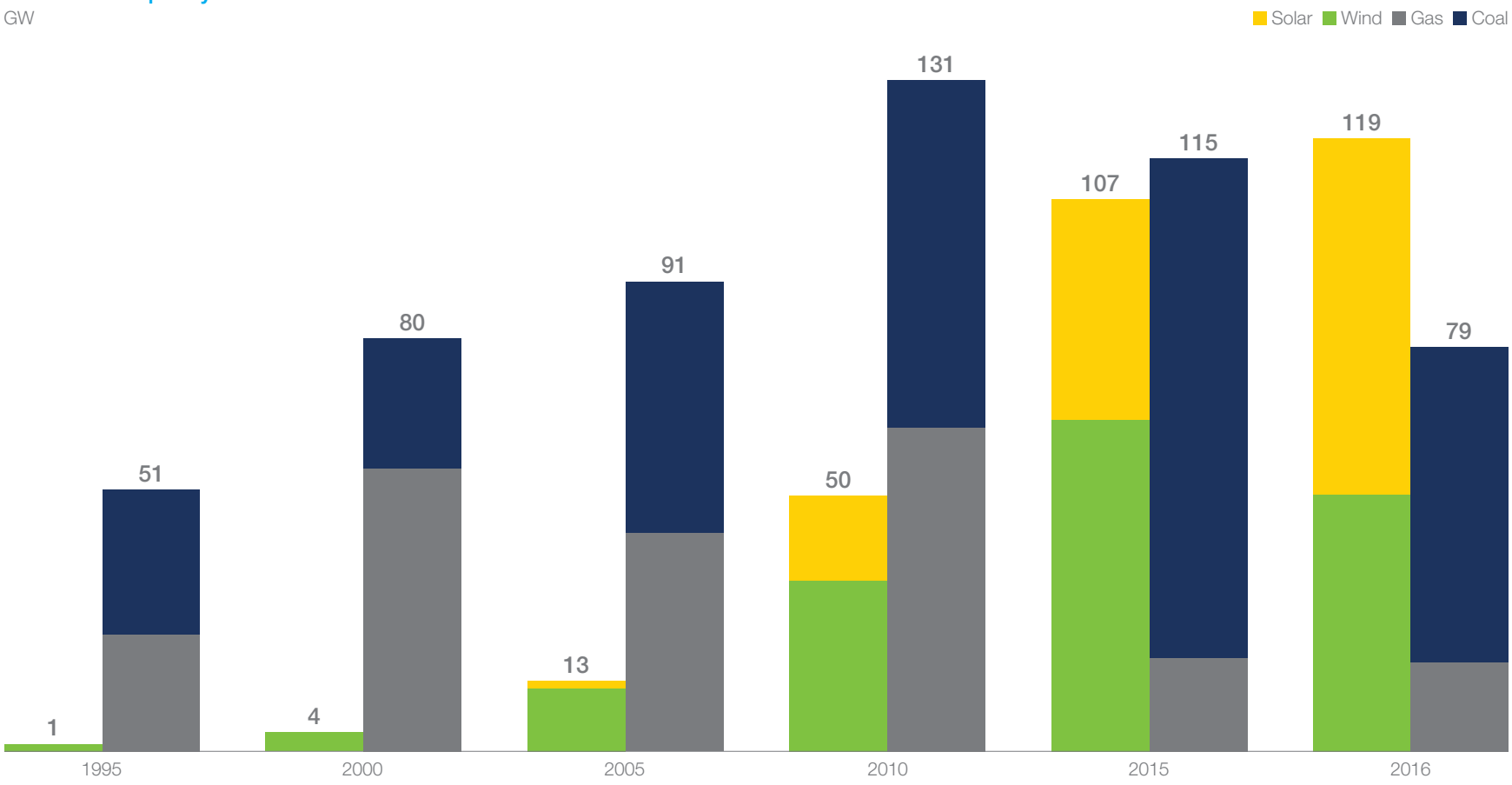
Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

3 Renewables' cost decline accelerates further, out-competing new-built fossil capacity today and existing capacity in 5-10 years

2016 was the first year in which solar and wind net additions exceeded coal and gas

Net annual capacity additions

GW



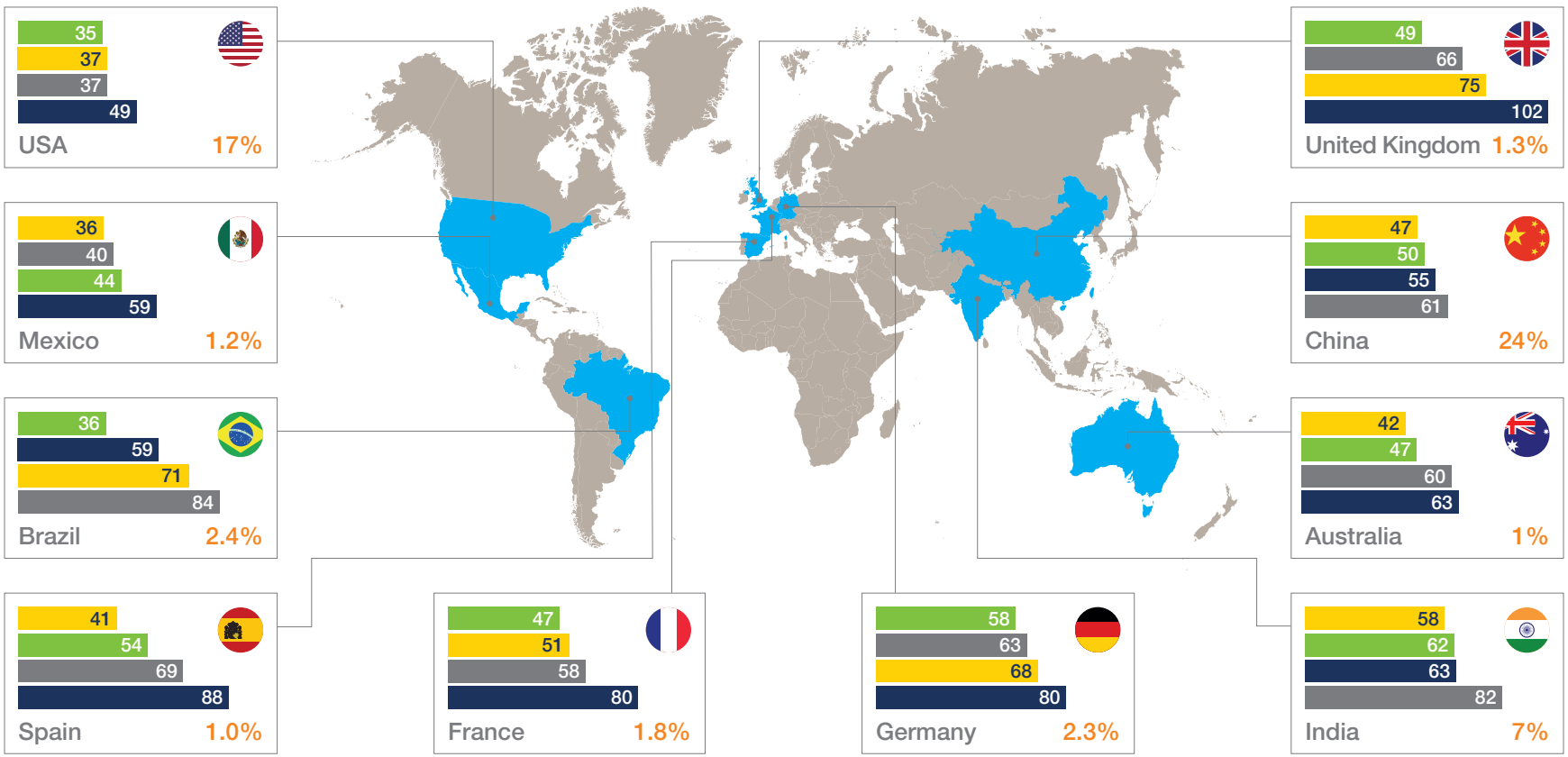
Source: Enerdata, UDI

This is driven by rapidly improving economics of renewables: already in 2020, they are the most economic new-build option across regions

Most economical new-build LCOE

2020, USD/MWh

Solar PV Wind Gas Coal 00 Share global electricity demand

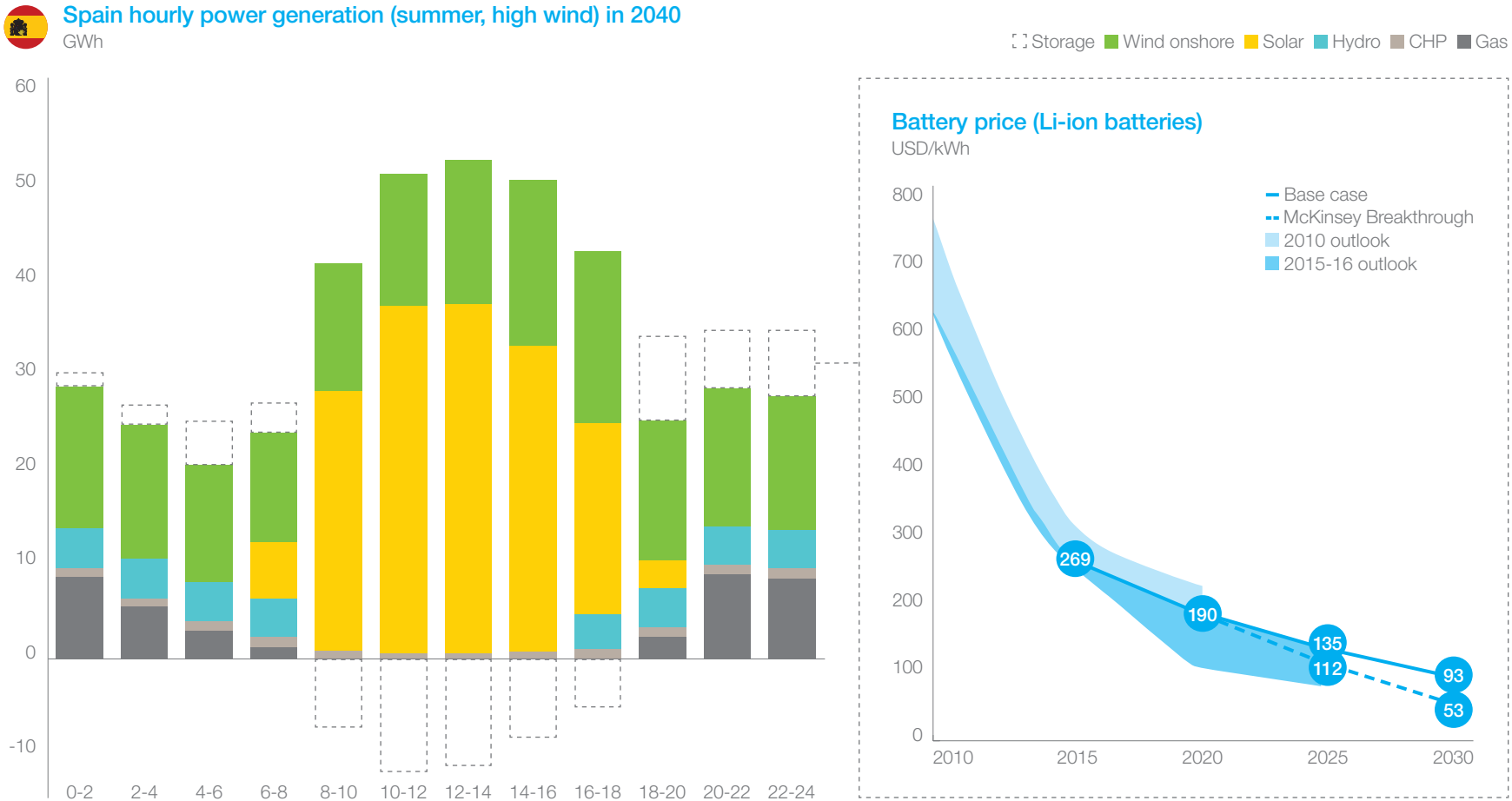


Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

New renewables become cheaper than even existing CCGTs by 2030 in some markets

1 Short run marginal cost for existing capacity and levelized cost of energy for new capacity
Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

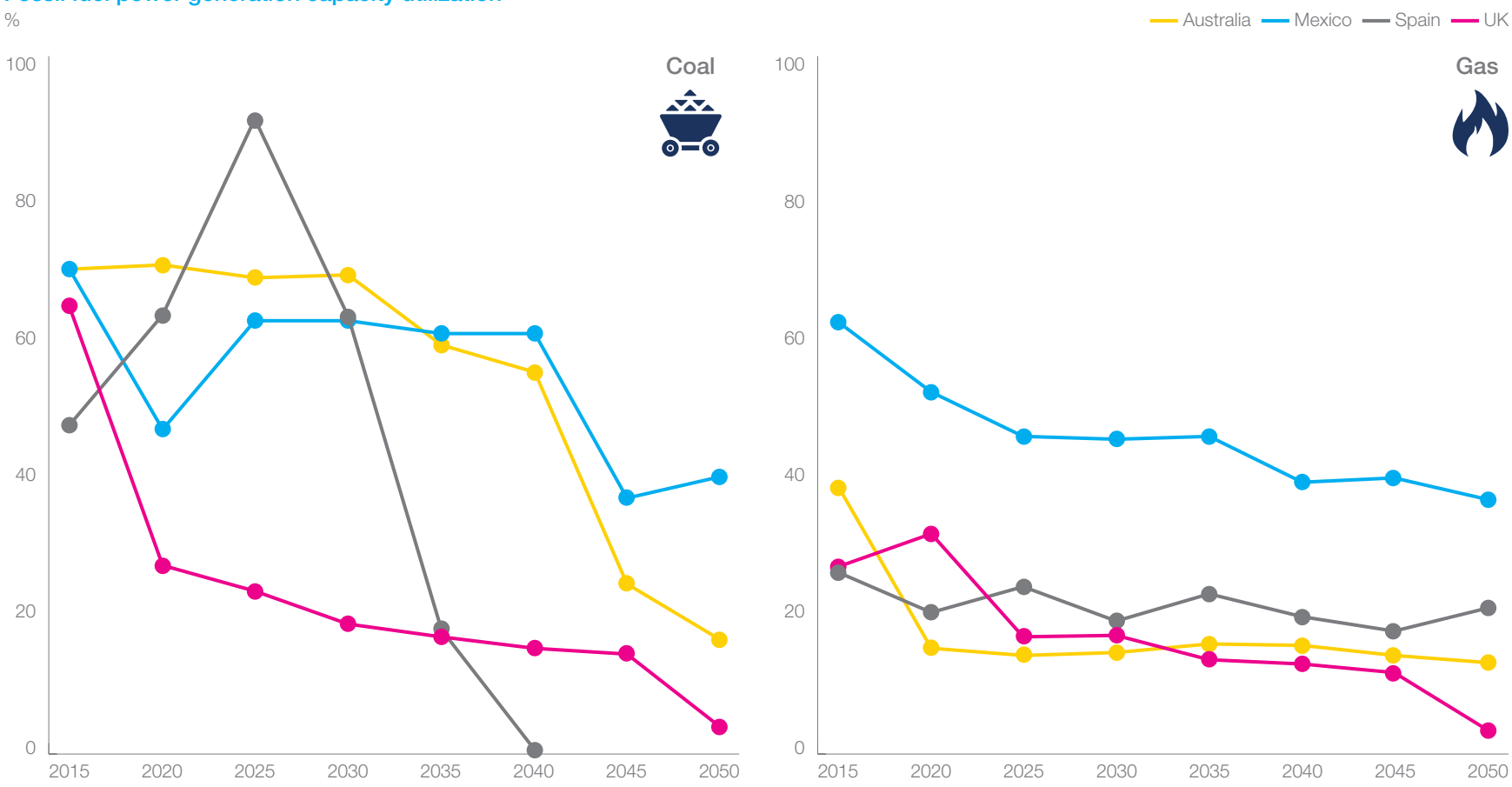
The large-scale shift to renewables is further catalyzed by fast-declining storage costs



Sources: McKinsey Energy Insights' Global Energy Perspective, December 2017; SNE research; Navigant; Bernstein Research; expert interviews

The rapid uptake of renewables will shift the role of fossil fuelled power plants, triggering steep declines in utilization rates

Fossil fuel power generation capacity utilization

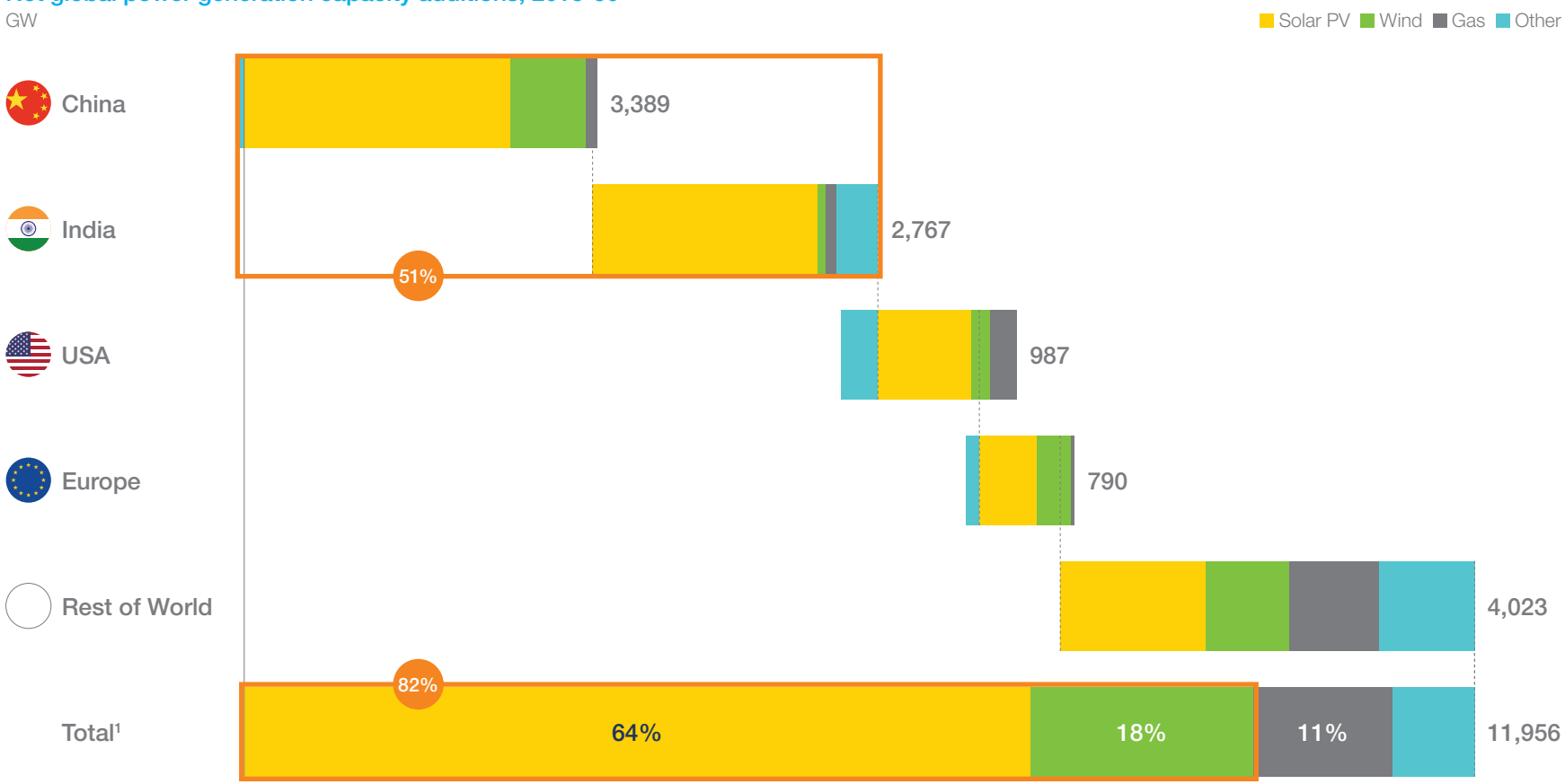


Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

Globally, more than 80% of capacity additions will be in solar and wind, with China and India contributing more than half

Net global power generation capacity additions, 2015-50

GW



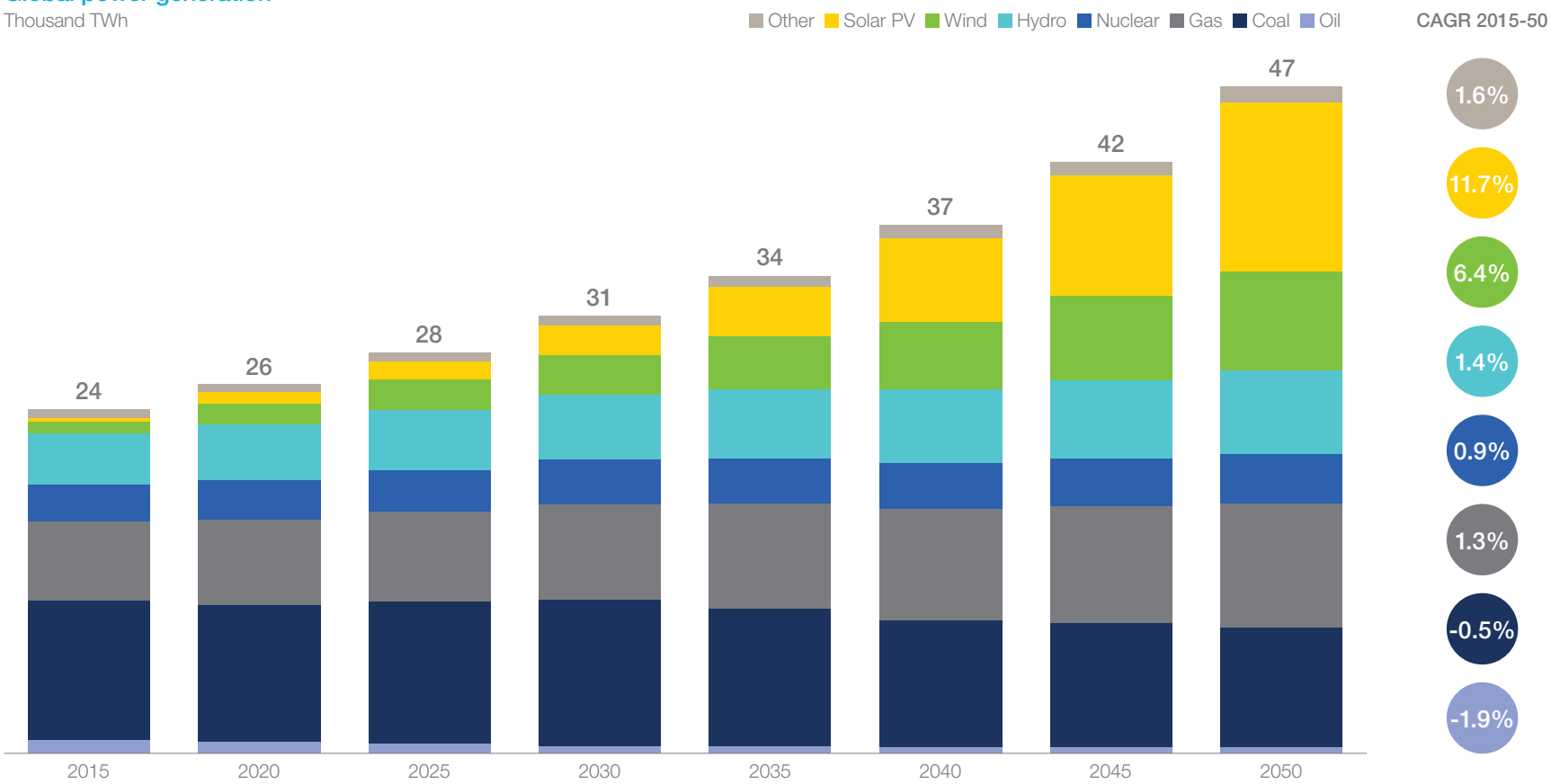
1 Based on bottom-up modelling of 14 countries representing 65% of global power demand, and top-down assessment of remainder of the world

Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

Solar and wind generation grow 5-10 times faster than gas, and coal declines after 2030

Global power generation

Thousand TWh

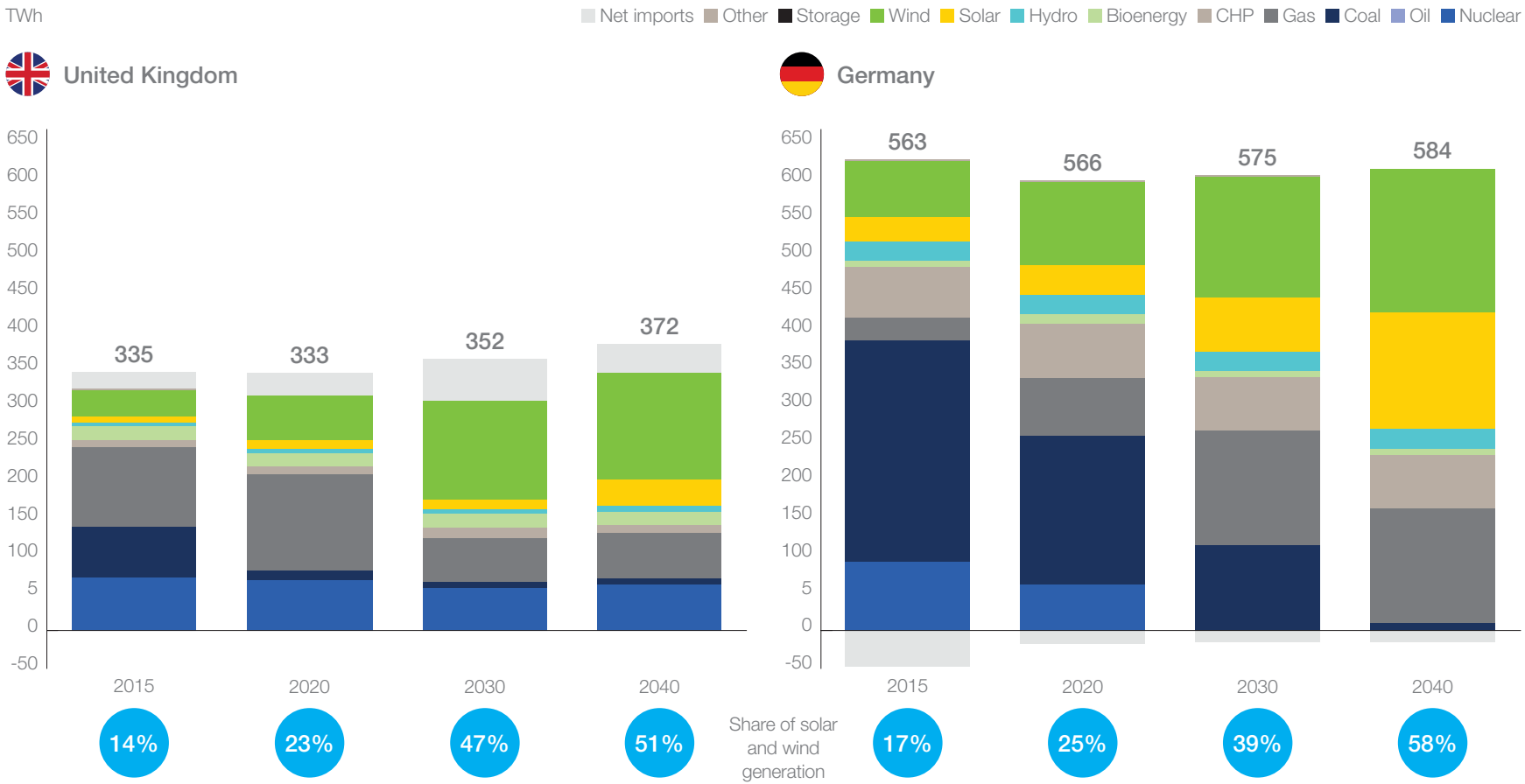


1 Other includes biomass, geothermal and marine

Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

The impact these developments will have on power systems vary substantially by market

Generation mix in the Reference Case

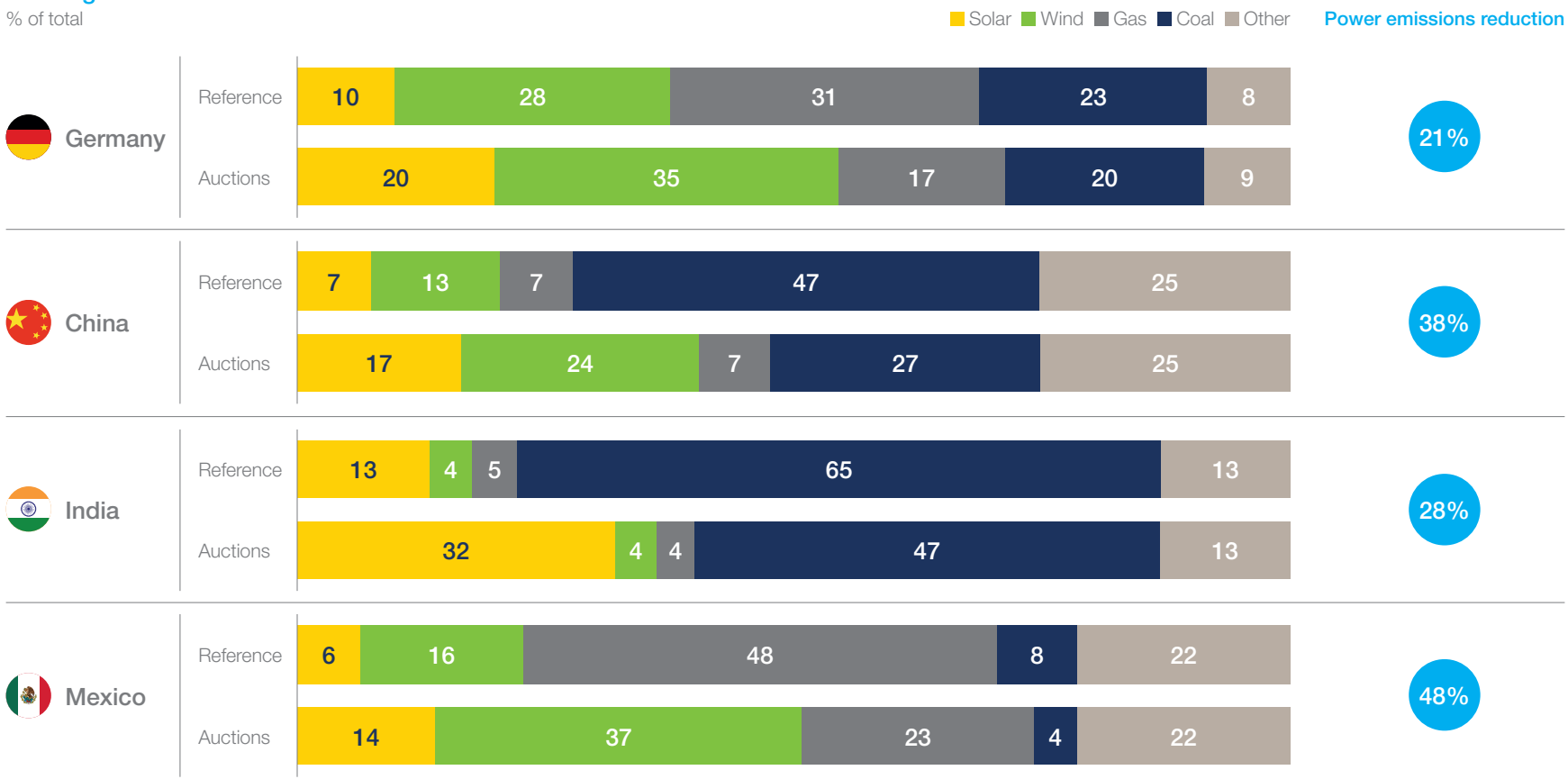


Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

If renewables are delivered at the low bids seen in recent auctions, we could witness even higher penetration of wind and solar, at the expense of gas and coal

Power generation mix in the Reference and Auctions[1] scenarios in 2030

% of total



1 'Auctions as Reality' scenario realizes substantially lower prices for solar PV and onshore wind (reflecting recent auction results) relative to the Reference Case

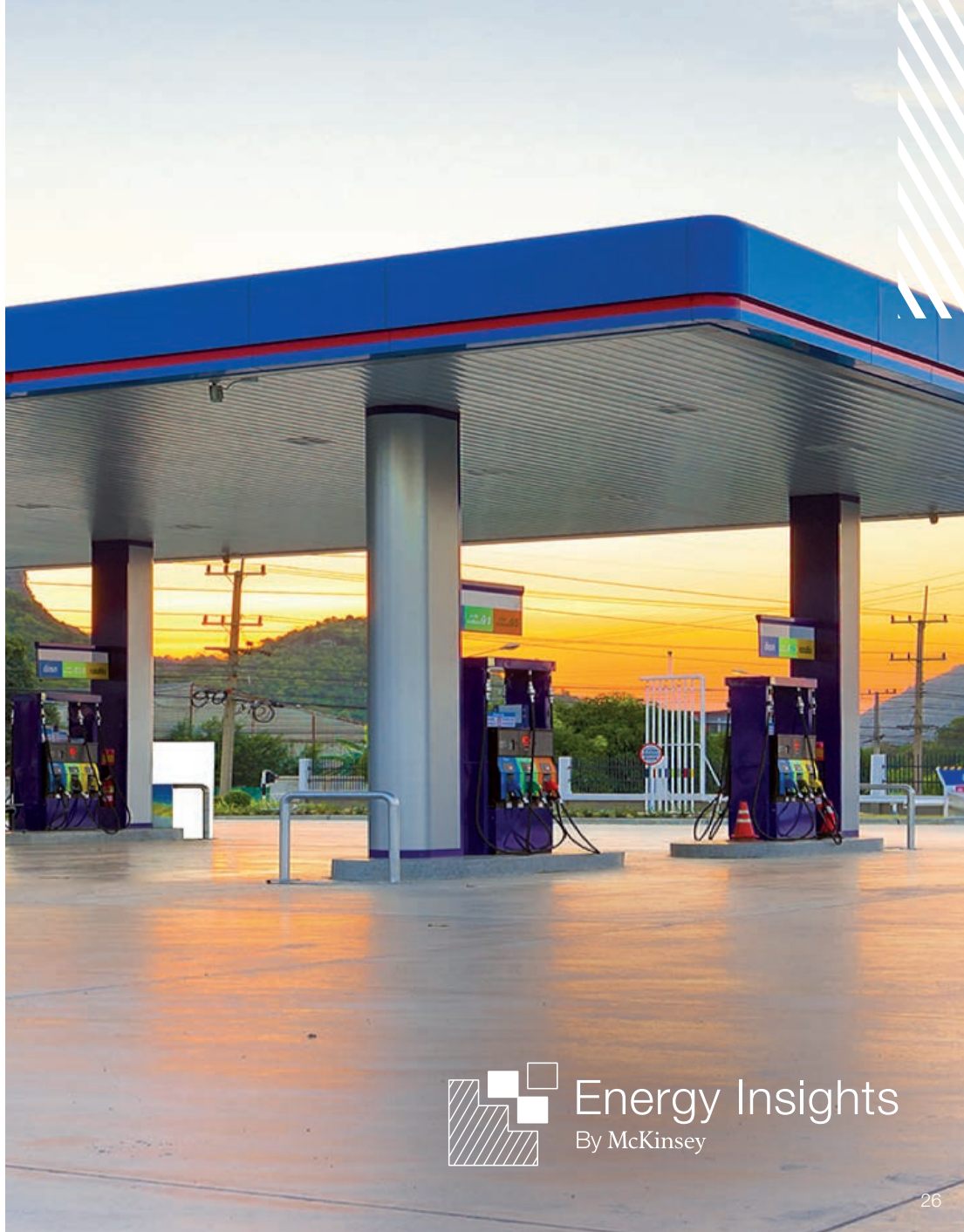
Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

In a fast-changing world, key uncertainties will determine how these developments play out locally

	**Regulatory/municipal push for electrification/decarbonization**	• Carbon prices • Efficiency requests pushing EVs/ electricity in buildings, e.g. C40 initiative
	**Market models and implications of high renewables systems**	• Sink for electricity in negative electricity spikes pushing hybrid • Capacity/storage markets
	**Increasing connectivity of power markets – electricity exports**	• Surge of inter-region and intra-country transmission/ grid design to connect to low RES regions • Hydrogen synthetic fuel exports
	**Nuclear and coal politics sensitivities**	• National plan scenarios of decommissioning vs. new push for small scale/next gen reactors • Coal subsidies for energy security/ jobs
	**Fossil fuel price impacts**	• Impact of potential low demand driving prices down: revival of other segments? Resulting investment cycles?
	**Resource and supply chain implications**	• Implied demand for e.g. copper, lithium, silicon, rare earths • Land use implications from solar/wind build out • Demand for installation and O&M of new technologies
	**Consumer consciousness**	• Pull for low efficiency technologies reducing demand vs. hunger for materialism

Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

4 Coal demand peaks in next decade, oil in the next two; in contrast, gas continues to grow modestly



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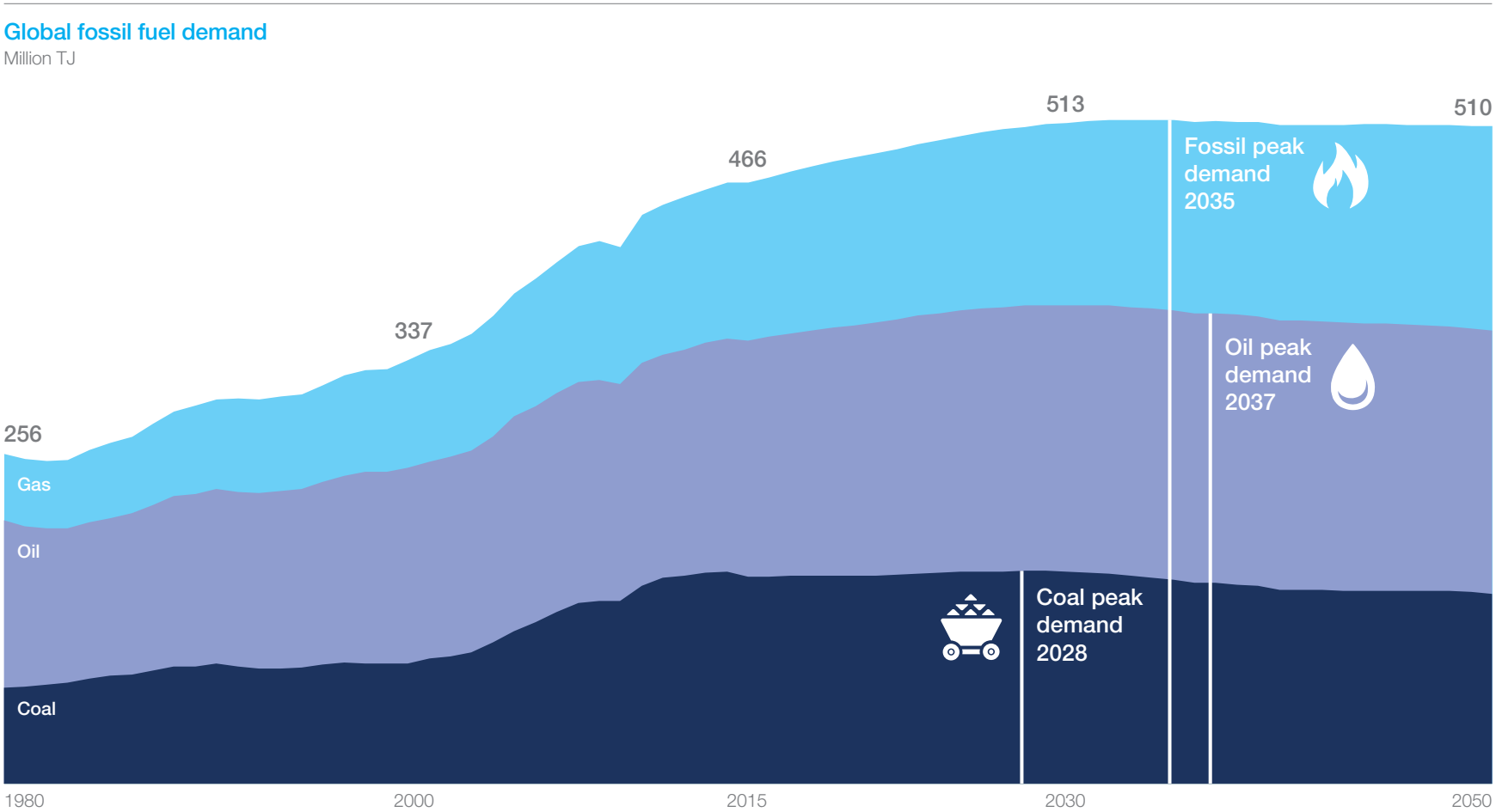
Fossil fuel use flattens from 2035, with oil and coal in decline but gas use continuing to expand

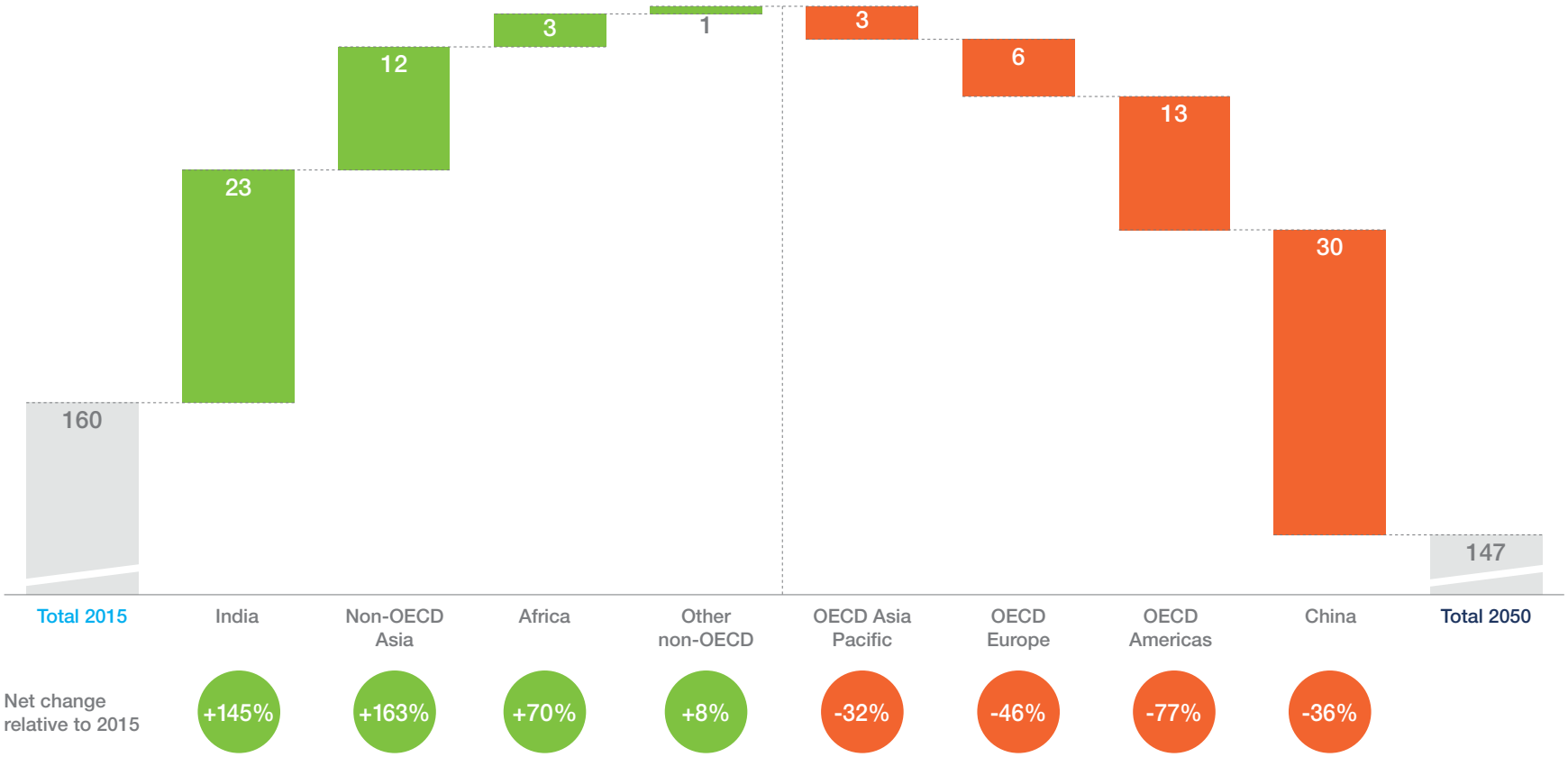


Sources: McKinsey Energy Insights' Global Energy Perspective, December 2017; IEA Energy Balances (Historical)

Strong growth in coal demand in India and other developing markets partially offsets declining demand in OECD countries and in China

Coal demand by region

Million TJ

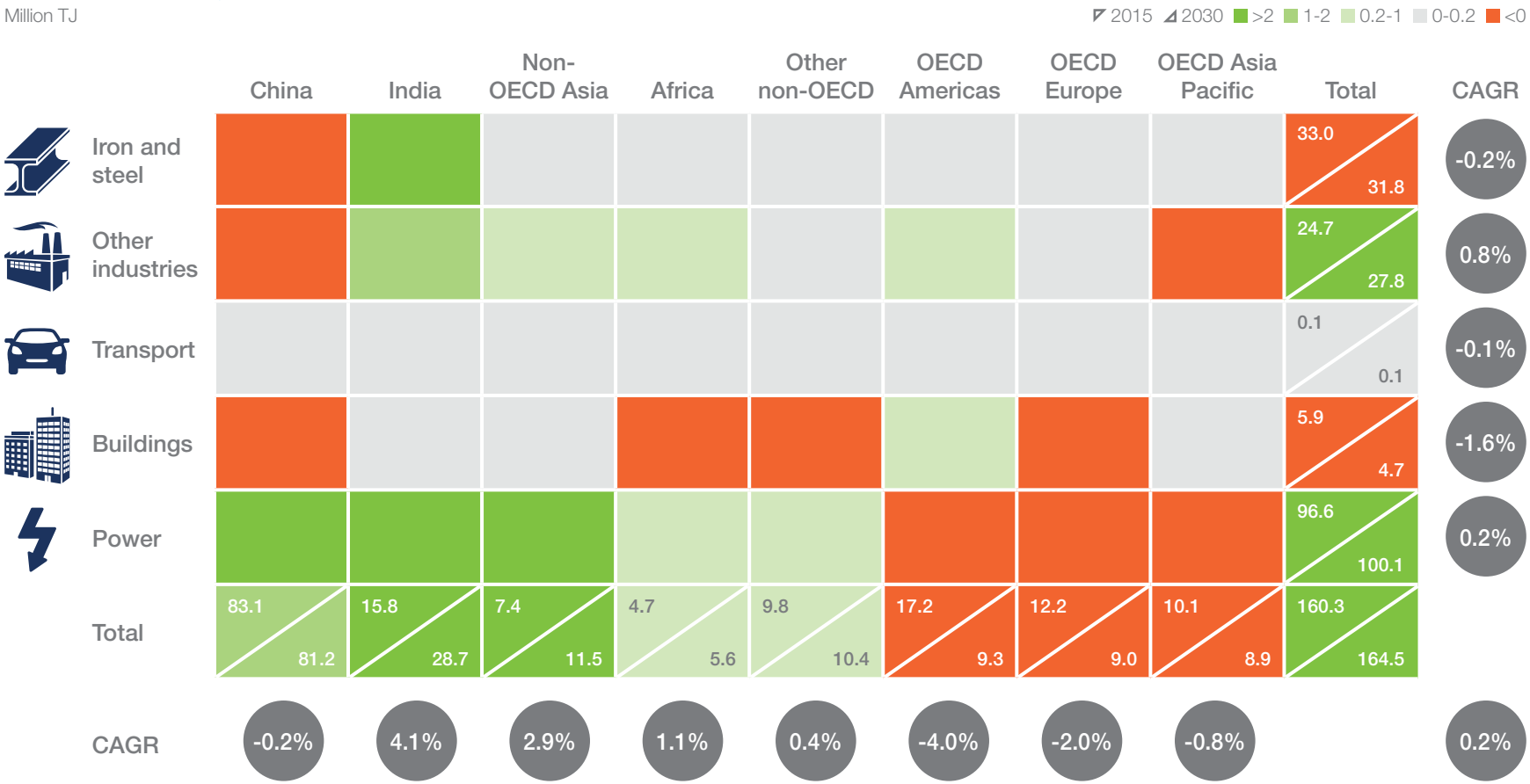


Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

By 2030, this still implies higher coal demand than today based on growth in power and other industries, and cement in particular

Global coal demand, 2015-30 delta

Million TJ



Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

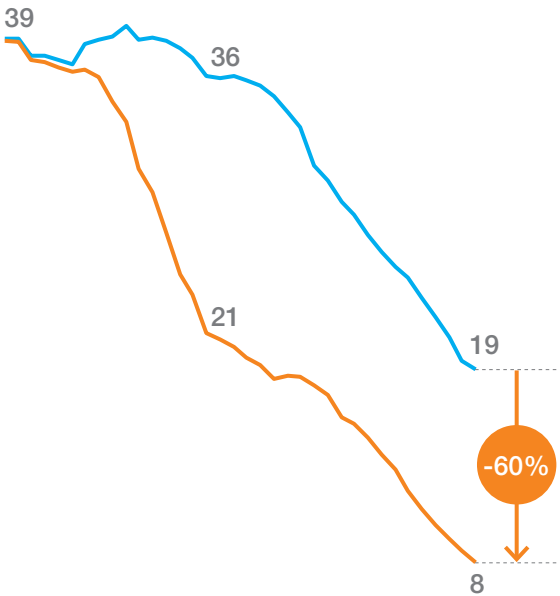
Additional acceleration of cost declines in renewables could reduce coal demand for power by over 50% in China and India

Coal demand for power generation

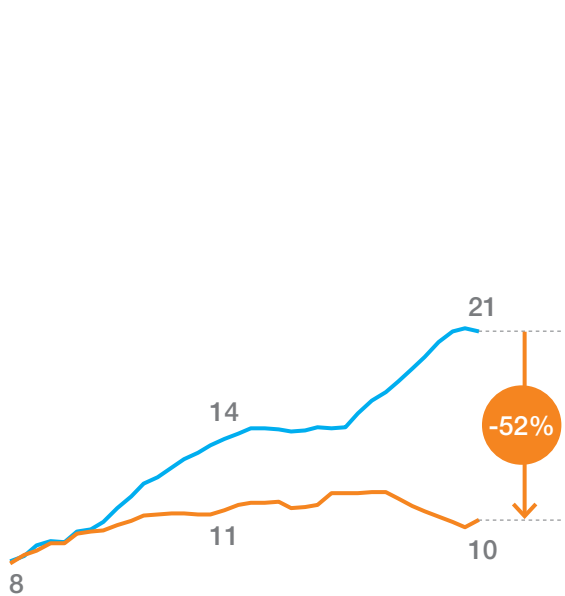
Million TJ

Reference Case — Auctions as Reality[1]

China

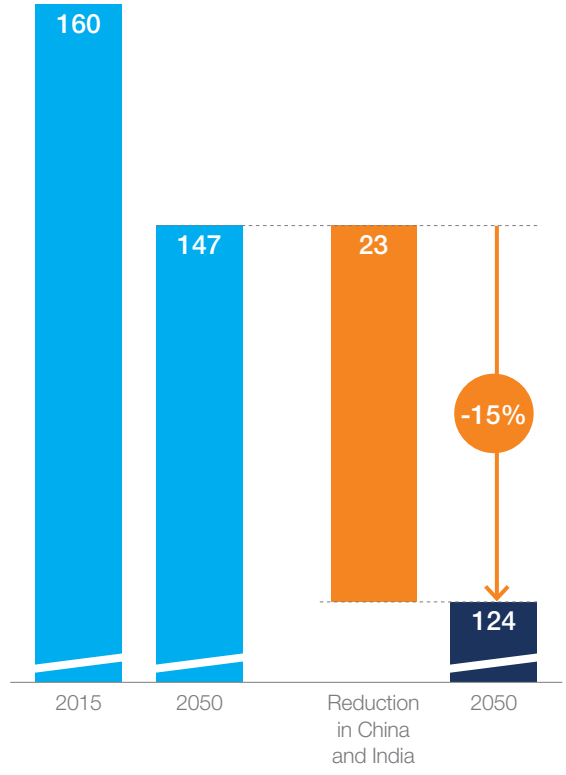


India



Global coal demand

Million TJ



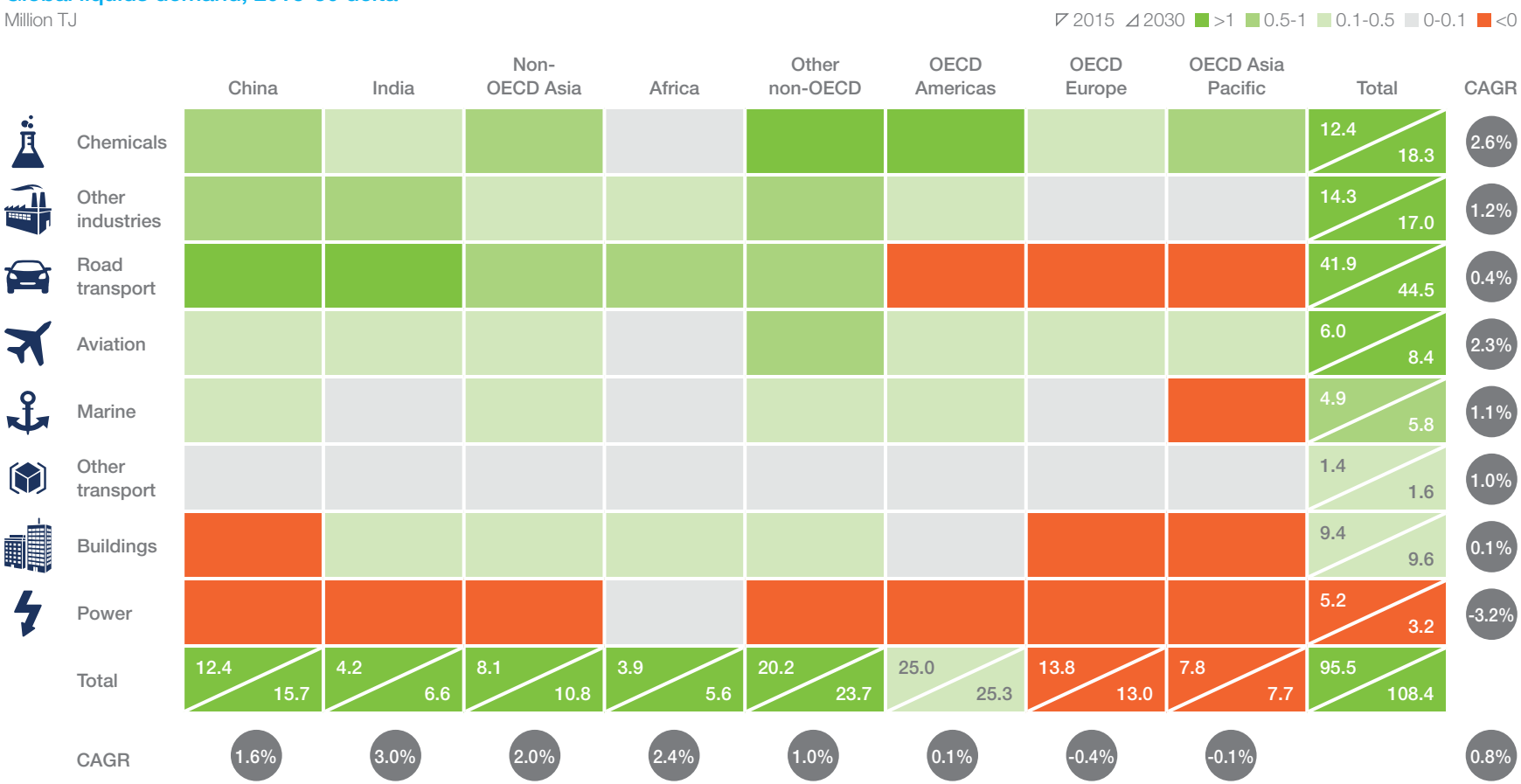
1 'Auctions as Reality' scenario realizes substantially lower prices for solar PV and onshore wind (reflecting recent auction results) relative to the Reference Case

Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

In the next decade, liquids demand growth is fueled by chemicals and transport

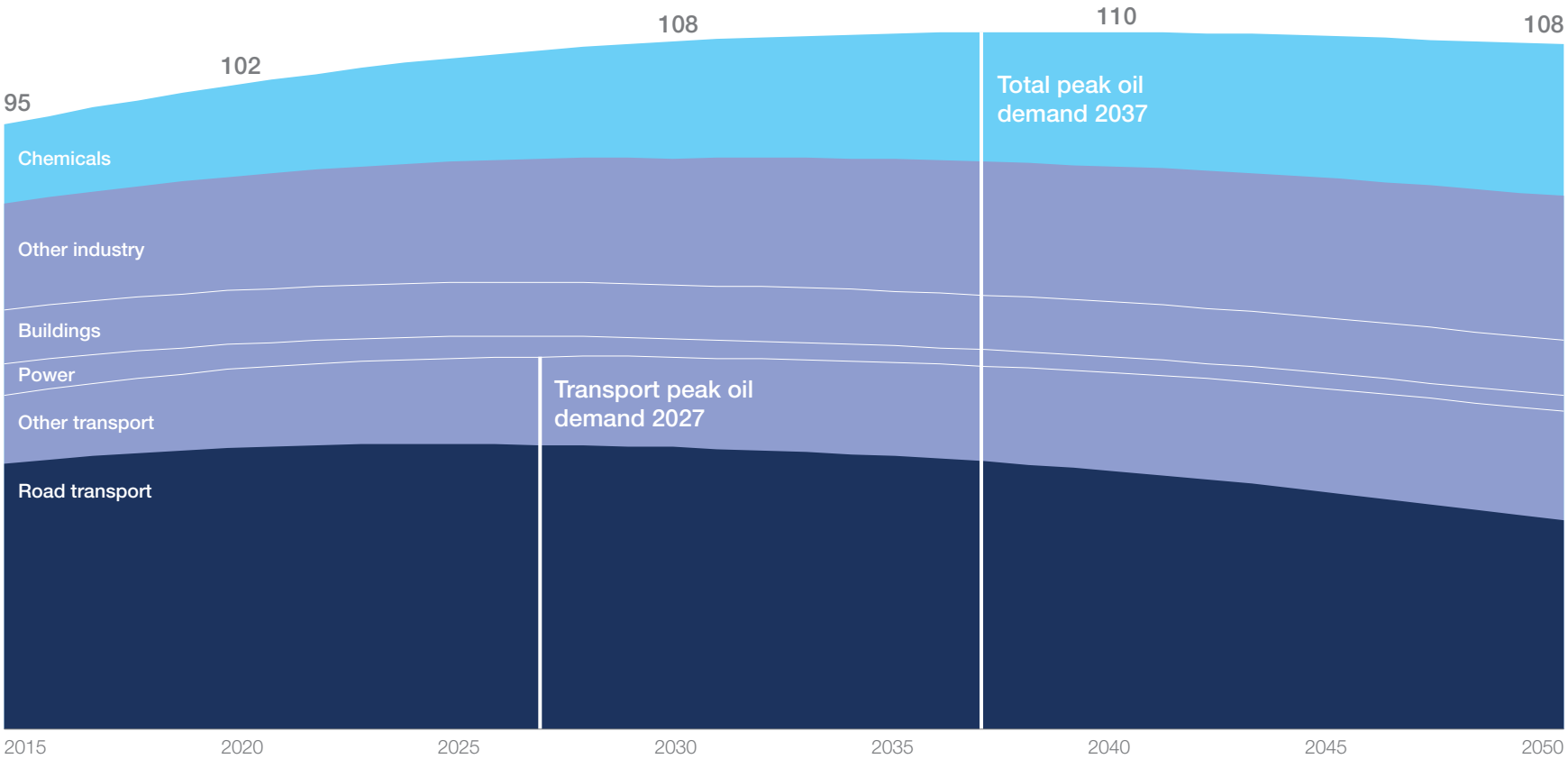
Global liquids demand, 2015-30 delta

Million TJ



Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

Yet, this growth is finite: peak oil demand is reached before 2040, driven by efficiency improvements and electrification in road transport

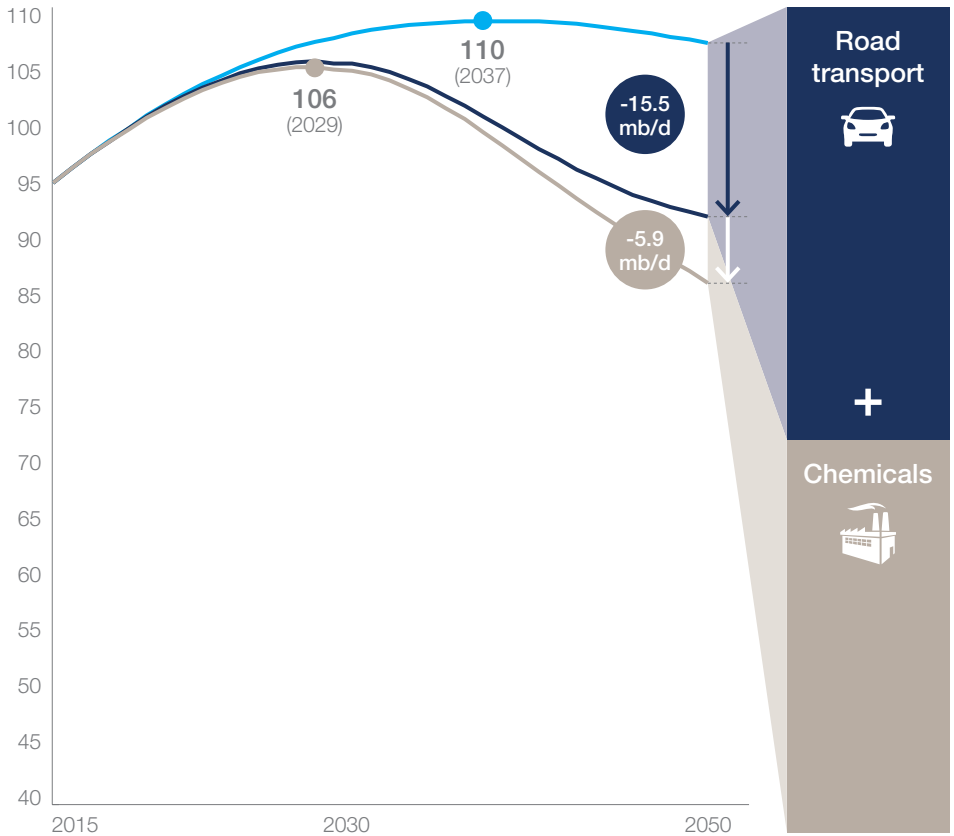


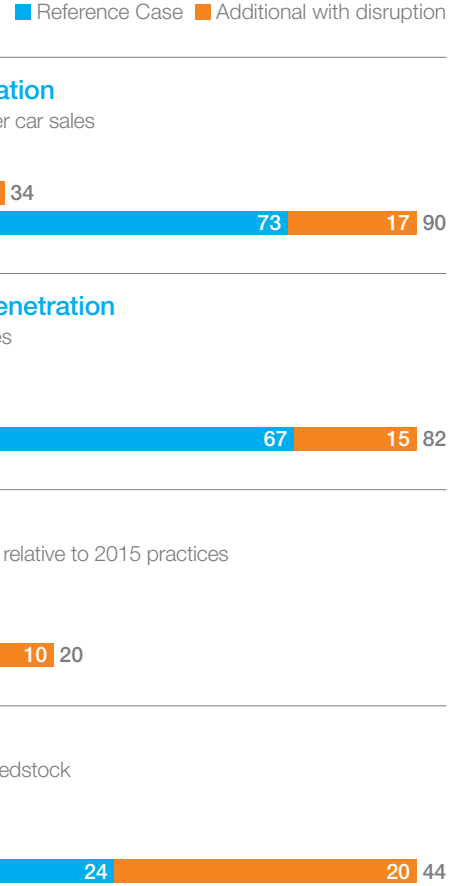
Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

With disruption in road transport and chemicals, oil demand could peak before 2030

Global liquids demand

Million barrels per day



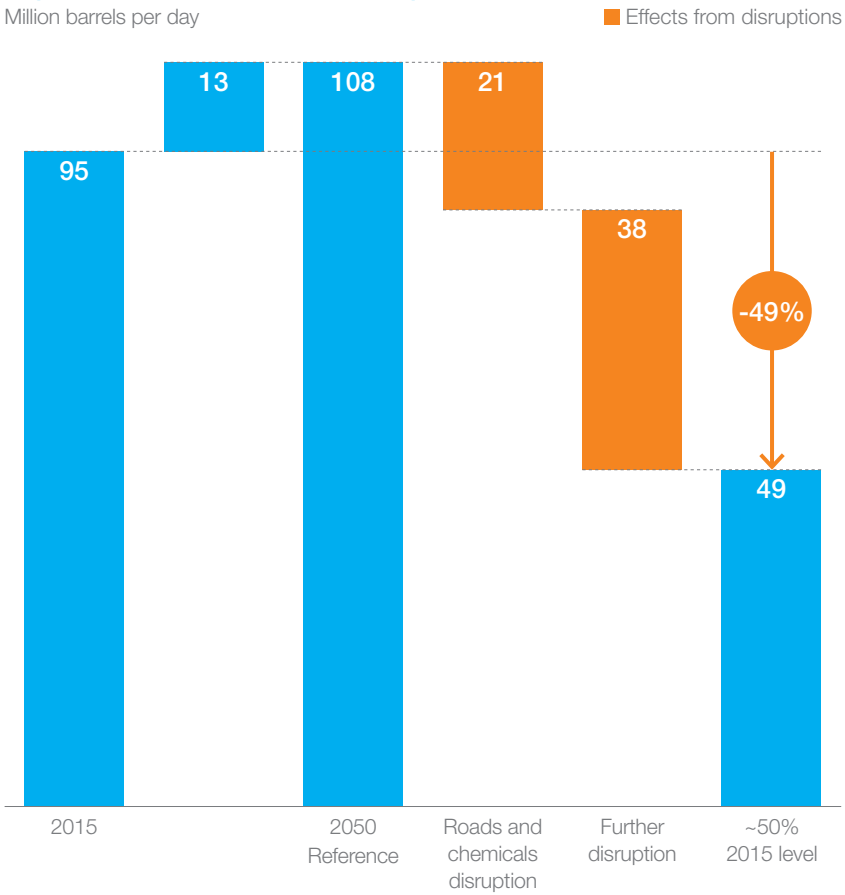


Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

What would you have to believe to see liquids demand plummet to half of today's level?

Liquids demand with further disruption

Million barrels per day



Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

What would you have to believe in each sector?

Road transport
All new vehicles sales are EVs as of 2030, causing rapid shift of OEM production lines and electric infrastructure build out

Marine
Stringent air emissions regulation prompt conversion to LNG of a substantial share (30%) of the shipping fleet

Aviation
The industry achieves its fuel economy improvement stretch target of 2.0% per year

Chemicals
Packaging efficiency reaches 30%, recycling of plastics 20-60% and 10% of virgin ethylene from biomass sources due to global, industry-wide standards to reduce plastics environmental impact

Other industry
Transport equipment within industry electrifies and historical rates of efficiency improvement are maintained

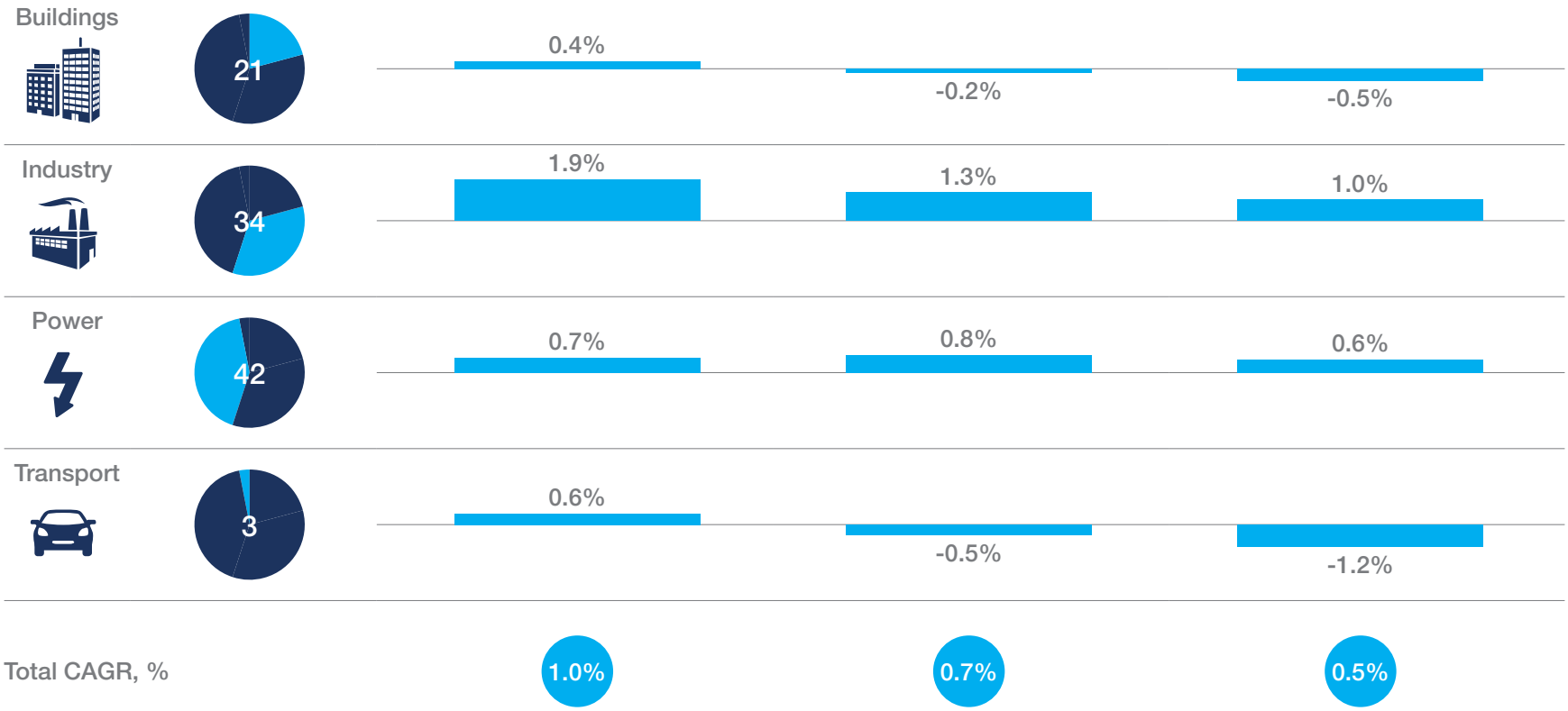
Buildings
OECD countries phase out oil-powered space and water heating in favour of more efficient gas or electricity

Power
Oil-fired generation is completely phased out as renewables with storage prove cheaper

Gas demand develops very differently by sector and over time – only industry and power continue to show growth

Global gas demand share and CAGRs by sector

CAGR %

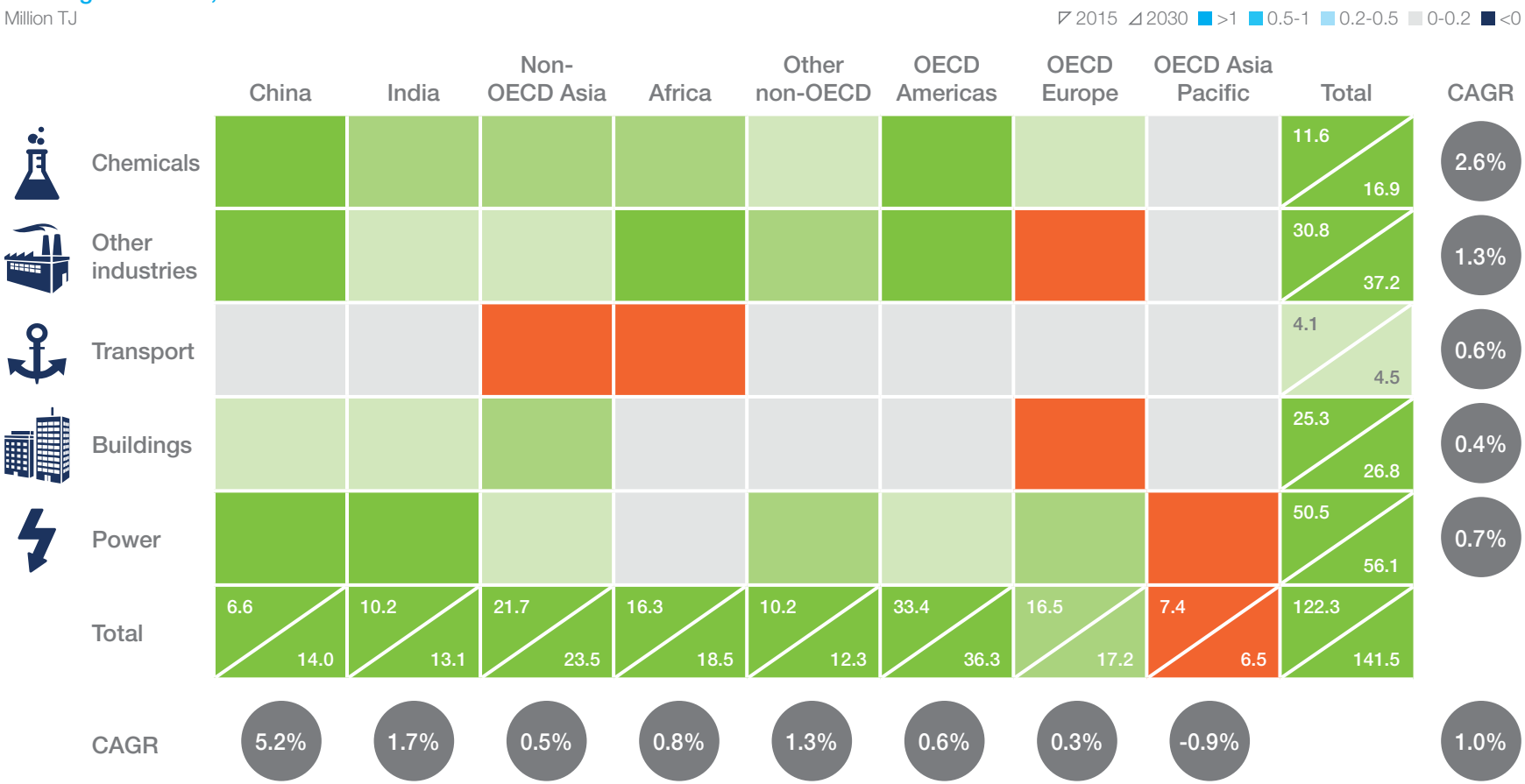


Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

Gas demand growth is driven by China's policy push for gas use in power and industry as well as by competitive prices in producing regions

Global gas demand, 2015-30 delta

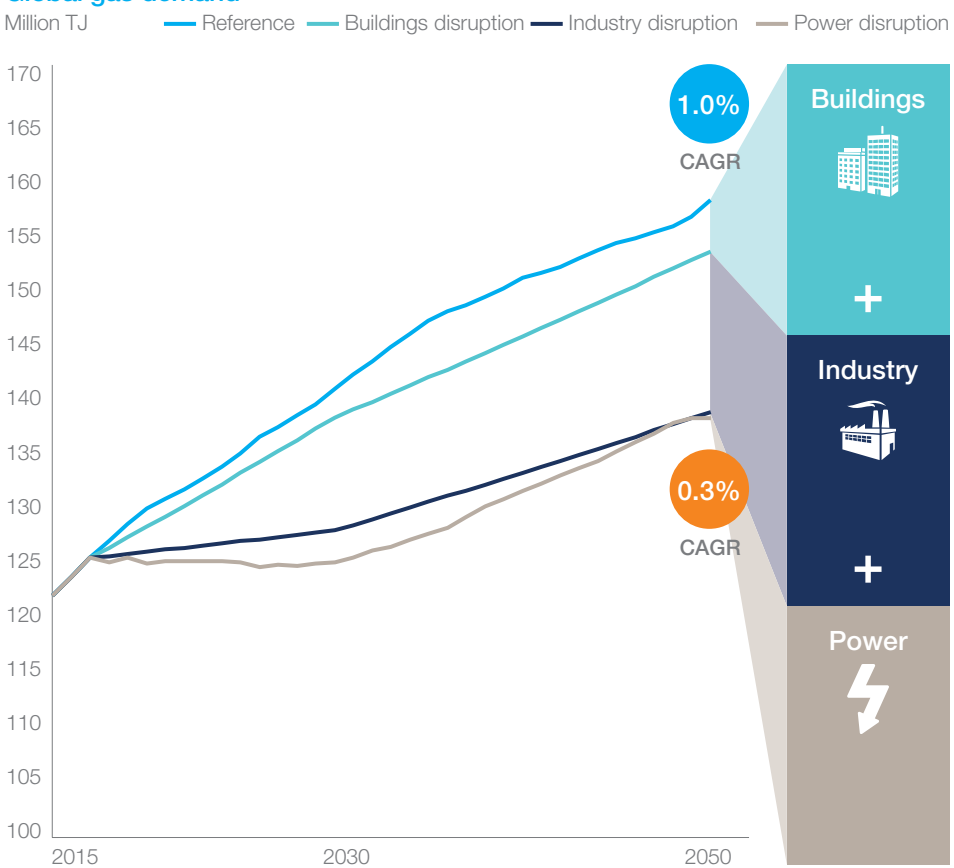
Million TJ

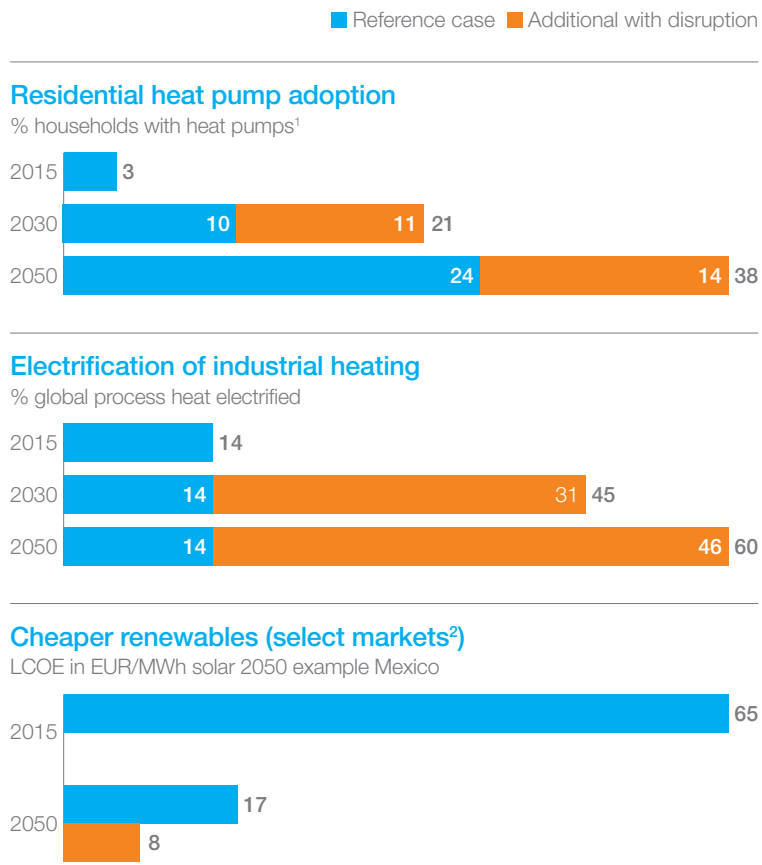


Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

A combination of industrial and residential disruptors could slow global gas demand growth to 0.3% per year, with power rebounding to balance renewables

Global gas demand



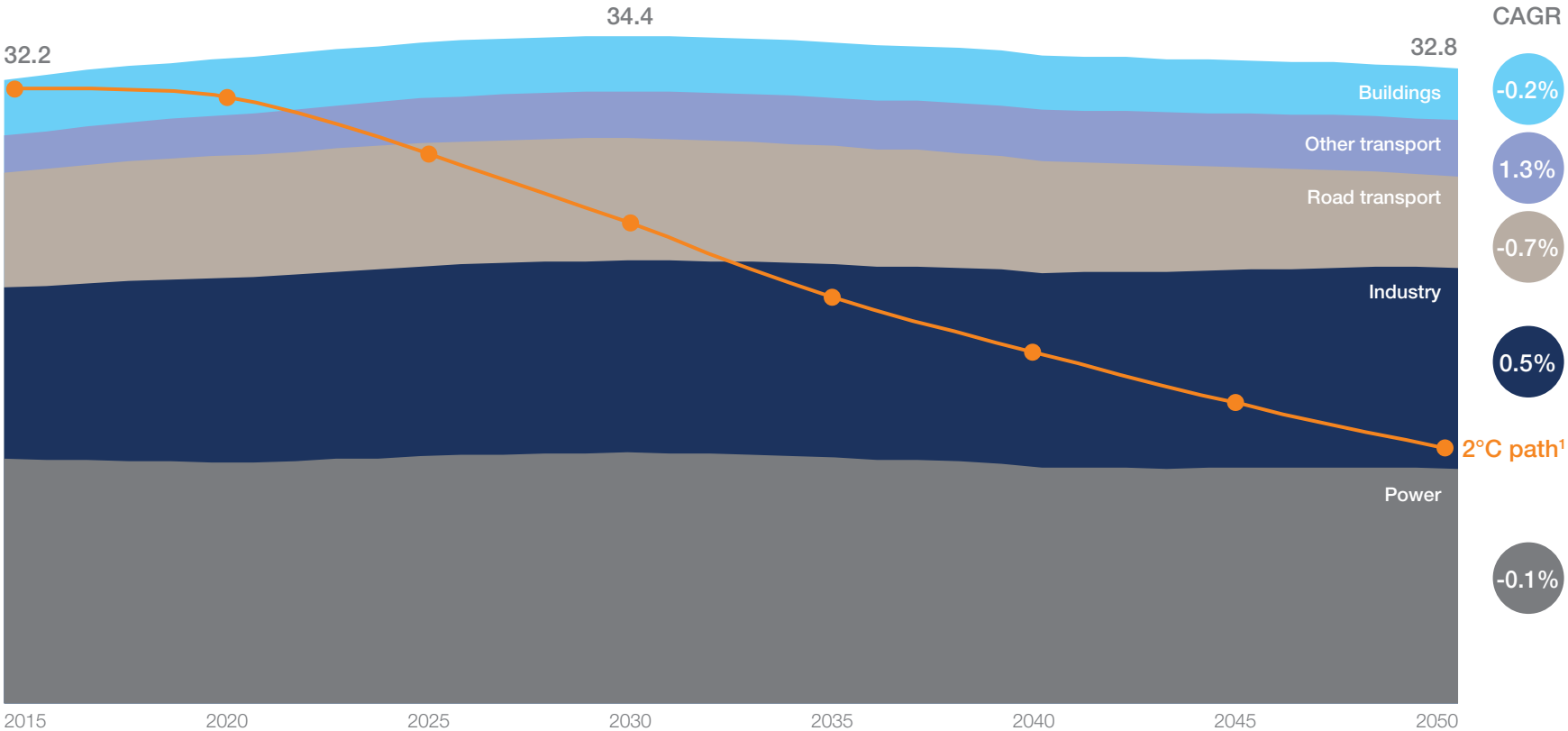


1 Only in OECD Americas and OECD Europe **2** Impact only assessed for: China, India, Germany, France, UK, Spain, Italy, Russia, Mexico, Brazil, Australia, and South Africa
Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

5 CO_2 emissions plateau by 2030 and remain far from a 2°C pathway

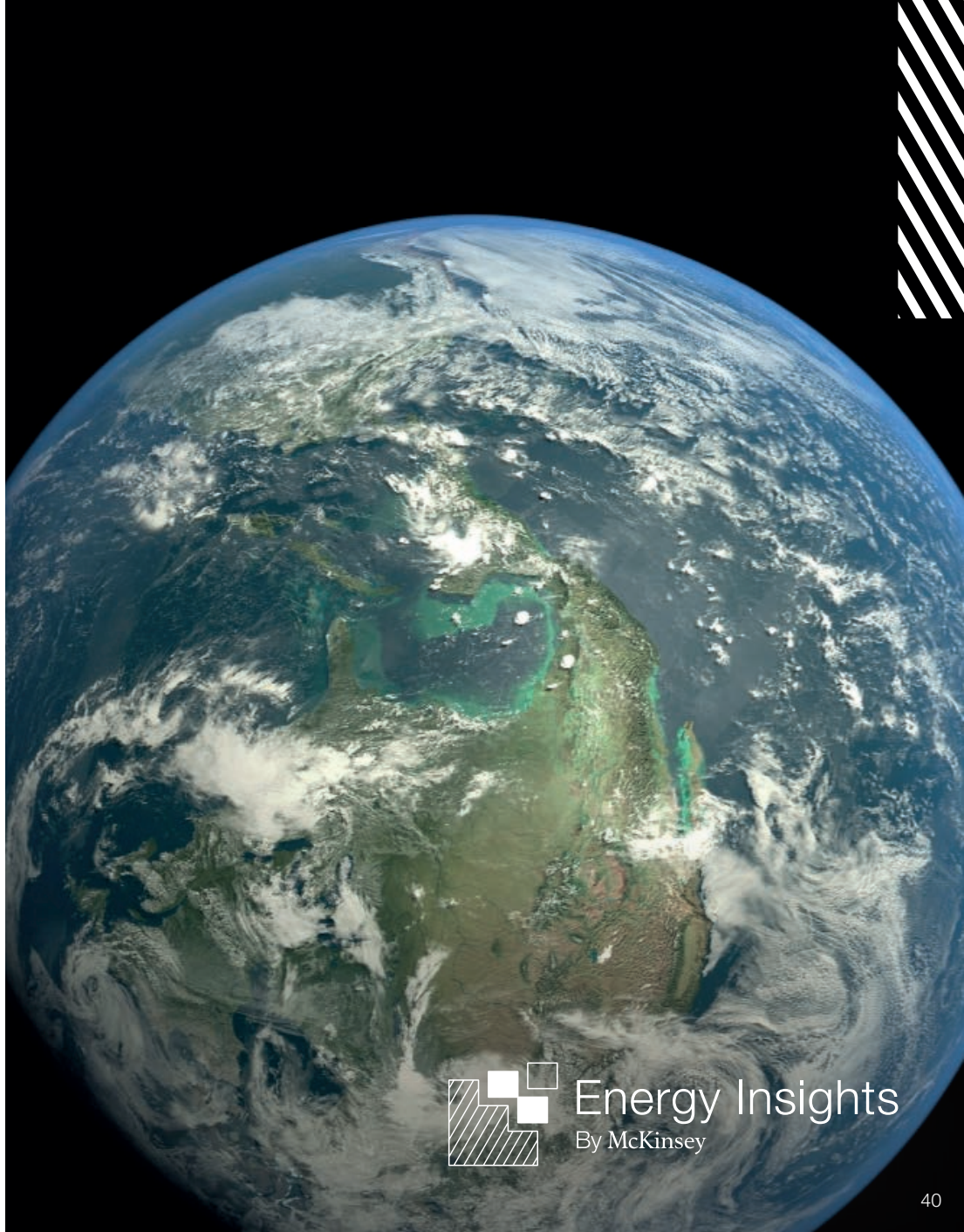
Energy-related CO_2 emissions peak around 2030 but remain more than double the level consistent with a 2°C long-term pathway

Energy-related CO_2 emissions by sector[1]
Gigatonnes CO_2-equivalent



1 IEA Sustainable Development Scenario emissions pathway consistent with a 1.5-2°C long-term global average temperature increase; extrapolated for 2040-50
Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

Implications



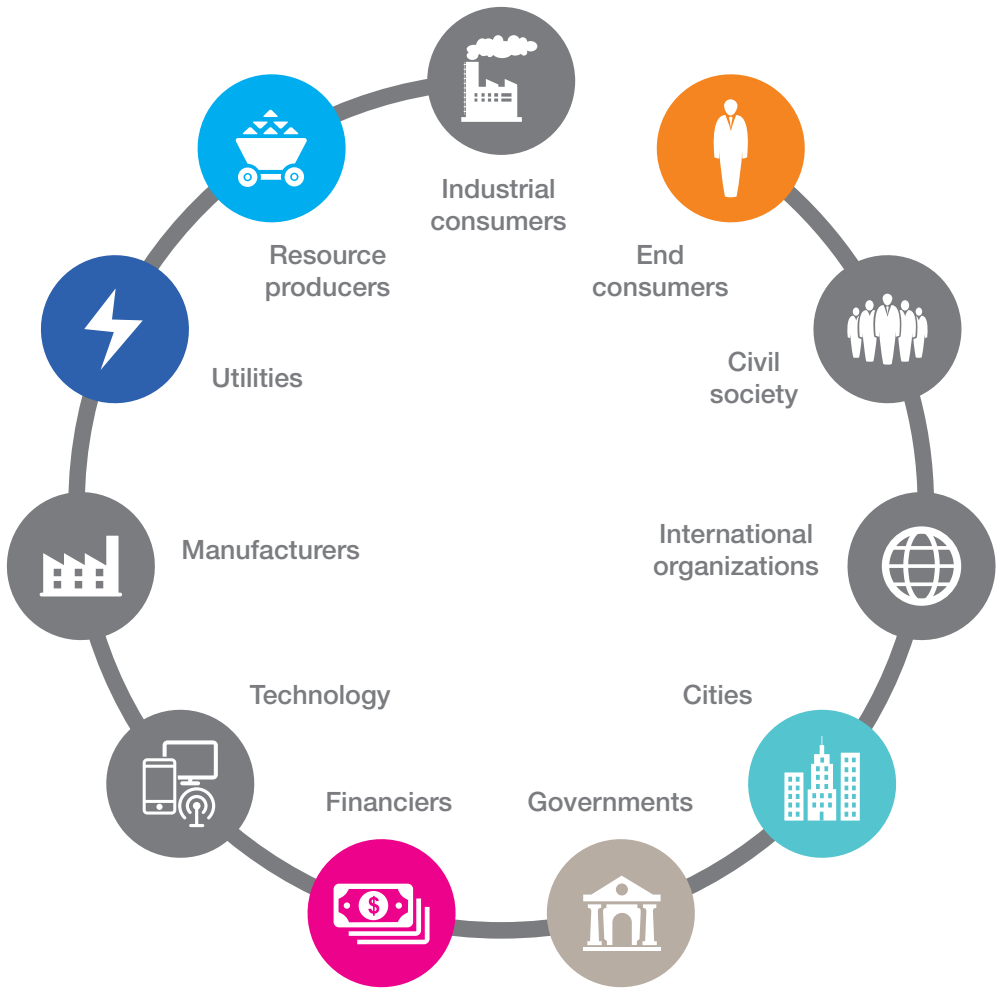
Questions we are discussing with our clients often affect multiple stakeholder groups: examples

Resource producers

- How will resource demand be affected by the regional and sectoral shifts in energy systems?
- Will there be increasing price pressure on resources like oil or coal?
- When do we get peak resource demand and what are the disruptions to watch out for?
- How big is the impact from EVs on oil demand?
- What amount of growth in chemicals would be required to offset impact from recycling?
- Which markets will be key importers of energy?

Utilities

- What are the storage/ renewables costs to be 'in the money'?
- Will there be sufficient demand for all the planned renewables projects?
- Under which circumstances would I still invest into fossil?
- What are the grid/system costs implications of a high renewables power system?



End consumers

- What will be the impact on energy prices for end consumers?

Cities

- What are optimal measures to reduce GHG emissions and how does that change in the future?
- Should I switch the city buses to natural gas or electric?

Governments

- By when will renewables be able to compete economically with conventional generation in my market?
- What are the implications of and pre-requisites for a high renewables power system?

Financiers

- Will value pools be shifting from upstream and resources to downstream?
- If emissions KPIs lead to a reallocation of capital from more to less emission-intense investments – where would that lead the capital?

Get in touch

For more information about McKinsey Energy Insights' Global Energy Perspective please contact
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About us

We are a global market intelligence and analytics group focused on the energy sector. We enable organizations to make well-informed strategic, tactical, and operational decisions, using an integrated suite of market models, proprietary industry data, and a global network of industry experts. We work with leading companies across the entire energy value chain to help them manage risk, optimize their organizations, and improve performance.

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