

Global Energy Perspective: Reference Case 2018

December 2017

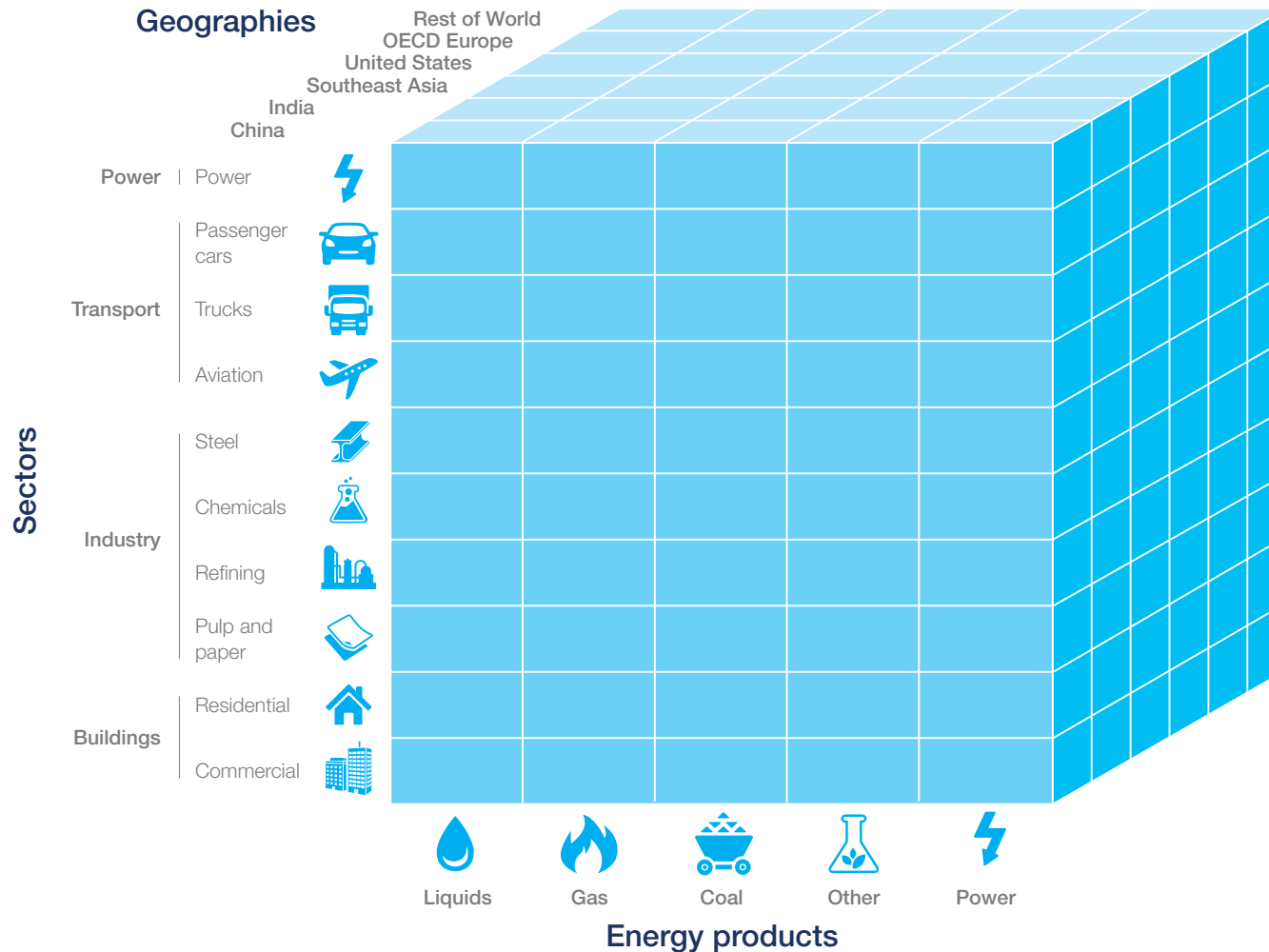
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Energy Insights
By McKinsey

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



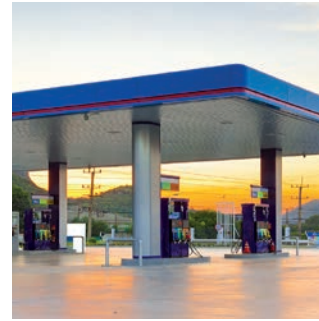
1 Global energy demand growth decelerates, following a structural decline in energy intensity



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

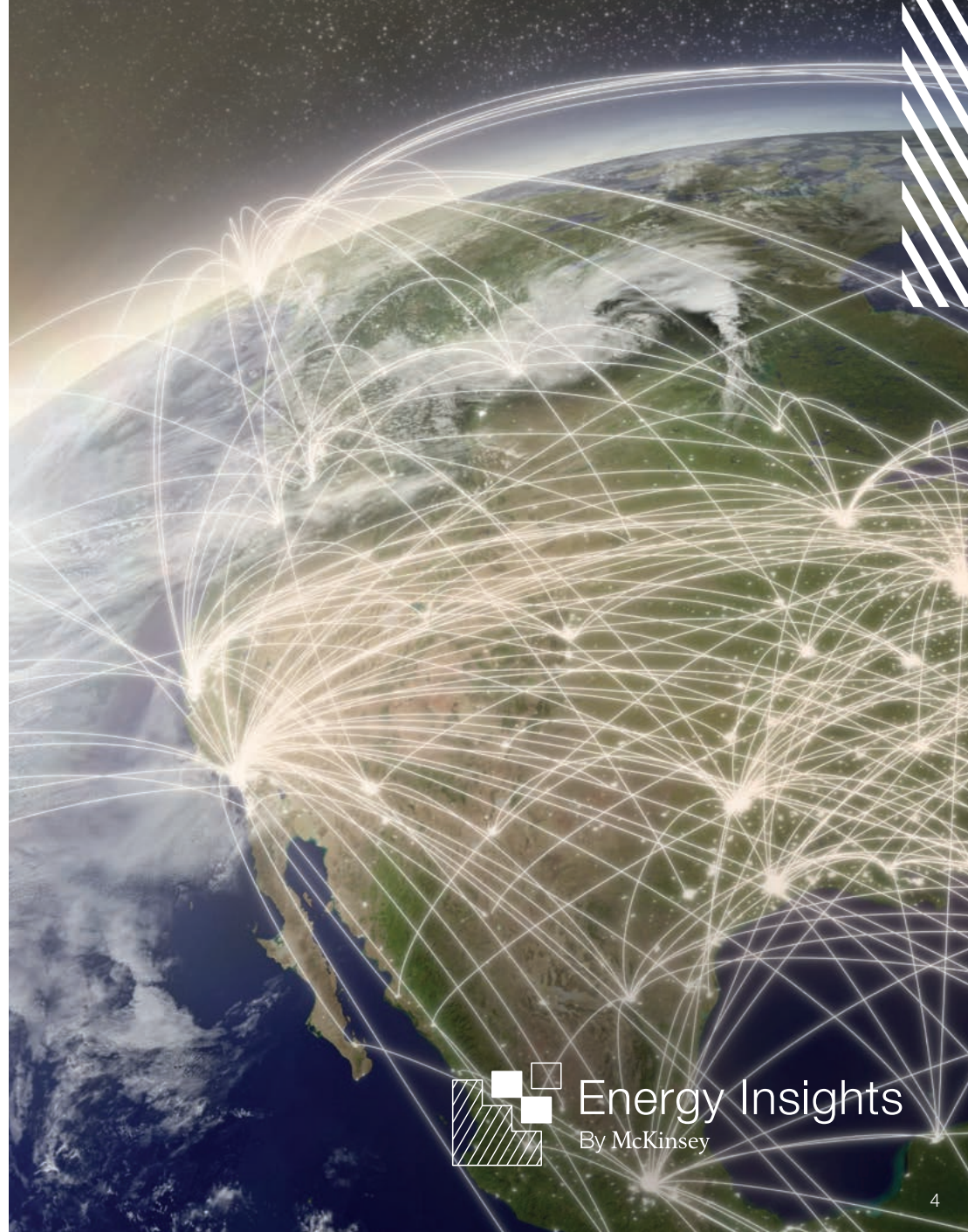


4 Coal demand peaks in next decade, oil in the next two; in contrast, gas continues to grow modestly



5 CO₂ 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

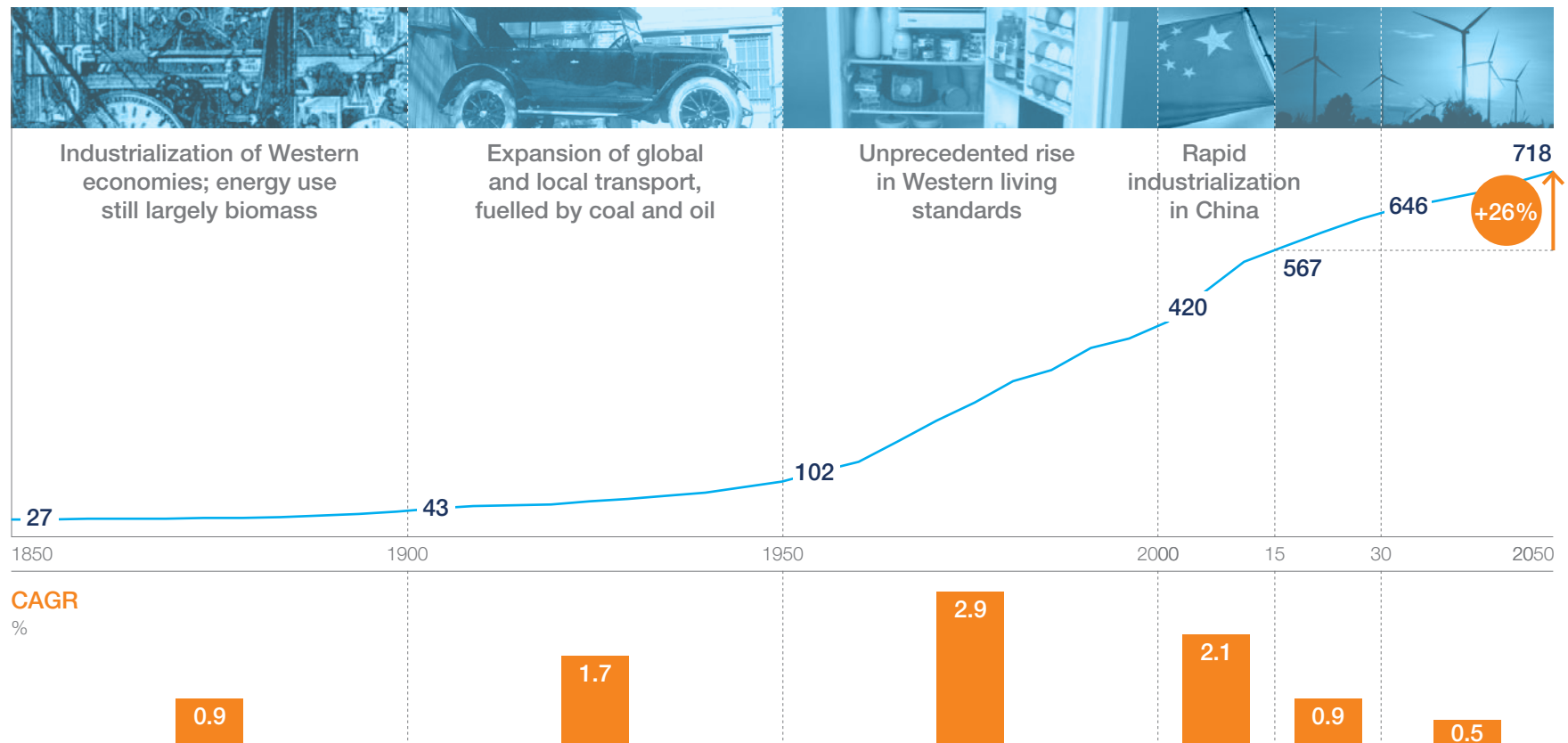


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Global energy demand rises by one quarter over 2015-50, but the rate of growth slows to a pace not seen in the past 100 years

Global primary energy demand

Million terajoules

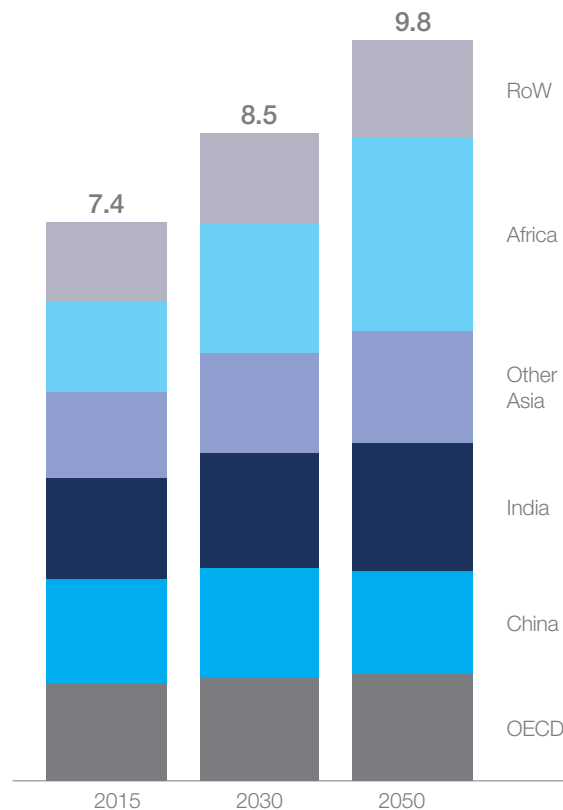


Sources: McKinsey Energy Insights' Global Energy Perspective, December 2017; IEA Energy Balances (Historical); Smil, V. (Historical)

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

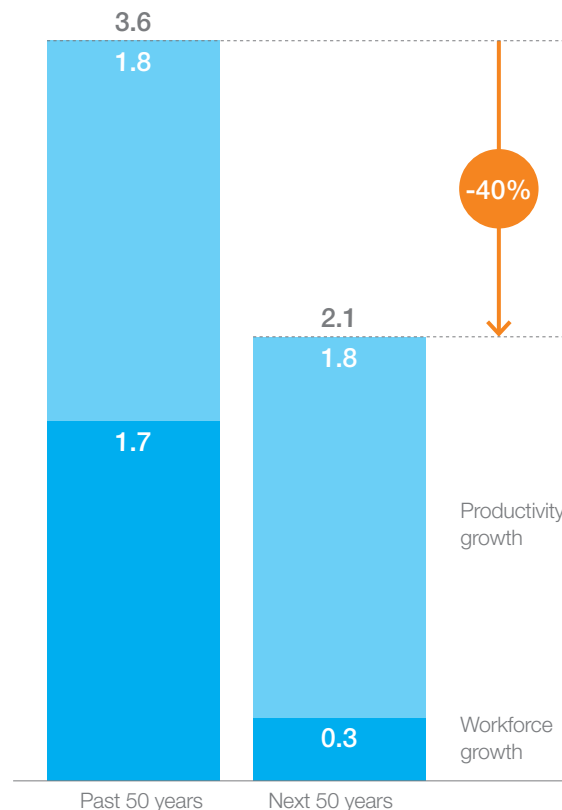
Population growth is concentrated in Asia (excluding China) and Africa

Population, billions



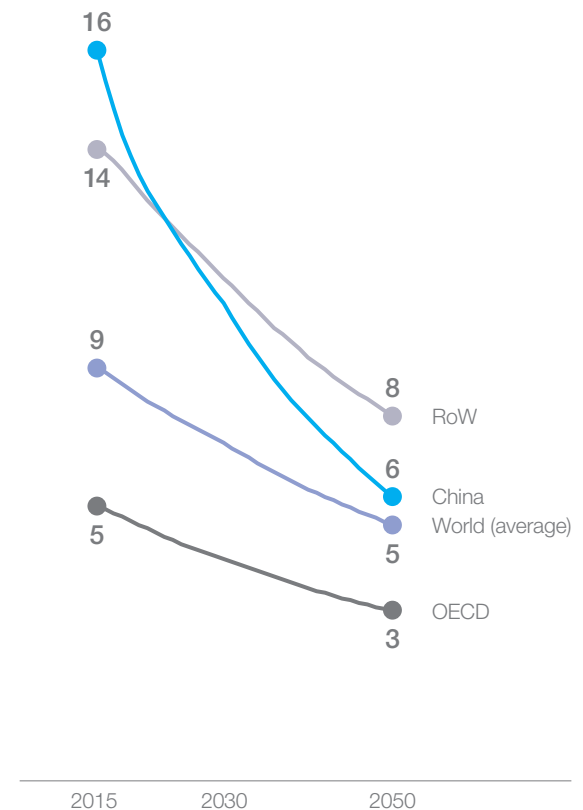
GDP growth relies on productivity gains due to an aging workforce

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
Buildings² 	Space heating	m ² floor space	10-20%	<10%	<10%	20-40%	<10%	10-20%	20-40%	10-20%
	Lighting	m ² floor space	>40%	20-40%	20-40%	20-40%	>40%	>40%	>40%	>40%
	Water heating	Household	10-20%	10-20%	10-20%	10-20%	10-20%	10-20%	10-20%	10-20%
Transport 	Passenger cars	km travelled	20-40%	20-40%	20-40%	20-40%	20-40%	10-20%	10-20%	10-20%
	Trucks	km travelled	20-40%	20-40%	10-20%	10-20%	10-20%	20-40%	20-40%	10-20%
	Aviation	Rev-passenger km travelled	10-20%	10-20%	10-20%	10-20%	10-20%	10-20%	10-20%	10-20%
Industry 	Chemicals	Ton produced	<10%	<10%	<10%	<10%	<10%	<10%	<10%	<10%
	Iron and steel	Ton produced	10-20%	10-20%	10-20%	<10%	20-40%	<10%	<10%	<10%

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 m²

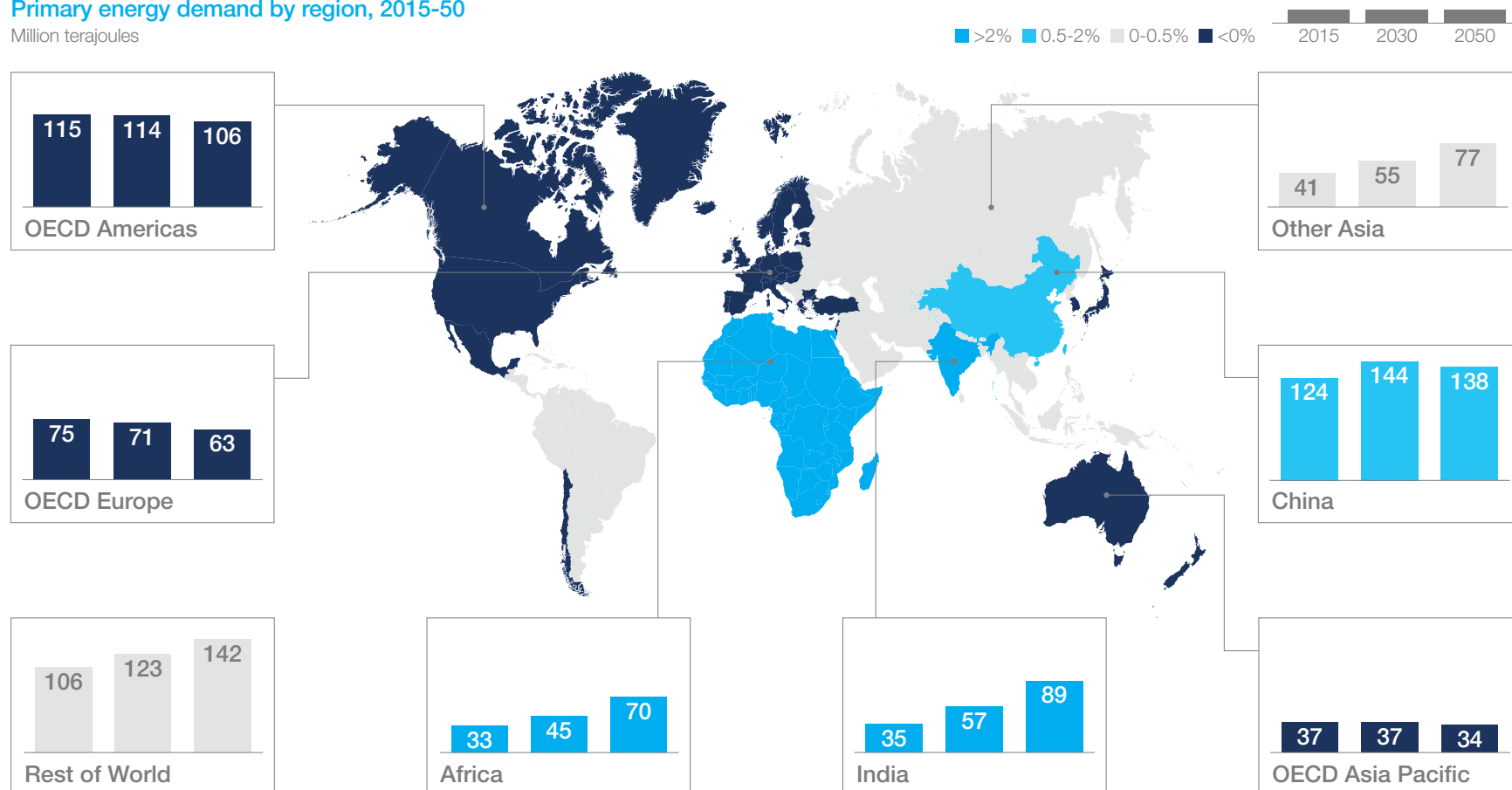
² Residential buildings only, excluding commercial buildings

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

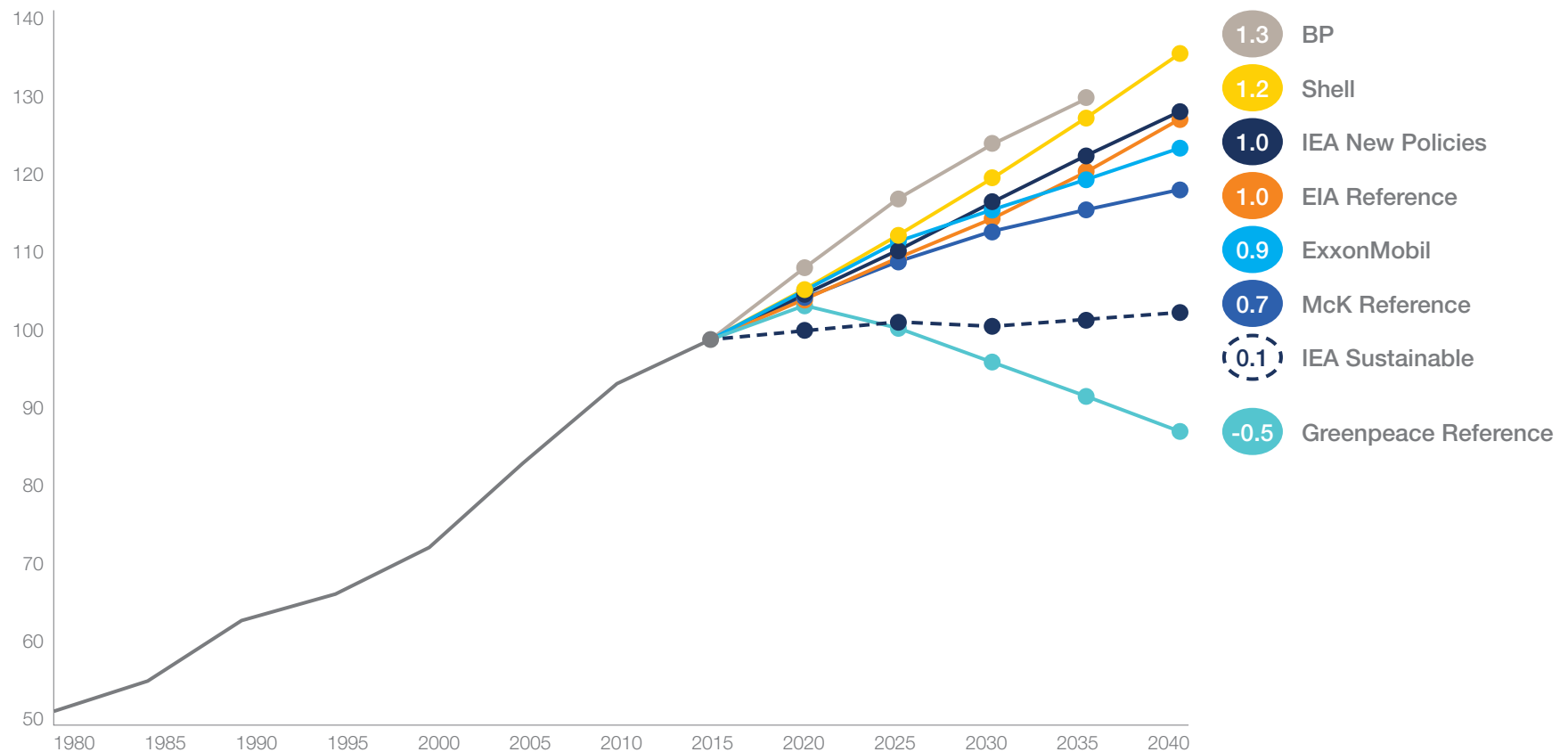


Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

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

Primary energy demand

2015=100



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



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

Electrification¹

Electricity % of final energy demand

■ Deep dives

Buildings



31

2015

43

2050

- 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



<1

2015

20

2050

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

Industry



21

2015

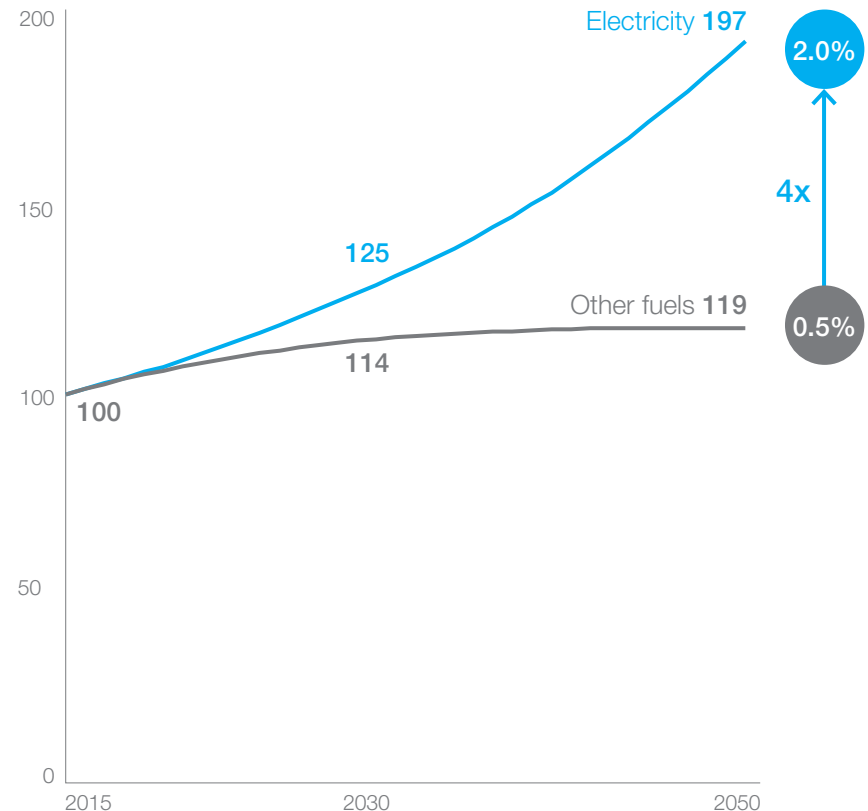
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2050

- 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



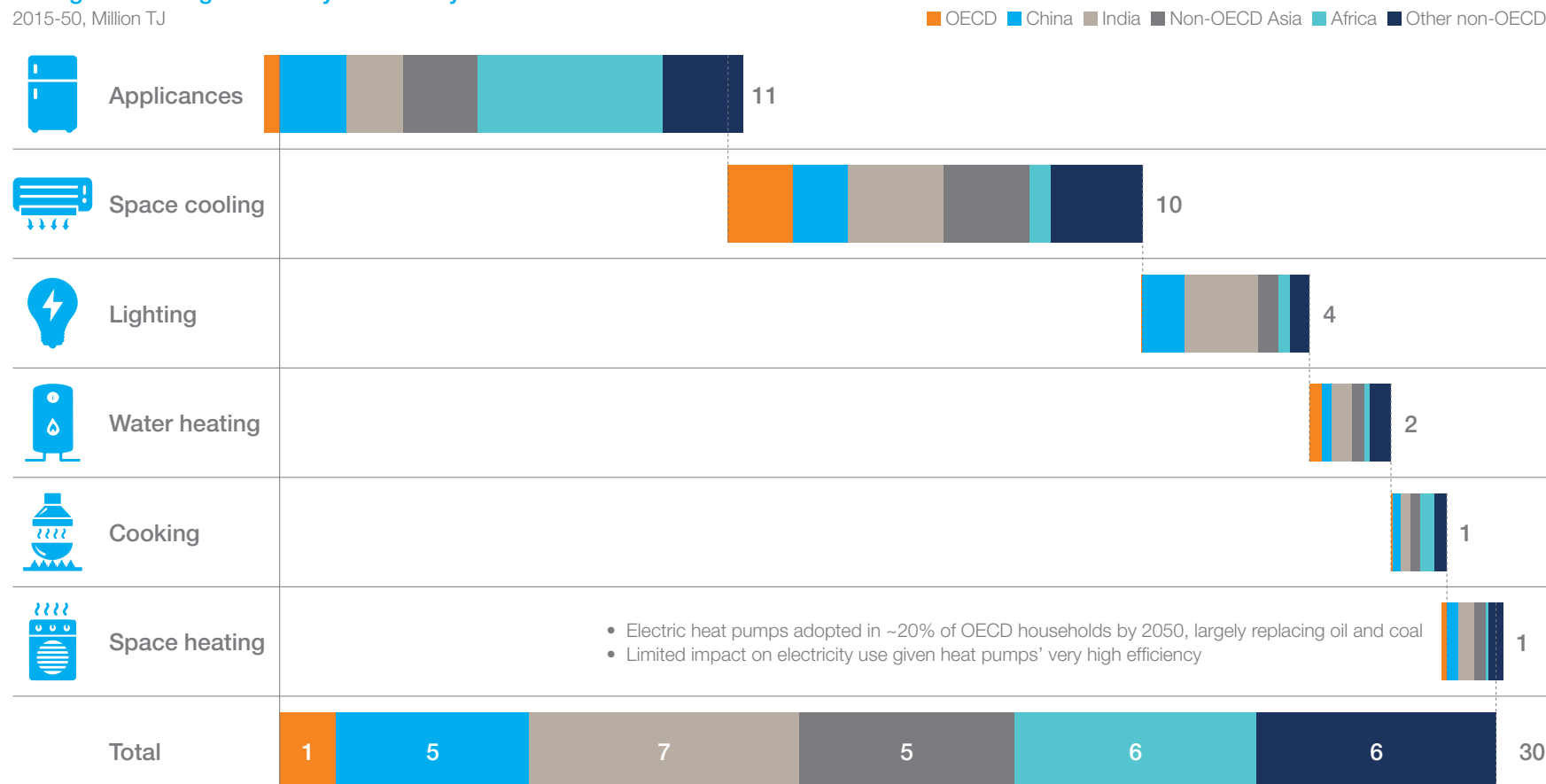
¹ Buildings includes residential buildings in OECD Europe and OECD Americas; transport includes passenger cars, trucks, vans, buses, and two- and three-wheelers

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

Change in buildings electricity demand by service

2015-50, Million TJ



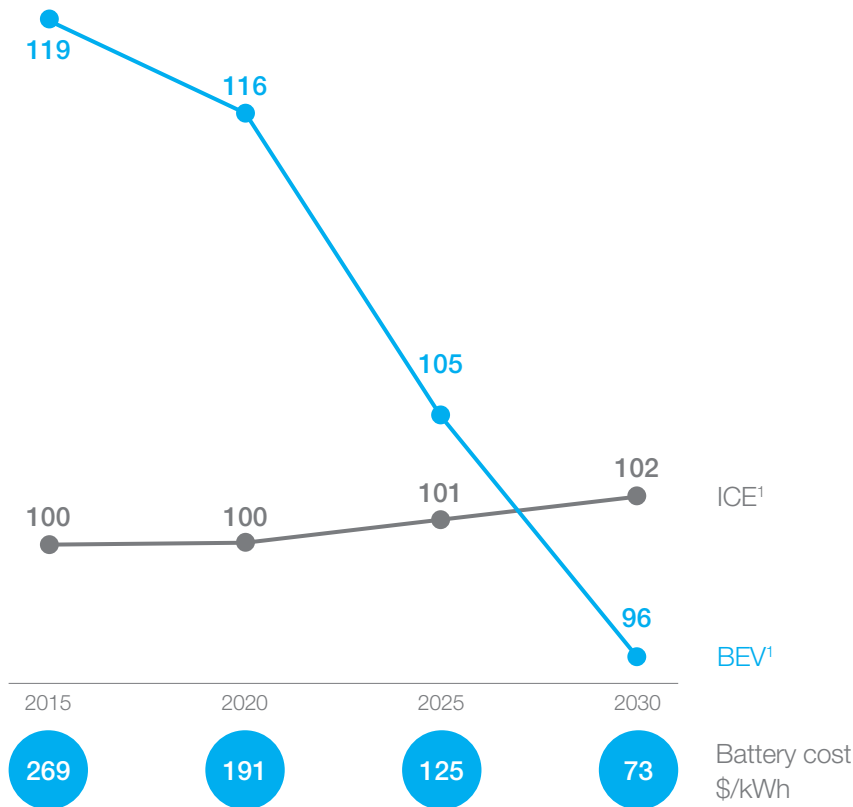
Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

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 ICE¹



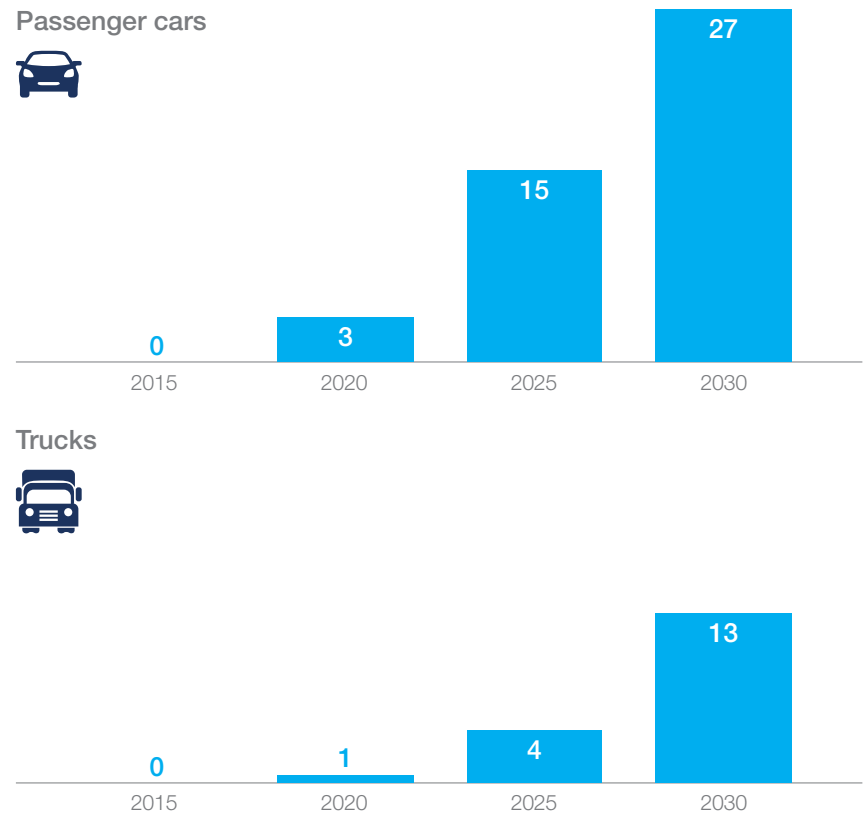
¹ ICE: internal combustion engine BEV: battery electric vehicle

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



US share of battery electric vehicles

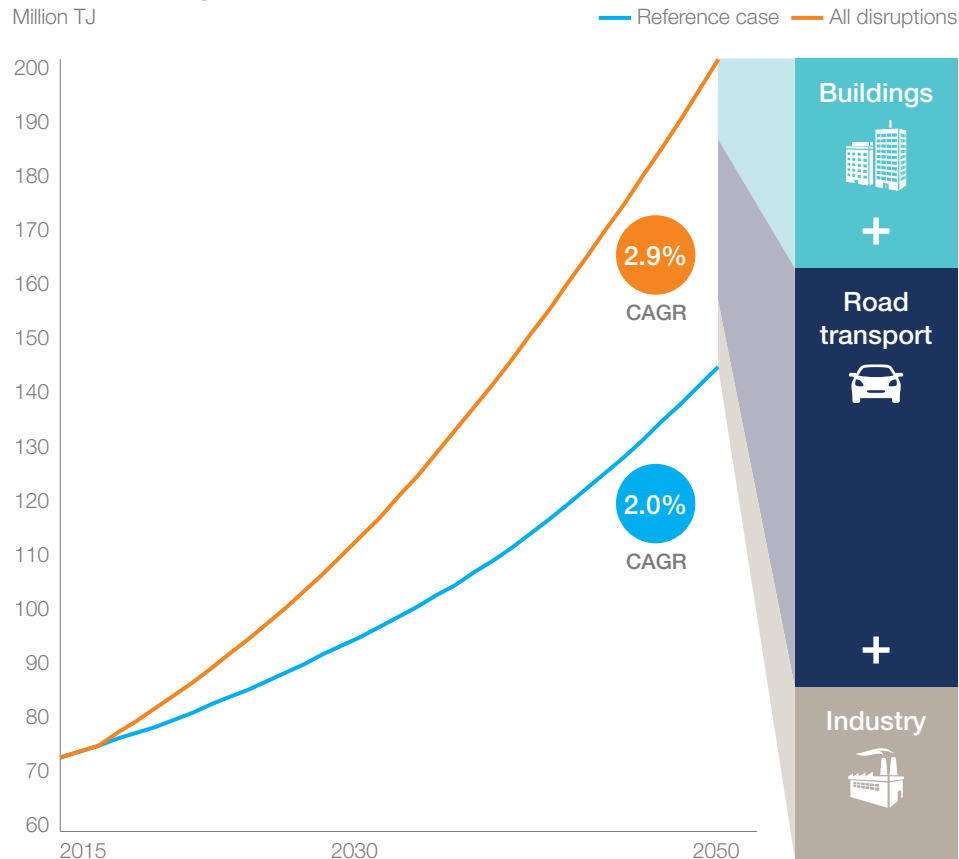
% of new vehicle sales



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 pumps¹



EV passenger car penetration

EVs as % of global new passenger car sales



EV commercial vehicle penetration

EVs as % of global new truck sales



Electrification of industrial heat

% global process heat electrified



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



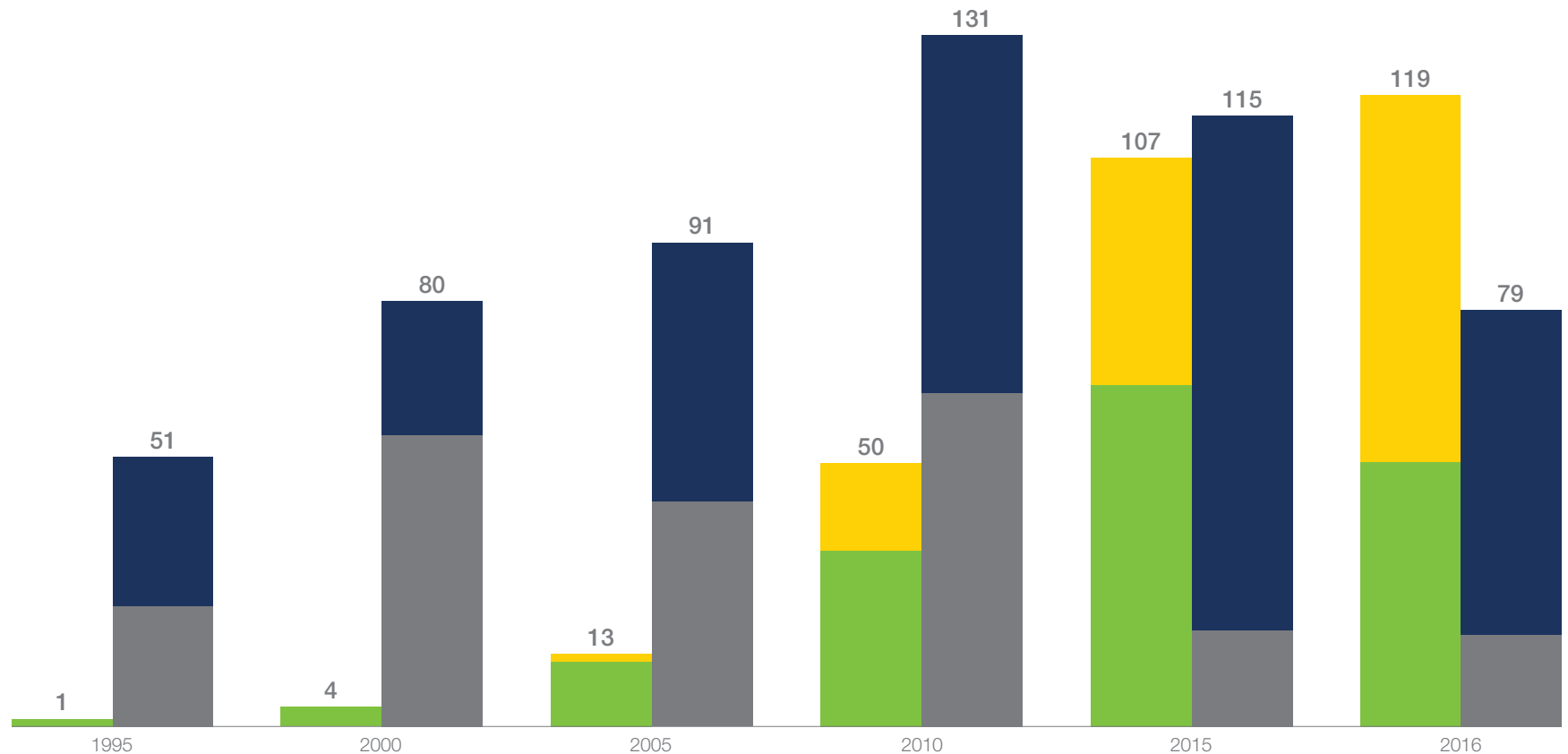
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2016 was the first year in which solar and wind net additions exceeded coal and gas

Net annual capacity additions

GW

■ Solar ■ Wind ■ Gas ■ Coal



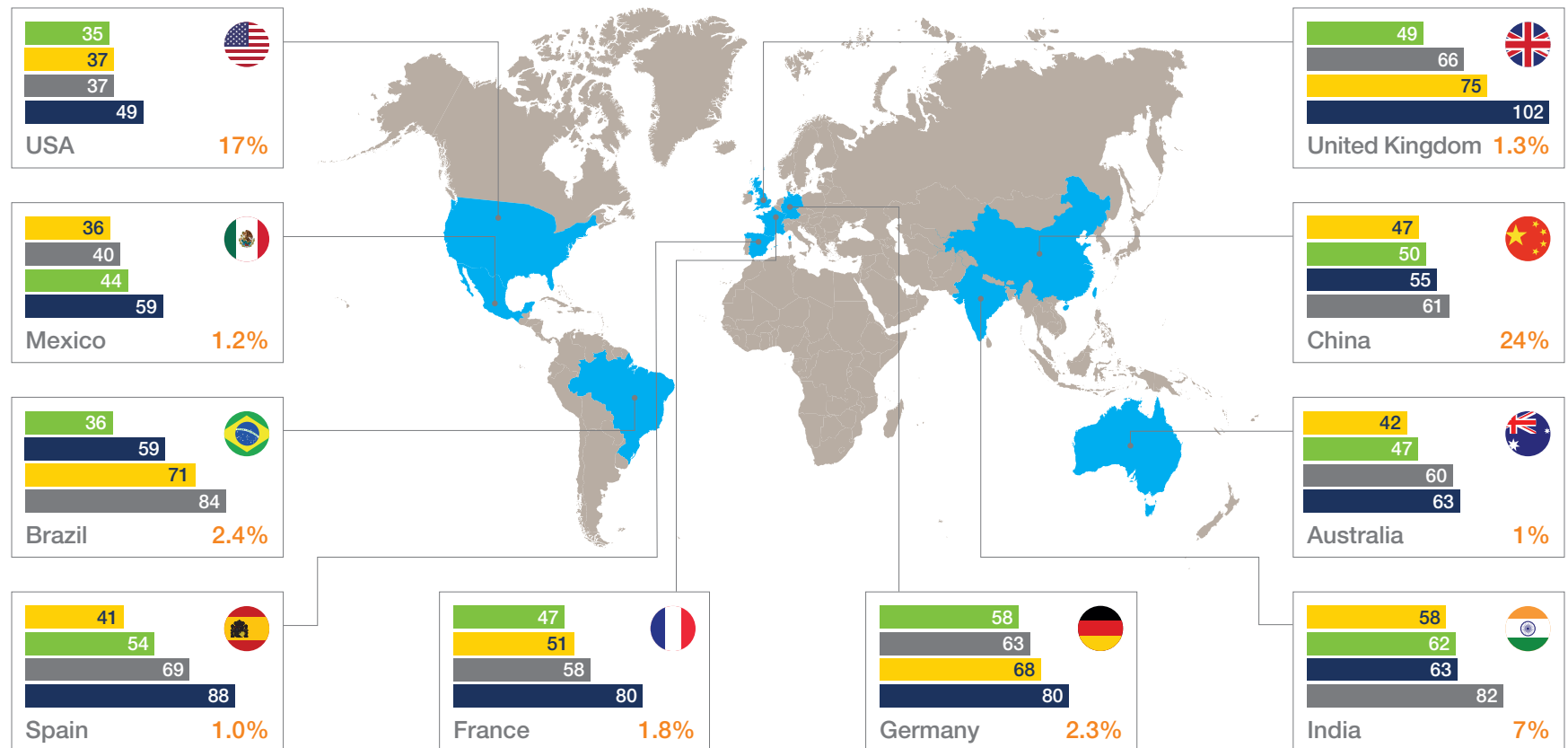
Source: Enerdata, UDI

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 ○○ 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

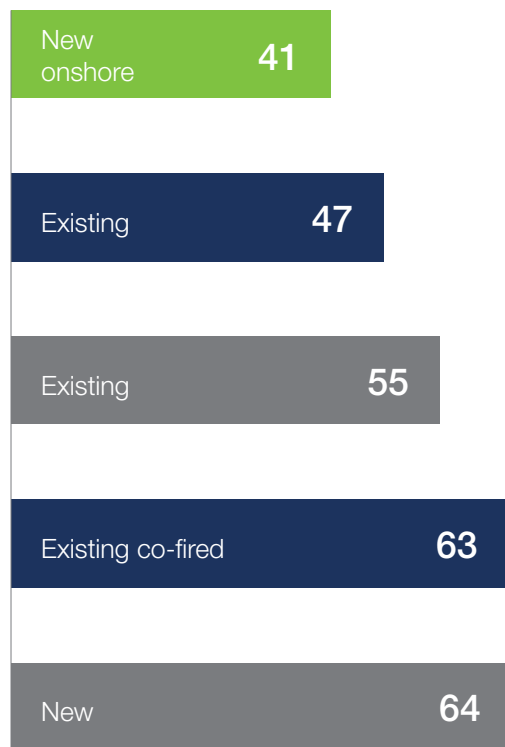


UK power generation costs¹

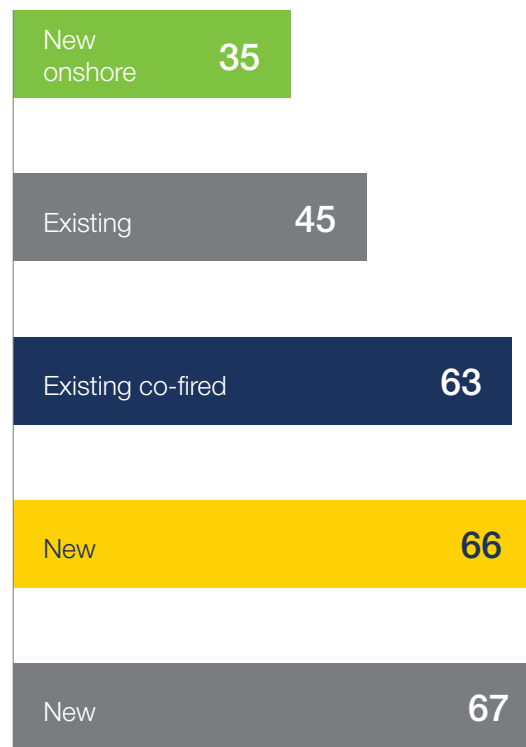
\$2015/MWh

■ Solar PV ■ Wind ■ CCGT ■ Coal

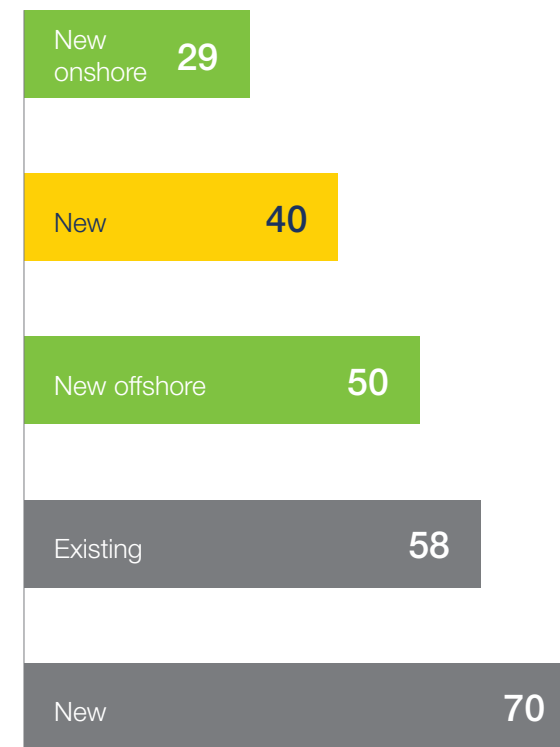
2015



2020



2030



¹ Short run marginal cost for existing capacity and levelized cost of energy for new capacity

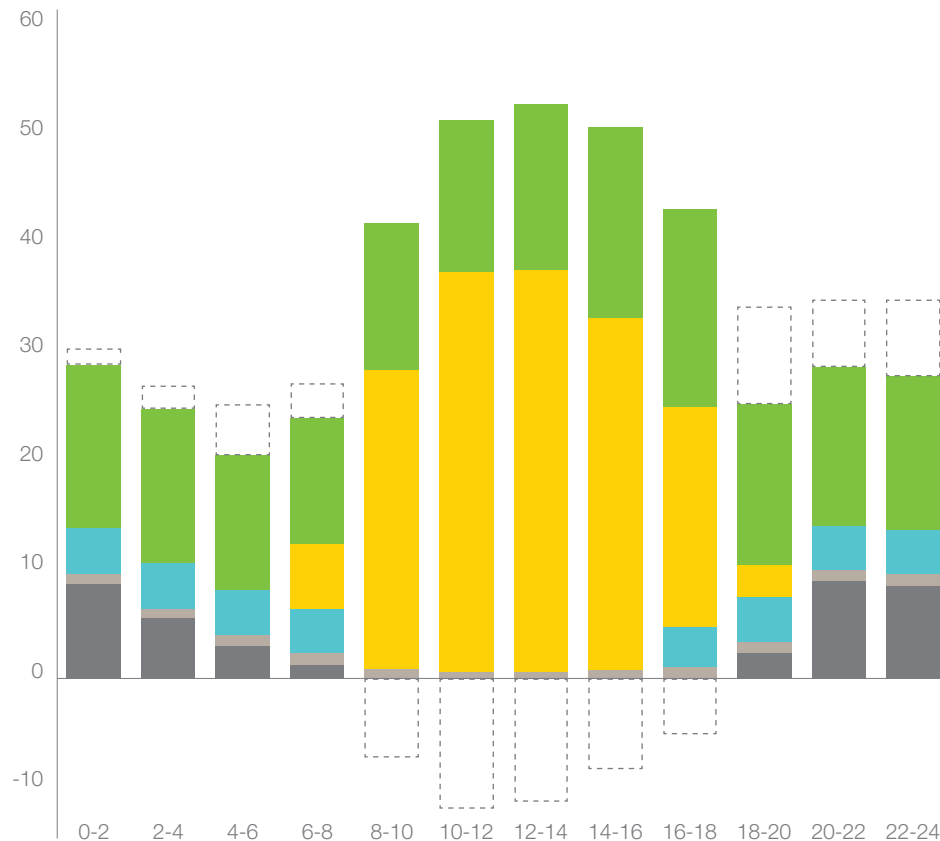
Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

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



Spain hourly power generation (summer, high wind) in 2040

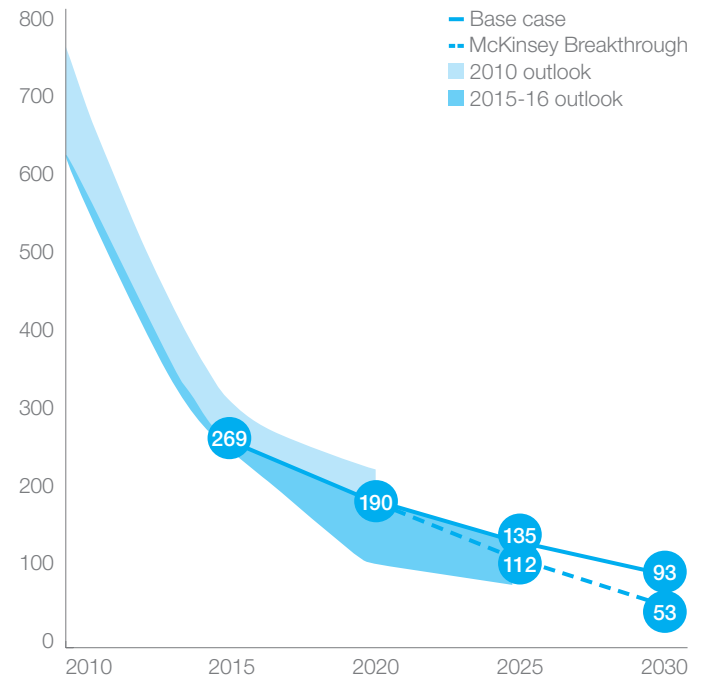
GWh



Storage Wind onshore Solar Hydro CHP Gas

Battery price (Li-ion batteries)

USD/kWh

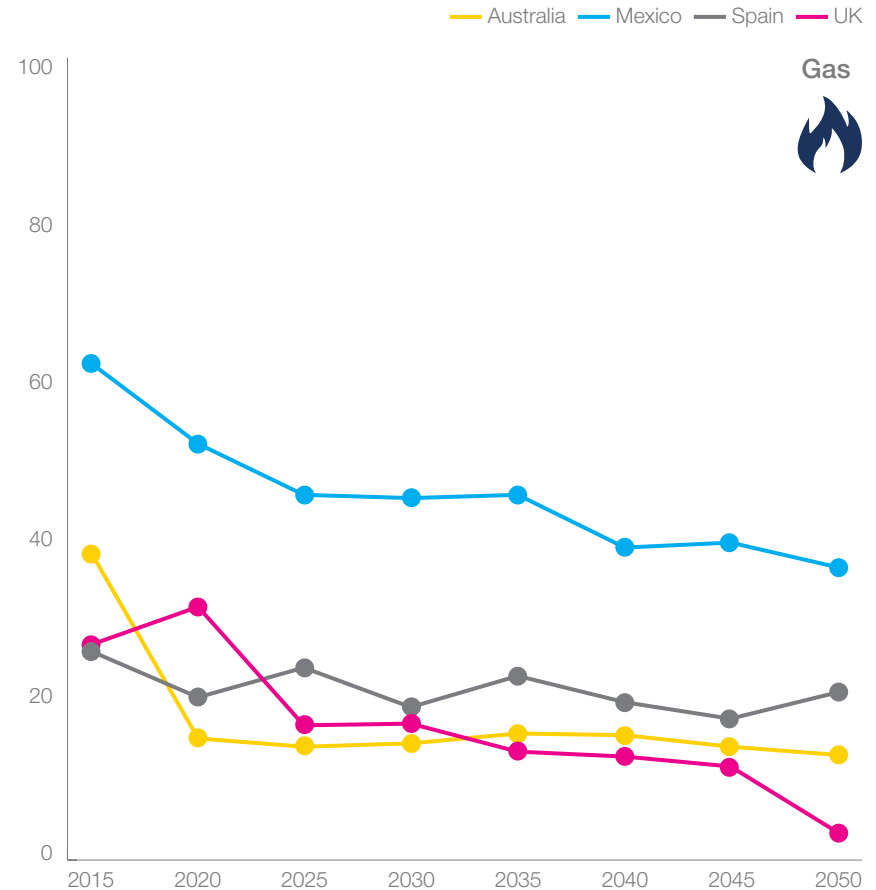


Sources: McKinsey Energy Insights' Global Energy Perspective, December 2017; SNE research; Navigant; Bernstein Research; expert interviews

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

%

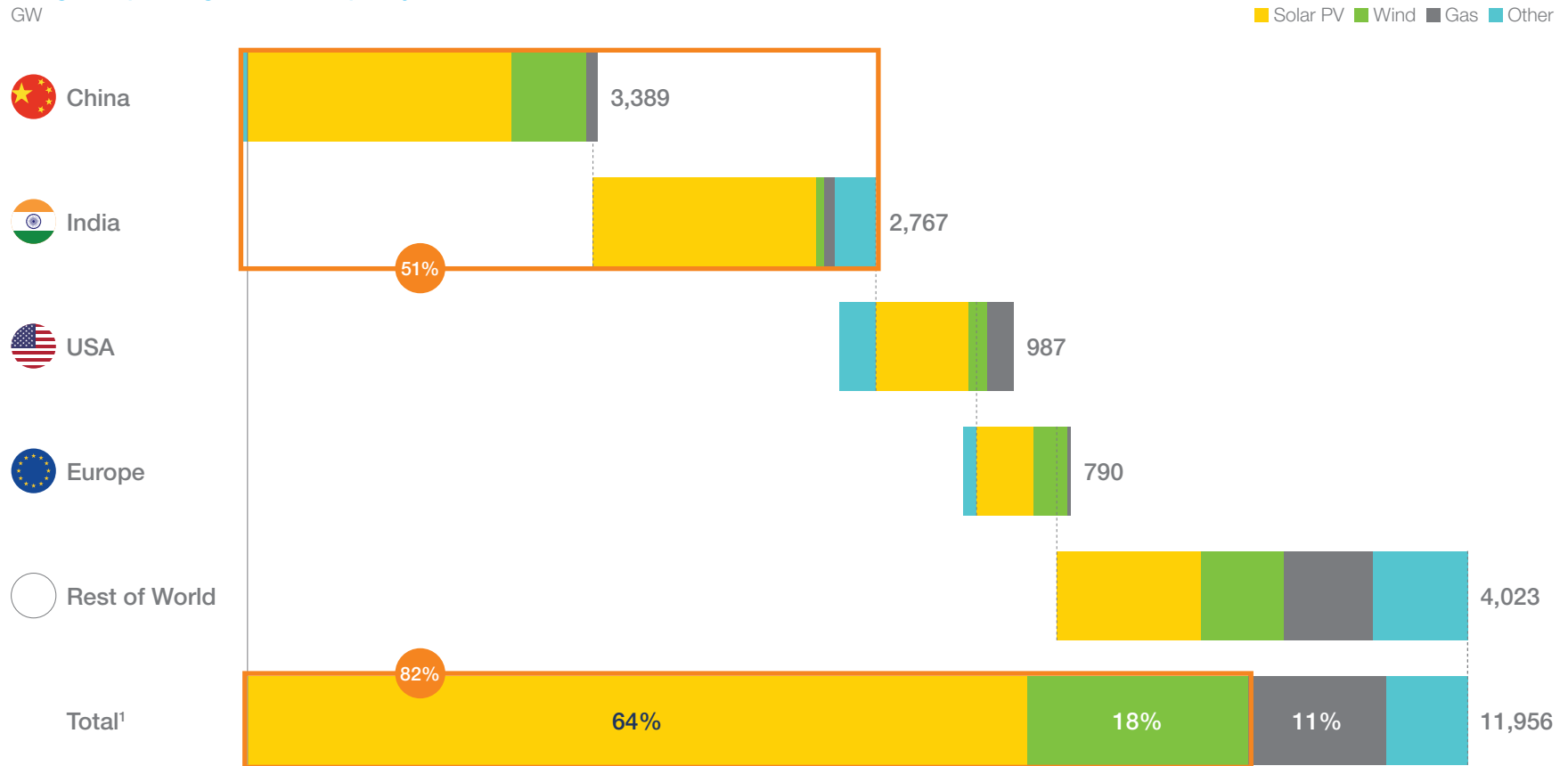


Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

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



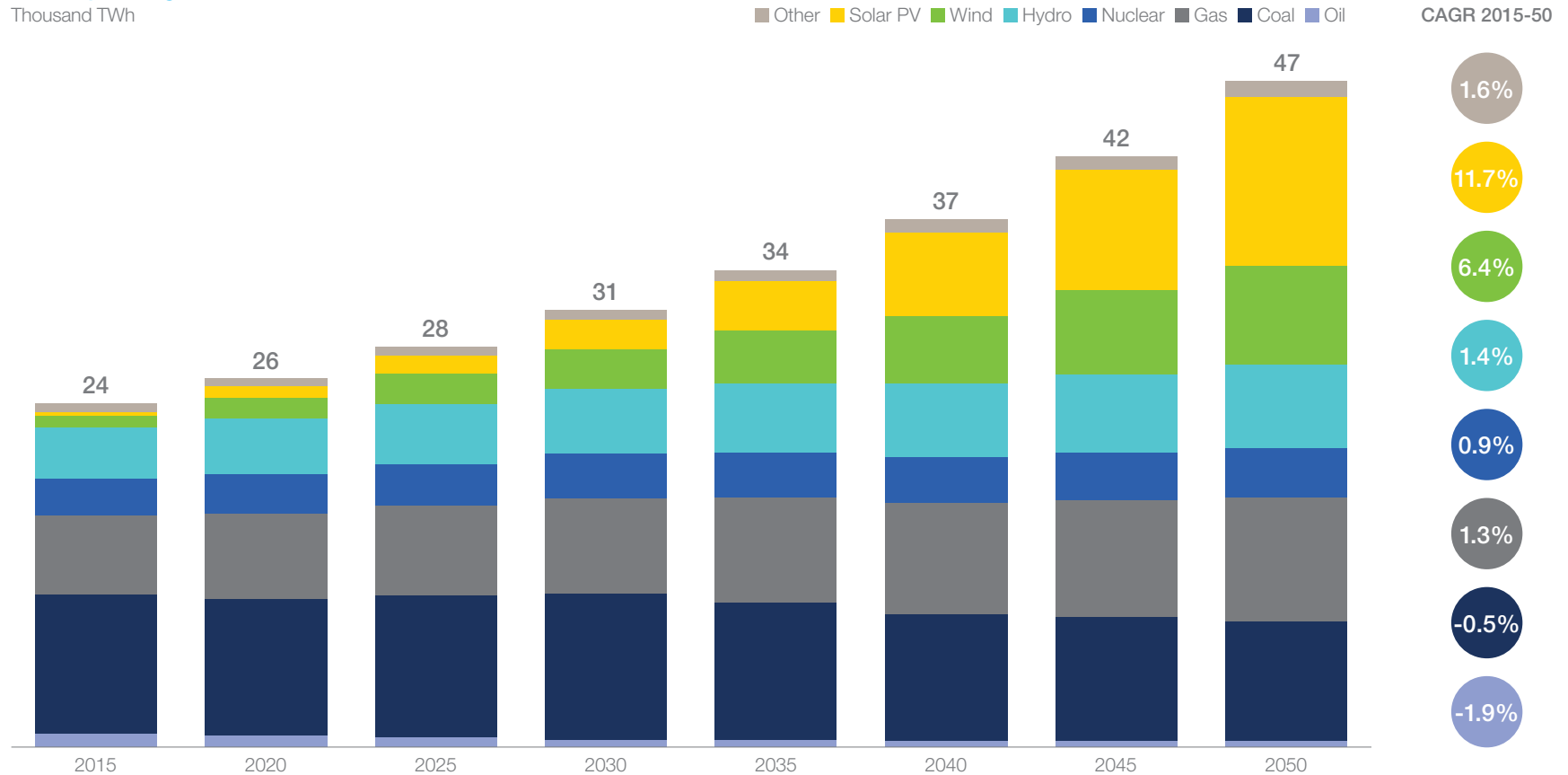
¹ Based on bottom-up modelling of 14 countries representing 65% of global power demand, and top-down assessment of remainder of the world

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

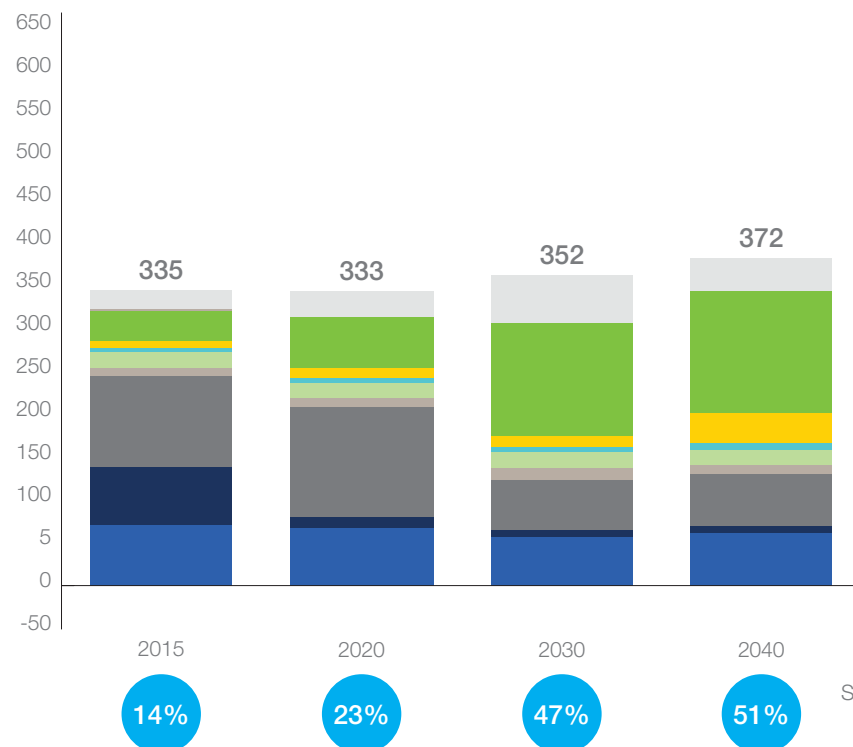
Generation mix in the Reference Case

TWh

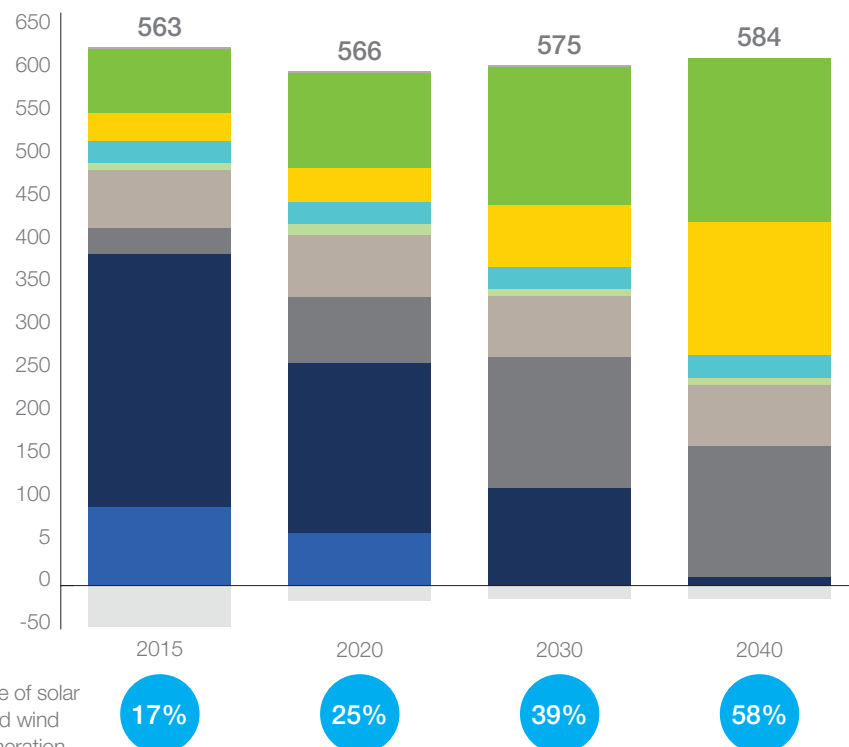
Net imports Other Storage Wind Solar Hydro Bioenergy CHP Gas Coal Oil Nuclear



United Kingdom



Germany



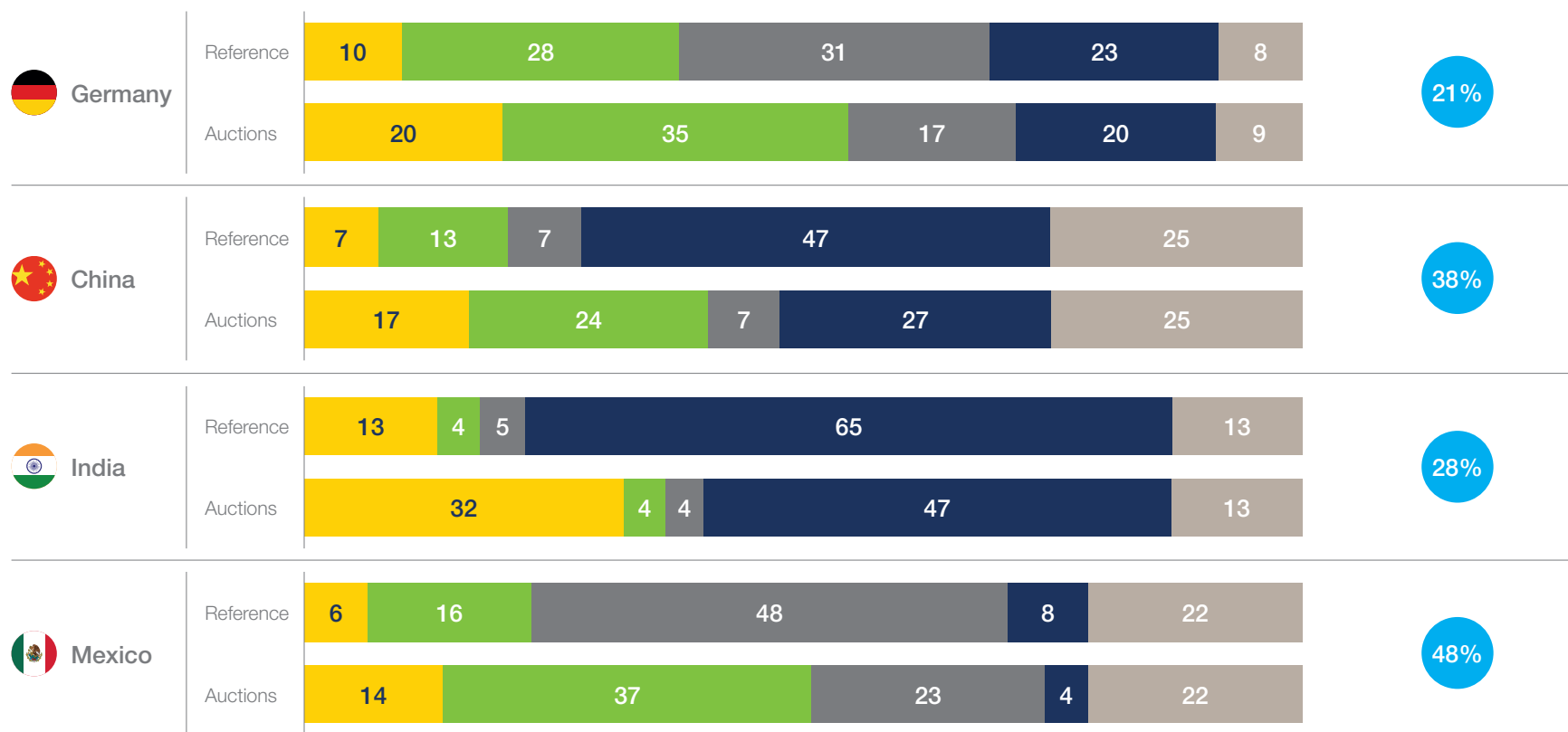
Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

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 Auctions¹ scenarios in 2030

% of total

■ Solar ■ Wind ■ Gas ■ Coal ■ Other Power emissions reduction



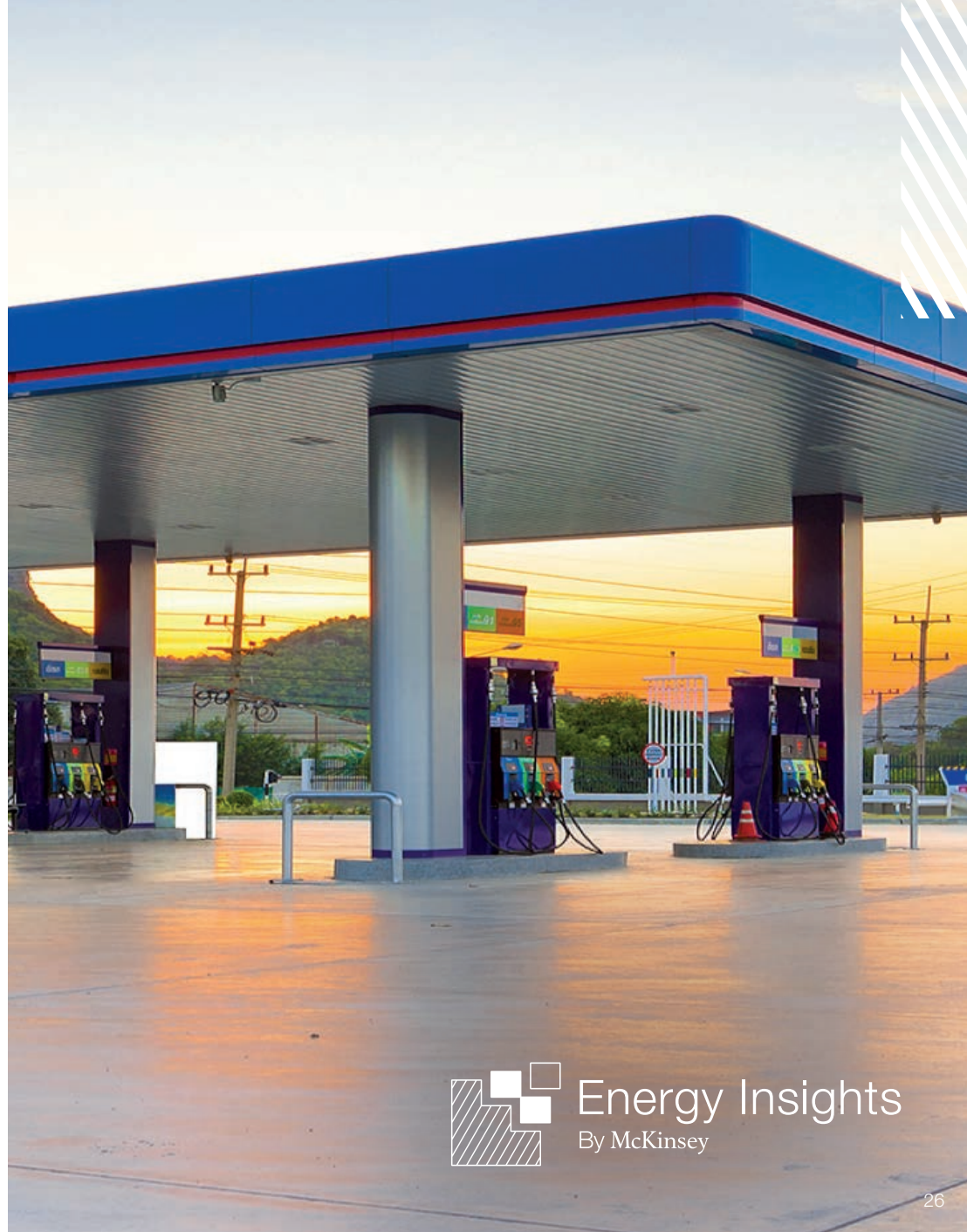
¹ 'Auctions as Reality' scenario realizes substantially lower prices for solar PV and onshore wind (reflecting recent auction results) relative to the Reference Case

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	<ul style="list-style-type: none"> • Carbon prices • Efficiency requests pushing EVs/ electricity in buildings, e.g. C40 initiative
	Market models and implications of high renewables systems	<ul style="list-style-type: none"> • Sink for electricity in negative electricity spikes pushing hybrid • Capacity/storage markets
	Increasing connectivity of power markets – electricity exports	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • National plan scenarios of decommissioning vs. new push for small scale/next gen reactors • Coal subsidies for energy security/ jobs
	Fossil fuel price impacts	<ul style="list-style-type: none"> • Impact of potential low demand driving prices down: revival of other segments? Resulting investment cycles?
	Resource and supply chain implications	<ul style="list-style-type: none"> • 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	<ul style="list-style-type: none"> • Pull for low efficiency technologies reducing demand vs. hunger for materialism

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

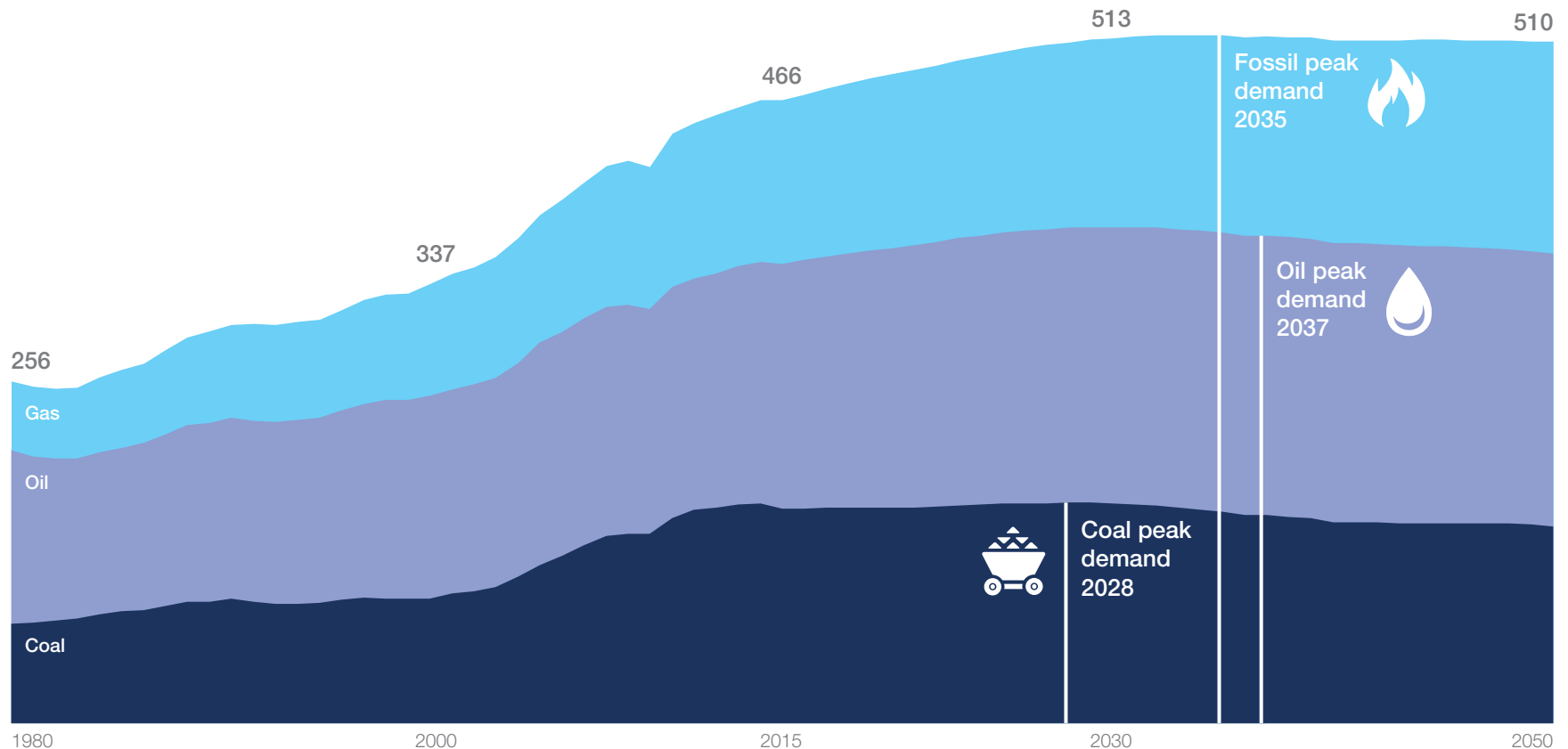


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Fossil fuel use flattens from 2035, with oil and coal in decline but gas use continuing to expand

Global fossil fuel demand

Million TJ



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

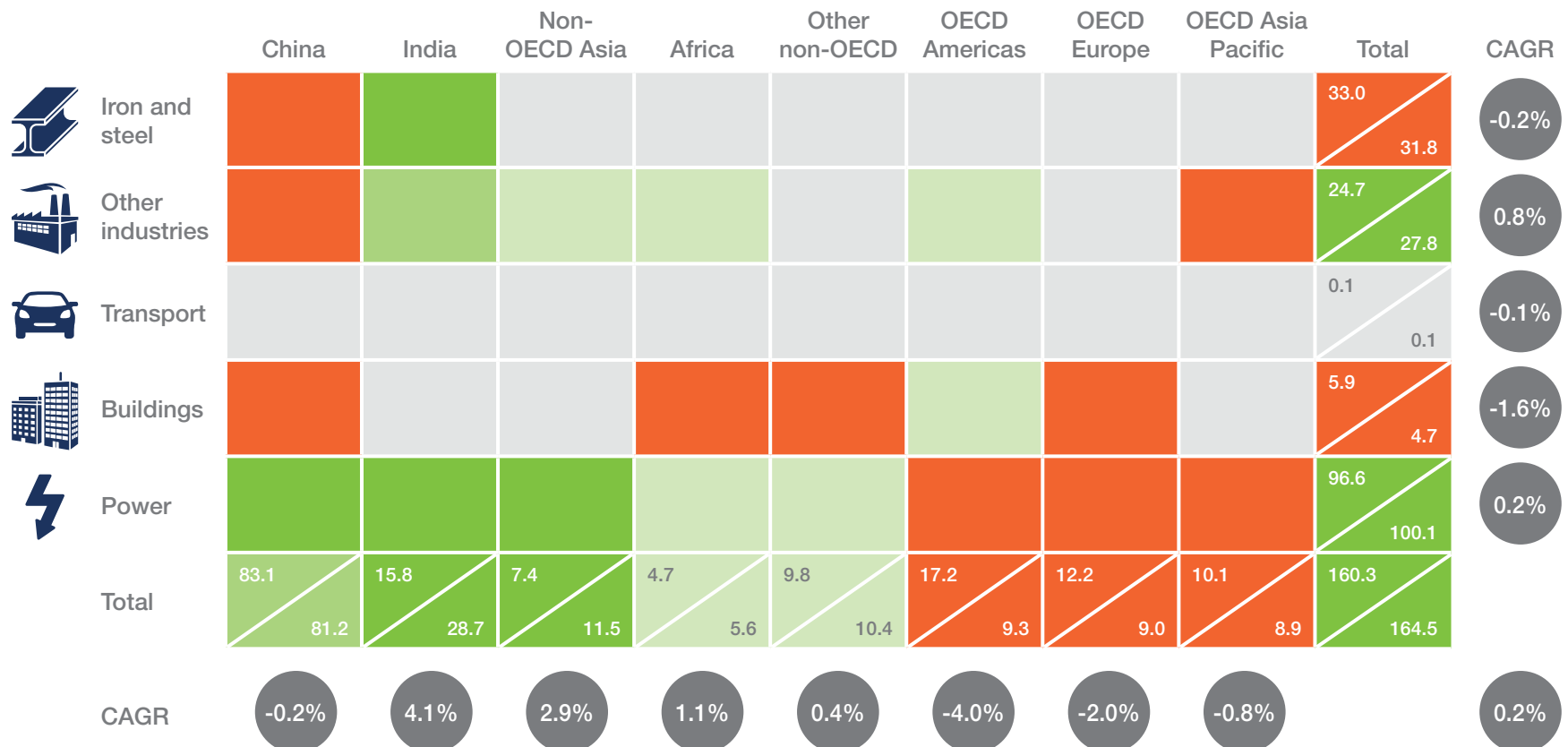
By 2030, this still implies higher coal demand than today based on growth in power and other industries, and cement in particular



Global coal demand, 2015-30 delta

Million TJ

▢ 2015 ▴ 2030 ■ >2 ■ 1-2 ■ 0.2-1 ■ 0-0.2 ■ <0



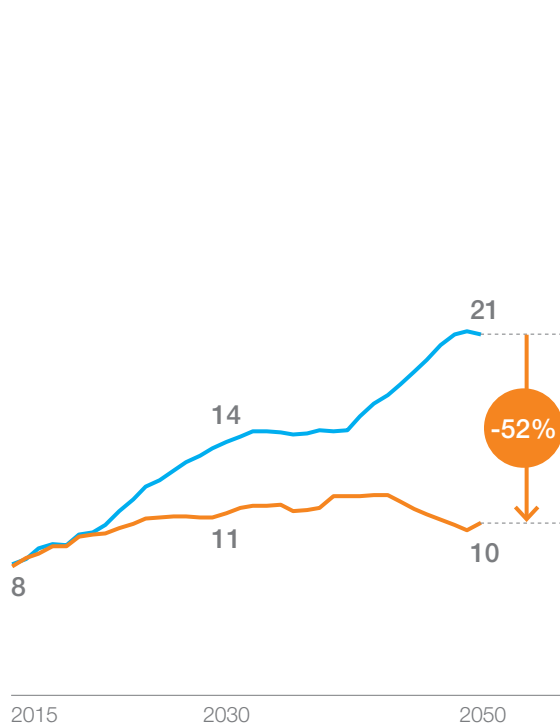
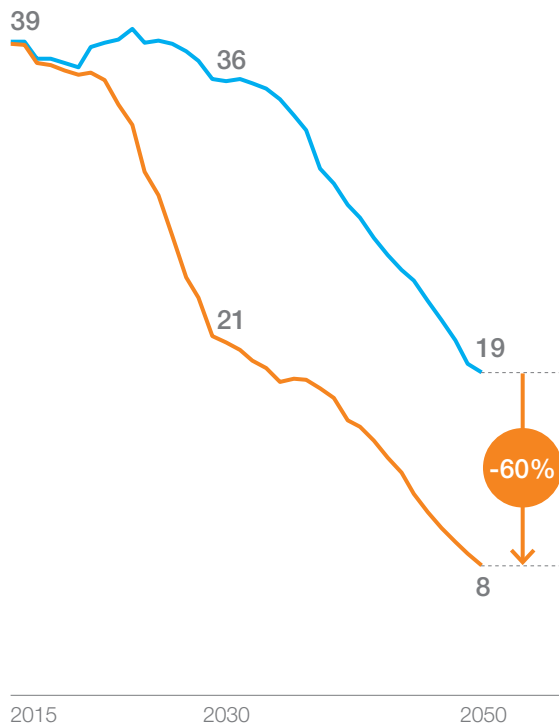
Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

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



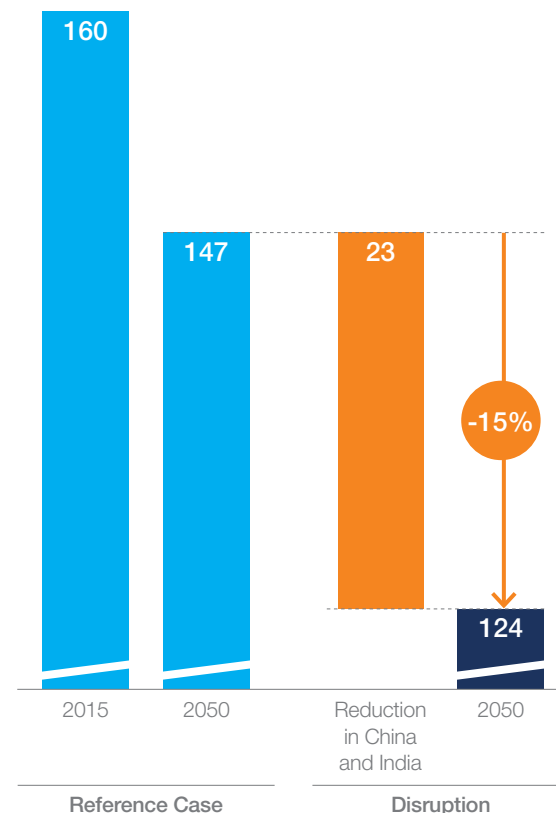
Coal demand for power generation

Million TJ



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

▮ 2015 ▮ 2030 ■ >1 ■ 0.5-1 ■ 0.1-0.5 ■ 0-0.1 ■ <0



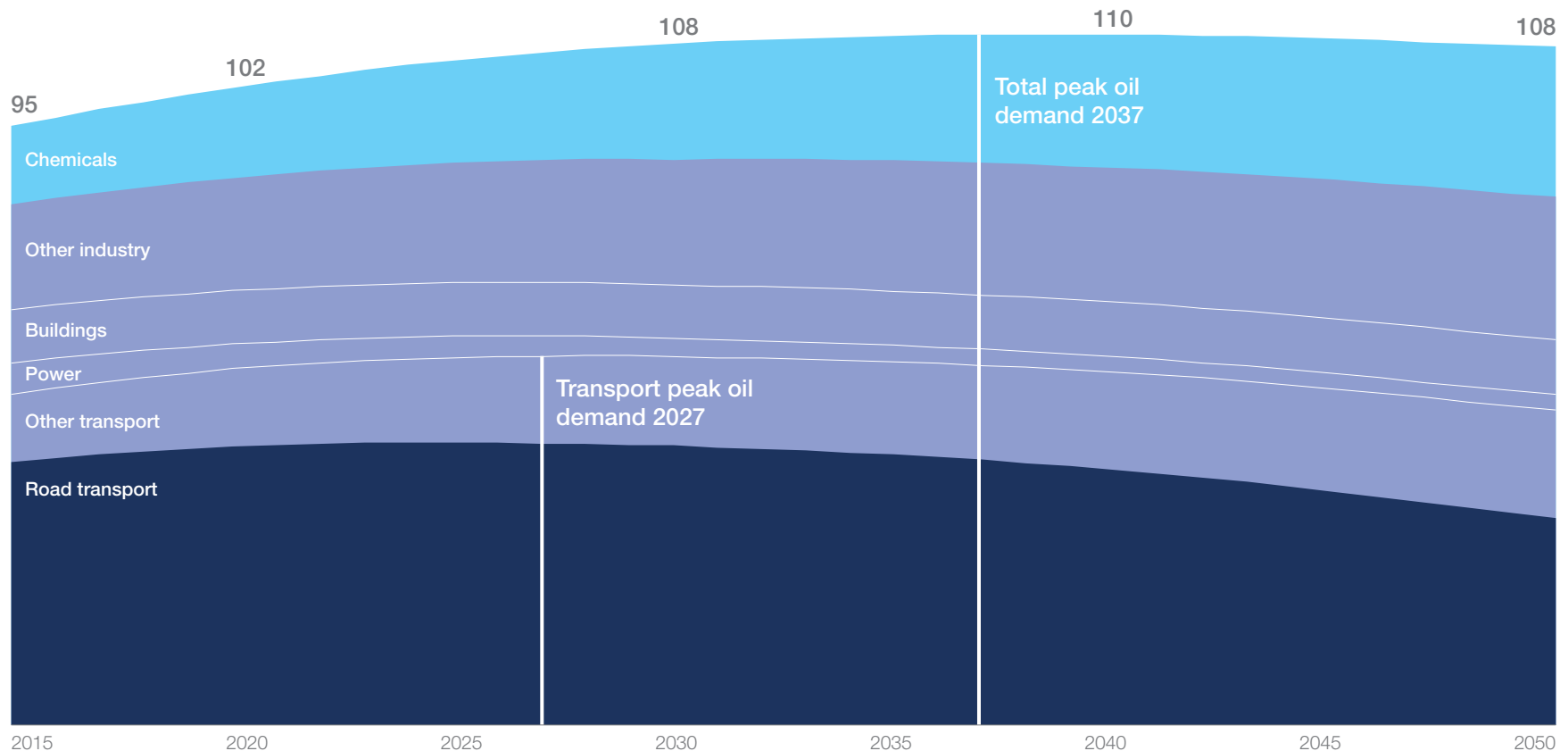
Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

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



Liquids demand

Million barrels per day



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

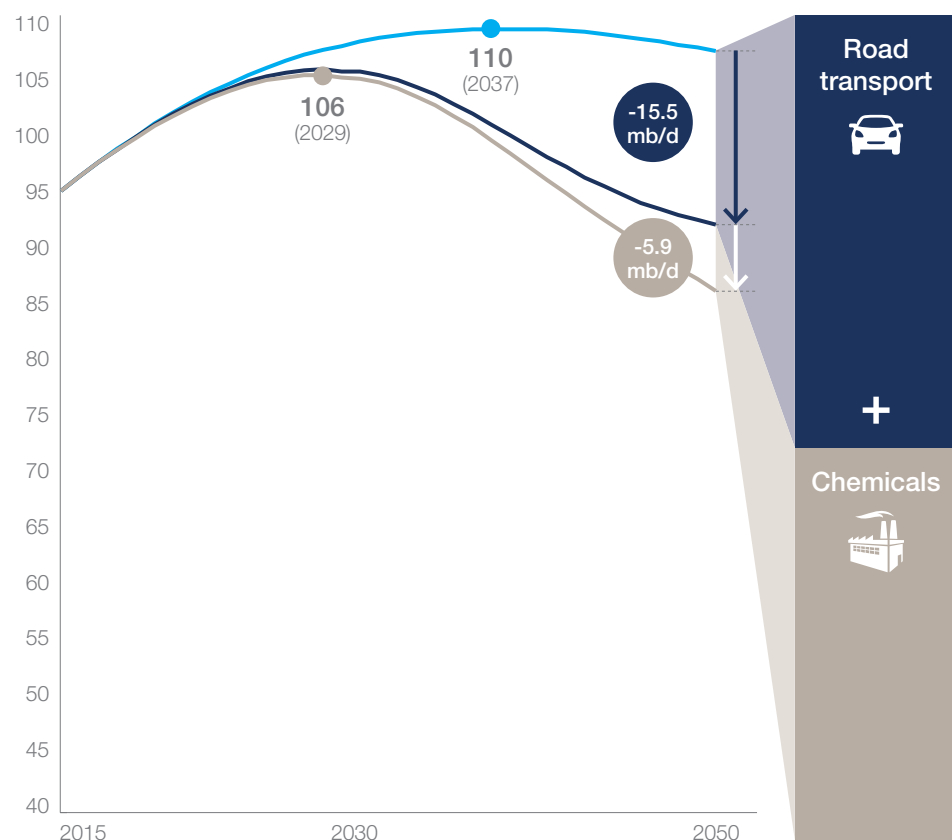
With disruption in road transport and chemicals, oil demand could peak before 2030



Global liquids demand

Million barrels per day

— Reference — Road transport disruption — Chemicals disruption



■ Reference Case ■ Additional with disruption

EV passenger car penetration

EVs as % of global new passenger car sales



EV commercial vehicle penetration

EVs as % of global new truck sales



Efficient packaging

% reduction in global plastics use relative to 2015 practices



Plastics recycling

% global plastics from recycled feedstock



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

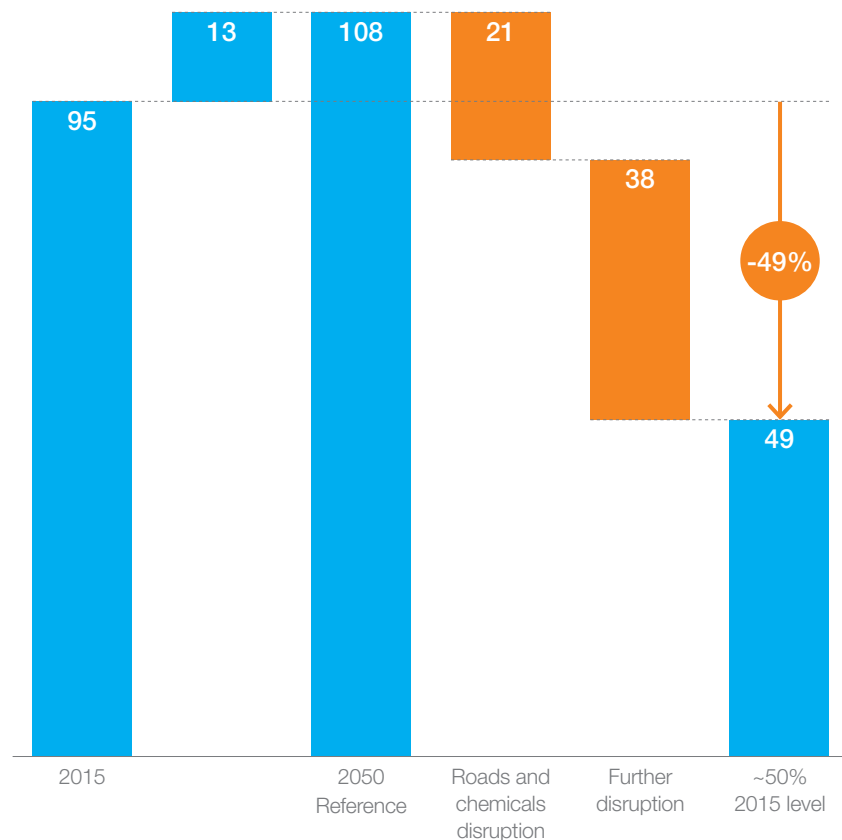
What would you have to believe to see liquids demand plummet to half of today's level?



Liquids demand with further disruption

Million barrels per day

■ Effects from disruptions



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

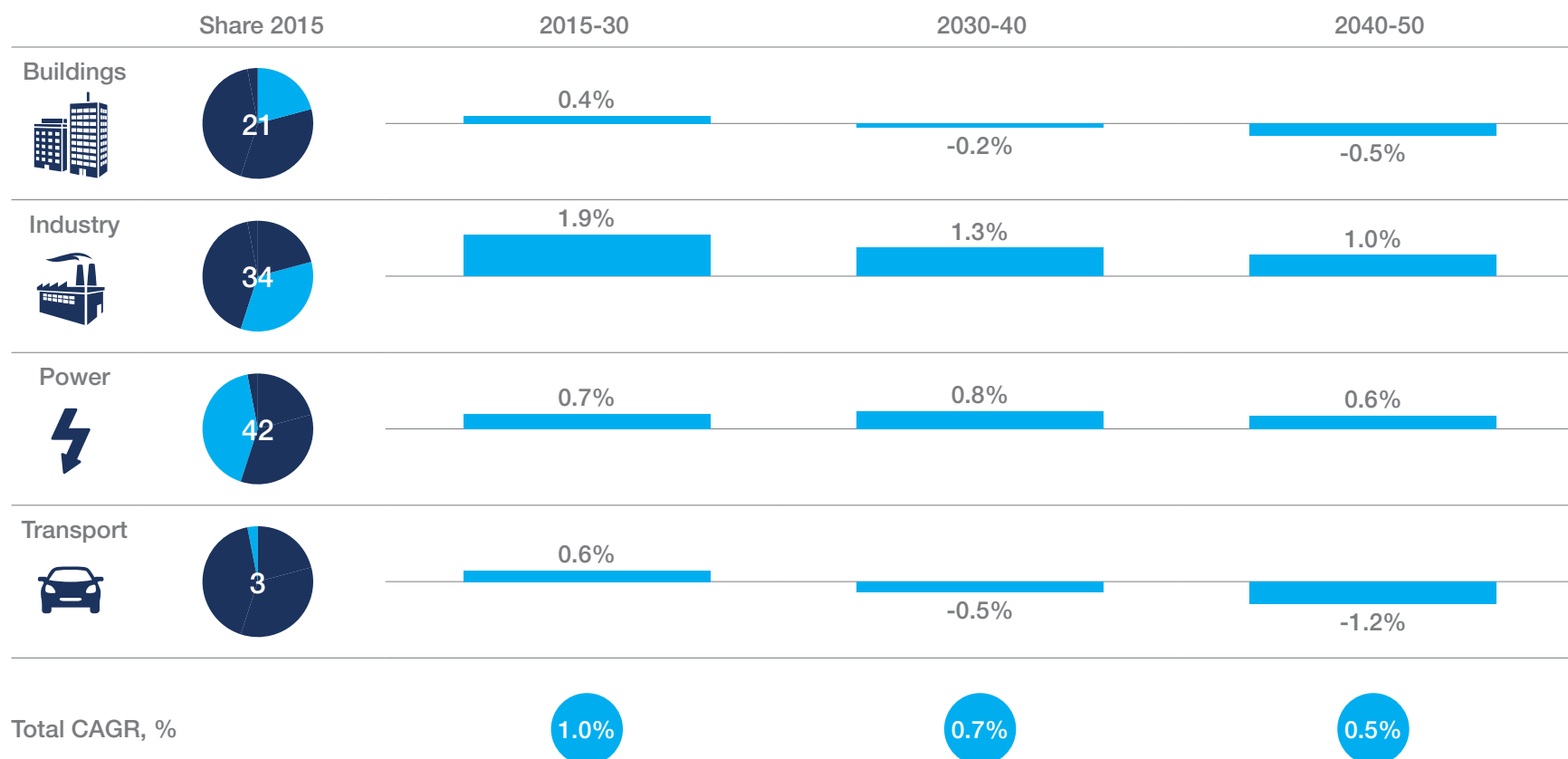
Oil-fired generation is completely phased out as renewables with storage prove cheaper

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

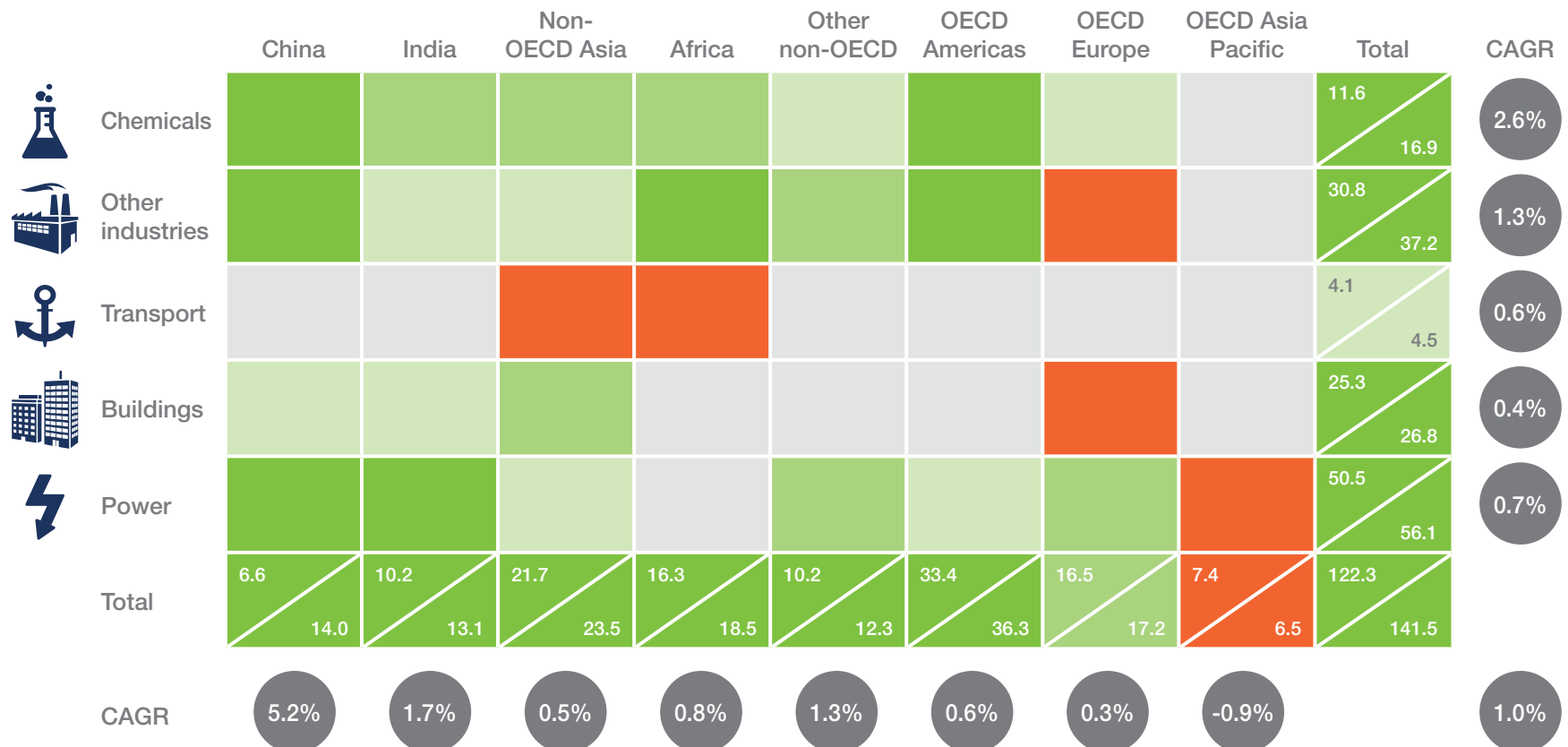
Gas demand growth is driven by China's policy push for gas use in power and industry as well as by competitive prices in producing regions



Global gas demand, 2015-30 delta

Million TJ

▮ 2015 ▮ 2030 ■ >1 ■ 0.5-1 ■ 0.2-0.5 ■ 0-0.2 ■ <0



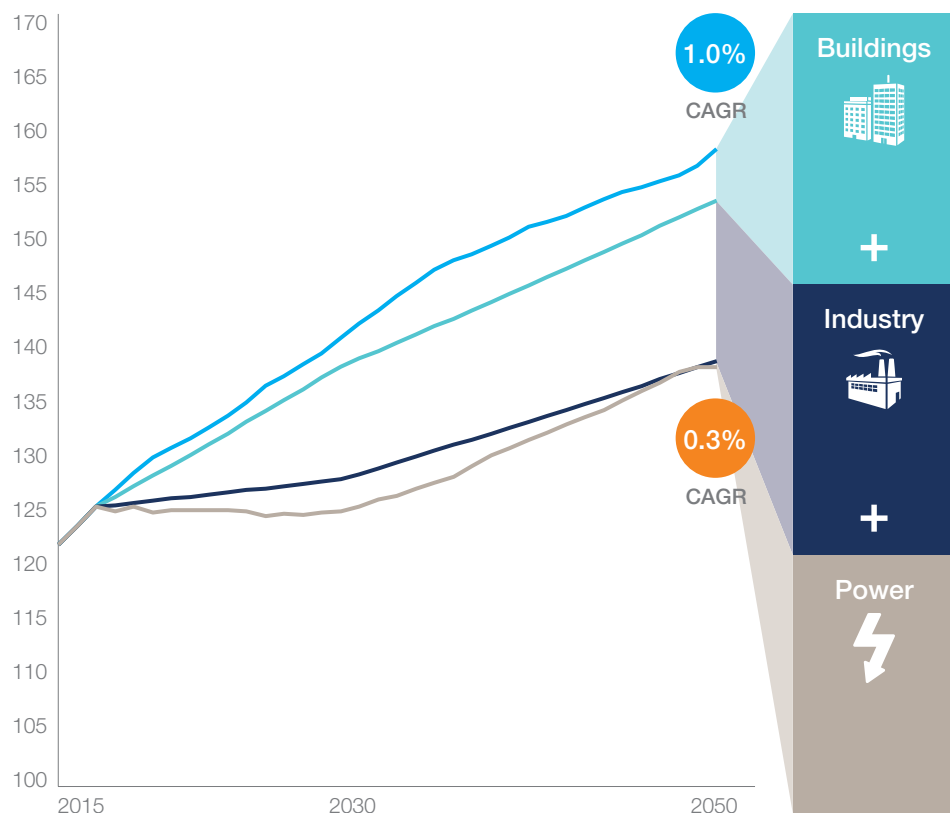
Source: McKinsey Energy Insights' Global Energy Perspective, December 2017

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



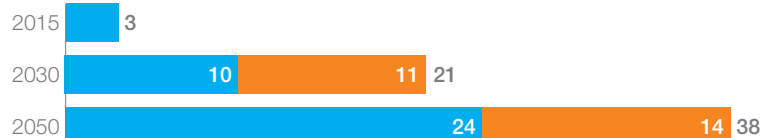
Global gas demand

Million TJ — Reference — Buildings disruption — Industry disruption — Power disruption



Residential heat pump adoption

% households with heat pumps¹



Electrification of industrial heating

% global process heat electrified



Cheaper renewables (select markets²)

LCOE in EUR/MWh solar 2050 example Mexico



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 CO₂ emissions
plateau by 2030
and remain far from a
2°C pathway

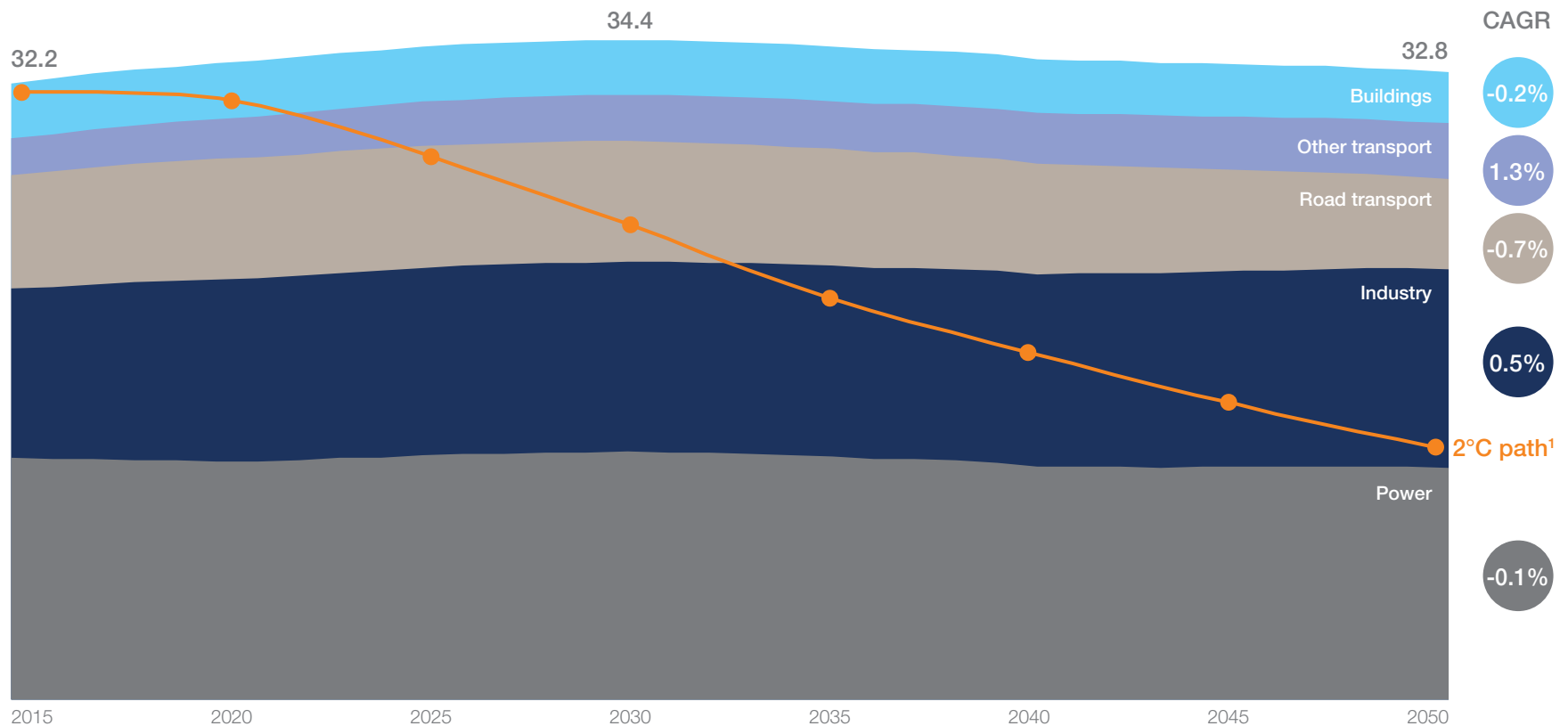


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Energy-related CO₂ emissions peak around 2030 but remain more than double the level consistent with a 2°C long-term pathway

Energy-related CO₂ emissions by sector¹

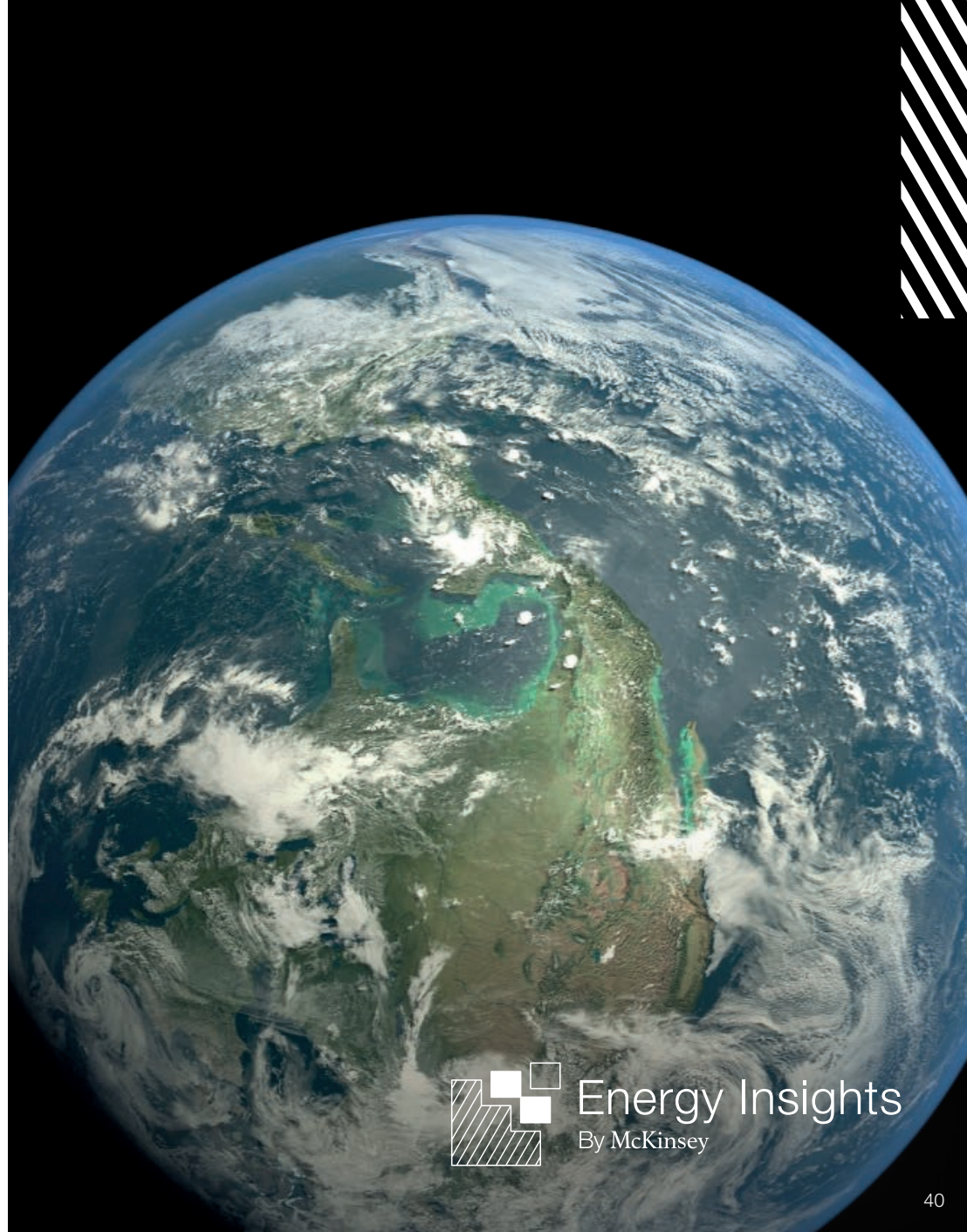
Gigatonnes CO₂-equivalent



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



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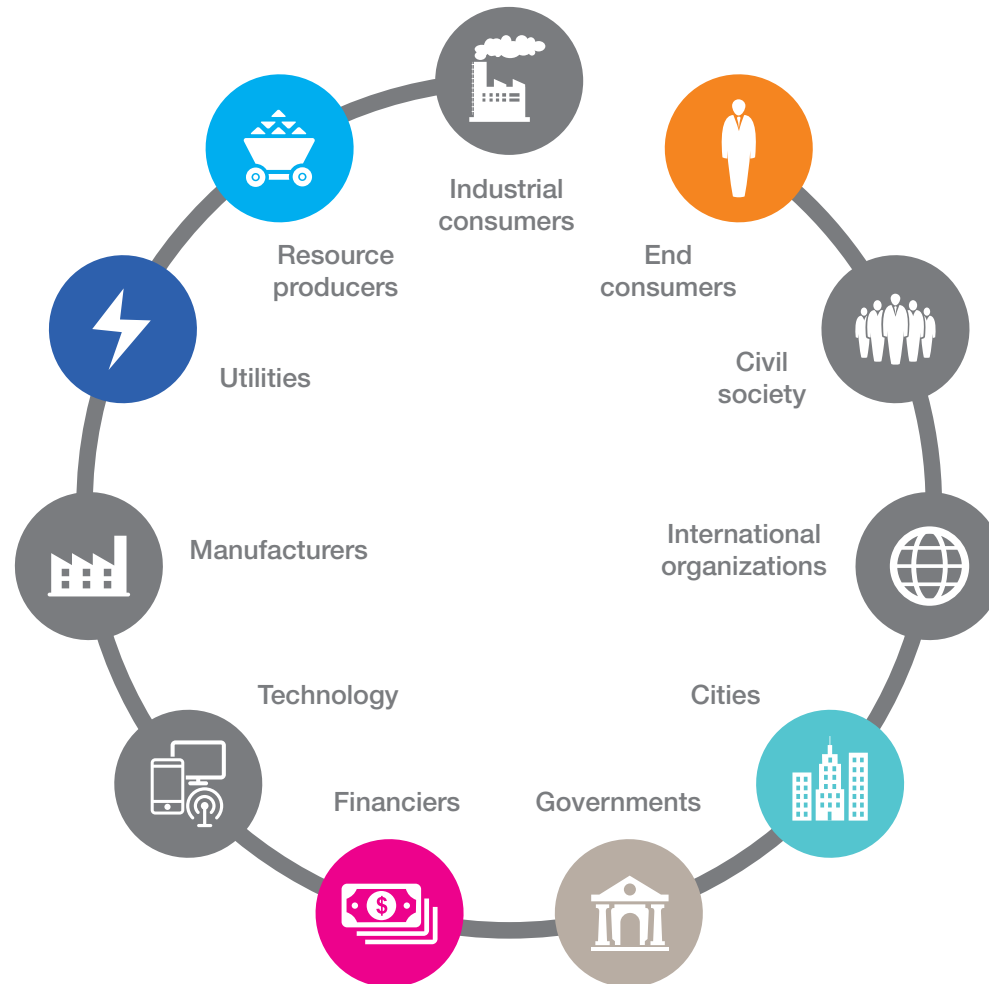
Questions we are discussing with our clients often affect multiple stakeholder groups: examples

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-intensive investments – where would that lead the capital?



Get in touch

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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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